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집합체간 열전달을 고려한 액체금속로 노심 열수력 해석

LMR Core Thermal Hydraulic Analysis Accounting for Inter-assembly Heat Transfer

2000. 6

한국원자력연구소

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제 출 문

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요 약

냉각재로 소듐을 사용하는 액체금속로에서는 피복재 온도나 핵연료의 최대온도에 설계 제한조건을 두게 된다. 이러한 설계요건을 만족하면서 냉각재 분배효율을 높이기 위해서는 노심의 온도분포를 정확히 예측할 필요가 있다.

소듐의 높은 열전도로 인하여 노심내 집합체간 열전달 현상이 집합체내 온도분포에 적지않은 영향을 미친다. 특히 이웃한 집합체간 온도차가 큰 경우에는 더 심하다. 따라서 액체금속로 노심 열수력 설계 및 해석시 집합체간 열전달 영향에 대한 고려는 필요하다. 현재 단일 집합체내에서의 온도분포 및 유량분포 계산이 가능한 MATRA-LMR 코드를 이러한 집합체간 열전달 영향을 고려하여 여러 집합체 계산 즉, 전체노심 해석이 가능하도록 개선작업을 수행하고 있다. 현재까지의 개발상태를 평가하기 위하여 여러 7-집합체 모의에 적용하여 계산을 수행하였고, 그 결과를 SLTHEN 및 THI3D 코드와 비교· 분석하였다. 계산결과, 집합체 평균 냉각재 출구온도는 집합체간 열전달 영향에 의해 변화하였으며, 최대 온도변화는 핵연료 집합체에서 보다 비 핵연료 집합체에서 그 영향이 크게 나타났다.

SUMMARY

It is essential to have an accurate prediction of core coolant and fuel temperature distribution in the liquid metal reactor (LMR) core thermal hydraulic design, because of the design limits are imposed on the maximum temperatures of claddings and fuel pins in the sodium cooled LMRs.

Due to the high thermal conductivity of the sodium, the transverse interassembly heat transfer may have a significant effect on the temperature profile within the subassembly, especially when it is adjacent to considerably hotter or colder subassemblies. Therefore, the interassembly heat transfer calculation should be considered in the LMR core thermal hydraulic design and analysis. For multi-assembly analysis, the interassembly heat transfer model was added in the MATRA-LMR code and the code was extended a single assembly analysis to multi-assembly analysis, i.e., a whole core code. For the assessment of the development status with interassembly heat transfer, the benchmark calculations were performed with SLTHEN and THI3D codes using the 7-assembly problems. It is founded that the subassembly mixed mean coolant temperature has been changed as an effect of the interassembly heat transfer. And the maximum temperature change was found in the non-fueled subassembly which is considerably colder than the fueled subassemblies.

목 차

부 록

1. 서론

액체금속로 노심 설계시 최대 핵연료 피복재 및 냉각재 온도에 대한 정확한 값을 요구하게 되는데 이는 원자로의 안전성 뿐만아니라 경제성까지 고려한 최적의 조건을 만들기 위한 것이다. 이와 같이 정확한 노심 열수력 해석을 위해서는 여러가지 요소가 있겠지만 그 중 노심내 집합체간 열전달 현상은 중요한 고려 대상중 하나이다. 소듐을 냉각재로 사용하고 있는 액체금속로에서는 소듐의 높은 열전도로 인하여 집합체간 열전달은 집합체내 온도분포에 영향을 미치며, 특히 이웃한 집합체간 온도차가 클 경우 그 영향은 더 커진다 (George et al., 1979 ; Carelli et al, 1978).

또한 집합체간 온도차로 인해 집합체의 열적 휨 현상이 일어날 수 있으며, 이는 곧 노심반응도에 영향을 줄뿐 아니라 집합체의 삽입 및 인출에 지장을 줄 수 있다. 특히 브랑켓 집합체가 핵연료 집합체와 서로 섞여 있는 비균질 (heterogeneous) 노심인 경우 집합체간 열전달은 덕트온도에 영향을 주며, 이러한 덕트온도의 변화는 덕트의 건전성 평가에 중요한 요소가 된다. 즉, 핵연료 집합체 사이의 반경방향 열전도는 온도차이가 작아 큰 영향이 없지만, 핵연료 집합체가 제어 집합체나 브랑켓 집합체와 이웃한 경우에는 그 영향이 심각하다. 집합체간 열전달은 덕트벽 온도 뿐 아니라 집합체내 온도분포를 변화시키므로, 집합체간 열전달을 무시하고 액체금속로 노심설계 관련 데이터를 구하는 것은 바람직하지 않다. 그러므로 집합체간 열전달 해석이 냉각재 온도분포에 어느정도 영향을 미치는지를 이해하는 것은 중요하며, 집합체간 열전달을 고려한 노심 열수력 해석은 집합체내 정확한 온도 및 유량분포를 예측하는데 필수적이다 (Chang, 1977 ; Wei, 1978). 지난 수십년간 해외에서는 집합체간 열전달과 관련하여 많은 실험이 수행되었으며, 해석적 차원에서도 여러 코드가 개발되었다. 대표적인 것으로는 THI3D (Sha, 1976), CORE-3D (Khan, 1977), TRITON (Carelli, 1978), COBRA-WC (George, 1980), 그리고 SLTHEN (Yang, 1997) 등이 있다.

본 보고서에서는 MATRA-LMR 코드의 해석능력을 단일 집합체에서 전체노심으로 확장한 작업을 기술하였으며, 이때 집합체간 열전달 및 덕트내 열발생도 함께 고려하였다. 한편 XX08, EBR-II, TED 7-집합체 계산을 통해 기존 코드와의 계산결과를 비교함으로써 MATRA-LMR 코드의 전체노심 해석기능에 대한 신뢰성 확보에 주력하였다. 또한 현재 개념 설계중인 KALIMER의 설계데이타를 이용하여 계산을 수행함으로써 설계 코드로서의 적용가능성을 분석하였다. 현재는 설계평가만을 고려하여 정상상태의 운전조건하에서 사용할 목적으로 개발하고 있으나 이를 좀더 확장하여 비운전조건 즉, 유동이 작은 자연대류과 같은 상황에서도 해석이 가능할 수 있도록 집합체간 유동 재분배 및 역류 해석 능력 등을 보완할 계획이다.

2. MATRA-LMR 코드

2.1. 개요

MATRA-LMR (Multichannel Analyzer for Transient and steady-state in Rod Aray-Liquid Metal Reactor)은 그 근간을 COBRA 코드 [Wheeler, 1976]에 두고 있다. COBRA (COolant Boiling in Rod Arrays) 코드는 부수로 해석이라는 기본적인 개념을 활용하고 있다. 즉, 핵연료봉 집합체의 유로면적을 여러개의 부수로로 나누고, 다시 각 부수로는 수직적으로 여러개의 control volume으로 나누어, 질량, 에너지 및 운동량 방정식을 유도하여 유량, 압력, 엔탈피 등을 계산한다.

국내에서는 1997년에 COBRA-IV-i를 근간으로하여 정확도를 향상시키고, 사용자 편리를 위해 여러 가지 기능을 추가한 MATRA 코드가 개발되었다 [유연종, 1997]. 추가된 주요 기능은 다음과 같다. 첫째, COBRA 코드가 여러해 계속적으로 개발되어오면서 갖고있는 불필요해지거나 사용이 정지된 subroutine이나 문장을 제거하여 코드구조를 단순화시켰으며, 코드내에서 사용되는 상수들의 유효숫자를 증가시키고 모든 실수들을 double precision으로 수정하여 보다 정확한 계산을 수행할 수 있도록 하였다. 둘째, Fortran 66으로 작성된 코드언어를 Fortran 90으로 수정하여 재구성 함으로써 보다 용이하게 코드구조를 파악할 수 있고 사용하기도 편리하도록 하였다. 셋째, 기존 COBRA-IV-i에서는 입·출력 단위가 british 단위 하나로 이루어져 있으나 이를 british와 SI 단위로 재구성해 사용자가 입력 및 출력의 단위를 선택할 수 있게 하였다. 넷째, COBRA-IV-i에서는 축방향 node를 나눌 때 균일한 길이로만 나누어야 계산이 가능하였으나, MATRA에서는 이를 가변적으로 사용할 수 있도록 수정하였다. 이는 부수로 blockage와 같은 문제시 특정 부분의 node를 자세히 나누어 사용하므로써 보다 효율적인 계산 수행이 되도록 하기 위한 것이다.

그러나 여전히 MATRA는 경수로에만 적용이 가능할 뿐 액체금속로에는 사용할 수가 없었다. 이를 액체금속로에 적용할 수 있도록 개발한 것이 MATRA-LMR이다. 이를 위해 다음과 같은 사항이 수정되거나 추가되었다. 첫째, 현재 경수로의 냉각재인 물 대신 액체금속로 냉각재인 소듐에 대한 물성치를 계산하는 상관식을 subroutine으로 작성하여 코드에 재구성함으로써 코드 운용시 기본적으로 계산되도록 하였다. 물에 대한 물성치는 선택적으로 지금과 같이 입력으로 줄 수 있게 하였다. 둘째, 열전달 계수에 대한 사항을 물 대신 소듐에 대한 상관식으로 수정하였으며, 현재 소듐 열전달 계수로 널리 사용중인 상관식중 세가지를 선택적으로 취하여 계산이 가능하도록 코드를 재구성하였다. 마지막으로 핵연료 집합체내 각 부수로의 형태 및 wire-wrap에 의해 유발되는 압력강하는 현재 자주 이용되는 압력강하 상관식 세가지를 코드내에 추가함으로써 선택적으로 적절한 상관식을 이용하여 마찰계수 및 압력강하에 관한 계산을 수행할 수 있도록 하였다. 즉, COBRA-IV-i에서는 매끈한 관내의 압력강하 상관식을 단순히 사용하고 있으나, wire-wrap이 있는 경우 축방향 위치에 따라서 부수로내 유량면적 및 유체가 접촉하는 둘레 길이는 변화함으로 이에 대한 적절한 평가를 적용해 주어야 한다. MATRA-LMR에서는 이에대한 영향을 고려한 압력강하 상관식 Novenstern (1972), Chiu-Rohsenow-Todreas (1978), Cheng-Todreas (1986)을 선택적으로 사용할 수 있도록하였다. 그림 1은 부수로 및 wire-wrap을 나타낸 것이며, 그림 2는 MATRA-LMR코드의 개발 과정을 나타낸 것이다.

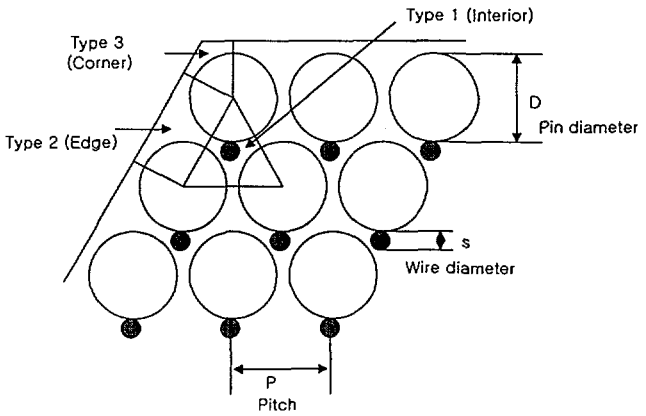


그림 1. 부수로 형태 및 wire-wrap 형상

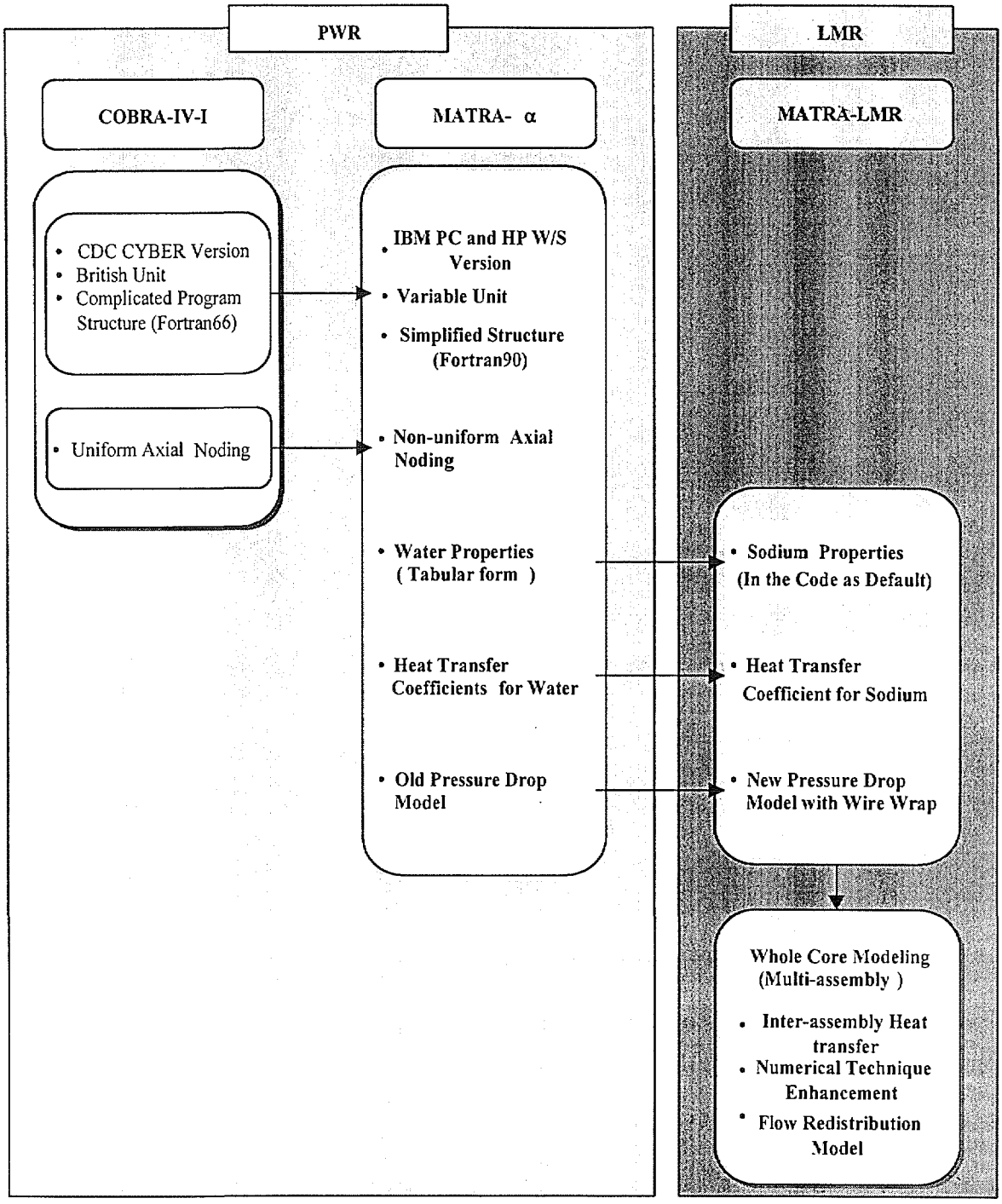


그림 2. MATRA-LMR 코드 개발 과정

2.2. 집합체간 열전달 모델

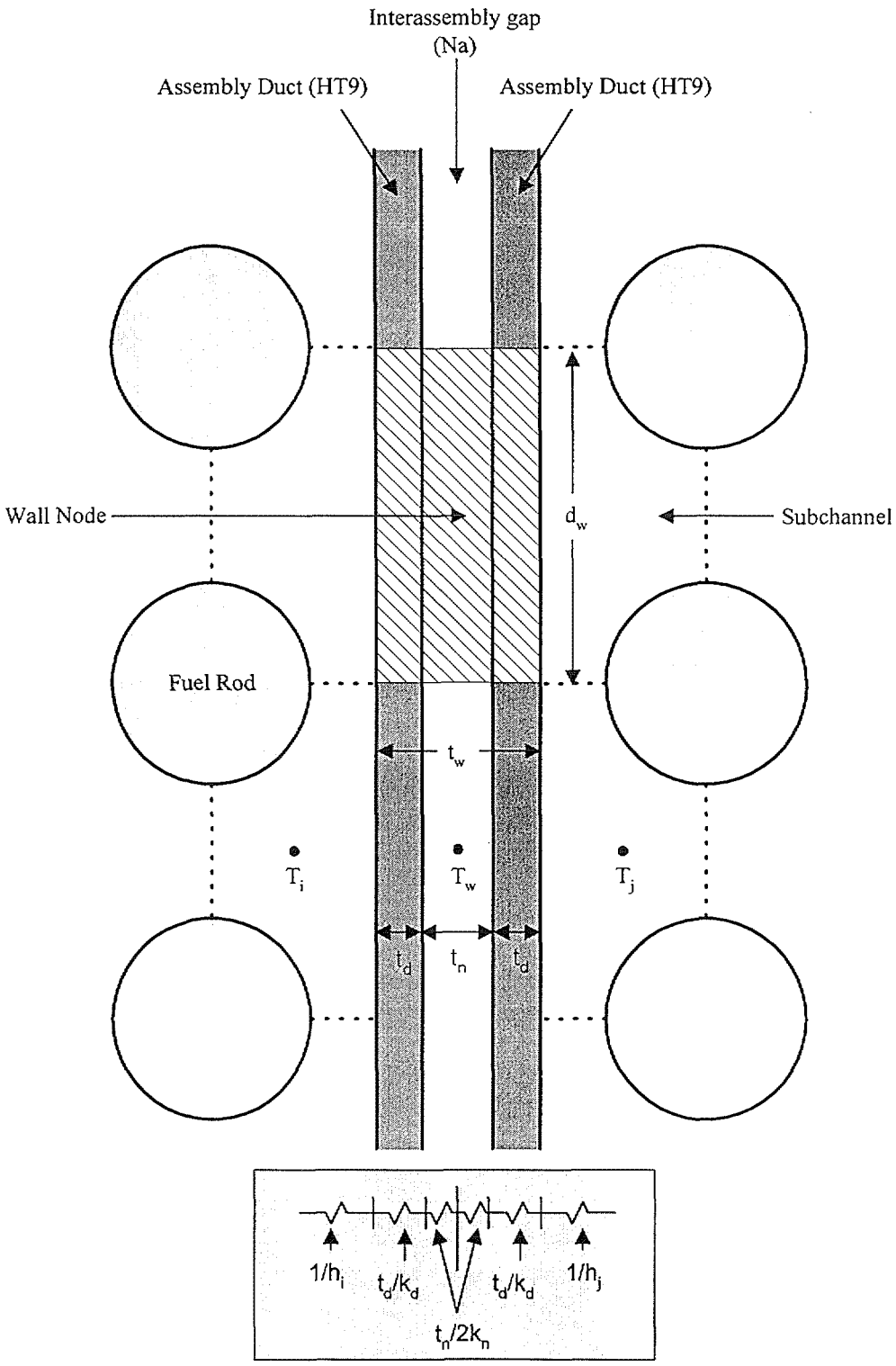


그림 3. 집합체간 열전달 모델

MATRA-LMR 코드는 액체금속로 온도분포 계산의 정확성을 높이기 위해 집합체간 열전달 모델을 개발하였으며, 이때 두 집합체 사이의 열전달 모델은 단일 node로 구성된 벽 영역을 설정하여 나타내었다. 그림 3은 액체금속로의 집합체간 열전달 모델를 나타낸 것이다. 즉, 그림은 두 집합체간 열전달을 설명하는 것으로 집합체내 가장자리 핵연료봉이 있고, 덕트벽이 있으며 덕트와 덕트 사이 (집합체와 집합체 사이)에는 소듐이 차 있는 것을 볼 수 있다. 이때 벽 node는 위 그림에서와 같이 두 집합체의 덕트벽과 그 사이 간격 (덕트벽 i + 집합체 사이 간격 + 덕트 j)을 포함하여 나타내고 있다. 이러한 벽 node를 이용한 에너지 방정식은 다음과 같다 (George, 1980).

$$(\rho_w C_{pw} t_w)\frac{(T_w - T_w^n)}{\Delta t} = - U_i(T_w - T_i) - U_j(T_w - T_j) + q'''_w t'_w \qquad (1)$$

[총열량] = [부수로 i로부터 전달된 열량] + [부수로j로부터 전달된열량] + [덕트벽내 열발생량]

벽 node의 온도 및 물성치에 대한 값은 아래첨자 w에 의해 나타내었다. 또한 부수로 i와 j에 대한 유효열전달계수 U_i와 U_j는 다음과 같이 정의하였다.

$$\frac{1}{U_i} = \frac{1}{h_i} + \frac{t_d}{k_d} + \frac{t_n}{2k_n} \qquad (2)$$

$$\frac{1}{U_j} = \frac{1}{h_j} + \frac{t_d}{k_d} + \frac{t_n}{2k_n} \qquad (3)$$

여기서,

h_i, h_j	= 부수로 열전달 계수
	= $(7. + 0.025\cdot(Re\cdot Pr)^{0.8})\cdot(k_n/D_h)$: (Lyon-Martinelli 열전달 상관식)
k_d	= 덕트의 열전도도 (HT9)
k_n	= 소듐의 열전도도
Re	= Reynold 수 (= $\rho\cdot V\cdot D_h/\mu$)
Pr	= Prandtl 수 (= $C_p\cdot\mu/k_n$)
D_h	= 수력적 직경 (= $4\cdot A/P_w$)
$1/(t_d/k_d)$	= 덕트벽 열전도
$1/(t_n/2k_n)$	= 집합체 사이 ($t_n/2$)에 있는 소듐의 열전도
$(\rho_w C_{pw} t_w)$	= 벽 effective heat capacitance
	= $2(\rho_d C_{pd} t_d) + (\rho_n C_{pn} t_n)$: (2 duct wall) + (sodium gap)
t_w	= Wall node thickness ($2t_d + t_n$)
t_w'	= Effective wall node thickness for heat generation ($2t_d$)

그림 3에서 보듯이 집합체내 가장자리 부수로와 덕트벽 사이에서의 대류 열전달은 완전한 난류유량 열전달 데이터로부터 구해지며, (즉, 여기에서는 Lyon-Martielli 상관식을 사용) 이웃한 집합체와의 사이에 있는 소듐에 의한 열전달은 열전도를 고려하여 얻어진다. 사실 집합체 사이에 소듐의 유동이 있지만 그 양이 집합체내 유량에 비해 상대적으로 매우 작아 이를 정지해 있다고 가정하여 벽 node에서의 축방향 대류 및 반경방향 유량혼합에 의한 항을 열전도 모델로 전환하여

구성한 것이다. 즉, 집합체 사이 소듐에 대해서도 덕트벽과 같이 열전도에 의한 저항값으로 보고 벽 node에서의 열전달은 이 세 저항값의 합으로 구성하였다. 이와 마찬가지로 벽 node의 effective heat capacitance 값도 2개의 덕트벽과 그 사이 소듐값에 대한 합으로 나타내었다.

식 (1)을 t_w에 대한 항으로 표현하면 다음과 같다.

$$\left[\frac{(\rho_w C_{pw} t_w)}{\Delta t} + U_1 + U_2\right] T_w = U_1 T_1 + U_2 T_2 + (\rho_w C_{pw} t_w)\frac{T_w^n}{\Delta t} + q_w''' t'_w \qquad (4)$$

식 (4)는 다시 아래와 같은 정의에 의해 벽온도 (t_w) 및 부수로 엔탈피 (h_k)에 대한 식으로 표현할 수있다.

$$C_p = \frac{h-\tilde{h}}{T-\tilde{T}} \quad : \text{비열 (specific heat)} \qquad (5)$$

$$U_1 T_1 = U_1\left(\frac{h_1}{C_p} + \tilde{T}_1 - \frac{\tilde{h}_1}{C_p}\right) = \frac{U_1}{C_p} h_1 + U_1\left(\tilde{T}_1 - \frac{\tilde{h}_1}{C_p}\right) \qquad (6)$$

$$U_2 T_2 = U_2\left(\frac{h_2}{C_p} + \tilde{T}_2 - \frac{\tilde{h}_2}{C_p}\right) = \frac{U_2}{C_p} h_2 + U_2\left(\tilde{T}_2 - \frac{\tilde{h}_2}{C_p}\right) \qquad (7)$$

윗첨자 n = 전단계 time step
윗첨자 ~ = 현재 time step 이고, 전단계 iteration 값

위에서 정의한 식을 사용하여 식 (4)를 정리하면 다음과 같다.

$$\left[\frac{(\rho_w C_{pw} t_w)}{\Delta t} + U_1 + U_2\right] T_w = \frac{U_1}{C_p} h_1 + \frac{U_2}{C_p} h_2 + U_1\left(\tilde{T}_1 - \frac{\tilde{h}_1}{C_p}\right) + U_2\left(\tilde{T}_2 - \frac{\tilde{h}_2}{C_p}\right) + (\rho_w C_{pw} t_w)\frac{T_w^n}{\Delta t} + q_w''' t'_w \qquad (8)$$

식 (8)은 부수로내 에너지 방정식과 함께 결합하여 미지값인 벽 node내 온도와 부수로의 엔탈피에 대한 matrix를 구성하여 해를 구하게 된다. 이때 해는 Gauss-Seidel 반복법을 사용한다.

집합체내 열원은 핵분열에 의한 열발생이 대부분을 차지하지만 감마선에 의한 열발생 (gamma heating) 또한 한 부분을 차지하고 있다. 따라서 덕트벽내에서 감마히팅에 의해 발생하는 열을 적절히 고려해 주어야 집합체간 열전달 계산결과가 보다 정확한 값을 갖게 될 것이다. 즉, 덕트내에서의 열발생을 고려하기 위해 식 (1)에서 마지막 항을 추가하는 것이다. 이때 사용한 가정은 다음과 같다. 덕트벽을 포함하여 한 집합체내 열발생율을 균질화 시켜 어느 영역에서나 똑같은 부피당 열발생량을 갖는다. 이는 실제 설계에서 덕트벽에서만의 감마히팅을 구하는 것이 어렵기 때문이다. 이에 대한 좀 더 구체적인 설명은 그림 4을 통해 나타내었다.

여기서,
h = $1/2 \cdot FFD + t_d$

FFD = 집합체 안쪽 길이 (flat to flat inside distance)

t_d = 덕트 두께

D_w = $2 \cdot h \cdot \tan 30$: 덕트 한면의 길이

A_t = $6 \cdot (1/2 \cdot h \cdot D_w)$: 덕트를 포함한 집합체 전체면적

V_t = $A_t \cdot L$: 덕트를 포함한 집합체 전체부피

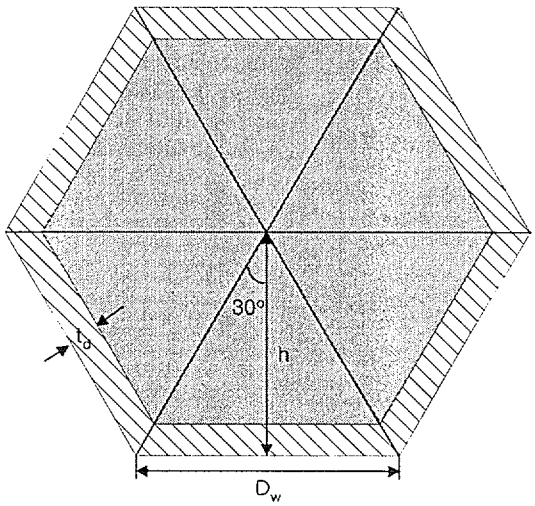


그림 4. 집합체의 덕트 구성도

따라서 집합체 출력밀도 q‴ (kW/m³)는 q/V_t이고 여기서 q는 각 집합체별 열발생율 (kW)로서 입력으로 주어지는 값이다.

$$q = q_w''' t_w' D_w P_a P_t \Delta x \tag{9}$$

여기서,

P_a = 축방향 출력분포

P_t = 과도기 출력분포

식 (1)의 마지막항에서 서로 이웃한 집합체의 덕트내 열발생량은 다음과 같다.

$$q_w''' t_w' = q_i''' t_d + q_j''' t_d \tag{10}$$

위에서 언급한 덕트내 열발생량을 포함한 벽 에너지 방정식을 이용하여 식 (8)을 다음과 같이 나타낼 수 있다.

$$\left[\frac{(\rho_w C_{pw} t_w)}{\Delta t}+U_1+U_2\right]T_w = \frac{U_1}{C_p}h_1+\frac{U_2}{C_p}h_2+U_1\left(\widetilde{T}_1-\frac{\widetilde{h}_1}{C_p}\right)+U_2\left(\widetilde{T}_2-\frac{\widetilde{h}_2}{C_p}\right)+(\rho_w C_{pw} t_w)\frac{T_w^n}{\Delta t} \quad (11)$$
$$+\frac{1}{2}t'_w\left[q'''(Ass.1)\cdot P_a(Ass.1)\cdot P_t(Ass.1)+q'''(Ass.2)\cdot P_a(Ass.2)\cdot P_t(Ass.2)\right]$$

여기서 Ass.1과 Ass.2는 이웃한 두 집합체를 나타낸 것이다. 이때 각 집합체별 P_a와 P_t는 입력으로 주어진다.

2.3. 전체노심 해석

현재의 MATRA-LMR 코드를 단일 집합체 해석에서 확장하여 전체노심을 해석할 수 있도록 개선하였다. 즉, 위에서 언급한 집합체간 열전달 모델을 바탕으로 여러 집합체에서의 유량과 온도 분포를 계산할 수 있다. 그림 5는 61개의 집합체로 구성된 노심을 예로 MATRA-LMR 코드에서 사용된 번호체제를 나타낸 것이다.

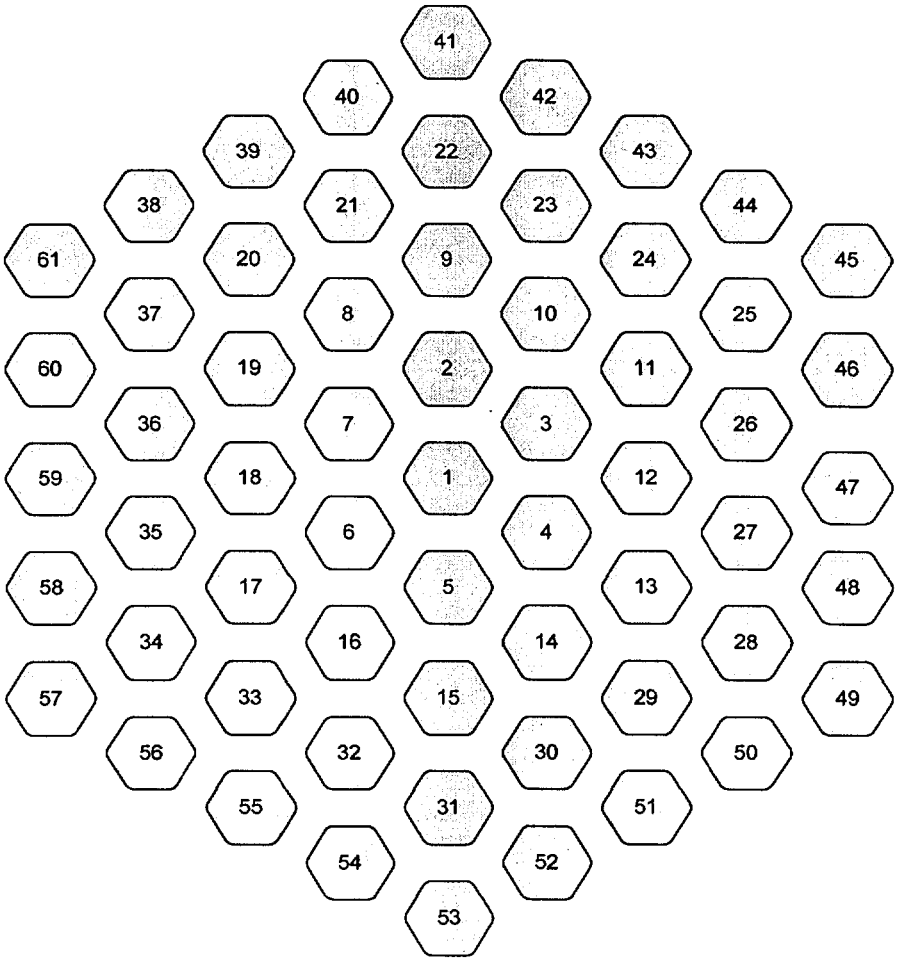


그림 5. MATRA-LMR 코드의 61 집합체 노심 번호체제

일반적인 액체금속로 노심에 집합체가 300 여개에 존재한다고 가정할 때 단일 집합체와 같은 부수로 배열 및 계산 방법으로는 그 계산시간이 오래 걸려 설계용 코드로는 비효율적이다. 따라서 전체노심으로 확장하는 과정에서 계산시간을 줄이려고 다음과 같은 몇가지 가정을 사용하였다. 그림 6은 MATRA-LMR 코드의 전체노심 해석을 위한 모델 및 집합체 구성도를 나타낸 것이다.

- 집합체 수에 관계없이 노심은 표준 집합체 1개와 나머지 주변 집합체들로 구성된다. 즉, 두 종류의 집합체가 사용되는데 하나는 표준 집합체로 실제 집합체의 형상대로 부수로와 핵연료봉을 모델하는 것이고, 다른 하나는 주변 집합체로 집합체의 형태에 관계없이 부수로는 12개, 핵연료봉은 7개로 단순화된 집합체를 말한다. 이는 다집합체 계산시 계산시간을 줄이기 위한 것이다.
- 전 집합체에 대해 동일한 축방향 node 수를 사용하였고, 덕트두께 또한 전 집합체가 균일하다고 가정하였다.
- 반경방향 온도분포 및 wire-wrap 사용은 표준 집합체에서만 고려할 수 있도록 하였다.
- 단상유동 (single phase) 문제에만 적용 가능하며, 이상유동 상태에서는 계산이 불가능하다.

기본적으로 부수로 해석 방법에 있어서는 단일 집합체 계산시와 차이가 없다. 즉, 질량, 에너지, 그리고 운동량에 대한 지배방정식을 풀어서 온도 및 유량분포를 계산한다. 전체노심으로 확장하면서 관심있는 표준 집합체만 단일 집합체와 같은 수준의 계산을 수행하고 나머지 집합체에 대해선 단순화시켜 표준 집합체와의 열전달을 통해 표준 집합체내에서 보다 정확한 온도분포를 얻고자 하였다. 이는 MATRA-LMR 코드가 상세설계 코드로서의 역할을 수행하기 위한 것으로 집합체내에서의 정확한 온도 및 유량분포에 대한 예측은 설계시 안정성 및 경제성에 있어서 향상을 가져올 것으로 판단한다.

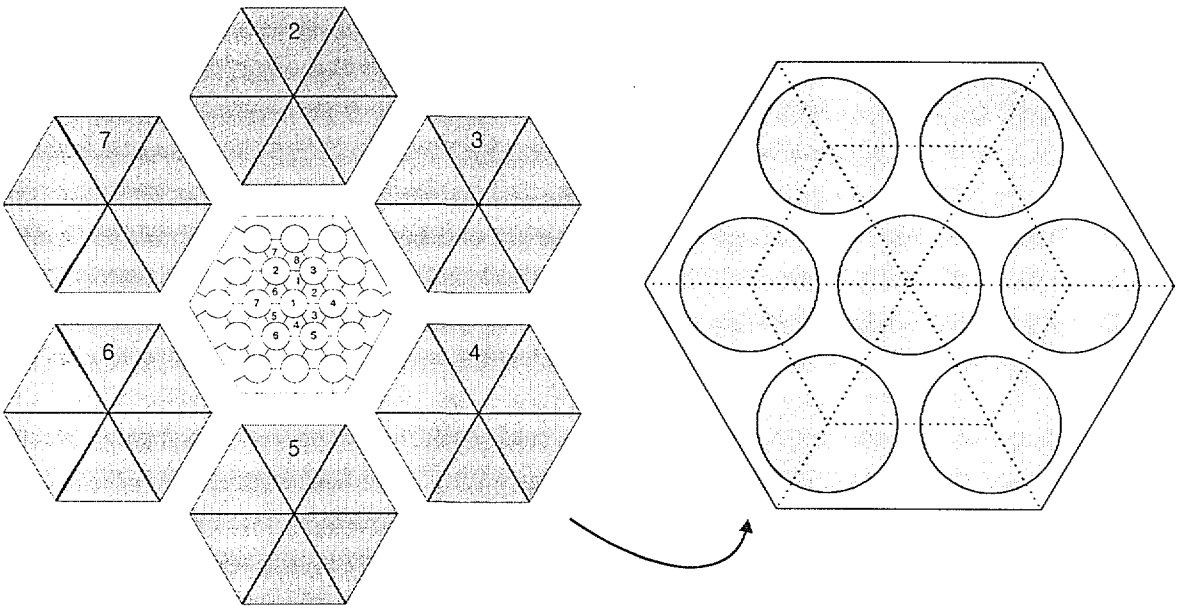


그림 6. MATRA-LMR 코드의 전체노심 해석 모델

3. 계산

3.1. 벤치마크 코드 개요

SLTHEN 코드

MATRA-LMR 및 SABRE4 (MacDougall, 1984) 코드와 같이 현재 사용되고 있는 대부분의 부수로 해석 코드들은 노심내 냉각재의 속도 및 온도 분포를 얻고자 복잡한 물리적 모델을 사용한다. 즉, 질량, 에너지, 축방향 운동량, 반경방향 운동량 보존방정식을 사용하여 계산을 수행하고 있다. 운동량 방정식에서 속도분포를 구하고 이를 에너지 방정식에서 다시 사용하여 수렴이 될 때까지 반복 계산을 수행한다. 이러한 특성상 많은 기억용량과 계산시간을 필요로 한다. 이러한 단점을 보완하여 보다 빠른 속도로 계산이 가능하도록 간단한 모델을 이용한 코드가 1970년대 중반 MIT (Massachusetts Institute of Technology)에서 개발되었다. 즉, 여기서 사용된 ENERGY 모델은 질량 및 운동량 보존 방정식을 풀지 않는다. 다만 이러한 방정식을 액체금속로 핵연료 집합체에 적합한 근사 모델로 전환하고 에너지 보존 방정식만 계산하게 된다.

ENERGY 모델을 근간으로 1970년대 중반에 MIT에서 ENERGY (Khan, 1975)와 SUPERENERGY (Chen, 1975)코드가 개발되었다. ENERGY 코드는 집합체 하나에 대해서만 해석이 가능하나, SUPERENERGY는 다집합체 해석이 가능하도록 개선되었다. 1980년대초 SUPERENERGY는 다시 SUPERENERGY-2로 Pacific Northwest Laboratory (PNL)에 의해 개발되었다. 여기에서는 강제대류시 다집합체 계산 및 정상상태 부수로 계산이 가능하도록 개선되었다. 1995년에는 SUPERENERGY-2에다 핵연료 및 피복재 온도 계산 모델과 Hot spot 해석 모델을 추가하여 Argonne National Laboratory (ANL)에 의해서 SE2-ANL 코드로 개발되었다 [Yang, 1995]. 국내에서는 SUPERENERGY-2를 개선하여 SLTHEN (Steady-state LMR core Thermal Hydraulics analysis code based on ENergy model)이 개발되었다 [Yang, 1997]. SUPERENERGY-2 코드에서는 에너지 방정식의 축방향 대류항 계산시 양해법 (Explicit)을 사용하는데, 수치해석적 불안정성 때문에 mesh을 상세히 나누어야 하는 단점이 있다. 그러나 mesh을 매우 작게 나누는 것은 상당한 계산시간을 요하므로 현실적으로 적용하기 힘들다. 따라서 실제 집합체간 gap 사이에 흐르는 유량이 매우 작으므로 이를 무시하여 유량이 흐르지 않는다고 가정하고 집합체간 열전달은 열전도에 의한 모델로만 계산한다. 반면 SLTHEN에서는 이를 고려하여 θ -방법을 추가하였다. 이는 θ 의 값에 따라 θ =0이면 완전 양해법 (Explicit)을 사용하고, θ =1이면 완전 음해법 (Implicit), θ =1/2이면 Crank-Nicholson 방법을 수행한다. 이에 대한 상세한 설명은 참고문헌 [Yang, 1997]에 나타나 있다.

앞서 말한대로 집합체내 모든 부수로의 유동방정식을 풀어 해를 구하는 방법은 많은 계산 시간을 요하는 단점을 안고 있다. 이를 위해 삼각수로 형상을 갖는 액체금속로 해석에 적합한 간단한 모델 ENERGY가 개발되었으며, 강제대류시에는 매우 정확한 온도분포 계산이 가능할 뿐만 아니라 계산시간도 현저하게 적게 걸리는 것으로 나타났다 [김원석, 1998]. ENERGY 모델의 단순성은 부수로간의 운동량 해석을 액체금속로 핵연료 집합체에 적합한 근사모델로 대체하여 오직 에너지 방정식만 푸는데에 있다. 이러한 모델 개발을 위해 집합체내 전체 부수로를 반경방향으로 두 지역으로 나눈다. 즉, 중심지역은 중심에 위치한 대부분의 부수로를 포함하며, 외곽지역은 duct에 인접한 부수로를 포함한다. 중심지역에서는 축방향 속도와 eddy 확산계수에 의해 모델되

고, 외곽지역에서는 축방향 속와 선회속도에 의해 모델된다. 이때 중심과 외곽의 두 축방향 속도는 Novendstern, Chiu-Rohsenow-Todreas, Cheng-Todreas와 같은 유동분할 모델을 사용하여 구할 수 있다. 그림 7은 SLTHEN 코드에 적용된 ENERGY 모델을 나타낸 것이다. 반면 wire-wrap 혼합효과에 의해 나타나는 eddy 확산계수 및 wire-wrap에 의해 duct 벽을 따라 발생하는 선회속도는 실험자료를 이용하여 기하학적 자료의 상관식으로 나타낼 수 있다. 이와같은 ENERGY 모델은 정상상태하에서 강제대류 해석시 계산시간을 많이 단축하면서도 정확한 결과를 얻을 수 있었다. 반면 자연대류, 과도상태, 유동 blockage 등과 같은 조건에서는 보다 상세한 열수력 모델을 사용한 코드에 비해 비효과적이다 [Yang, 1995].

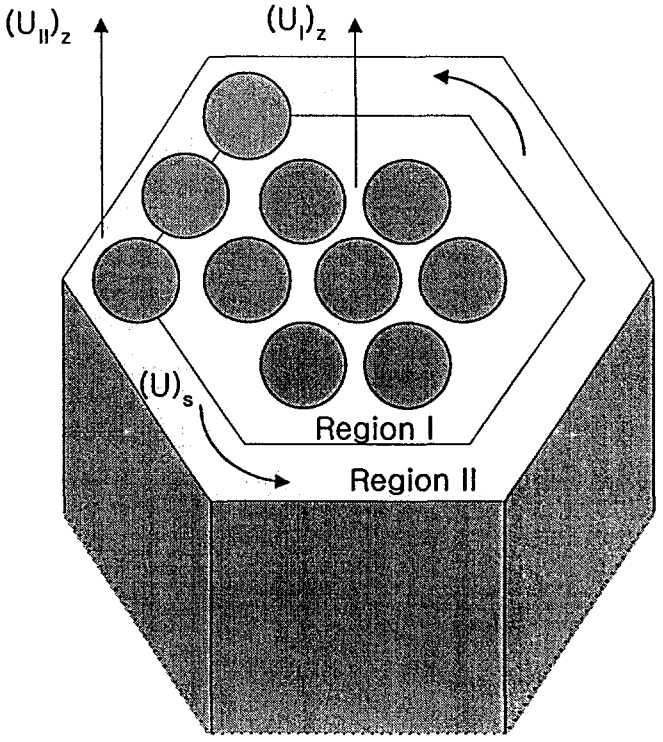


그림 7. SLTHEN 코드에서의 두 지역 유동영역 구분

THI3D 코드

THI3D (Thermal Hydraulic Interaction in 3 Dimensions) 코드는 정상상태, 단상류에서의 다유로(multichannel) 열수력 해석코드로서, 열전달 및 유체의 흐름을 해석하기 위하여 만들어졌으며, 비선형 경계조건 문제를 압력강하 조건과 함께 계산한다. 이 코드에는 난류에 의한 상호작용, 반경방향 열전도, 유로사이의 wire-wrap이나 grid에 의해 발생하는 강제유량이 고려되어 있다. THI3D 코드는 압력강하 경계조건에 따른 질량, 에너지, 운동량 보존식에서 비선형 multipoint 경계조건 문제를 유도하여 이것을 계산하는 방식으로 되어 있으며, 냉각재, 피복관, 핵연료 및 덕트벽에서의 온도분포를 계산할 수 있다. THI3D 코드는 유로간의 상호작용을 고려한 multipin 해석 또는 유로간의 상호작용을 고려하지 않은 multiassembly 계산을 수행할 수 있다. Multipin 해석에서는 각각의 연료봉을 하나의 유로로 보고 유로간의 유량교환이나 입구 및 출구에서의 수력적 커플링을 고

려하고 있다. Multiassembly 계산에서는 핵연료 집합체를 하나의 유로로 하고, 집합체 내부에서 전형적인 핀을 하나 선택하여 모든 핀을 대표한다고 가정하여 계산을 수행한다. 또한 multiassembly 계산에서는 유로간의 유량교환이 일어나지 않는다 [Sha, 1976]. 그림 8과 9는 전형적인 multipin 및 multiassembly 모델을 나타낸 것이다.

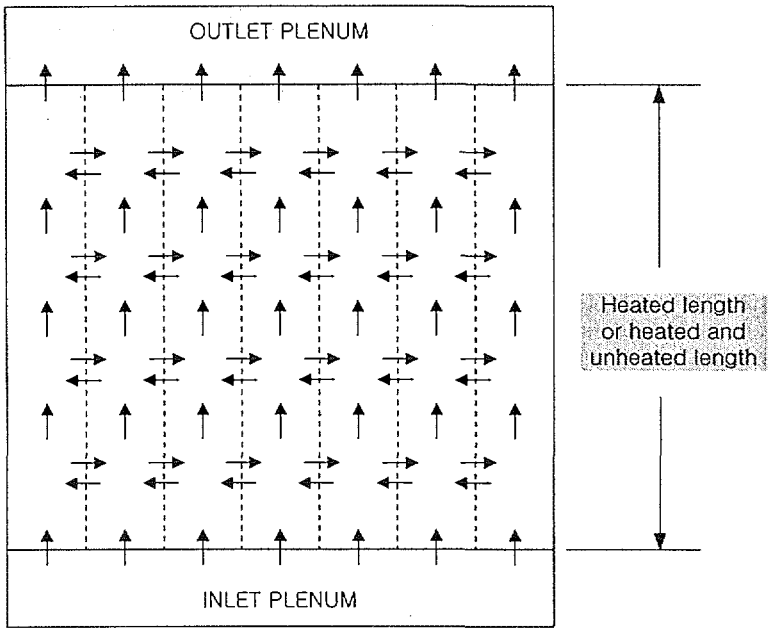


그림 8. THI3D multi-pin 계산 모델

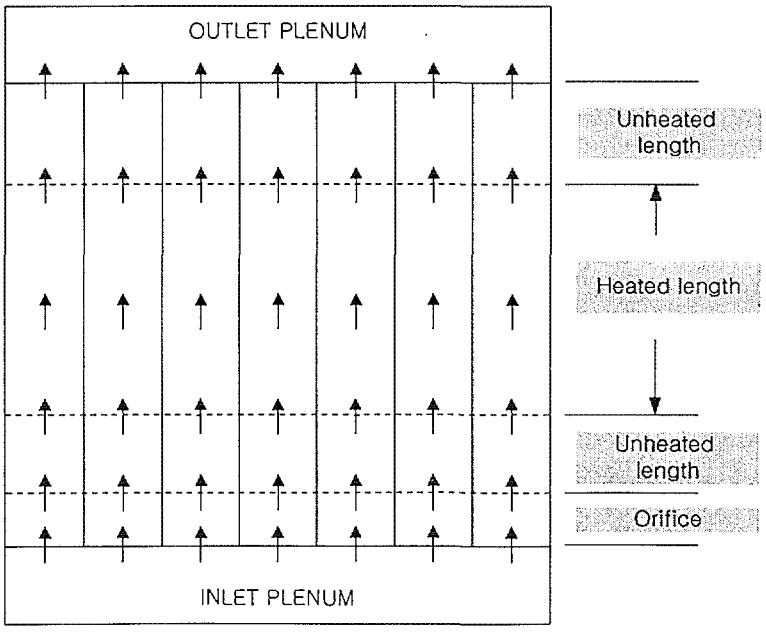


그림 9. THI3D multi-assembly 계산 모델

THI3D 코드에서 사용하고 있는 유체와 에너지의 수송을 기술한 지배방정식은 유체의 질량, 에너지 및 운동량 보존법칙을 오일러 제어체적에 적용하여 유도할 수 있다. 이 지배방정식들을 적당한 경계조건과 보조상관식들을 사용하여 수치해법으로 계산한다. THI3D에서는 수학적 모델 계산시 다음과 같은 몇가지를 기본적으로 가정하고 있다.

- 음속전파로 인해 나타나는 효과를 고려하지 않았다.
- Lumped parameter를 사용하였다. 즉, 같은 높이에 있는 유로내의 물리량들은 균일하며 등방성을 갖는다.
- 난류 Reynolds stress 및 모든 난류유동변수는 일정한 값을 갖는 것으로 가정하였다.
- 인접유로와의 반경방향 운동량 교환은 1차원으로 하였다.
- 축방향 node 내에서 여러가지 메카니즘에 의해 발생하는 교차유량들간의 상호작용은 없는 것으로 하였다.
- 축방향으로의 열전도는 무시하였다.

지배방정식은 질량, 에너지 및 운동량 보존방정식과 냉각재의 상태방정식, 혼합계수 및 마찰계수등의 보조방정식으로 구성된다. 지배방정식에는 난류교환, 반경방향 열전도 및 wire-wrap이나 grid에 의한 강제혼합과 같은 모든 반경방향의 상호작용이 고려되어 있다. THI3D 코드에서 계산은 노심의 입구에서부터 출구방향으로 진행하며 각 단계마다 전 유로에 대하여 계산을 수행한다. 전 유로에 대하여 입구 냉각재의 온도, 압력, 밀도 및 열속 분포는 입력으로 주어진다. 입구의 유속은 초기치를 가정한 후 전단계 계산치를 이용한 반복계산 수행에 의하여 해를 구하게 된다. 계산결과의 수렴속도는 초기조건에 크게 좌우되는데, 이를 해소하기 위하여 다음과 같은 몇가지 방법을 적용하게 된다.

- Newton-Raphson 법의 수렴속도가 초기조건에 크게 좌우되는 것을 해결하기 위하여, 교차 유로면적 감소법 (Cross-flow Area Reduction Method)을 이용한다. 이것은 교차 유로면적을 초기에는 실제보다 작게하여 계산하고, 계산이 진행됨에 따라서 실제면적까지 점차적으로 증가시키며 계산하는 방법이다.

- 유로가 많은 문제를 계산할 때에는 Jacobi 행렬을 계산하는데 소비하는 급증하는 시간을 줄이기 위하여 한 유로에서 발생한 작은 교란은 인접한 소수의 유로에만 영향을 미친다고 가정한다. 즉, 작은 교란이 발생하였을 경우에 인접하지 않은 멀리 떨어져 있는 유로에 미치는 영향은 없다고 가정하여 계산한다.

3.2. XX08 7-집합체

개요

위에서 언급한 것처럼 집합체간 열전달을 고려하여 전체노심으로 수정·보완된 MATRA-LMR에 대한 벤치마크 검증계산을 XX08 7-집합체 문제를 이용하여 수행하였다. XX08 실험 (George, 1980)은 EBR-II에서 수행한 자연대류에 관한 실험중 하나로서, 초기 출력 및 유량이 정상상태에 비해 낮은값을 갖는다. 즉, 출력은 정상상태 값의 28.5 %, 유량은 32.1 % 이다. 이 실험은 5분간의 과

도상태를 모사하고, 이 기간중 자연대류 상태에서의 집합체간 열전달에 의한 온도 및 유량분포를 측정한 것이다. 이 실험에 사용된 집합체는 7개로서, 중심에 위치한 XX08 집합체는 rod 수가 61개이며, 이중 덕트 구조를 이루고 있다. 나머지 주변 집합체는 2개의 핵연료 집합체와 4개의 실험 집합체로 이루어져 있다. 이중 2개의 핵연료 집합체는 91개의 rod로 구성되며, 실험 집합체는 7개, 19개, 19개, 37개의 rod를 가지고 있다. 표 1은 표준 집합체의 입력 특성을, 그림 10은 표준 집합체의 이중 덕트 구조를 나타낸 것이다.

표 1. XX08 표준 집합체 입력 특성

	Input parameters	Values
Rod information	Number of rods	61
	Rod diameter (m)	4.42E-3
	Rod pitch (m)	5.664 E-3
	Wire wrap diameter (m)	1.245E-3
	Wire wrap pitch (m)	0.1524
	Rod pitch/rod diameter	1.282
	Duct inside flat-to-flat distance (m)	5.613E-2
	Total length (m)	0.6096
Initial conditions	System pressure (Pa)	1.379E5
	Inlet temperature (C)	351
	Inlet mass flow (kg/s)	0.8075
	Subassembly power (kW)	110.1
	Axial power distribution	nonuniform
	Radial power distribution	nonuniform
Calculation parameters	Wire pitch fraction (δ)	0.1667
	Turbulent mixing factor (β)	0.01
	Conduction shape factor (G_k)	0.5
	Number of axial nodes (MATRA-LMR)	24
Correlation	Pressure drop model (Novendstern)	$0.316Re^{-0.25}$
	Heat transfer model	Lyon-Martinelli

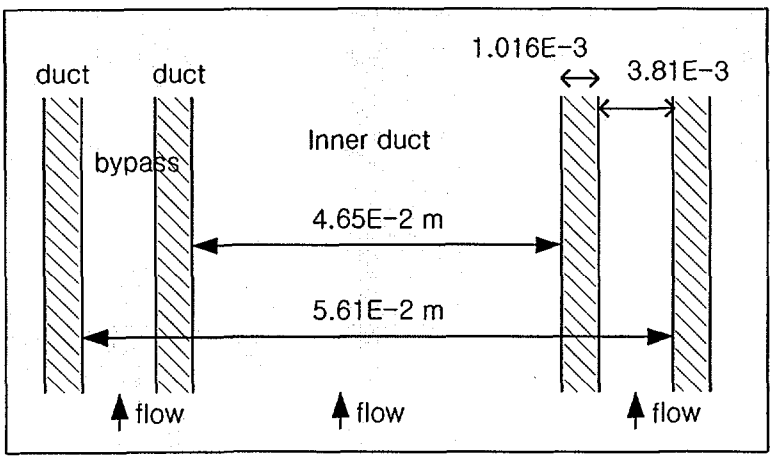


그림 10. XX08 이중 덕트 구조

MATRA-LMR 계산모델

위에서 언급한 바와 같이 MATRA-LMR 코드의 전체노심 모델링 방법은 집합체 수에 관계없이 1개의 표준 집합체와 나머지 주변 집합체로 구성된 것으로 가정하는 것이다. 따라서 XX08 7-집합체 계산에서도 중심에 위치한 XX08 집합체를 표준 집합체로 가정하고, 주변 집합체들은 단순 집합체로 모델하였다. 또한 실험은 5분간의 과도상태를 모사하였으나 이번 계산에서는 0초에서의 초기조건을 이용하여 100 % 출력 및 유량의 정상상태 계산만을 수행하였다. 그 외의 geometry 데이터 및 축방향 출력분포등 기타 초기조건 및 경계조건은 실험에서 사용된 값과 일치한다.

그림 11은 이중 덕트 구조를 가지고 있는 XX08 표준 집합체에 대한 MATRA-LMR 코드의 rod 및 부수로 번호체제를 나타낸 것이다. Rod 수는 61개, 안쪽 덕트내 부수로는 120개, 이중 덕트를 포함하면 총 144개의 부수로가 있으며, 부수로 사이 gap은 안쪽 덕트만을 고려하여 180개로 모델링하였다. 집합체 입구유량은 덕트 안쪽과 이중덕트에 흐르는 유량을 구별하고 있으며, 두 지역 모두 코드내의 압력강하에 의한 반복계산에 의해 적절한 유량이 각 부수로에 유입된다. Wire-wrap option을 사용하였으며, 압력강하 상관식은 Novendstern 상관식을 사용하였다.

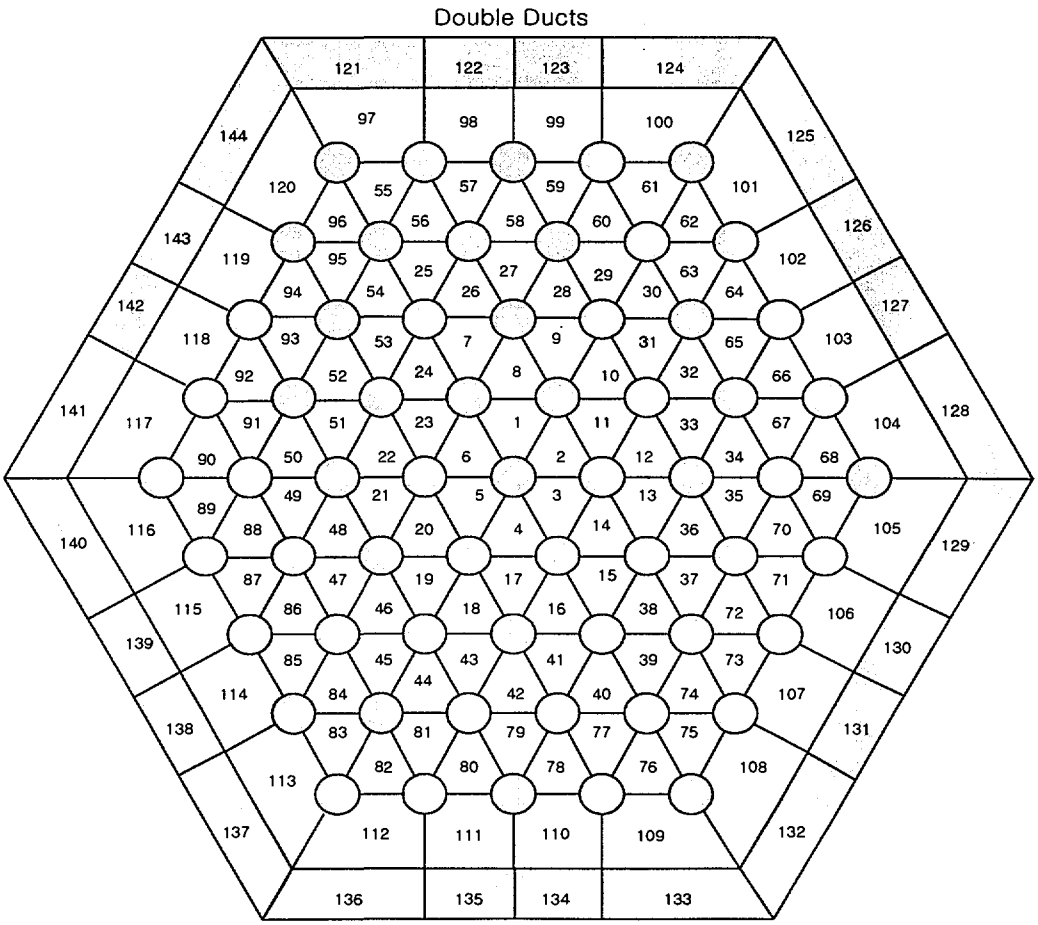


그림 11. XX08 표준 집합체 부수로 번호체제

그림 9는 주변 집합체에 대한 부수로 번호체계 및 각 집합체의 출력과 유량을 나타낸 것이다. 이때 각 집합체의 출력 및 유량이 많은 차이를 나타내고 있는데, 이는 실험 자체가 집합체간 열전달 영향을 살펴보기 위한 목적으로 이웃한 집합체간의 영향을 크게 하기 위한 것이다. 중심에 위치한 표준 집합체의 출력대 유량비는 0.136으로 그림 12에서 보듯이 주변 집합체의 그것에 비해 대체적으로 낮은 편이며, 특히 이번 모의에서 가장 낮은 출력대 유량비를 갖는 2번 집합체인 경우 집합체간 열전달이 집합체내 온도분포에 중요한 영향을 미친다. MATRA-LMR 코드의 전체노심 모델링 방법에 따라 표준 집합체를 제외한 다른 모든 집합체는 rod 수에 관계없이 7개의 rod와 12개의 부수로로 모델되어 계산을 수행하게 된다. 최종적으로 XX08 7-집합체 계산시 사용된 rod 수는 103개, 부수로는 216개, gap 수는 288개로 구성된다.

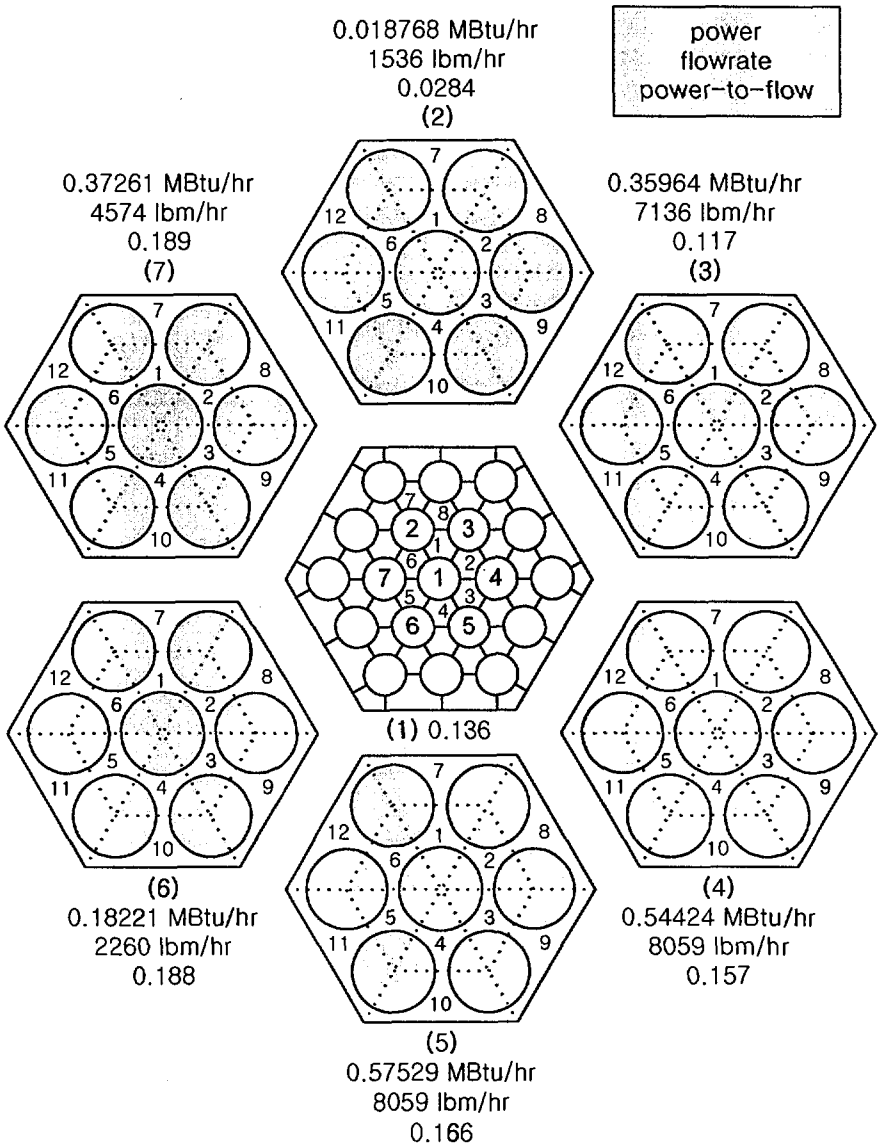


그림 12. 주변 집합체 구성도

SLTHEN 계산모델

집합체는 문제에 따라 유로관 크기, 연료봉 수, 연료봉 직경 및 피치, wire-wrap 직경 및 리드 길이 등에서 여러가지 형태의 구조를 갖는다. 따라서 여러 형태의 집합체를 포함한 전체 노심을 해석하기 위해서는 방대한 양의 기하학적 정보를 필요로 한다. SLTHEN에서는 사용자의 편의를 위해 아래 몇 개의 입력자료에 의해 계산 node 및 node간 연결 정보를 자동으로 생산하도록 하고 있다.

- 중앙 연료봉을 둘러싸고 있는 육방형 연료봉 고리 수 (N_R)
- 연료봉 피치 (P) 및 리드 길이 (D)
- Wire-wrap 직경 (Dw) 및 리드 길이 (H)
- 유로관 내벽 사이의 거리 (D_F) 및 두께 (t_D)
- 측수로 간극 (bypass gap), 두께 (g_c) 및 내부 유로관 두께 (t_c)
- 집합체 간극 (g_i)

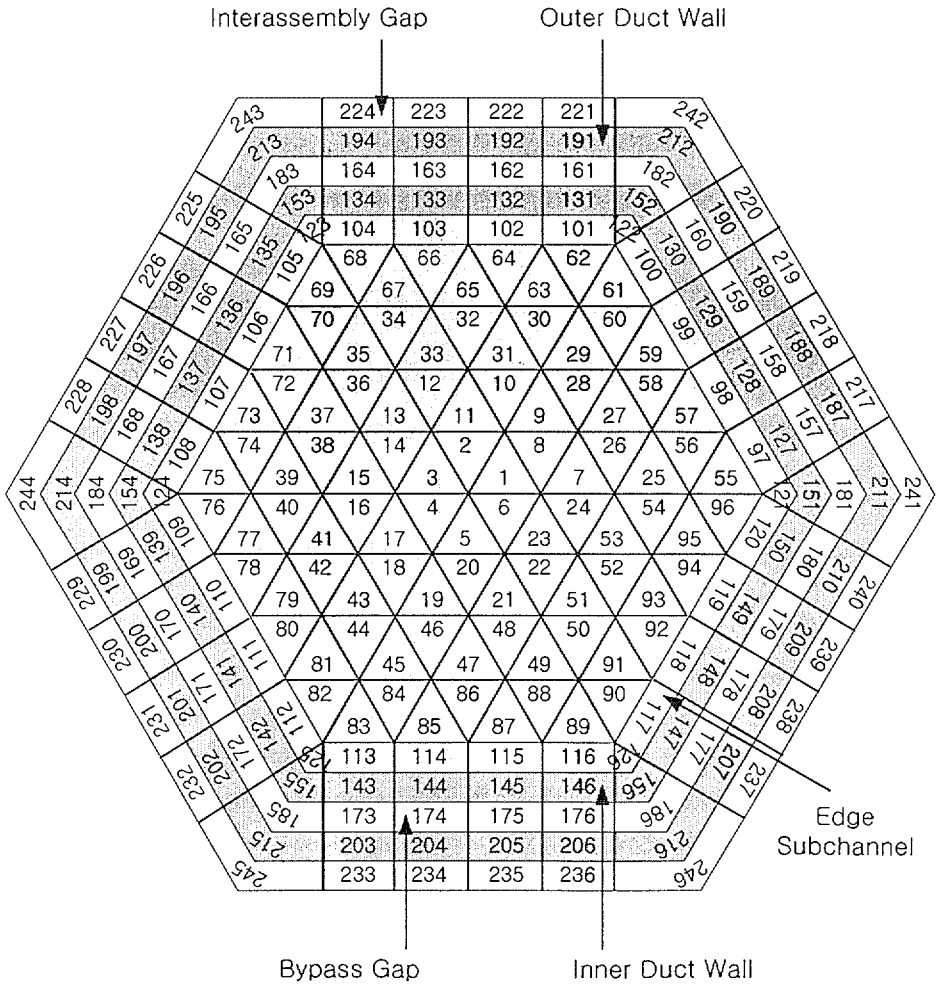
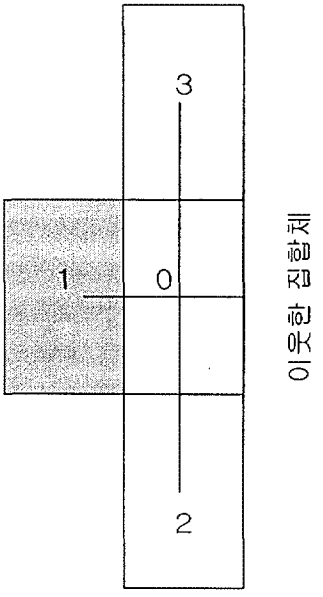


그림 13. SLTHEN 코드의 XX08 표준 집합체 부수로

그림 13은 XX08 표준 집합체에 대한 SLTHEN 코드의 부수로 형태를 나타낸 것이다. 축방향 mesh는 사용자의 입력 자료에 따라 결정되고, 각 집합체의 반경방향 mesh는 내부, 가장자리, 코너 부수로 등 그림 13과 같이 나뉜다. 축방향 대류항은 explicit 방법으로 차분화하고 반경방향의 eddy 확산 및 열전도는 미분항을 차분화하는 대신 검사 체적내 열평형을 통하여 고려한다. 그러나 explicit 방법은 수치 해석적 불안정성으로 인하여 매우 세밀한 축방향 mesh를 필요로 한다. XX08 모의에는 MATRA-LMR은 축방향 mesh 수를 24로 사용하였고, SLTHEN은 120개를 사용하고 있다. 특히, 집합체 사이의 유량은 통상 매우 적음으로 심각한 수치 해석적 불안정을 유발한다. 집합체 사이의 유동을 고려하기 위하여 두 가지 모델을 제시하고 있다. 하나는 유동 모델로서, 유량이 적을 때는 미세한 축방향 mesh를 요하며 계산시간을 증가 시킨다. 다른 하나는 정지 모델로서, 집합체 사이의 소듐이 정지해 있다고 가정하여 집합체간 열전달을 1차원적 열전도 모델를 사용하였다. SLTHEN에서는 이번 계산에서 MATRA-LMR과 같은 조건을 구현하기 위해 정지 모델를 사용하였다.



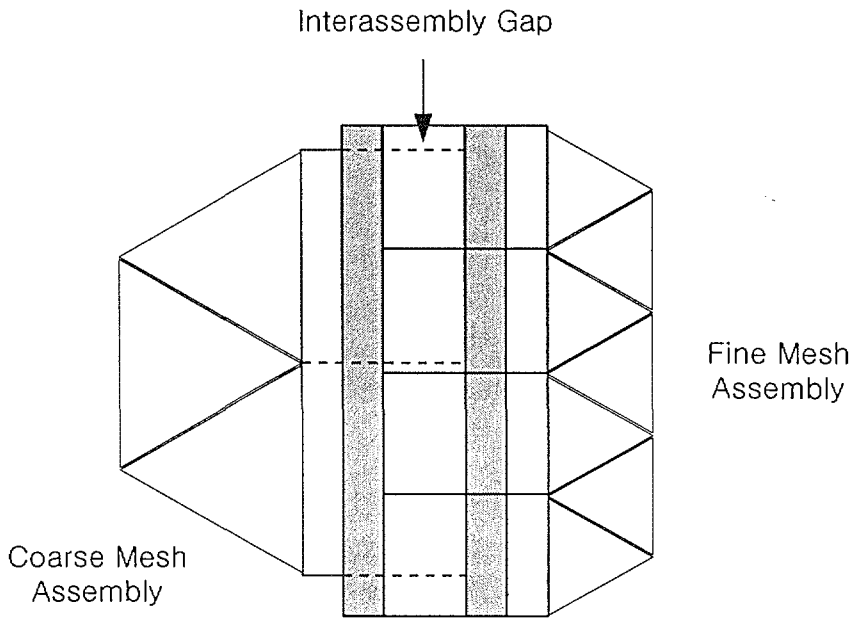


그림 14. 집합체 간극 가장자리 부수로 및 인접 부수로 관계

각 node에서 냉각재 에너지의 변화량은 열원으로부터의 에너지와 인접한 node로부터 전달되는 에너지의 합으로 나타난다. 따라서 각 부수로 간의 eddy 확산 및 열전달, 유로관을 따라 흐르는 대류, 유로관 벽과 냉각재 사이의 열전달을 고려하여 계산이 수행된다. 특히, 집합체 사이와 같이 인접한 집합체에 의해 공유된 부분인 경우 그림 14에서 보듯이 서로 다른 종류의 집합체가 인접하고 있을 경우엔 집합체 간극의 mesh 크기가 일치하지 않는다. 이 경우 작은 mesh 크기를 사용하고 인접 집합체의 온도는 큰 mesh의 온도를 내삽하여 구한다. 큰 mesh 집합체의 집합체 간극 온도는 작은 mesh 집합체의 간극 온도를 구한 후 내삽하여 구한다. 간극 가장자리 부수로는 인접한 유로관 벽을 통하여 인접한 집합체와 연결되고, 집합체 간극 부수로 간의 열전달은 열전도에 의해서만 발생된다고 가정한다.

앞서 언급한 바와 같이 수치 해석적 불안정성을 제거하기 위하여 SLTHEN에서는 대류항의 차분화에 explicit 방법 대신 보다 융통성 있는 θ-방법을 도입하였다. 이 방법에 의해 θ가 0인 경우에는 양적 차분 (fully explicit scheme)이 되며, θ가 1인 경우에는 음적 차분 (fully implicit scheme)이 된다. θ가 1/2인 경우에는 crank-nicolson 방법으로 계산된다. 참고로 MATRA-LMR에서는 음적 차분으로 계산이 수행되었다. 이와같은 차분법을 사용하여 주어진 입구 온도 분포를 가지고 노심 입구에서 출구까지 진행하면서 계산을 반복하면 전체 노심에서의 냉각재 온도 분포가 결정된다. 이 때 반복 계산 방법은 Gauss-Seidal를 사용하고 있다.

THI3D 계산모델

THI3D 계산을 위한 pin 및 부수로 형태는 MATRA-LMR의 그것과 약간 달라 입력 및 계산결과 해석시 주의가 필요하다. 단일 집합체 계산시 이중 덕트 모델이 가능하나 이때 입력으로 덕트벽

의 안쪽 및 바깥쪽 열속값을 필요로 한다. THI3D 코드에서 다 집합체 개념이란 MATRA-LMR이나 SLTHEN과 같이 집합체간 열전달에 의한 전체 노심 계산과 함께 집합체내 부수로에 대한 필요한 계산도 동시에 할 수 있는 것이 아니다. 여기서는 단일 집합체 계산시 사용된 집합체 형태를 그대로 다 집합체 계산에 활용하는 것으로 이때 pin이 곧 집합체가 되는 것이다. 따라서 다 집합체 계산시 개별 부수로 계산은 동시에 수행할 수 없다. 이에 대해 좀 더 자세히 살펴보면, THI3D 계산 방법에는 두 가지 option이 있는데 하나는 단일 집합체 option이며, 다른 하나는 다 집합체 option이 있다. 여기서 단일 집합체 option 사용시 계산 방식은 MATRA-LMR의 그것과 유사하며, 다 집합체 option 사용시에는 반경방향 유량뿐 아니라 집합체간 전도에 의한 열전달 현상도 계산이 되지 않는다. 따라서 THI3D 코드에서 다 집합체 option을 사용하려는 근본적인 목적은 각 집합체내 평균 출력과 노심 총유량을 입력으로 균일한 출구압력을 이용한 노심내 각 집합체별 유량 분배에 있다.

XX08 7-집합체 모의와 같이 각 집합체별 출력과 유량이 결정되어 있는 상황에서 집합체간 열전달 현상에 의한 집합체내 온도분포의 변화를 확인하기 위해서는 반경방향 유량 (여기서는 열전도도 포함)을 완전히 배제한 다 집합체 option 보다는 단일 집합체 option을 사용하는 것이 합리적이다. 이때 pin을 집합체라 가정하고, 부수로 형태는 hexagonal을 사용하며, 반경방향 유량은 저항값을 크게 주어 유량의 흐름이 없게 하였다. 그러나 실제 모의에서는 집합체에 덕트가 있으며, 덕트와 덕트 사이에 소듐에 의한 gap이 존재하며 그 사이를 전도에 의해 열이 전달되는 것이나, THI3D hexagonal 모델에서는 덕트가 없고, 단순히 인접한 부수로가 바로 접해 있으며, 계산에서는 직접 부수로와 부수로 사이에 열전달이 발생하는 것으로 가정한다. 다만 이때 덕트에 의한 저항값을 반경방향 유량면적을 조절하여 보상하나 이에 대한 실제 물리적 값을 얻는데 어려움이 있었다. 그림 15 및 16은 XX08 7-집합체 문제에 대해 단일 집합체 계산시 부수로 번호 형태 및 다 집합체 계산을 위한 hexagonal 부수로 형태를 나타낸 것이다.

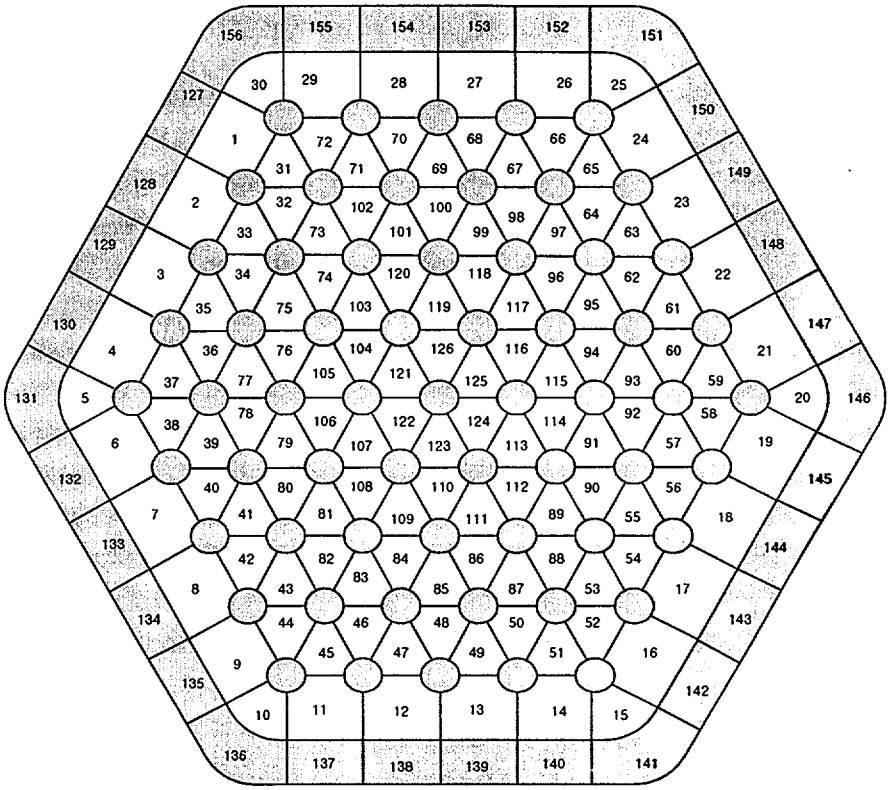


그림 15. XX08 표준 집합체 부수로 형태 (61 pin)

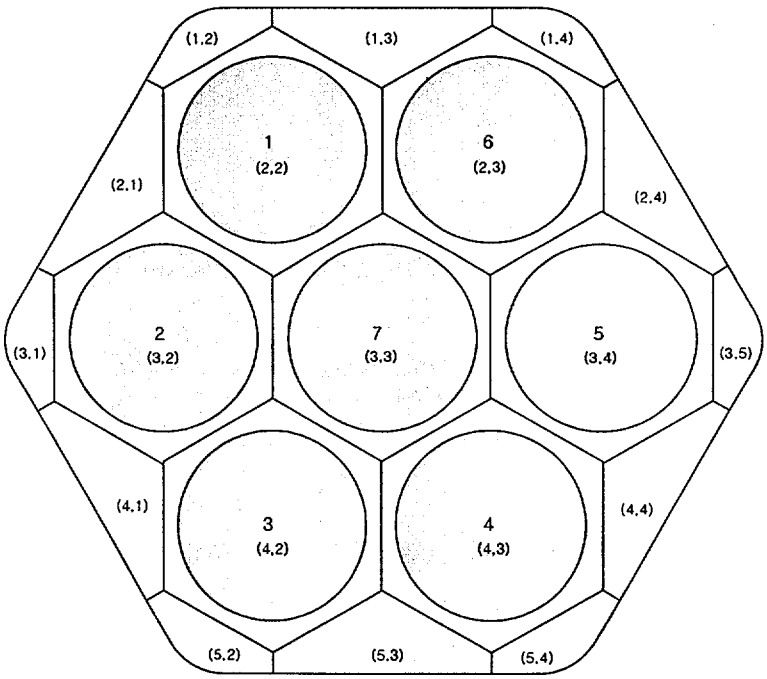


그림 16. 다 집합체 계산을 위한 hexagonal 부수로 형태

계산결과

그림 17은 XX08 표준 집합체의 집합체내 부수로별 출구온도에 대하여 단일 집합체로 가정하여 계산한 결과와 7 개의 집합체를 함께 포함하여 집합체간 열전달을 고려한 계산결과를 비교한 것이다. 집합체간 열전달로 인한 가장 큰 영향은 가장자리 부수로에서의 온도변화이며, 이어서 전체적으로 집합체내 부수로별 온도분포가 달라지게 된다. XX08 7-집합체 초기조건에서 보듯이 표준 집합체를 둘러싼 주변 집합체의 평균온도가 전체적으로 표준 집합체에 비해 높아 주변 집합체에서 표준 집합체로 열이 전달되는 현상이 발생한다. 즉, 주변 집합체가 없는 것을 제외한 다른 모든 조건이 같은 상황에서 계산된 단일 집합체의 평균 집합체 출구온도가 457 °C 인데 비해 다집합체 계산에서는 459 °C 로 2 °C 높게 예측하고 있다. 이는 이만큼에 해당되는 열이 주변 집합체로부터 전달되어 표준 집합체의 온도를 높이는데 사용된 것이다. 그림 10에서 부수로 번호 140 부근의 온도분포를 살펴보면 단일 집합체 계산결과가 낮게 나타난 반면, 반대로 부수로 번호 128 부근에서는 높게 예측하고 있다. 이와 같은 결과는 이들 부수로가 접한 이웃 집합체의 직접적인 영향에 의한 것으로 부수로 140에 접한 주변 집합체의 평균온도는 표준 집합체에 비해 높고 부수로 128에서는 그 반대로 주변 집합체의 온도가 낮아서 발생한 현상이다. 안쪽 부수로의 온도분포 또한 주변으로부터 열이 전달되면서 전체적으로 온도가 높아진 것으로 판단된다.

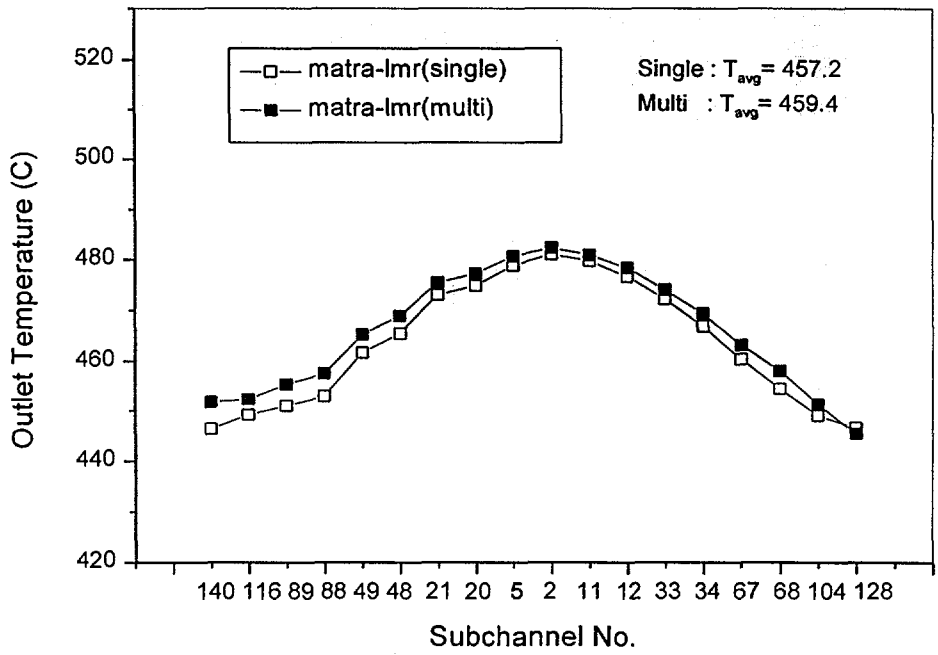


그림 17. 단일 및 전체 집합체 해석에 의한 XX08 출구온도 (MATRA-LMR)

그림 18은 표준 집합체의 가장자리 부수로에 대한 출구온도 분포로 단일 집합체로 계산한 결과와 다 집합체 해석으로 계산한 결과를 비교한 것이다. 단일 집합체 경우 가장자리 부수로의 온도분포는 안쪽 부수로와의 유량혼합에 의한 영향뿐 아니라 가장자리 부수로를 연결하는 원주방향

유량에 의해 결정된다. 이와 같이 결정된 가장자리 부수로 온도분포는 다 집합체 경우 다시 주변 집합체와의 열교환 효과로 인하여 그림 18과 같이 나타난다. 그림 17에서도 언급한 바와같이 주변 집합체의 온도가 낮은 경우는 열을 빼앗겨 온도가 낮아지고, 높으면 열을 받아 온도가 높아지는 현상을 볼 수 있다. 즉, 주변 집합체 2, 3인 경우 평균 집합체 출구온도가 396, 443 °C로 표준 집합체 457 °C에 비해 낮아 표준 집합체에서 주변으로 열이 빠져나가 단일 집합체 계산에서보다 가장자리 부수로 온도가 낮아진 반면, 나머지 집합체 4, 5, 6, 7인 경우에는 그 반대로 평균 집합체 온도가 473, 480, 493, 494 °C인 주변 집합체로부터 열을 받으므로써 표준 집합체의 온도가 올라가 그림에서 보듯이 단일 집합체에 비해 높은 부수로 온도분포를 보이고 있다. 그림 18 아래에 표시한 것은 주변 집합체의 평균 출구온도로 표준 집합체와 접하는 부분의 가장자리 부수로 온도분포는 이것과 약간 다를 수가 있지만 전체적인 경향은 비슷할 것으로 판단된다.

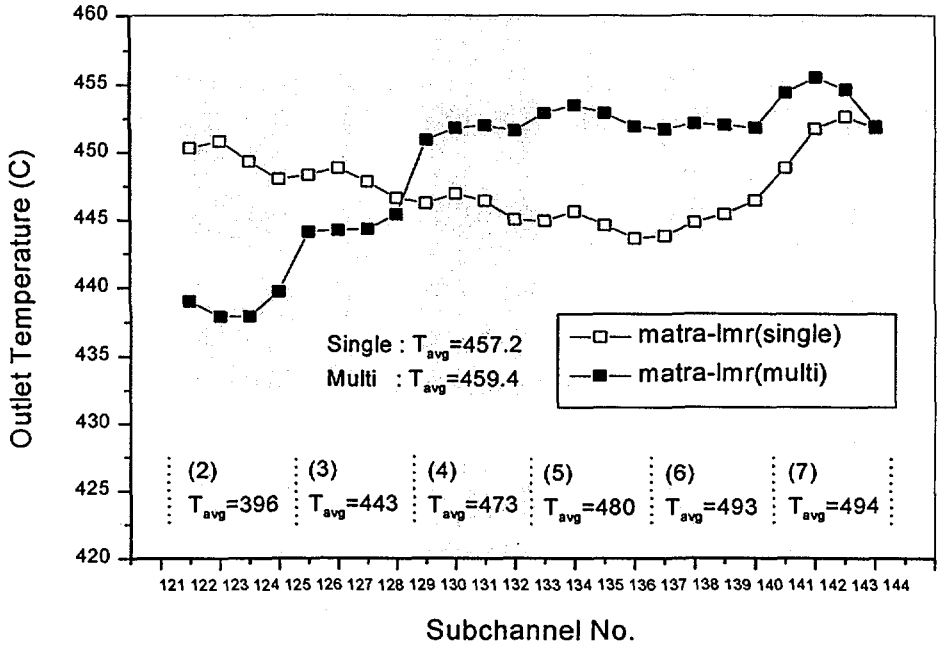


그림 18. XX08 가장자리 부수로 출구온도 비교 (MATRA-LMR)

그림 19는 다집합체 계산에서 얻은 집합체 평균 출구온도를 SLTHEN 및 THI3D 코드의 계산결과와 비교한 것이다. 각 집합체를 단일 집합체로 계산했을 때 각 집합체에 대해 세 코드의 집합체 평균 출구온도가 같다고 가정할 경우 그림 19는 집합체간 열전달에 의한 코드의 계산결과 차이라 할 수 있다. 즉, 그림에서 1번(표준) 집합체의 경우 주변으로부터 열을 받는데 그 양에 있어서 SLTHEN이 MATRA-LMR에 비해 크며, 그 차이가 약 10 °C 이다. 2번 집합체 역시 주변으로부터 열을 받으며 두 코드의 차이는 1번 집합체보다 큰 25 °C 이다. 3, 4, 5번 집합체에서는 두 코드의 결과가 같고, 6번과 7번 집합체에서는 반대로 열을 주변으로 내 주는데 그 양에 있어서 두 코드의 차이는 7 °C로 나타났다. 이와 같이 집합체간 열전달 차이로 인해 평균 집합체 출구온도에 있어서 차이가 나 MATRA-LMR인 경우 다 집합체 계산시 표준 집합체의 평균온도는 459 °C로 단일 집합체 계산결과보다 2 °C 높은데 반해 SLTHEN은 다 집합체시 471 °C로 단일 집합체에 비해

13 °C 높다. 특히 이러한 온도상승은 주로 가장자리 부수로에 주로 영향을 주어 그곳의 온도를 상승시키고 있다.

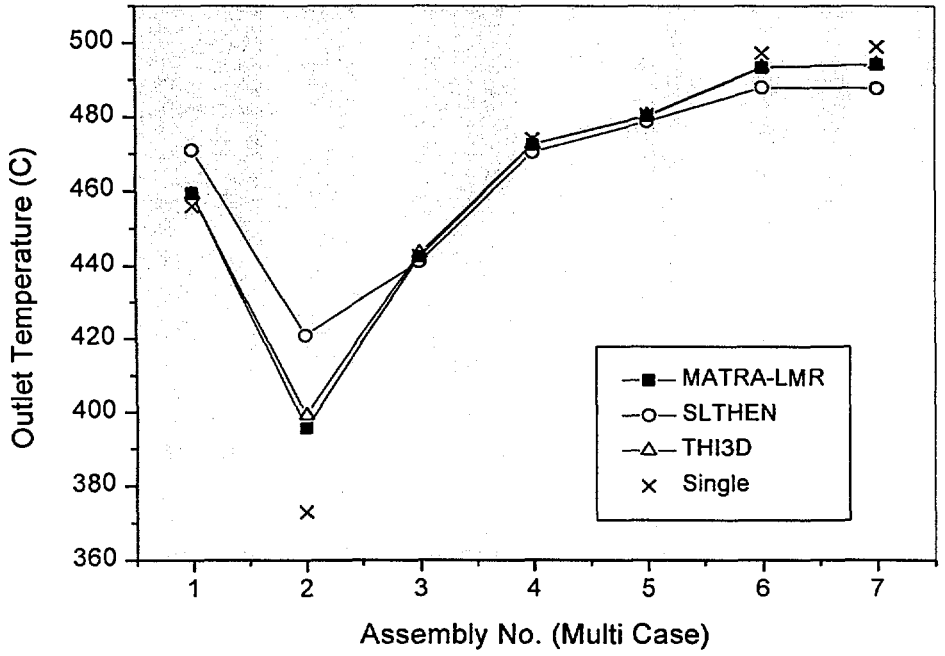


그림 19. XX08 집합체 평균 출구온도

3.3. EBR-II 7-집합체

개요 및 코드 계산모델

EBR-II 7-집합체 모의 (Yang, 1997)는 중심에 위치한 표준 집합체와 6개의 주변 집합체로 구성되어 있다. 표준 집합체는 61-pin이며 단일 덕트로 구성되어 있다. 이 표준 집합체의 입력특성은 표 2에 나타내었다. 또한 각 집합체의 출력, 유량, 출력대 유량비는 그림 20에 표시되어 있다. MATRA-LMR 계산에서는 음해법 (fully implicit scheme)이 사용되었고, 집합체간 열전달은 전도에 의한 저항값으로 가정하였다. 6개의 주변 집합체는 실제 1개의 7-pin, 1개의 61-pin, 그리고 4개의 91-pin으로 구성되어 있으나 MATRA-LMR 모델에서는 모두 동일하게 7-pin, 12-부수로로 단순화하여 구성하였다.

SLTHEN 및 THI3D 계산 모델의 전반적인 내용은 위에 언급된 XX08 7-집합체에 적용된 것과 유사하다. SLTHEN 계산에서도 MATRA-LMR과 같은 환경을 만들어 비교하기 위해 주변 집합체에 대한 모델에서 실제 pin 및 부수로가 아닌 7-pin 및 12 부수로를 사용하였다. SLTHEN 코드는 상세 부수로 해석 코드인 MATRA-LMR과는 달리, 전체 노심을 실제 형태로 모델하여 계산한다 하여도 계산시간이 그리 크지 않을 것으로 판단된다. THI3D 계산에서 단일 집합체에 대한 계산은 수행하지 않았으며, 전체 노심 계산만 수행하여 그 계산결과를 MATRA-LMR 비교 계산에 활

용하였다. 이는 THI3D 계산 목적이 MATRA-LMR 코드의 집합체간 열전달 모델에 대한 비교·분석에 있으므로 이 의도에 맞게 THI3D 계산결과를 이용하였다.

표 2. EBR-II 표준 집합체 입력 특성

	Input parameters	Values
Rod information	Number of rods	61
	Rod diameter (m)	5.842E-3
	Rod pitch (m)	6.909E-3
	Wire wrap diameter (m)	1.067E-3
	Wire wrap pitch (m)	0.1524
	Rod pitch/rod diameter	1.183
	Duct inside flat-to-flat distance (m)	5.817E-2
	Total length (m)	1.402
Initial conditions	System pressure (Pa)	1.013E5
	Inlet temperature (C)	371
	Inlet mass flow (kg/s)	2.4537
	Subassembly power (kW)	530
	Axial power distribution	nonuniform
	Radial power distribution	nonuniform
Calculation parameters	Wire pitch fraction (δ)	0.0667
	Turbulent mixing factor (β)	0.01
	Conduction shape factor (G_k)	0.5
	Number of axial nodes (MATRA-LMR)	138
Correlation	Pressure drop model (Novendstern)	$0.316Re^{-0.25}$
	Heat transfer model	Lyon-Martinelli

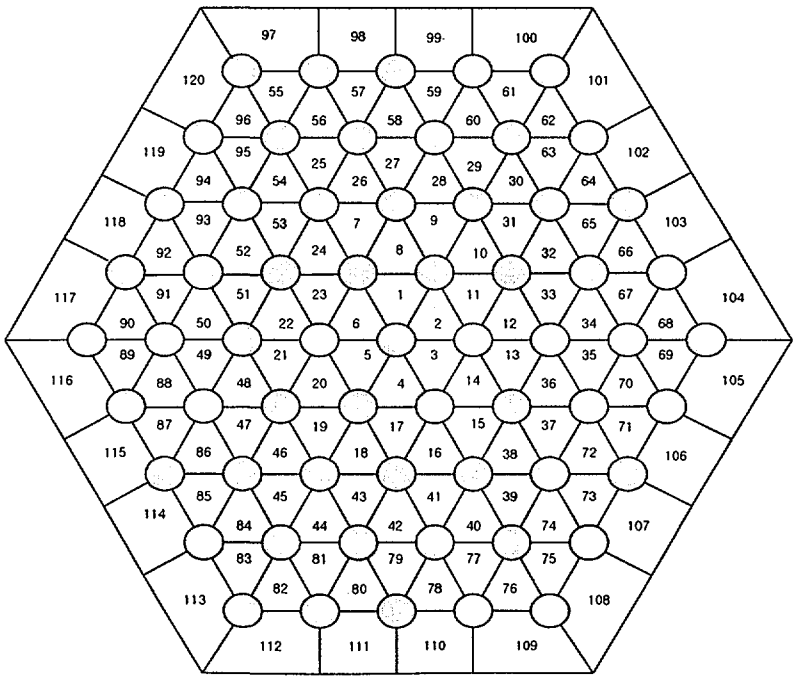


그림 20. EBR-II 61-pin 표준 집합체

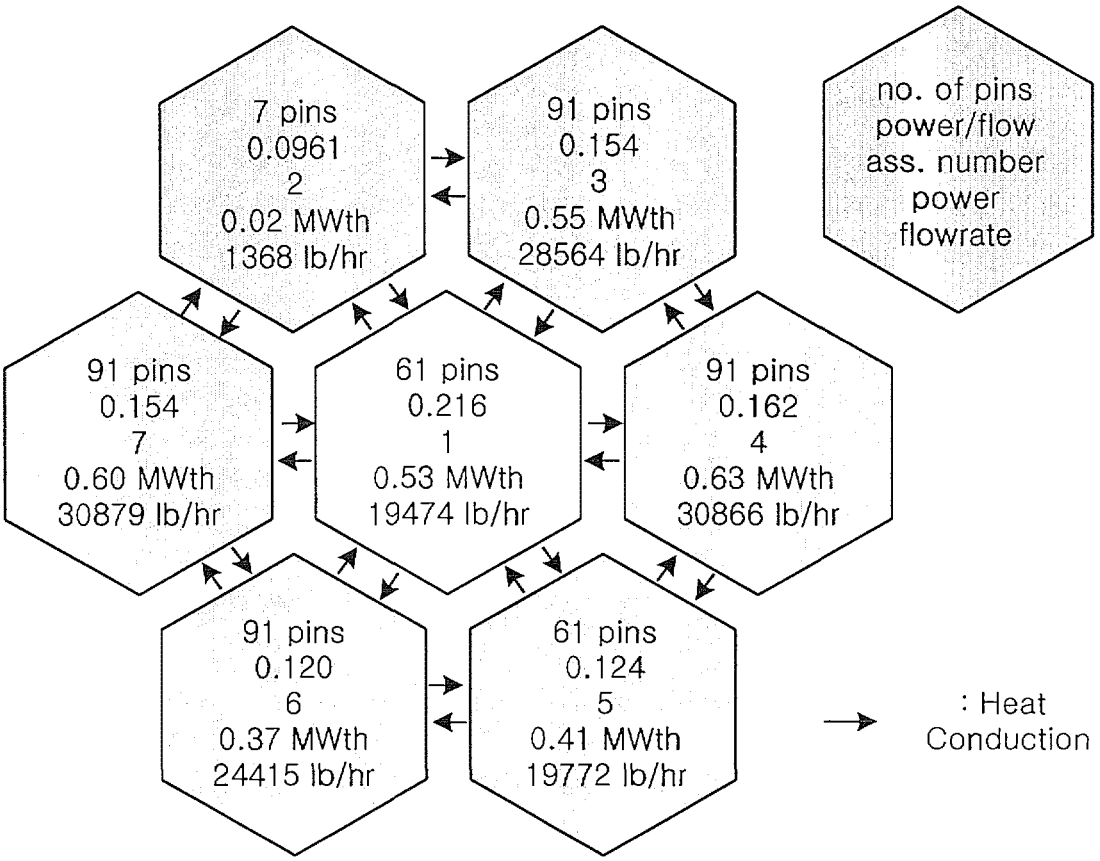


그림 21. EBR-II 7-집합체 구성도

계산결과

그림 22는 EBR-II 표준 집합체 부수로 출구 온도분포를 나타낸 것이다. 그림 21에서 보듯이 중심에 위치한 표준 집합체의 출력대 유량비는 주변 집합체의 그것에 비해 가장 높다. 즉, 이 경우 집합체간 열전달은 중심 집합체에서 주변 집합체로 열이 전달되는 현상이 나타난다. 그림 22의 MATRA-LMR 계산결과를 보면, 표준 집합체 단일 계산인 경우 평균 출구온도가 541 °C인데 반해 주변 집합체와의 열전달을 고려한 다 집합체인 경우 이보다 8 °C가 낮은 533 °C이다. SLTHEN 계산결과도 이와 비슷한 경향을 보이고 있다. 다만 가장자리 부수로에서 단일 및 다 집합체 계산 사이에 차이가 MATRA-LMR 보다 크게 나타났다. 이러한 결과는 두 코드의 집합체간 열전달 능력에 있어서의 SLTHEN 코드가 MATRA-LMR에 비해 크게 나타나고 있음을 보여주고 있다. 그림 23은 세 코드 (MATRA-LMR, SLTHEN, THI3D)의 집합체간 열전달을 고려한 집합체 평균 출구온도를 단일 집합체 계산결과와 비교한 것이다. 단일 집합체 계산결과와 최대 차이를 나타내는 집합체는 번호 2로 그 양은 약 20 °C를 나타내고 있다. 그림 23의 MATRA-LMR 계산결과를 다른 코드의 계산결과와 비교해 볼 때 큰 차이 없이 집합체간 열전달 현상을 잘 예측하고 있다.

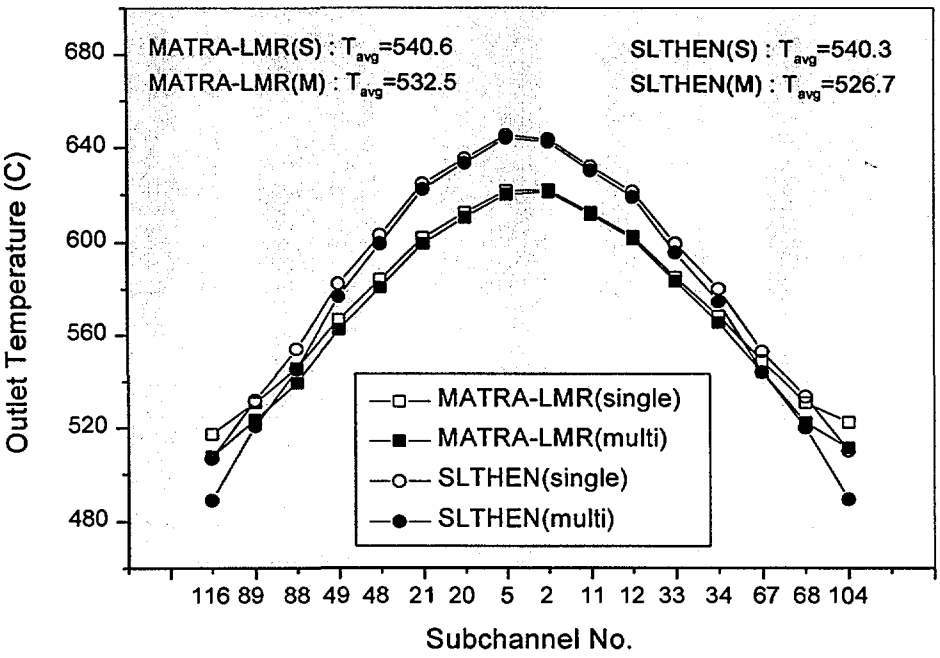


그림 22. EBR-II 표준 집합체 부수로 출구온도

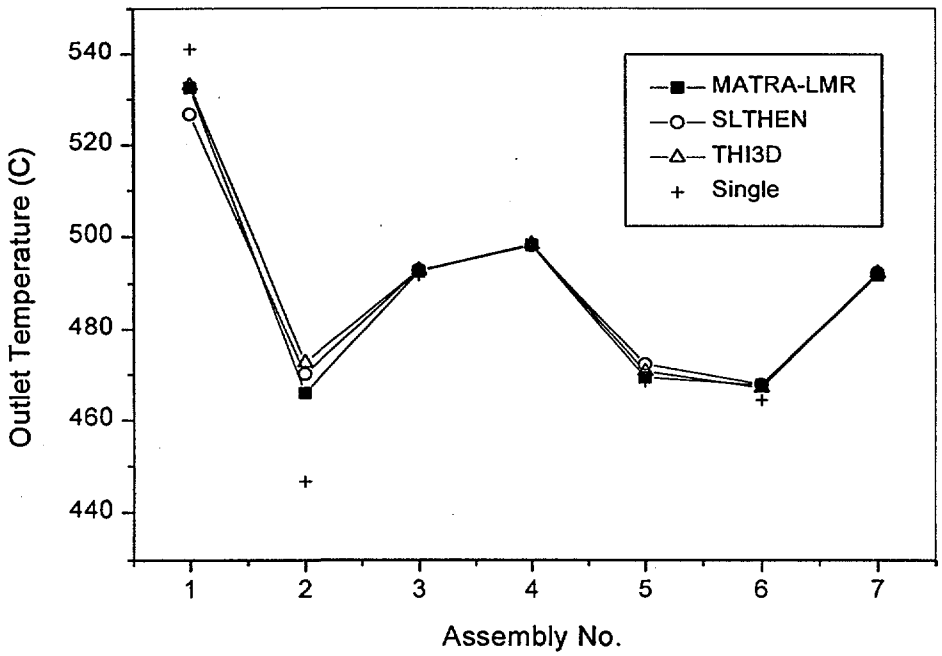


그림 23. EBR-II 집합체 평균 출구온도

3.4. TED 7-집합체

개요

TED 7-집합체 (Yang, 1995)는 EBR-II에서 수행된 실험의 하나로 집합체내에 장착된 열팽창 온도차 측정기 (TED : thermal expansion difference temperature monitors)에 의해 실험 집합체내의 소듐 온도분포를 측정하는 것이다. 이때 EBR-II 실험장치는 노심내 16개의 집합체 ring으로 구성되어 총 637개의 집합체가 존재하고 있다. 노심은 비균질로 여러 타입의 집합체가 혼합되어 있다. 중심에서부터 7줄까지는 대부분 핵연료 집합체이며, 일부 실험 집합체가 들어가 있다. 다음 8에서 10줄은 반사체, 그 다음 마지막 줄까지는 브랑켓으로 구성되어 있다. 그림 24는 이러한 노심 구성 중 본 계산에 사용된 두 경우 TED X494 7-집합체와 TED X495 7-집합체 모의 관련 이들 집합체의 위치를 보여주고 있다.

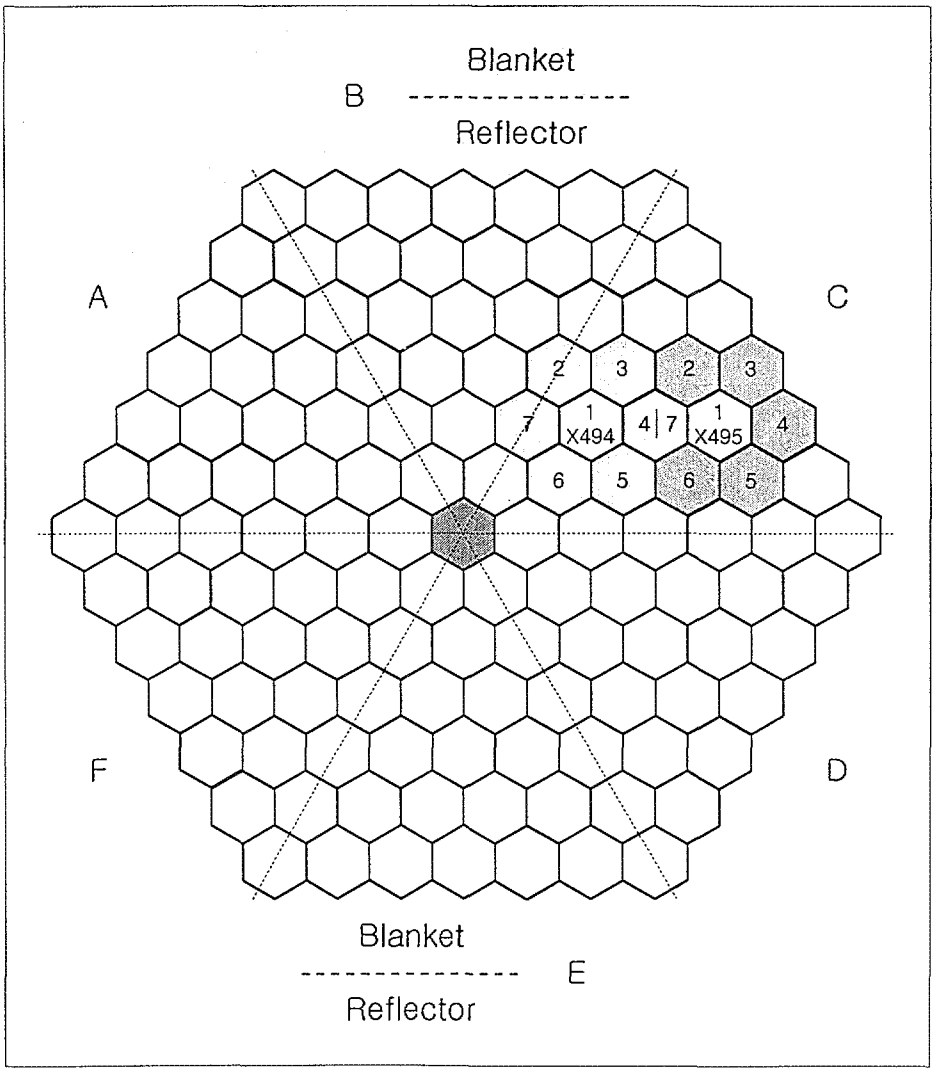


그림 24. TED 7-집합체 모의를 위한 노심 구성도

TED 실험은 두 경우에 대해 수행되었는데 하나는 X494 7-집합체이며, 다른 하나는 X495 7-집합체이다. 이들 두 경우의 집합체 구성 및 각 집합체의 출력과 유량이 그림 25에 나타나 있다. 특히 각 경우의 중심에 위치한 X494 및 X495 집합체는 실험을 위해 구성된 집합체로 이들 집합체는 모두 61-pin으로 구성되어 있으나, 그림 26에서와 같이 11개의 빈 pin이 삽입되어 그 속에 소듐이 차게되고, 따라서 이 pin 안에 장착된 TED에 의해 집합체내 소듐 온도분포가 측정된다.

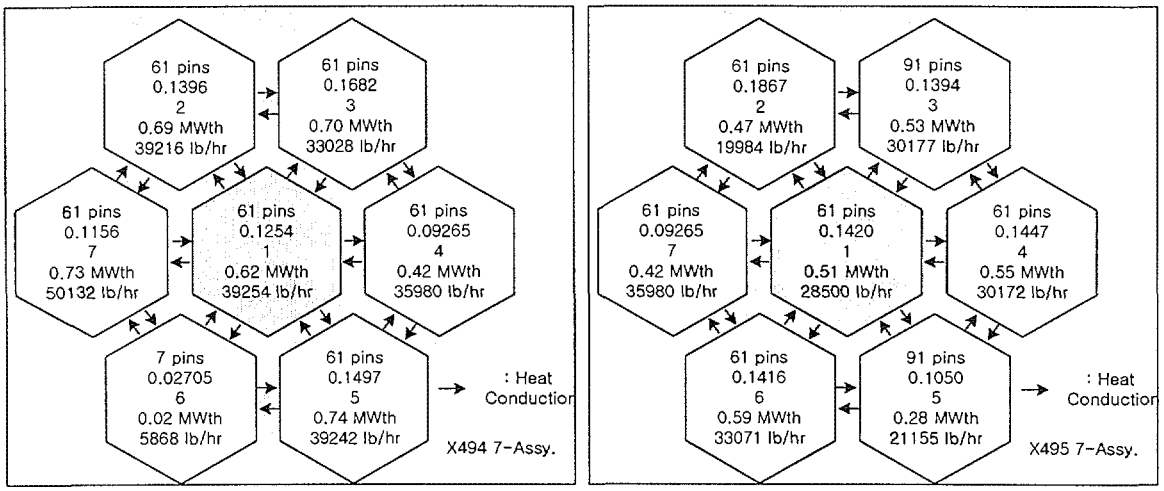


그림 25. TED 7-집합체 구성도

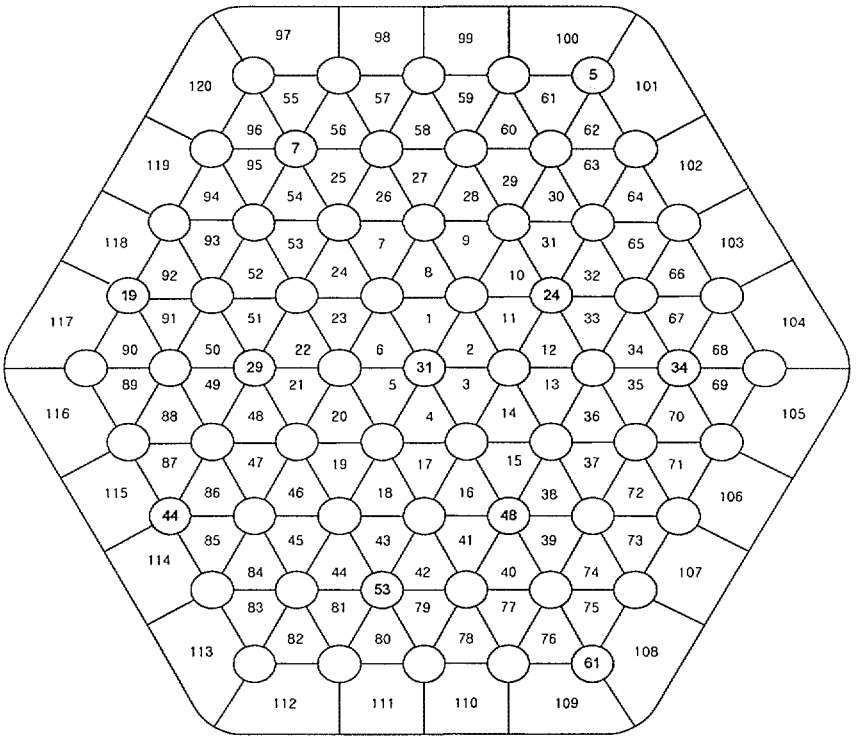


그림 26. TED 실험 집합체내 온도측정용 pin

계산결과

표 3. 집합체 X494와 X495에 대한 계산결과 비교

X494		Core Center				Core Top				Element Top			
Row No.	Pin No.	ME (°C)	M(S) -ME	M(M) -ME	SL -ME	ME (°C)	M(S) -ME	M(M) -ME	SL -ME	ME (°C)	M(S) -ME	M(M) -ME	SL -ME
1	31												
3	24	426	0.1	0.1	0.3	488	-6.8	-6.7	-9.0	488	-8.5	-8.3	-9.1
	29	421	7.1	7.1	6.8	480	-1.1	-1.2	0.2	480	-5.3	-6.0	-3.5
	48	425	2.8	2.8	2.7	485	-4.0	-4.0	-5.2	488	-10.4	-10.6	-12.4
4	7	418	6.0	6.0	5.1	475	-7.0	-6.9	-7.2	471	-2.1	-1.9	-9.4
	34	421	0.0	0.0	0.8	482	-12.3	-12.3	-17.3	479	-8.9	-9.4	-22.2
	53	432	-5.8	-5.7	-5.7	489	-9.1	-9.2	-14.6	478	-5.7	-6.9	-12.4
5	5	409	-1.3	-0.8	-3.6	459	-6.6	-5.2	-18.6	467	-2.3	-1.0	-27.9
	19	403	12.0	12.0	2.7	442	14.0	13.5	-11.1	456	8.1	6.9	-23.1
	44	429	-11.5	-11.9	-15.6	461	-2.6	-4.5	-10.3	468	-4.3	-7.6	-22.4
	61												
x495		Core Center				Core Top				Element Top			
Row No.	Pin No.	ME (°C)	M(S) -ME	M(M) -ME	SL -ME	ME (°C)	M(S) -ME	M(M) -ME	SL -ME	ME (°C)	M(S) -ME	M(M) -ME	SL -ME
1	31	432	2.5	2.5	2.8	498	2.8	2.8	0.7	505	-5.3	-5.2	-1.3
3	24	436	-3.6	-3.6	-3.3	498	-2.7	-2.7	-5.5	508	-14.2	-14.2	-16.4
	29	435	1.0	1.0	0.8	490	5.3	5.1	6.5	489	1.2	0.2	1.9
	48	430	4.6	4.6	4.6	496	-0.2	-0.2	-2.2	493	-0.4	-1.0	-3.8
4	7	439	-8.3	-8.3	-9.3	484	-2.5	-2.3	-3.8	485	-2.7	-2.4	-16.9
	34	437	-10.6	-10.6	-10.0	496	-14.2	-14.1	-21.4	490	-7.1	-6.6	-26.4
	53	434	-0.4	-0.4	-0.3	493	3.0	2.8	-4.4	482	5.5	4.1	-5.2
5	5	418	-6.2	-5.7	-5.8	475	-12.5	-11.8	-29.3	479	-2.4	-2.8	-37.7
	19	400	21.4	21.1	17.0	452	17.0	14.9	5.1	464	13.6	9.7	-15.0
	44	431	-6.7	-6.6	-11.8	473	-0.9	-1.1	-12.1	476	1.8	-0.9	-24.5
	61	408	8.2	8.3	2.2	456	13.0	12.0	-8.6	463	15.0	11.2	-21.1

* ME : Measured values, M(S) : MATRA-LMR single case, M(M) : MATRA-LMR multi case, SL : SLTHEN

표 3은 X494와 X495 두 경우에 대해 실험 및 코드의 축방향 위치별 온도분포를 비교한 것이다. X494인 경우 31 및 61 pin에 대한 결과는 실험에서 부정확한 데이터로 판정되 포함시키지 않은 관계로 계산에서도 이 두 pin에 대한 비교는 하지 않았다. 실험에서는 앞에서도 언급하였듯이 dummy pin 안에 TED를 장착하여 그 속에 차있는 소듐의 온도를 측정한 반면, 계산에서는 실험과 같은 상황을 모의할 수 없기 때문에 dummy pin은 출력이 없는 pin으로 가정하고, 이 pin 주위의 부수로에서의 온도를 계산하여 평균한 값을 사용하였다. 표 3에서 MATRA-LMR은 단일 및 집합체간 열전달을 고려한 다 집합체 계산 결과를 함께 나타내었는데 서로 비슷한 계산결과를 나타내었다. 이는 중심에 위치한 X494 및 x495와 주변 집합체간에 출력대 유량비가 큰 차이를 나타내지 않았고, 또한 표 3에 나타낸 온도값은 dummy pin 주위의 부수로 온도에 대한 평균값을 나타내므로써 그 차이를 좀 더 줄였던 것으로 판단된다. 실험치와의 비교에서는 X494에 대해 MATRA-LMR에서는 최대 14 °C를 보인 반면, SLTHEN은 이 보다 큰 28 °C로 그 차이가 3 %, 6 %로 나타났다. 또한 X495인 경우 MATRA-LMR은 5 %, SLTHEN은 8 %를 보여, 두 경우에서 모두 MATRA-LMR이 SLTHEN에 비해 실험값에 근접한 계산결과를 얻었다.

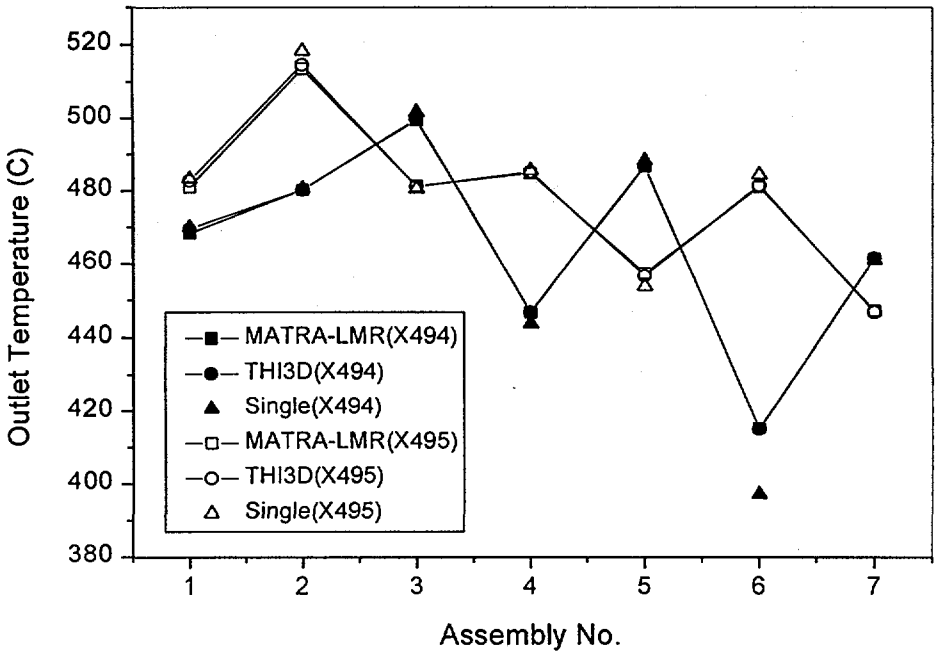


그림 27. 집합체 평균 출구온도

그림 27은 X494 및 X495 7-집합체, 두 경우에 대해 집합체별 평균 출구온도를 나타냈으며, 또한 단일 집합체시 온도와 비교하여 집합체간 열전달 영향에 의한 온도차이를 나타낸 것이다. 대체로 MATRA-LMR 및 THI3D 계산결과는 일치하며, 단일 집합체와의 비교에서도 주변 집합체와의 출력대 유량비에 있어서 큰 차이를 나타내지 않는 집합체 온도분포는 비슷한 결과를 보여주고 있다. 다만 X494의 6번 집합체인 경우 출력대 유량비가 주변 집합체의 평균치의 20 %로 단일 집합체와 비교할 때 다른 집합체에 비해 집합체간 열전달 현상에 의한 영향이 크게 나타났다.

3.5. KALIMER 7-집합체

개요

표 4. KALIMER 증식노심 (D48H120)에 대한 설계자료

Core	Core thermal output (MWth)	392.2
	Core electric power (MWe)	150.0
	Core inlet / outlet temperature (℃)	386.2 / 530.0
	Total flow rate (kg/s)	2143
	Active core height (cm)	120
	Core diameter (cm)	344.3
	Pins per assembly (Fuel/Radial blanket)	271 / 127
No. of pins (271/127)	Total axial height (mm)	3970.7
	Rod outer diameter (mm)	7.45 / 12.08
	Rod pitch (mm)	8.95 / 13.07
	Wire wrap diameter (mm)	1.41 / 0.96
	Wire wrap lead (mm)	206.2 / 301.9
	Cladding thickness (mm)	0.55 / 0.54
	Duct wall thickness (mm)	3.72
	Duct flat-to-flat distance(mm)	150.4
	Number of axial nodes	397
	Radial power distribution	uniform

전기출력 150 MWe (열출력 392 MWth)의 pool-type 소듐 냉각로인 KALIMER (Korea Advanced Liquid Metal Reactor)는 현재 개념 설계중이다. 1 단계 연구기간 동안에, KALIMER는 U-노심 (U-10%Zr)이 제안되어 이에 대한 타당성 조사 및 설계특성에 대한 연구가 진행되었다 (Park, 1998). 제 2 단계에서는 이를 Pu-노심 (U-Pu-Zr)으로 전환하여, 증식특성를 갖는 비균질 노심이 제안되어 현재 이에 대한 개념 설계가 진행중이다. 표 4는 이 증식특성 노심에 대한 기본적인 설계자료를 나타낸 것이다.

그림 28은 KALIMER 증식특성 1/6 노심을 나타낸 것으로, 본 계산에서는 집합체간 열전달 영향 분석과 관련하여 두 경우를 수행하였는데, 그림에서 보듯이 하나는 핵연료 집합체 (DR0302)를 중심으로 한 7-집합체, 다른 하나는 축방향 브랑켓 (RB0602)를 중심으로한 7-집합체이다. 이때 주된 관심은 주변 집합체에 의한 중심 집합체에서의 온도분포로, 실상 집합체간 열전달은 전 노심에 걸쳐 모든 집합체에 다각도로 진행되나, 한 집합체를 중심으로 첫번째 원을 이루는 6개의 주변 집합체에 의해 중심 집합체에 미치는 집합체간 열전달 영향이 대부분을 이루며, 두번째 원부터 그 이후의 집합체에 의해서는 영향이 거의 없다는 가정하에 본 계산을 수행하였다 (Chen, 1975). 그림 29는 두 경우에 대해 각 집합체의 pin 수, 출력대 유량비, 집합체 번호, 출력, 및 유량을 나타낸 것으로 특히 출력대 유량비를 비교해 보면, 두 경우 모두 중심 및 주변 집합체와의 사이에 큰 차이가 없는 것으로 나타나 실제 계산에서도 단일 집합체 계산결과와 집합체간 열전달을 고려한 계산결과 사이에 큰 차이가 없을 것으로 판단된다.

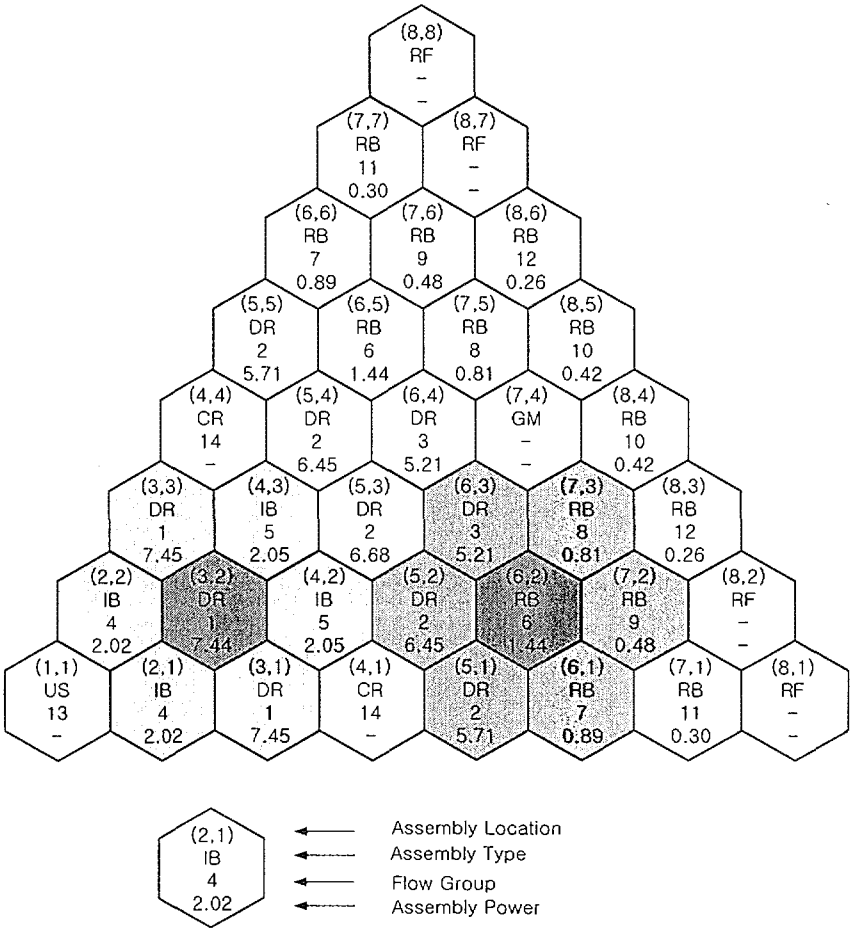


그림 28. KALIMER 증식특성 1/6 노심 (D48H120)

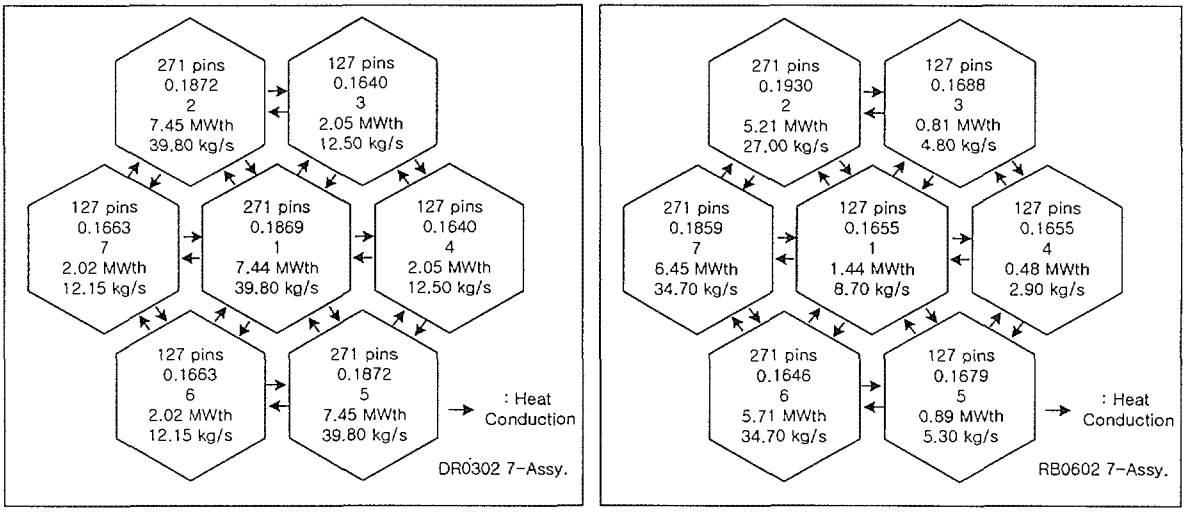


그림 29. KALIMER 집합체 설계특성

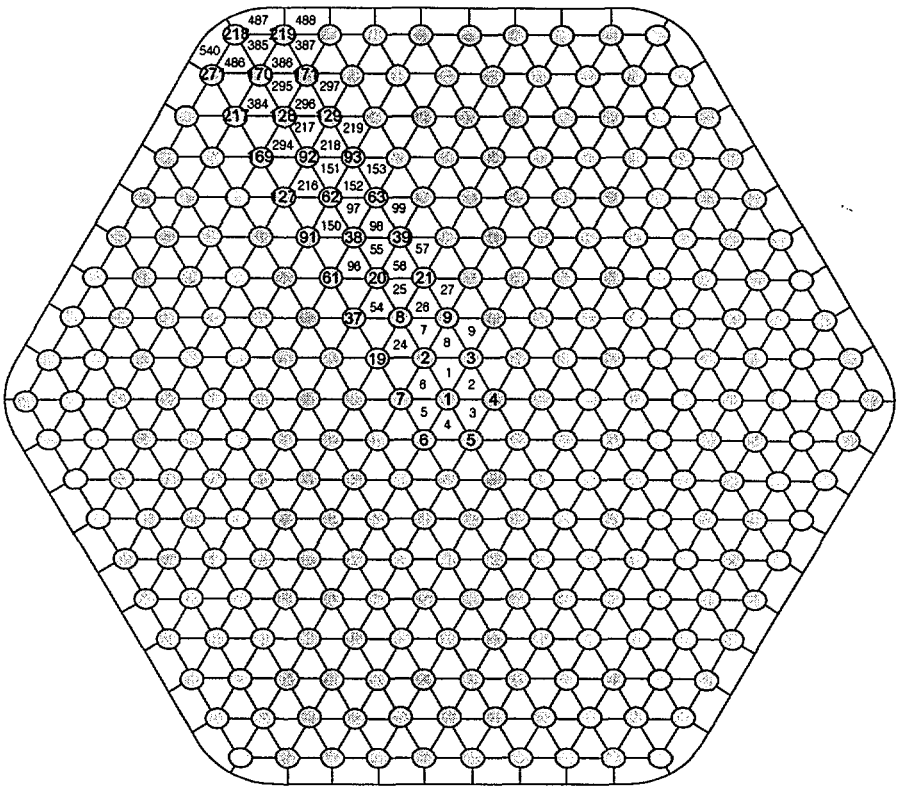


그림 30. KALIMER 271-pin 구성도

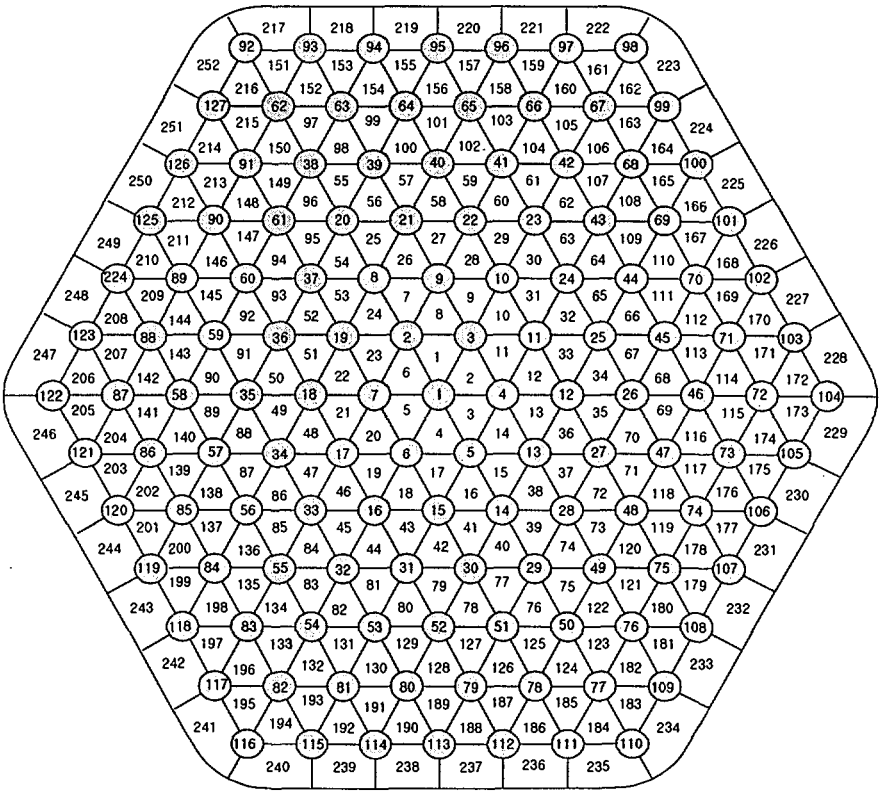


그림 31. KALIMER 127-pin 구성도

그림 30과 31은 KALIMER 271-pin 핵연료 및 127-pin 반경방향 브랑켓 집합체에 대한 MATRA-LMR 코드의 pin 및 부수로 형태와 번호구성을 나타낸 것이다. 특히, MATRA-LMR에서 코너 부수로는 따로 구분하지 않고 가장자리 부수로에 포함시켜 나타내었다.

계산결과

그림 32는 KALIMER 1/6 노심에 대해 SLTHEN 계산결과를 나타낸 것으로 집합체간 열전달 영향이 없는 경우와 있는 경우에 대해 비교한 것이다. MATRA-LMR과는 달리 ENERGY 모델를 사용하는 SLTHEN은 그 계산시간에 있어서 상대적으로 적은 량이 사용되므로 계산시간이 문제가 되지않아 1/6 노심 전체를 함께 계산하였다. 그림에서 US (Ultimate Shutdown), CR (Control Rod), GM (Gas expansion Modules), 및 RF (Reflector) 집합체는 현단계에서는 고려하지 않아 본 계산에서도 이들에 대해서는 출력 및 유량이 없는 상태로 계산이 수행되었다. SLTHEN 계산에서 집합체간 열교환이 없는 경우, 각 집합체는 주어진 출력 및 유량에 따른 온도분포만이 계산되어 서로에 대해 독립된 형태를 나타내고 있다. 하지만 그 밑에 그림에서 집합체 사이에 열교환이 있을 경우 그 양이 비록 작지만 집합체의 각 면과 접한 이웃 집합체의 영향을 받아 가장자리의 온도분포는 윗 그림과는 달리 변화된 모습을 볼 수 있다. 이 경우 한 집합체내 가장자리 사이의 온도차가 최대 9 °C를 보이고 있다. 개요에서도 언급했듯이 여기에 사용된 노심데이타는 설계과정에 의해 최대 피복재 온도 및 각 집합체의 평균 출구온도등이 설계제한치 범위에 맞게 출력에 따른 유량분포를 적절히 수행한 결과로써 집합체 사이의 출력대 유량비 값에 있어서 큰 차이를 보이지 않고 있으며, 이로인해 집합체간 열전달에 의한 영향은 크지 않은 것으로 나타났다. 다만 정상상태가 아닌 과도상태에서는 그 영향이 지금에 비해 상당히 클 것으로 판단된다.

그림 33은 DR0302 7-집합체 경우에서 중심 집합체인 DR0302내 부수로 출구온도를 나타낸 것이다. 평균 집합체 출구온도에 있어서 단일 및 다 집합체의 계산결과는 MATRA-LMR이나 SLTHEN 모두 544 °C, 543 °C로 단일 집합체의 평균온도가 1 °C 높게 나타났다. 집합체내 부수로 사이의 온도분포에 있어서 단일 및 다 집합체 차이는 안쪽 부수로에서는 차이가 없고 다만 가장자리 부수로에서 두 코드 모두 비슷한 결과를 나타냈다. 단일 및 다 집합체 사이의 온도분포에 대한 경향 외에, 두 코드 계산결과의 절대값에서의 차이 즉, SLTHEN 계산결과가 MATRA-LMR에 비해 안쪽 부수로에서 높고, 가장자리 부수로에서는 낮게 예측하는 것은 두 코드의 기본적인 모델 차이에서 나타나는 것으로 판단된다 (Kim, 1998).

DR0302 7-집합체 경우와는 반대로 RB0602 7-집합체 경우에서는 중심 집합체인 RB0602가 주변 집합체로부터 열을 받아 평균온도가 MATRA-LMR은 1 °C, SLTHEN은 2 °C 상승하였다. 이때에도 주로 단일 및 다 집합체 계산결과의 차이가 가장자리 부수로에서 온도의 영향이 크고 안쪽 부수로에서는 그 영향이 적은 것으로 나타났다. 그림 34는 이러한 RB0602 7-집합체의 계산결과를 보여주고 있다. 그림 35와 36은 특히 두 경우의 중심 집합체인 DR0302와 RB0602내 가장자리 부수로의 온도분포를 나타낸 것이다. 주변 집합체와 접하는 면에서의 온도차이에 따라 가장자리 부수로의 온도분포가 조금씩 달리 나타나고 있다. 특히 그림 36에서 주변 집합체 2번과 7번에 접한 부수로의 온도분포가 단일 집합체 계산결과에 비해 높게 나타나는데 이는 이들 주변 집합체의 출력대 유량비가 중심 집합체의 그것에 비해 현격히 크기 때문이다.

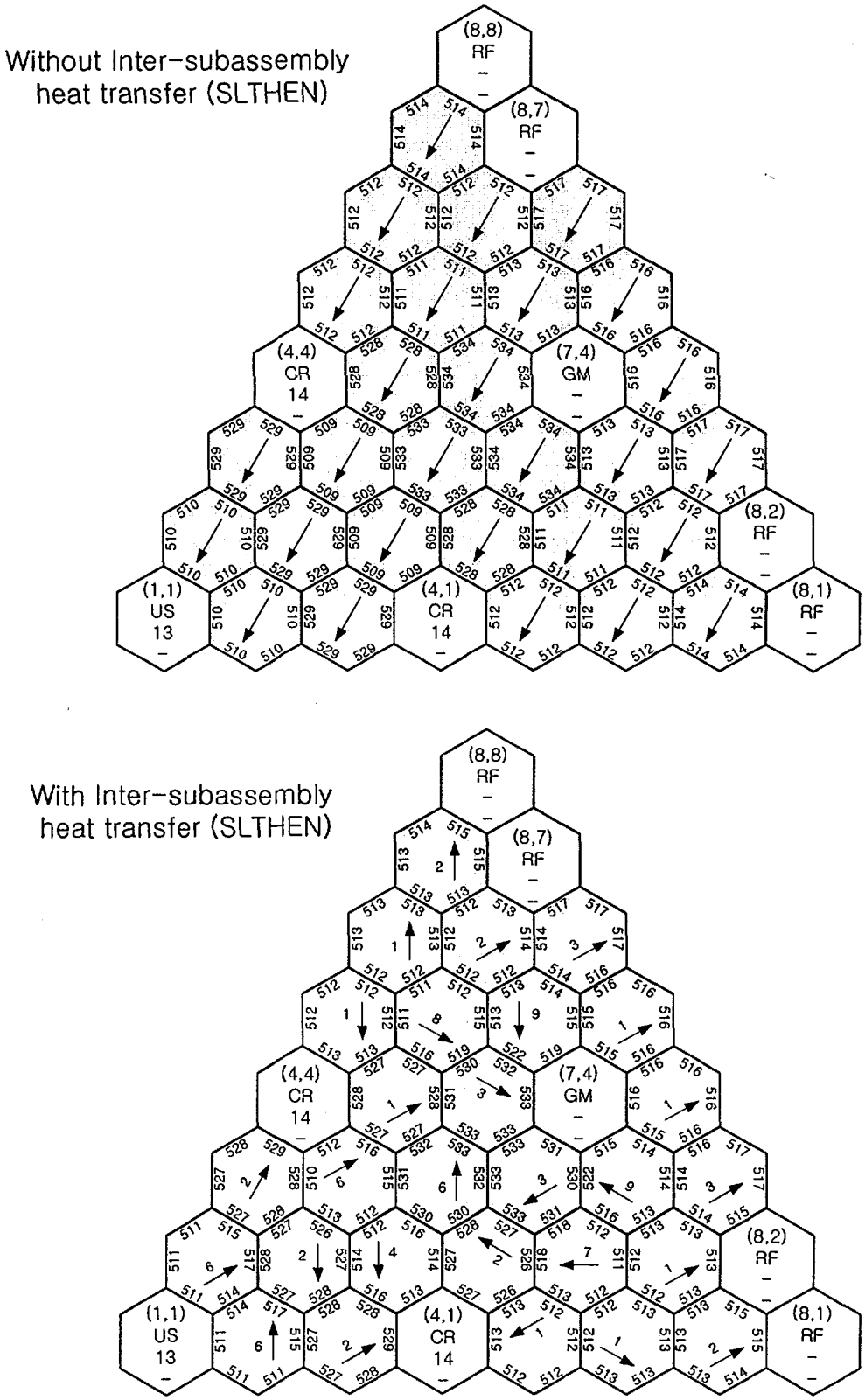


그림 32. 가장자리 부수로의 온도분포 및 최대 온도차

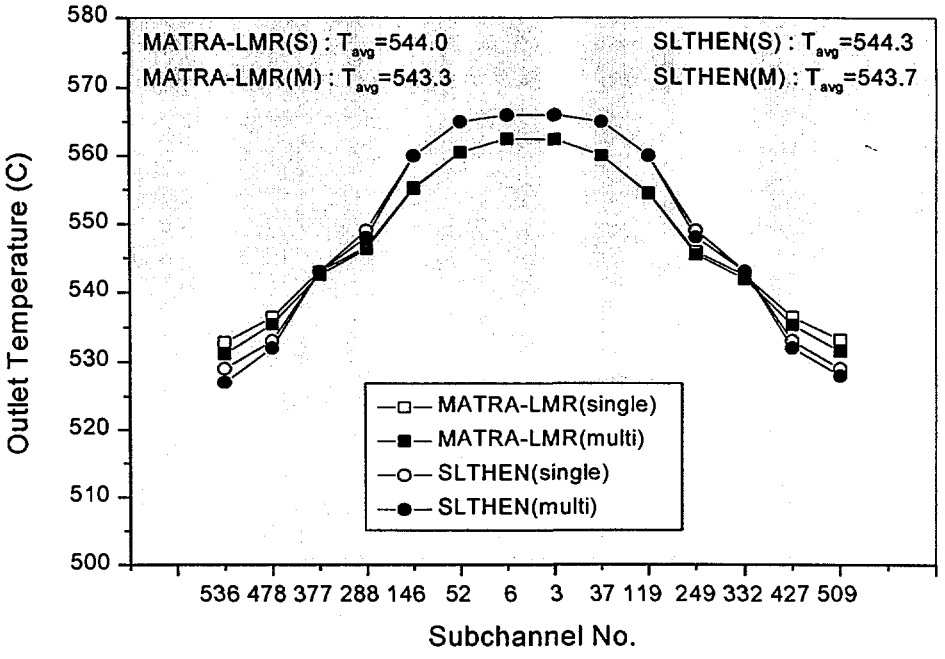


그림 33. KALIMER DR0302 집합체 출구온도

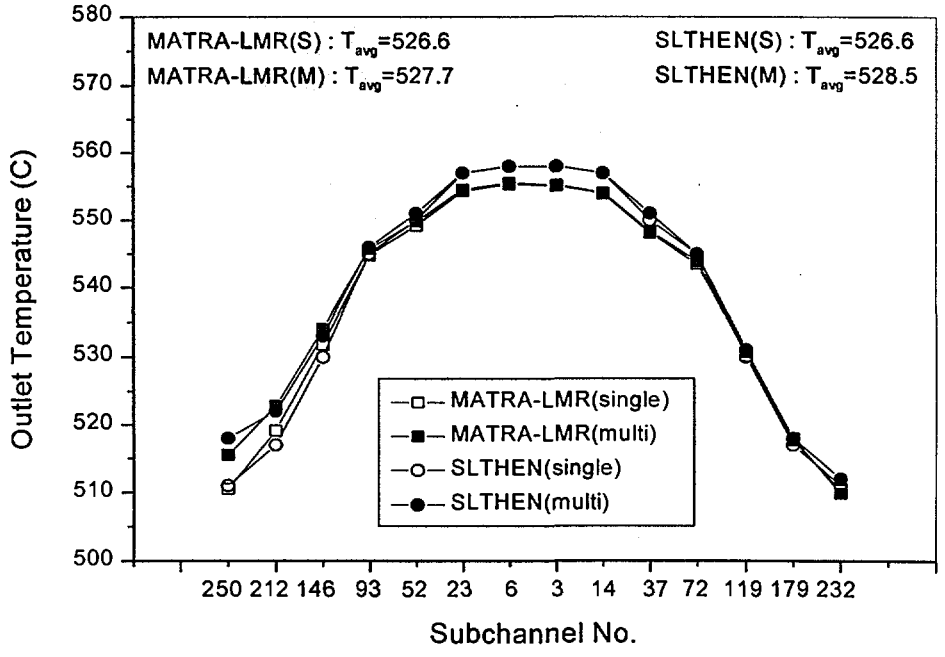


그림 34. KALIMER RB0602 집합체 출구온도

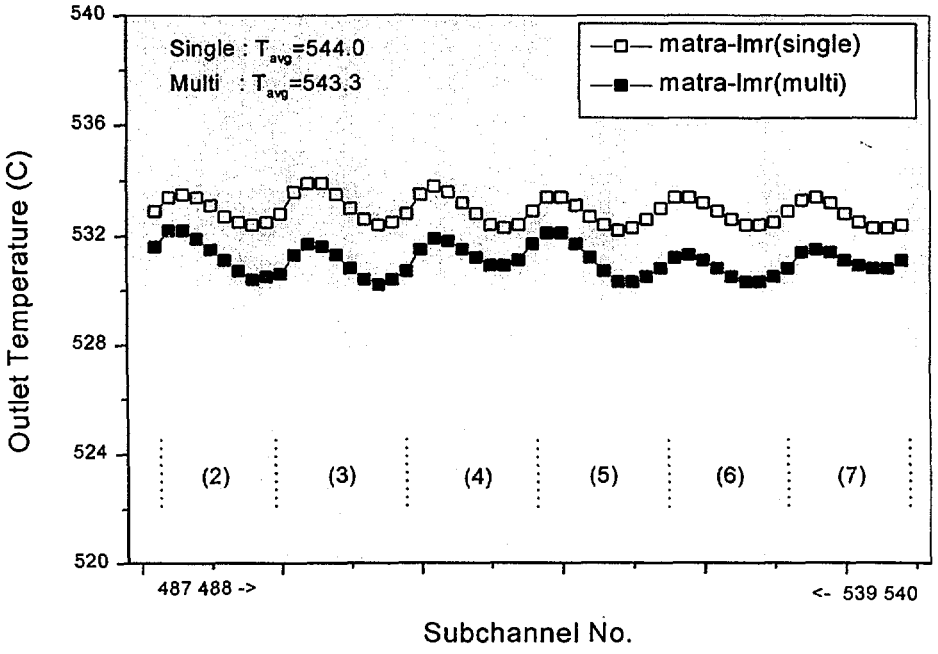


그림 35. DR0302 집합체 가장자리 부수로 출구온도

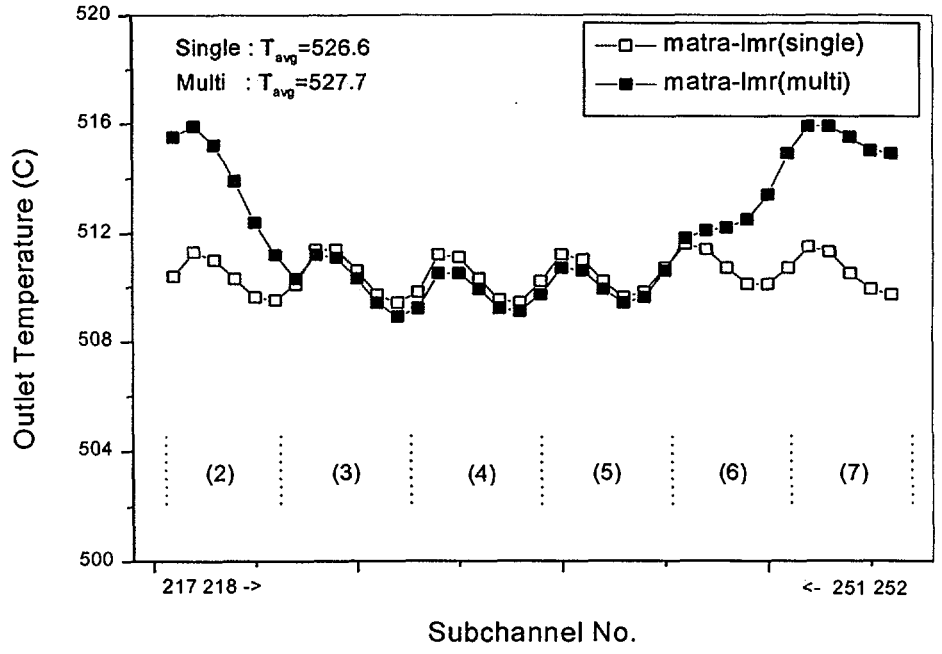


그림 36. RB0602 집합체 가장자리 부수로 출구온도

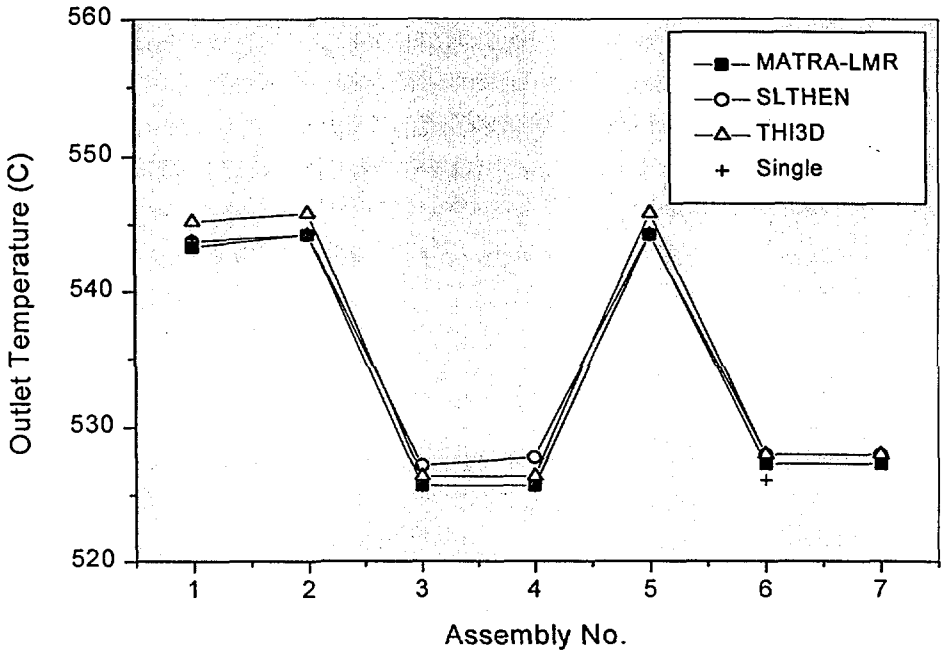


그림 37. DR0302 7-집합체 평균 출구온도

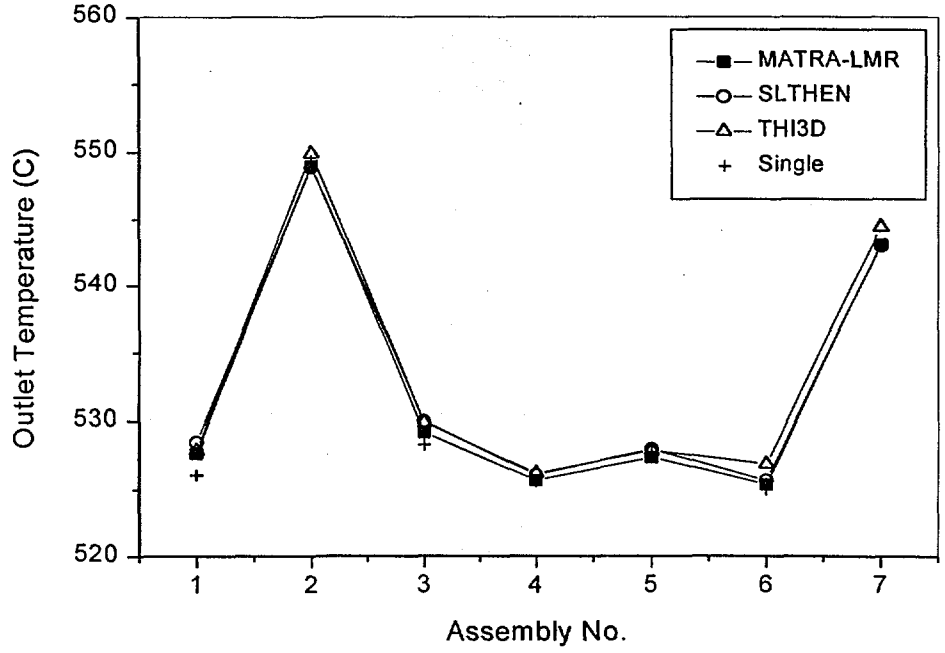


그림 38. RB0602 7-집합체 평균 출구온도

그림 37과 38은 각 집합체의 평균 출구온도를 나타낸 것이다. 여기에는 MATRA-LMR, SLTHEN, THI3D, 및 단일 집합체 계산결과를 함께 비교하였다. 전체적으로 세 코드 계산결과가 비슷한 경향을 보이고 있으며, 단일 집합체와 비교에서도 큰 차이를 보이지 않고 있다. 이는 위에서도 언급하였듯이, KALIMER 설계데이타가 정상상태를 고려하고 있고, 또 설계시에 피복재 중심온도 및 집합체 평균 출구온도에 제한치를 두어 적절한 집합체간 유량분배를 수행함으로써 집합체 사이에 큰 온도차이가 발생하지 않았기 때문이다. 다만 과도기 상태나 적절하지 못한 유량분배가 이루어졌을 경우에는 집합체간 열전달에 의한 집합체내 온도분포에 적지 않은 영향이 발생할 수 있을 것이다.

5. 결론

소듐을 냉각재로 사용하고 있는 액체금속로에서는 이 소듐의 높은 열전도로 인하여 노심내 집합체간 열전달 현상이 집합체내 온도분포에 적지않은 영향을 미친다. 특히, 이웃한 집합체간 온도차가 큰 경우에는 더 심하다.

현재 단일 집합체내 온도분포 및 유량분포 계산이 가능한 MATRA-LMR 코드에 집합체간 열전달 모델링 방법을 추가하여 전체노심 해석이 가능하도록 개선하였다. 이때 덕트벽을 통하여 이웃한 집합체와의 열교환 발생 모델링시 집합체 사이의 소듐은 그 유량이 매우 적어 정지해 있다고 가정하고 대류항 대신에 전도항으로 취급하여 덕트벽과 함께 열전달 저항값으로 계산하였다.

또한 전체노심 해석에서는 집합체 수가 많아져 계산시간이 많이 소요되기 때문에 계산시간을 단축하기 위하여 다음과 같은 가정을 도입하였다. 전체노심 해석시 집합체 수에 관계없이 단일 집합체의 계산조건과 동일한 모의가 가능하도록 표준 집합체를 1개 두고 나머지는 모두 주변 집합체로 가정하여 그 모델을 단순화 하였다. 즉, rod 수에 관계없이 주변 집합체는 7개의 rod와 12개의 부수로로 단순화하여 사용된다.

이와 같이 수정 및 보완된 MATRA-LMR 코드를 여러 7-집합체 모의에 적용하여 계산을 수행하였고, 그 결과를 SLTHEN 및 THI3D 코드와 비교 분석하였다. MATRA-LMR로 단일 집합체 조건에서 그리고 집합체간 열전달을 고려한 조건에서 계산한 결과 주변 집합체가 있는 경우 이들과의 열전달이 발생하여 특히 가장자리 부수로의 온도분포에 영향을 주었고, 전체적으로는 주변 집합체와의 열교환에 의해 평균 집합체 온도가 변하는 현상이 나타났다. SLTHEN 코드 계산결과, 주변 집합체와의 열전달이 MATRA-LMR에 비해 많이 발생하는 것으로 나타났다. 그러나, KALIMER 설계데이타를 사용한 계산결과에서는 단일 및 다 집합체 사이에 큰 차이가 없었다. 이는 현재의 설계 데이타가 정상상태만을 고려한 값이기 때문에 나타나는 결과이지만, 과도기 상태에서는 현재의 결과보다 더 심각한 집합체간 열전달 영향이 나타날 것으로 판단된다.

본 계산에 사용된 4개의 모의 즉, XX08 7-집합체, EBR-II 7-집합체, TED 7-집합체, KALIMER 7-집합체 모두 실험 데이터가 부재한 상태에서 벤치마크 코드에 의한 계산결과 비교만이 이루어져, 직접적이고 상세한 분석은 실행하지 못하였다. 따라서, 향후 MATRA-LMR 코드의 신뢰성을 확보하기 위해서는 기존 실험데이터의 수집이나 자체 실험에 의한 데이터 생산이 반드시 필요하다.

6. 참고문헌

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부록 1. XX08 7-집합체 입력특성

1) XX08 7 Assembly Problem Input deck (Ass. No. 1 - Double Ducted)

Number of fuel pins	61
Axial height	24 in
Fuel pin pitch	0.223 in
Wire wrap lead	6. in
Duct inside flat-to-flat distance	1.83 in (2.21 in), g=0.0555 (in.)
Duct wall thickness	0.04 in
Thimble gap (between hex walls)	0.15 in.
Fuel pin diameter	0.174 in
Wire wrap diameter	0.049 in
Cladding thickness	0.012 in
Wire wrap zero reference angle (start of fuel, Z=0.5 in.)	105°

Number of axial meshes	12
Axial power profile	normalized
Heat transfer correlation	Lyon-Martinelli
Flow split model	Novendstern
Ass. Nominal flow rate	6409.2 lbm/hr
Heat flux per pin	0.0676 Mbtu/hr-ft2
Ass. Power	0.37568 Mbtu/hr
Ass. coolant inlet temp.	664 F
Ass. outlet pressure	20 psia

Number of axial height for power input (22)

.0000, .0200, .0210, .0420, .0830, .1250, .1670, .2080, .2500, .2920,
.3330, .3750, .4170, .4580, .5000, .5420, .5830, .5840, .6670, .7500,
.8330, 1.000

Axial power multiplier (22)

0.017, 0.020, 1.240, 1.240, 1.706, 1.784, 1.853, 1.909, 1.931, 1.939,
1.920, 1.877, 1.810, 1.713, 1.610, 1.508, 1.414, 0.020, 0.010, 0.006,
0.004, 0.001

Radial pin power multiplier (61)

1.04, 1.06, 1.05, 1.04, 1.03, 1.04, 1.04, 1.06, 1.06, 1.05, 1.04, 1.03, 1.03, 1.02, 1.03, 1.03, 1.04, 1.05, 1.06, 1.08
1.08, 1.07, 1.06, 1.05, 1.03, 1.02, 1.02, 1.02, 1.01, 1.02, 1.02, 1.02, 1.04, 1.04, 1.05, 1.06, 1.07, 1.09, 1.09, 1.08
1.07, 1.06, 1.05, 1.04, 1.02, 1.02, 1.01, 1.01, 1.01, 1.01, 1.01, 1.01, 1.01, 1.01, 1.02, 1.03, 1.04, .010, .010, 1.07
1.08

2) XX08 7 Assembly Problem Input deck (Ass. No. 2)

Number of fuel pins	7
Axial height	24 in
Fuel pin pitch	0.791 in
Wire wrap lead	6. in
Duct inside flat-to-flat distance	2.21 in
Duct wall thickness	0.04 in
Thimble gap (between hex walls)	0.15 in.
Fuel pin diameter	0.742 in
Wire wrap diameter	0.049 in
Cladding thickness	0.012 in
Wire wrap zero reference angle (start of fuel, Z=0.5 in.)	105°

Number of axial meshes	12
Axial power profile	normalized
Heat transfer correlation	Lyon-Martinelli
Flow split model	Novendstern
Ass. Nominal flow rate	1536 lbm/hr
Heat flux per pin	0.006900 Mbtu/hr-ft2
Ass. Power	0.018767 Mbtu/hr
Ass. coolant inlet temp.	664 F
Ass. outlet pressure	20 psia

Number of axial height for power input (22)

.0000, .0200, .0210, .0420, .0830, .1250, .1670, .2080, .2500, .2920, .3330, .3750, .4170, .4580, .5000, .5420, .5830, .5840, .6670, .7500, .8330, 1.000

Axial power multiplier (22)

0.835, 0.992, 0.993, 1.150, 1.354, 1.499, 1.590, 1.653, 1.681, 1.698, 1.690, 1.673, 1.622, 1.555, 1.426, 1.273, 0.992, 0.992, 0.508, 0.293, 0.189, 0.068

Radial pin power multiplier (7)

1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00

3) XX08 7 Assembly Problem Input deck (Ass. No. 3, 4, 5, 6, 7)

Number of fuel pins	7
Axial height	24 in
Fuel pin pitch	0.791 in
Wire wrap lead	6. in
Duct inside flat-to-flat distance	2.21 in
Duct wall thickness	0.04 in
Thimble gap (between hex walls)	0.15 in.
Fuel pin diameter	0.742 in
Wire wrap diameter	0.049 in
Cladding thickness	0.012 in
Wire wrap zero reference angle (start of fuel, Z=0.5 in.)	105°

Number of axial meshes	12
Axial power profile	normalized
Heat transfer correlation	Lyon-Martinelli
Flow split model	Novendstern
Ass. Nominal flow rate (lbm/hr)	7136/ 8059/ 8059/ 2260/ 4574
Heat flux per pin (Mbtu/hr-ft2)	0.13224/ 0.20011/ 0.21153/ 0.066997/ 0.13701
Ass. Power (Mbtu/hr)	0.35964/ 0.54424/ 0.57529/ 0.18221/ 0.37261
Ass. coolant inlet temp.	664 F
Ass. outlet pressure	20 psia

Number of axial height for power input (22)

.0000, .0200, .0210, .0420, .0830, .1250, .1670, .2080, .2500, .2920, .3330, .3750, .4170, .4580, .5000, .5420, .5830, .5840, .6670, .7500, .8330, 1.000

Axial power multiplier (22)

0.017, 0.020, 1.240, 1.240, 1.706, 1.784, 1.853, 1.909, 1.931, 1.939, 1.920, 1.877, 1.810, 1.713, 1.610, 1.508, 1.414, 0.020, 0.010, 0.006, 0.004, 0.001

Radial pin power multiplier (7)

1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00

4) XX08 7-집합체 계산을 위한 MATRA-LMR 입력자료 (단일 집합체)

```
30000     0     0     1     0
    1     0 (XX08 7 Subassembly Problem)
    1     0     0     0     0     3     1
    2     0     0     0     0     1     0     0
0.316  -0.25   0.0
  64.    -1.   0.0
    3    22
.0000 .0200 .0210 .0420 .0830 .1250 .1670 .2080 .2500 .2920
.3330 .3750 .4170 .4580 .5000 .5420 .5830 .5840 .6670 .7500
.8330 1.000
0.017 0.020 1.240 1.240 1.706 1.784 1.853 1.909 1.931 1.939
1.920 1.877 1.810 1.713 1.610 1.508 1.414 0.020 0.010 0.006
0.004 0.001
    4   144   144         24     0     0
    1 .0096 .2733 .2733     2 .0490 .1287     6 .0490 .1287     8 .0490 .1287
    2 .0096 .2733 .2733     3 .0490 .1287    11 .0490 .1287
    3 .0096 .2733 .2733     4 .0490 .1287    14 .0490 .1287
    4 .0096 .2733 .2733     5 .0490 .1287    17 .0490 .1287
    5 .0096 .2733 .2733     6 .0490 .1287    20 .0490 .1287
    6 .0096 .2733 .2733    23 .0490 .1287
    7 .0096 .2733 .2733     8 .0490 .1287    24 .0490 .1287    26 .0490 .1287
    8 .0096 .2733 .2733     9 .0490 .1287
    9 .0096 .2733 .2733    10 .0490 .1287    28 .0490 .1287
   10 .0096 .2733 .2733    11 .0490 .1287    31 .0490 .1287
   11 .0096 .2733 .2733    12 .0490 .1287
   12 .0096 .2733 .2733    13 .0490 .1287    33 .0490 .1287
   13 .0096 .2733 .2733    14 .0490 .1287    36 .0490 .1287
   14 .0096 .2733 .2733    15 .0490 .1287
   15 .0096 .2733 .2733    16 .0490 .1287    38 .0490 .1287
   16 .0096 .2733 .2733    17 .0490 .1287    41 .0490 .1287
   17 .0096 .2733 .2733    18 .0490 .1287
   18 .0096 .2733 .2733    19 .0490 .1287    43 .0490 .1287
   19 .0096 .2733 .2733    20 .0490 .1287    46 .0490 .1287
   20 .0096 .2733 .2733    21 .0490 .1287
   21 .0096 .2733 .2733    22 .0490 .1287    48 .0490 .1287
   22 .0096 .2733 .2733    23 .0490 .1287    51 .0490 .1287
   23 .0096 .2733 .2733    24 .0490 .1287
   24 .0096 .2733 .2733    53 .0490 .1287
   25 .0096 .2733 .2733    26 .0490 .1287    54 .0490 .1287    56 .0490 .1287
   26 .0096 .2733 .2733    27 .0490 .1287
   27 .0096 .2733 .2733    28 .0490 .1287    58 .0490 .1287
   28 .0096 .2733 .2733    29 .0490 .1287
   29 .0096 .2733 .2733    30 .0490 .1287    60 .0490 .1287
   30 .0096 .2733 .2733    31 .0490 .1287    63 .0490 .1287
   31 .0096 .2733 .2733    32 .0490 .1287
   32 .0096 .2733 .2733    33 .0490 .1287    65 .0490 .1287
   33 .0096 .2733 .2733    34 .0490 .1287
   34 .0096 .2733 .2733    35 .0490 .1287    67 .0490 .1287
   35 .0096 .2733 .2733    36 .0490 .1287    70 .0490 .1287
   36 .0096 .2733 .2733    37 .0490 .1287
   37 .0096 .2733 .2733    38 .0490 .1287    72 .0490 .1287
   38 .0096 .2733 .2733    39 .0490 .1287
   39 .0096 .2733 .2733    40 .0490 .1287    74 .0490 .1287
   40 .0096 .2733 .2733    41 .0490 .1287    77 .0490 .1287
   41 .0096 .2733 .2733    42 .0490 .1287
   42 .0096 .2733 .2733    43 .0490 .1287    79 .0490 .1287
   43 .0096 .2733 .2733    44 .0490 .1287
   44 .0096 .2733 .2733    45 .0490 .1287    81 .0490 .1287
   45 .0096 .2733 .2733    46 .0490 .1287    84 .0490 .1287
   46 .0096 .2733 .2733    47 .0490 .1287
   47 .0096 .2733 .2733    48 .0490 .1287    86 .0490 .1287
   48 .0096 .2733 .2733    49 .0490 .1287
   49 .0096 .2733 .2733    50 .0490 .1287    88 .0490 .1287
   50 .0096 .2733 .2733    51 .0490 .1287    91 .0490 .1287
```

51	.0096	.2733	.2733	52	.0490	.1287						
52	.0096	.2733	.2733	53	.0490	.1287	93	.0490	.1287			
53	.0096	.2733	.2733	54	.0490	.1287						
54	.0096	.2733	.2733	95	.0490	.1287						
55	.0096	.2733	.2733	56	.0490	.1287	96	.0490	.1287	97	.0490	.1356
56	.0096	.2733	.2733	57	.0490	.1287						
57	.0096	.2733	.2733	58	.0490	.1287	98	.0490	.1356			
58	.0096	.2733	.2733	59	.0490	.1287						
59	.0096	.2733	.2733	60	.0490	.1287	99	.0490	.1356			
60	.0096	.2733	.2733	61	.0490	.1287						
61	.0096	.2733	.2733	62	.0490	.1287	100	.0490	.1356			
62	.0096	.2733	.2733	63	.0490	.1287	101	.0490	.1356			
63	.0096	.2733	.2733	64	.0490	.1287						
64	.0096	.2733	.2733	65	.0490	.1287	102	.0490	.1356			
65	.0096	.2733	.2733	66	.0490	.1287						
66	.0096	.2733	.2733	67	.0490	.1287	103	.0490	.1356			
67	.0096	.2733	.2733	68	.0490	.1287						
68	.0096	.2733	.2733	69	.0490	.1287	104	.0490	.1356			
69	.0096	.2733	.2733	70	.0490	.1287	105	.0490	.1356			
70	.0096	.2733	.2733	71	.0490	.1287						
71	.0096	.2733	.2733	72	.0490	.1287	106	.0490	.1356			
72	.0096	.2733	.2733	73	.0490	.1287						
73	.0096	.2733	.2733	74	.0490	.1287	107	.0490	.1356			
74	.0096	.2733	.2733	75	.0490	.1287						
75	.0096	.2733	.2733	76	.0490	.1287	108	.0490	.1356			
76	.0096	.2733	.2733	77	.0490	.1287	109	.0490	.1356			
77	.0096	.2733	.2733	78	.0490	.1287						
78	.0096	.2733	.2733	79	.0490	.1287	110	.0490	.1356			
79	.0096	.2733	.2733	80	.0490	.1287						
80	.0096	.2733	.2733	81	.0490	.1287	111	.0490	.1356			
81	.0096	.2733	.2733	82	.0490	.1287						
82	.0096	.2733	.2733	83	.0490	.1287	112	.0490	.1356			
83	.0096	.2733	.2733	84	.0490	.1287	113	.0490	.1356			
84	.0096	.2733	.2733	85	.0490	.1287						
85	.0096	.2733	.2733	86	.0490	.1287	114	.0490	.1356			
86	.0096	.2733	.2733	87	.0490	.1287						
87	.0096	.2733	.2733	88	.0490	.1287	115	.0490	.1356			
88	.0096	.2733	.2733	89	.0490	.1287						
89	.0096	.2733	.2733	90	.0490	.1287	116	.0490	.1356			
90	.0096	.2733	.2733	91	.0490	.1287	117	.0490	.1356			
91	.0096	.2733	.2733	92	.0490	.1287						
92	.0096	.2733	.2733	93	.0490	.1287	118	.0490	.1356			
93	.0096	.2733	.2733	94	.0490	.1287						
94	.0096	.2733	.2733	95	.0490	.1287	119	.0490	.1356			
95	.0096	.2733	.2733	96	.0490	.1287						
96	.0096	.2733	.2733	120	.0490	.1356						
97	.0232	.6165	.3189	98	.0555	.2230	120	.0555	.3432			
98	.0199	.4963	.2733	99	.0555	.2230						
99	.0199	.4963	.2733	100	.0555	.2230						
100	.0232	.6165	.3189	101	.0555	.3432						
101	.0232	.6165	.3189	102	.0555	.2230						
102	.0199	.4963	.2733	103	.0555	.2230						
103	.0199	.4963	.2733	104	.0555	.2230						
104	.0232	.6165	.3189	105	.0555	.3432						
105	.0232	.6165	.3189	106	.0555	.2230						
106	.0199	.4963	.2733	107	.0555	.2230						
107	.0199	.4963	.2733	108	.0555	.2230						
108	.0232	.6165	.3189	109	.0555	.3432						
109	.0232	.6165	.3189	110	.0555	.2230						
110	.0199	.4963	.2733	111	.0555	.2230						
111	.0199	.4963	.2733	112	.0555	.2230						
112	.0232	.6165	.3189	113	.0555	.3432						
113	.0232	.6165	.3189	114	.0555	.2230						
114	.0199	.4963	.2733	115	.0555	.2230						
115	.0199	.4963	.2733	116	.0555	.2230						
116	.0232	.6165	.3189	117	.0555	.3432						
117	.0232	.6165	.3189	118	.0555	.2230						

118	.0199	.4963	.2733	119	.0555	.2230
119	.0199	.4963	.2733	120	.0555	.2230
120	.0232	.6165	.3189			
121	.0447	.5966				
122	.0334	.4460				
123	.0334	.4460				
124	.0447	.5966				
125	.0447	.5966				
126	.0334	.4460				
127	.0334	.4460				
128	.0447	.5966				
129	.0447	.5966				
130	.0334	.4460				
131	.0334	.4460				
132	.0447	.5966				
133	.0447	.5966				
134	.0334	.4460				
135	.0334	.4460				
136	.0447	.5966				
137	.0447	.5966				
138	.0334	.4460				
139	.0334	.4460				
140	.0447	.5966				
141	.0447	.5966				
142	.0334	.4460				
143	.0334	.4460				
144	.0447	.5966				
1	.2240	.3040	97	.4620	121	.4620
2	.2240	.2240	98	.4620	122	.4620
3	.2240	.2240	99	.4620	123	.4620
4	.2240	.3040	100	.4620	124	.4620
5	.2240	.3040	101	.4620	125	.4620
6	.2240	.2240	102	.4620	126	.4620
7	.2240	.2240	103	.4620	127	.4620
8	.2240	.3040	104	.4620	128	.4620
9	.2240	.3040	105	.4620	129	.4620
10	.2240	.2240	106	.4620	130	.4620
11	.2240	.2240	107	.4620	131	.4620
12	.2240	.3040	108	.4620	132	.4620
13	.2240	.3040	109	.4620	133	.4620
14	.2240	.2240	110	.4620	134	.4620
15	.2240	.2240	111	.4620	135	.4620
16	.2240	.3040	112	.4620	136	.4620
17	.2240	.3040	113	.4620	137	.4620
18	.2240	.2240	114	.4620	138	.4620
19	.2240	.2240	115	.4620	139	.4620
20	.2240	.3040	116	.4620	140	.4620
21	.2240	.3040	117	.4620	141	.4620
22	.2240	.2240	118	.4620	142	.4620
23	.2240	.2240	119	.4620	143	.4620
24	.2240	.3040	120	.4620	144	.4620
7	1	180	0	0	0	0
6.0	0.174	0.049	0.223			
1	.1667	-.709	.209			
2	.1667	-.375	.875			
3	.1667	-.042	.542			
4	.1667	-.542	.042			
5	.1667	-.875	.375			
6	.1667	-.375	.875			
7	.1667	-.709	.209			
8	.1667	-.209	.709			
9	.1667	-.542	.042			
10	.1667	-.042	.542			
11	.1667	-.375	.875			
12	.1667	-.209	.709			
13	.1667	-.709	.209			
14	.1667	-.375	.875			

15	.1667	-.042	.542
16	.1667	-.875	.375
17	.1667	-.709	.209
18	.1667	-.042	.542
19	.1667	-.542	.042
20	.1667	-.875	.375
21	.1667	-.709	.209
22	.1667	-.542	.042
23	.1667	-.875	.375
24	.1667	-.375	.875
25	.1667	-.709	.209
26	.1667	-.542	.042
27	.1667	-.375	.875
28	.1667	-.709	.209
29	.1667	-.209	.709
30	.1667	-.542	.042
31	.1667	-.375	.875
32	.1667	-.209	.709
33	.1667	-.542	.042
34	.1667	-.042	.542
35	.1667	-.375	.875
36	.1667	-.209	.709
37	.1667	-.042	.542
38	.1667	-.375	.875
39	.1667	-.875	.375
40	.1667	-.209	.709
41	.1667	-.042	.542
42	.1667	-.209	.709
43	.1667	-.709	.209
44	.1667	-.375	.875
45	.1667	-.042	.542
46	.1667	-.875	.375
47	.1667	-.709	.209
48	.1667	-.042	.542
49	.1667	-.875	.375
50	.1667	-.709	.209
51	.1667	-.042	.542
52	.1667	-.542	.042
53	.1667	-.875	.375
54	.1667	-.709	.209
55	.1667	-.542	.042
56	.1667	-.875	.375
57	.1667	-.709	.209
58	.1667	-.542	.042
59	.1667	-.875	.375
60	.1667	-.375	.875
61	.1667	-.709	.209
62	.1667	-.542	.042
63	.1667	-.375	.875
64	.1667	-.709	.209
65	.1667	-.542	.042
66	.1667	-.375	.875
67	.1667	-.709	.209
68	.1667	-.209	.709
69	.1667	-.542	.042
70	.1667	-.375	.875
71	.1667	-.209	.709
72	.1667	-.542	.042
73	.1667	-.375	.875
74	.1667	-.209	.709
75	.1667	-.542	.042
76	.1667	-.042	.542
77	.1667	-.375	.875
78	.1667	-.209	.709
79	.1667	-.042	.542
80	.1667	-.375	.875
81	.1667	-.209	.709

82	.1667	-.042	.542
83	.1667	-.375	.875
84	.1667	-.875	.375
85	.1667	-.209	.709
86	.1667	-.042	.542
87	.1667	-.875	.375
88	.1667	-.209	.709
89	.1667	-.042	.542
90	.1667	-.209	.709
91	.1667	-.709	.209
92	.1667	-.375	.875
93	.1667	-.042	.542
94	.1667	-.875	.375
95	.1667	-.709	.209
96	.1667	-.042	.542
97	.1667	-.875	.375
98	.1667	-.709	.209
99	.1667	-.042	.542
100	.1667	-.875	.375
101	.1667	-.709	.209
102	.1667	-.042	.542
103	.1667	-.542	.042
104	.1667	-.875	.375
105	.1667	-.709	.209
106	.1667	-.542	.042
107	.1667	-.875	.375
108	.1667	-.709	.209
109	.1667	-.542	.042
110	.1667	-.875	.375
111	.1667	-.709	.209
112	.1667	-.542	.042
113	.1667	-.875	.375
114	.1667	-.375	.875
115	.1667	-.709	.209
116	.1667	-.542	.042
117	.1667	-.375	.875
118	.1667	-.709	.209
119	.1667	-.542	.042
120	.1667	-.375	.875
121	.1667	-.709	.209
122	.1667	-.542	.042
123	.1667	-.375	.875
124	.1667	-.709	.209
125	.1667	-.209	.709
126	.1667	-.542	.042
127	.1667	-.375	.875
128	.1667	-.209	.709
129	.1667	-.542	.042
130	.1667	-.375	.875
131	.1667	-.209	.709
132	.1667	-.542	.042
133	.1667	-.375	.875
134	.1667	-.209	.709
135	.1667	-.542	.042
136	.1667	-.042	.542
137	.1667	-.375	.875
138	.1667	-.209	.709
139	.1667	-.042	.542
140	.1667	-.375	.875
141	.1667	-.209	.709
142	.1667	-.042	.542
143	.1667	-.375	.875
144	.1667	-.209	.709
145	.1667	-.042	.542
146	.1667	-.375	.875
147	.1667	-.875	.375
148	.1667	-.209	.709

149	.1667	-.042	.542											
150	.1667	-.875	.375											
151	.1667	-.209	.709											
152	.1667	-.042	.542											
153	.1667	-.875	.375											
154	.1667	-.209	.709											
155	.1667	-.042	.542											
156	.1667	-.209	.709											
157	.1667	-.792												
158	.1667	.875												
159	.1667	-.792												
160	.1667	-.792												
161	.1667	-.709												
162	.1667	-.625												
163	.1667	-.625												
164	.1667	-.625												
165	.1667	-.542												
166	.1667	-.459												
167	.1667	-.459												
168	.1667	-.459												
169	.1667	-.375												
170	.1667	-.292												
171	.1667	-.292												
172	.1667	-.292												
173	.1667	-.209												
174	.1667	-.125												
175	.1667	-.125												
176	.1667	-.125												
177	.1667	-.042												
178	.1667	-.959												
179	.1667	-.959												
180	.1667	-.959												
0	1	0	1	0	1	0	1	0	1					
0	1	0	1	0	1	0	1	0	1					
0	1	0	1	0	1	0	1	0	1					
0	1	0	1	0	1	0	1	0	1					
0	1	0	1	0	1	0	1	0	1					
0	1	0	1	0	1	0	1	0	1					
0	1	0	1	0	1	0	1	0	1					
0	1	0	1	0	1	0	1	0	1					
0	1	0	1	0	1	0	1	0	1					
0	1	0	1	0	1	1	1	1	1					
0	0	0	0	0	0	0	0	0	0					
0	0	1	1	1	1	2	1	1	1					
0	0	0	0	0	0	0	0	0	0					
0	0	0	0	0	0	0	0	0	0					
0	0	0	0											
8	61	61	0	0	0	0	0	0	0					
1	.1740	1.040	1	.1667	2	.1667	3	.1667	4	.1667	5	.1667	6	.1667
2	.1740	1.060	1	.1667	6	.1667	7	.1667	8	.1667	23	.1667	24	.1667
3	.1740	1.050	1	.1667	2	.1667	8	.1667	9	.1667	10	.1667	11	.1667
4	.1740	1.040	2	.1667	3	.1667	11	.1667	12	.1667	13	.1667	14	.1667
5	.1740	1.030	3	.1667	4	.1667	14	.1667	15	.1667	16	.1667	17	.1667
6	.1740	1.040	4	.1667	5	.1667	17	.1667	18	.1667	19	.1667	20	.1667
7	.1740	1.040	5	.1667	6	.1667	20	.1667	21	.1667	22	.1667	23	.1667
8	.1740	1.060	7	.1667	24	.1667	25	.1667	26	.1667	53	.1667	54	.1667
9	.1740	1.060	7	.1667	8	.1667	9	.1667	26	.1667	27	.1667	28	.1667
10	.1740	1.050	9	.1667	10	.1667	28	.1667	29	.1667	30	.1667	31	.1667
11	.1740	1.040	10	.1667	11	.1667	12	.1667	31	.1667	32	.1667	33	.1667
12	.1740	1.030	12	.1667	13	.1667	33	.1667	34	.1667	35	.1667	36	.1667
13	.1740	1.030	13	.1667	14	.1667	15	.1667	36	.1667	37	.1667	38	.1667
14	.1740	1.020	15	.1667	16	.1667	38	.1667	39	.1667	40	.1667	41	.1667
15	.1740	1.030	16	.1667	17	.1667	18	.1667	41	.1667	42	.1667	43	.1667
16	.1740	1.030	18	.1667	19	.1667	43	.1667	44	.1667	45	.1667	46	.1667
17	.1740	1.040	19	.1667	20	.1667	21	.1667	46	.1667	47	.1667	48	.1667
18	.1740	1.050	21	.1667	22	.1667	48	.1667	49	.1667	50	.1667	51	.1667
19	.1740	1.060	22	.1667	23	.1667	24	.1667	51	.1667	52	.1667	53	.1667

20	.1740	1.080	25	.1667	54	.1667	55	.1667	56	.1667	95	.1667	96	.1667
21	.1740	1.080	25	.1667	26	.1667	27	.1667	56	.1667	57	.1667	58	.1667
22	.1740	1.070	27	.1667	28	.1667	29	.1667	58	.1667	59	.1667	60	.1667
23	.1740	1.060	29	.1667	30	.1667	60	.1667	61	.1667	62	.1667	63	.1667
24	.1740	1.050	30	.1667	31	.1667	32	.1667	63	.1667	64	.1667	65	.1667
25	.1740	1.030	32	.1667	33	.1667	34	.1667	65	.1667	66	.1667	67	.1667
26	.1740	1.020	34	.1667	35	.1667	67	.1667	68	.1667	69	.1667	70	.1667
27	.1740	1.020	35	.1667	36	.1667	37	.1667	70	.1667	71	.1667	72	.1667
28	.1740	1.020	37	.1667	38	.1667	39	.1667	72	.1667	73	.1667	74	.1667
29	.1740	1.010	39	.1667	40	.1667	74	.1667	75	.1667	76	.1667	77	.1667
30	.1740	1.020	40	.1667	41	.1667	42	.1667	77	.1667	78	.1667	79	.1667
31	.1740	1.020	42	.1667	43	.1667	44	.1667	79	.1667	80	.1667	81	.1667
32	.1740	1.020	44	.1667	45	.1667	81	.1667	82	.1667	83	.1667	84	.1667
33	.1740	1.040	45	.1667	46	.1667	47	.1667	84	.1667	85	.1667	86	.1667
34	.1740	1.040	47	.1667	48	.1667	49	.1667	86	.1667	87	.1667	88	.1667
35	.1740	1.050	49	.1667	50	.1667	88	.1667	89	.1667	90	.1667	91	.1667
36	.1740	1.060	50	.1667	51	.1667	52	.1667	91	.1667	92	.1667	93	.1667
37	.1740	1.070	52	.1667	53	.1667	54	.1667	93	.1667	94	.1667	95	.1667
38	.1740	1.090	55	.1667	96	.1667	97	.3333	120	.3333				
39	.1740	1.090	55	.1667	56	.1667	57	.1667	97	.2500	98	.2500		
40	.1740	1.080	57	.1667	58	.1667	59	.1667	98	.2500	99	.2500		
41	.1740	1.070	59	.1667	60	.1667	61	.1667	99	.2500	100	.2500		
42	.1740	1.060	61	.1667	62	.1667	100	.3333	101	.3333				
43	.1740	1.050	62	.1667	63	.1667	64	.1667	101	.2500	102	.2500		
44	.1740	1.040	64	.1667	65	.1667	66	.1667	102	.2500	103	.2500		
45	.1740	1.020	66	.1667	67	.1667	68	.1667	103	.2500	104	.2500		
46	.1740	1.020	68	.1667	69	.1667	104	.3333	105	.3333				
47	.1740	1.010	69	.1667	70	.1667	71	.1667	105	.2500	106	.2500		
48	.1740	1.010	71	.1667	72	.1667	73	.1667	106	.2500	107	.2500		
49	.1740	1.010	73	.1667	74	.1667	75	.1667	107	.2500	108	.2500		
50	.1740	1.010	75	.1667	76	.1667	108	.3333	109	.3333				
51	.1740	1.010	76	.1667	77	.1667	78	.1667	109	.2500	110	.2500		
52	.1740	1.010	78	.1667	79	.1667	80	.1667	110	.2500	111	.2500		
53	.1740	1.010	80	.1667	81	.1667	82	.1667	111	.2500	112	.2500		
54	.1740	1.010	82	.1667	83	.1667	112	.3333	113	.3333				
55	.1740	1.020	83	.1667	84	.1667	85	.1667	113	.2500	114	.2500		
56	.1740	1.030	85	.1667	86	.1667	87	.1667	114	.2500	115	.2500		
57	.1740	1.040	87	.1667	88	.1667	89	.1667	115	.2500	116	.2500		
58	.1740	.0100	89	.1667	90	.1667	116	.3333	117	.3333				
59	.1740	.0100	90	.1667	91	.1667	92	.1667	117	.2500	118 .	.2500		
60	.1740	1.070	92	.1667	93	.1667	94	.1667	118	.2500	119	.2500		
61	.1740	1.080	94	.1667	95	.1667	96	.1667	119	.2500	120	.2500		
9	0	0	0	0	0	0								
24.	0.		1.E-5	0.001								0.5		
24		200	200											
10	0	0	1	0	0	0								
0.01														
0.5														
11	1	2	0	0	0	0	0	0	0	0				
20.	664.	.39236	.0676											
.0059220	.0059220	.0059220	.0059220	.0059220	.0059220	.0059220	.0059220	.0059220	.0059220					
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.0059220	.0059220	.0059220	.0059220	.0059220	.0059220	.0059220	.0059220	.0059220	.0059220					
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.0059220	.0059220	.0059220	.0059220	.0059220	.0059220	.0059220	.0059220	.0059220	.0059220					
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.0045009	.0033681	.0033681	.0045009	.0045009	.0033681	.0033681	.0045009	.0045009	.0033681					
.0033660	.0045030	.0045030	.0033660	.0033660	.0045030	.0045030	.0033660	.0033660	.0045030					
.0045030	.0033660	.0033660	.0045030											
12	1	0	0	0	0	0	0	0						

5) XX08 7-집합체 계산을 위한 MATRA-LMR 입력자료 (다 집합체)

```
3000       0       0       1       1
   1       0 (XX08 7 Subassembly Problem)
   1       0       0       0       0       3       1
   2       0       0       0       0       1       0       0
0.316    -0.25     0.0
  64.      -1.     0.0
   3      22       2
.0000    .0200   .0210   .0420   .0830   .1250   .1670   .2080   .2500   .2920
.3330    .3750   .4170   .4580   .5000   .5420   .5830   .5840   .6670   .7500
.8330   1.000
0.017    0.020   1.240   1.240   1.706   1.784   1.853   1.909   1.931   1.939
1.920    1.877   1.810   1.713   1.610   1.508   1.414   0.020   0.010   0.006
0.004    0.001
0.835    0.992   0.993   1.150   1.354   1.499   1.590   1.653   1.681   1.698
1.690    1.673   1.622   1.555   1.426   1.273   0.992   0.992   0.508   0.293
0.189    0.068
   4       7      24       1
 664.     0.04    0.15    2.21     24.     24
   1     144       1       0       0       0
   1   .0096   .2733   .2733     2   .0490   .1287     6   .0490   .1287     8   .0490   .1287
   2   .0096   .2733   .2733     3   .0490   .1287    11   .0490   .1287
   3   .0096   .2733   .2733     4   .0490   .1287    14   .0490   .1287
   4   .0096   .2733   .2733     5   .0490   .1287    17   .0490   .1287
   5   .0096   .2733   .2733     6   .0490   .1287    20   .0490   .1287
   6   .0096   .2733   .2733    23   .0490   .1287
   7   .0096   .2733   .2733     8   .0490   .1287    24   .0490   .1287    26   .0490   .1287
   8   .0096   .2733   .2733     9   .0490   .1287
   9   .0096   .2733   .2733    10   .0490   .1287    28   .0490   .1287
  10   .0096   .2733   .2733    11   .0490   .1287    31   .0490   .1287
  11   .0096   .2733   .2733    12   .0490   .1287
  12   .0096   .2733   .2733    13   .0490   .1287    33   .0490   .1287
  13   .0096   .2733   .2733    14   .0490   .1287    36   .0490   .1287
  14   .0096   .2733   .2733    15   .0490   .1287
  15   .0096   .2733   .2733    16   .0490   .1287    38   .0490   .1287
  16   .0096   .2733   .2733    17   .0490   .1287    41   .0490   .1287
  17   .0096   .2733   .2733    18   .0490   .1287
  18   .0096   .2733   .2733    19   .0490   .1287    43   .0490   .1287
  19   .0096   .2733   .2733    20   .0490   .1287    46   .0490   .1287
  20   .0096   .2733   .2733    21   .0490   .1287
  21   .0096   .2733   .2733    22   .0490   .1287    48   .0490   .1287
  22   .0096   .2733   .2733    23   .0490   .1287    51   .0490   .1287
  23   .0096   .2733   .2733    24   .0490   .1287
  24   .0096   .2733   .2733    53   .0490   .1287
  25   .0096   .2733   .2733    26   .0490   .1287    54   .0490   .1287    56   .0490   .1287
  26   .0096   .2733   .2733    27   .0490   .1287
  27   .0096   .2733   .2733    28   .0490   .1287    58   .0490   .1287
  28   .0096   .2733   .2733    29   .0490   .1287
  29   .0096   .2733   .2733    30   .0490   .1287    60   .0490   .1287
  30   .0096   .2733   .2733    31   .0490   .1287    63   .0490   .1287
  31   .0096   .2733   .2733    32   .0490   .1287
  32   .0096   .2733   .2733    33   .0490   .1287    65   .0490   .1287
  33   .0096   .2733   .2733    34   .0490   .1287
  34   .0096   .2733   .2733    35   .0490   .1287    67   .0490   .1287
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  39   .0096   .2733   .2733    40   .0490   .1287    74   .0490   .1287
  40   .0096   .2733   .2733    41   .0490   .1287    77   .0490   .1287
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  49   .0096   .2733   .2733    50   .0490   .1287    88   .0490   .1287
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  51   .0096   .2733   .2733    52   .0490   .1287
  52   .0096   .2733   .2733    53   .0490   .1287    93   .0490   .1287
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  54   .0096   .2733   .2733    95   .0490   .1287
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59	.0096	.2733	.2733	60	.0490	.1287	99	.0490	.1356			
60	.0096	.2733	.2733	61	.0490	.1287						
61	.0096	.2733	.2733	62	.0490	.1287	100	.0490	.1356			
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63	.0096	.2733	.2733	64	.0490	.1287						
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65	.0096	.2733	.2733	66	.0490	.1287						
66	.0096	.2733	.2733	67	.0490	.1287	103	.0490	.1356			
67	.0096	.2733	.2733	68	.0490	.1287						
68	.0096	.2733	.2733	69	.0490	.1287	104	.0490	.1356			
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73	.0096	.2733	.2733	74	.0490	.1287	107	.0490	.1356			
74	.0096	.2733	.2733	75	.0490	.1287						
75	.0096	.2733	.2733	76	.0490	.1287	108	.0490	.1356			
76	.0096	.2733	.2733	77	.0490	.1287	109	.0490	.1356			
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78	.0096	.2733	.2733	79	.0490	.1287	110	.0490	.1356			
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80	.0096	.2733	.2733	81	.0490	.1287	111	.0490	.1356			
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82	.0096	.2733	.2733	83	.0490	.1287	112	.0490	.1356			
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87	.0096	.2733	.2733	88	.0490	.1287	115	.0490	.1356			
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93	.0096	.2733	.2733	94	.0490	.1287						
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97	.0232	.6165	.3189	98	.0555	.2230	120	.0555	.3432			
98	.0199	.4963	.2733	99	.0555	.2230						
99	.0199	.4963	.2733	100	.0555	.2230						
100	.0232	.6165	.3189	101	.0555	.3432						
101	.0232	.6165	.3189	102	.0555	.2230						
102	.0199	.4963	.2733	103	.0555	.2230						
103	.0199	.4963	.2733	104	.0555	.2230						
104	.0232	.6165	.3189	105	.0555	.3432						
105	.0232	.6165	.3189	106	.0555	.2230						
106	.0199	.4963	.2733	107	.0555	.2230						
107	.0199	.4963	.2733	108	.0555	.2230						
108	.0232	.6165	.3189	109	.0555	.3432						
109	.0232	.6165	.3189	110	.0555	.2230						
110	.0199	.4963	.2733	111	.0555	.2230						
111	.0199	.4963	.2733	112	.0555	.2230						
112	.0232	.6165	.3189	113	.0555	.3432						
113	.0232	.6165	.3189	114	.0555	.2230						
114	.0199	.4963	.2733	115	.0555	.2230						
115	.0199	.4963	.2733	116	.0555	.2230						
116	.0232	.6165	.3189	117	.0555	.3432						
117	.0232	.6165	.3189	118	.0555	.2230						
118	.0199	.4963	.2733	119	.0555	.2230						
119	.0199	.4963	.2733	120	.0555	.2230						
120	.0232	.6165	.3189									
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122	.0334	.4460										
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125	.0447	.5966										
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0.39236
   2      3       4       5       6       7
   4    121     122     123     124
   4    125     126     127     128
   4    129     130     131     132
   4    133     134     135     136
   4    137     138     139     140
   4    141     142     143     144
   2     12       2       0       0       0
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   2  .0547   1.166   1.166       3  .0490   .4567       8  .0490   .4383
   3  .0547   1.166   1.166       4  .0490   .4567       9  .0490   .4383
   4  .0547   1.166   1.166       5  .0490   .4567      10  .0490   .4383
   5  .0547   1.166   1.166       6  .0490   .4567      11  .0490   .4383
   6  .0547   1.166   1.166      12  .0490   .4383
   7  .1363   2.785   1.554       8  .0490   1.205      12  .0490   1.205
   8  .1363   2.785   1.554       9  .0490   1.205
   9  .1363   2.785   1.554      10  .0490   1.205
  10  .1363   2.785   1.554      11  .0490   1.205
  11  .1363   2.785   1.554      12  .0490   1.205
  12  .1363   2.785   1.554
0.1930
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   1      7
   1      8
   1      9
   1     10
   1     11
   1     12
   3     12       1       0       0       0
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   2  .0547   1.166   1.166       3  .0490   .4567       8  .0490   .4383
   3  .0547   1.166   1.166       4  .0490   .4567       9  .0490   .4383
   4  .0547   1.166   1.166       5  .0490   .4567      10  .0490   .4383
   5  .0547   1.166   1.166       6  .0490   .4567      11  .0490   .4383
   6  .0547   1.166   1.166      12  .0490   .4383
   7  .1363   2.785   1.554       8  .0490   1.205      12  .0490   1.205
   8  .1363   2.785   1.554       9  .0490   1.205
   9  .1363   2.785   1.554      10  .0490   1.205
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0.89667
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   1     10
   1     11
   1     12
   4     12       1       0       0       0
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   2  .0547   1.166   1.166       3  .0490   .4567       8  .0490   .4383
   3  .0547   1.166   1.166       4  .0490   .4567       9  .0490   .4383
   4  .0547   1.166   1.166       5  .0490   .4567      10  .0490   .4383
   5  .0547   1.166   1.166       6  .0490   .4567      11  .0490   .4383
   6  .0547   1.166   1.166      12  .0490   .4383
   7  .1363   2.785   1.554       8  .0490   1.205      12  .0490   1.205
   8  .1363   2.785   1.554       9  .0490   1.205
   9  .1363   2.785   1.554      10  .0490   1.205
  10  .1363   2.785   1.554      11  .0490   1.205
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1.01265
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  2   .0547   1.166   1.166   3   .0490   .4567   8   .0490   .4383
  3   .0547   1.166   1.166   4   .0490   .4567   9   .0490   .4383
  4   .0547   1.166   1.166   5   .0490   .4567   10  .0490   .4383
  5   .0547   1.166   1.166   6   .0490   .4567   11  .0490   .4383
  6   .0547   1.166   1.166   12  .0490   .4383
  7   .1363   2.785   1.554   8   .0490   1.205   12  .0490   1.205
  8   .1363   2.785   1.554   9   .0490   1.205
  9   .1363   2.785   1.554   10  .0490   1.205
 10   .1363   2.785   1.554   11  .0490   1.205
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1.01265
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  1       8
  1       9
  1       10
  1       11
  1       12
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  2   .0547   1.166   1.166   3   .0490   .4567   8   .0490   .4383
  3   .0547   1.166   1.166   4   .0490   .4567   9   .0490   .4383
  4   .0547   1.166   1.166   5   .0490   .4567   10  .0490   .4383
  5   .0547   1.166   1.166   6   .0490   .4567   11  .0490   .4383
  6   .0547   1.166   1.166   12  .0490   .4383
  7   .1363   2.785   1.554   8   .0490   1.205   12  .0490   1.205
  8   .1363   2.785   1.554   9   .0490   1.205
  9   .1363   2.785   1.554   10  .0490   1.205
 10   .1363   2.785   1.554   11  .0490   1.205
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0.28398
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  1       10
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  1       12
  7       12      1       0       0       0
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  2   .0547   1.166   1.166   3   .0490   .4567   8   .0490   .4383
  3   .0547   1.166   1.166   4   .0490   .4567   9   .0490   .4383
  4   .0547   1.166   1.166   5   .0490   .4567   10  .0490   .4383
  5   .0547   1.166   1.166   6   .0490   .4567   11  .0490   .4383
  6   .0547   1.166   1.166   12  .0490   .4383
  7   .1363   2.785   1.554   8   .0490   1.205   12  .0490   1.
  9   .1363   2.785   1.554   10  .0490   1.205
 10   .1363   2.785   1.554   11  .0490   1.205
 11   .1363   2.785   1.554   12  .0490   1.205
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  1       12
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  1       1       98      122   .224   .224   .04   .462   .462
  1       1       99      123   .224   .224   .04   .462   .462
  1       1       100     124   .224   .304   .04   .462   .462
  1       1       101     125   .224   .304   .04   .462   .462
  1       1       102     126   .224   .224   .04   .462   .462
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1	1	112	136	.224	.304	.04	.462	.462
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25	.1740	1.030	32	.1667	33	.1667	34	.1667	65	.1667	66	.1667	67	.1667	
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28	.1740	1.020	37	.1667	38	.1667	39	.1667	72	.1667	73	.1667	74	.1667	
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45	.1740	1.020	66	.1667	67	.1667	68	.1667	103	.2500	104	.2500			
46	.1740	1.020	68	.1667	69	.1667	104	.3333	105	.3333					
47	.1740	1.010	69	.1667	70	.1667	71	.1667	105	.2500	106	.2500			
48	.1740	1.010	71	.1667	72	.1667	73	.1667	106	.2500	107	.2500			
49	.1740	1.010	73	.1667	74	.1667	75	.1667	107	.2500	108	.2500			
50	.1740	1.010	75	.1667	76	.1667	108	.3333	109	.3333					
51	.1740	1.010	76	.1667	77	.1667	78	.1667	109	.2500	110	.2500			
52	.1740	1.010	78	.1667	79	.1667	80	.1667	110	.2500	111	.2500			
53	.1740	1.010	80	.1667	81	.1667	82	.1667	111	.2500	112	.2500			
54	.1740	1.010	82	.1667	83	.1667	112	.3333	113	.3333					
55	.1740	1.020	83	.1667	84	.1667	85	.1667	113	.2500	114	.2500			
56	.1740	1.030	85	.1667	86	.1667	87	.1667	114	.2500	115	.2500			
57	.1740	1.040	87	.1667	88	.1667	89	.1667	115	.2500	116	.2500			
58	.1740	.0100	89	.1667	90	.1667	116	.3333	117	.3333					
59	.1740	.0100	90	.1667	91	.1667	92	.1667	117	.2500	118	.2500			
60	.1740	1.070	92	.1667	93	.1667	94	.1667	118	.2500	119	.2500			
61	.1740	1.080	94	.1667	95	.1667	96	.1667	119	.2500	120	.2500			
2	7	0													
1	.7420	1.000	1	.1667	2	.1667	3	.1667	4	.1667	5	.1667	6	.1667	
2	.7420	1.000	1	.1667	6	.1667	7	.3333	12	.3333					
3	.7420	1.000	1	.1667	2	.1667	7	.3333	8	.3333					
4	.7420	1.000	2	.1667	3	.1667	8	.3333	9	.3333					
5	.7420	1.000	3	.1667	4	.1667	9	.3333	10	.3333					
6	.7420	1.000	4	.1667	5	.1667	10	.3333	11	.3333					
7	.7420	1.000	5	.1667	6	.1667	11	.3333	12	.3333					
3	7	0													
1	.7420	1.000	1	.1667	2	.1667	3	.1667	4	.1667	5	.1667	6	.1667	
2	.7420	1.000	1	.1667	6	.1667	7	.3333	12	.3333					
3	.7420	1.000	1	.1667	2	.1667	7	.3333	8	.3333					
4	.7420	1.000	2	.1667	3	.1667	8	.3333	9	.3333					
5	.7420	1.000	3	.1667	4	.1667	9	.3333	10	.3333					
6	.7420	1.000	4	.1667	5	.1667	10	.3333	11	.3333					
7	.7420	1.000	5	.1667	6	.1667	11	.3333	12	.3333					
4	7	0													
1	.7420	1.000	1	.1667	2	.1667	3	.1667	4	.1667	5	.1667	6	.1667	
2	.7420	1.000	1	.1667	6	.1667	7	.3333	12	.3333					
3	.7420	1.000	1	.1667	2	.1667	7	.3333	8	.3333					
4	.7420	1.000	2	.1667	3	.1667	8	.3333	9	.3333					
5	.7420	1.000	3	.1667	4	.1667	9	.3333	10	.3333					
6	.7420	1.000	4	.1667	5	.1667	10	.3333	11	.3333					
7	.7420	1.000	5	.1667	6	.1667	11	.3333	12	.3333					
5	7	0													
1	.7420	1.000	1	.1667	2	.1667	3	.1667	4	.1667	5	.1667	6	.1667	
2	.7420	1.000	1	.1667	6	.1667	7	.3333	12	.3333					
3	.7420	1.000	1	.1667	2	.1667	7	.3333	8	.3333					
4	.7420	1.000	2	.1667	3	.1667	8	.3333	9	.3333					
5	.7420	1.000	3	.1667	4	.1667	9	.3333	10	.3333					
6	.7420	1.000	4	.1667	5	.1667	10	.3333	11	.3333					
7	.7420	1.000	5	.1667	6	.1667	11	.3333	12	.3333					

```
      6       7       0
      1   .7420   1.000       1   .1667       2   .1667       3   .1667       4   .1667       5   .1667       6   .1667
      2   .7420   1.000       1   .1667       6   .1667       7   .3333      12   .3333
      3   .7420   1.000       1   .1667       2   .1667       7   .3333       8   .3333
      4   .7420   1.000       2   .1667       3   .1667       8   .3333       9   .3333
      5   .7420   1.000       3   .1667       4   .1667       9   .3333      10   .3333
      6   .7420   1.000       4   .1667       5   .1667      10   .3333      11   .3333
      7   .7420   1.000       5   .1667       6   .1667      11   .3333      12   .3333
      7       7       0
      1   .7420   1.000       1   .1667       2   .1667       3   .1667       4   .1667       5   .1667       6   .1667
      2   .7420   1.000       1   .1667       6   .1667       7   .3333      12   .3333
      3   .7420   1.000       1   .1667       2   .1667       7   .3333       8   .3333
      4   .7420   1.000       2   .1667       3   .1667       8   .3333       9   .3333
      5   .7420   1.000       3   .1667       4   .1667       9   .3333      10   .3333
      6   .7420   1.000       4   .1667       5   .1667      10   .3333      11   .3333
      7   .7420   1.000       5   .1667       6   .1667      11   .3333      12   .3333
      9       0       0       0       0       0       0
    24.      0.          1.E-5   0.001                                                      0.5
     24             200     200
     10       0       0       1       0       0       0
   0.01
    0.5
     11       1       2       0       0       0       0       0       0       0       0
    20.    664.
0.37568 0.018767 0.35964 0.54424 0.57529 0.18221 0.37261
 0.0676   0.0069 0.13224 0.20011 0.21153 0.066997 0.13701
.0059220 .0059220 .0059220 .0059220 .0059220 .0059220 .0059220 .0059220 .0059220 .0059220
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.0045009 .0033681 .0033681 .0045009 .0045009 .0033681 .0033681 .0045009 .0045009 .0033681
.0033660 .0045030 .0045030 .0033660 .0033660 .0045030 .0045030 .0033660 .0033660 .0045030
.0045030 .0033660 .0033660 .0045030
     12       1       0       0       0       0       0       0       0
```

6) XX08 7-집합체 계산을 위한 THI3D 입력자료 (단일 집합체)

```
 XX08 7-ASSEMBLY PROBLEM (SINGLE CASE)   SEPTEMBER 1, 1999
 156     1    48     1    48    30     0     3     1    61     6     0
   0     2     1     1     0     2     1    20     1     0     2     1
   0     0     1     1    49     0     0     0     0     1     1     1
   0     0     0     0     0     0     0
  0.223      0.0   0.0065      6.0    0.049   0.1425  6.76E4      1.23
   0.02   85.813     0.97     1.03       1.0     0.0     0.0      2.0
  0.028      0.0      0.0      0.0       0.0    0.01    0.01     0.01
  0.028    0.028    0.028      0.0       0.0     0.0     0.0      0.0
   0.04     0.15  1.69E3   1.69E3    0.3325 8.3354E4     0.0
3 3 3 3 5 3 3 3 3 5 3 3 3 3 5 3 3 3 3 5 3 3 3 3 5 3 3 3 3 5 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 7 7 7 7 6 7 7 7 7 6 7 7 7 7 6 7 7 7
7 6 7 7 7 7 6 7 7 7 7 6
   0     0     0     0     0     0     0     0     0     0     0     0     0
   0     0     0
    0.5    0.162    0.162    0.174 6.2930E5      0.0   1123.7      1.0
    0.0      0.0      0.0  1.36092   1000.0      1.0      0.0
    1.0      1.0      1.0      1.0      1.0      1.0      1.0      1.0
 1  2  3  4  5  6  1  2  3  4  5  6  1  2  3  4  5  6  1  2  3  4  5  6
 1  2  3  4  5  6  1  2  3  4  5  6  1  2  3  4  5  6  1  2  3  4  5  6
 1
 0  60 120 180 240 300
 1   0  90 150 240 300   0  60 180
 2   0  60 150 240 300   0  90 210
 3   0  60 150 210 300   0 120 240
 4   0  60 120 210 300   0 150 270
 5   0  60 120 210 270   0 180 300
 6   0  60 120 180 270   0 210 330
 7  60 120 180 270 330   0 240   0
 8  60 120 180 240 330   0 270  30
 9  30 120 180 240 330   0 300  60
10  30 120 180 240 300   0 330  90
11  30  90 180 240 300   0   0 120
12   0  90 180 240 300   0  30 150
13   0  60 120 180 240 300           1
 1   1  29  30   1  31  72   0
 2   2  31   1   2  33  32   0
 3   2  33   2   3  35  34   0
 4   2  35   3   4  37  36   0
 5   3  37   4   5   6  38   0
 6   4  39  38   6   7  40   0
 7   4  41  40   7   8  42   0
 8   4  43  42   8   9  44   0
 9   5  45  44   9  10  11   0
10   6  47  46  45  11  12   0
11   6  49  48  47  12  13   0
12   6  51  50  49  13  14   0
13   7  52  51  14  15  16   0
14   8  54  53  52  16  17   0
15   8  56  55  54  17  18   0
16   8  58  57  56  18  19   0
17   9  21  59  58  19  20   0
18  10  22  61  60  59  21   0
19  10  23  63  62  61  22   0
20  10  24  65  64  63  23   0
21  11  25  26  66  65  24   0
22  12  26  27  68  67  66   0
23  12  27  28  70  69  68   0
24  12  28  29  72  71  70   0
25  13  71  72  31  32  73 102
26  13  73  32  33  34  75  74
27  13  75  34  35  36  77  76
```

```
28  13  77  36  37  38  39  78
29  13  79  78  39  40  41  80
30  13  81  80  41  42  43  82
31  13  83  82  43  44  45  46
32  13  85  84  83  46  47  48
33  13  87  86  85  48  49  50
34  13  53  88  87  50  51  52
35  13  55  90  89  88  53  54
36  13  57  92  91  90  55  56
37  13  59  60  93  92  57  58
38  13  61  62  95  94  93  60
39  13  63  64  97  96  95  62
40  13  65  66  67  98  97  64
41  13  67  68  69 100  99  98
42  13  69  70  71 102 101 100
43  13 101 102  73  74 103 120
44  13 103  74  75  76 105 104
45  13 105  76  77  78  79 106
46  13 107 106  79  80  81 108
47  13 109 108  81  82  83  84
48  13 111 110 109  84  85  86
49  13  89 112 111  86  87  88
50  13  91 114 113 112  89  90
51  13  93  94 115 114  91  92
52  13  95  96 117 116 115  94
53  13  97  98  99 118 117  96
54  13  99 100 101 120 119 118
55  13 119 120 103 104 121 126
56  13 121 104 105 106 107 122
57  13 123 122 107 108 109 110
58  13 113 124 123 110 111 112
59  13 115 116 125 124 113 114
60  13 117 118 119 126 125 116
61  13 125 126 121 122 123 124
    1.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
 1.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
   0
   0    0    0    1    0
```

7) XX08 7-집합체 계산을 위한 THI3D 입력자료 (다 집합체)

```
XX08 7-ASSEMBLY PROBLEM (MULTI CASE)   SEPTEMBER 22, 1999
    5     5    48     1    48     0     0     2     1     7     1     0
    0     2     1     0     0     2     1    20     1     0     2     1
   -1     0     0     0     0     0     0     0     0     1     1     1
    0     0     0     0     0     0     0
   2.21     0.3  0.4709     0.0     0.0   1.426   2.6E5    1.23
   0.02  85.813    0.97    1.03     1.0     0.0     0.0     2.0
  0.028     0.0     0.0     0.0     0.0    2.01    0.01    0.01
  0.028   0.028   0.028     0.0     0.0     0.0     0.0     0.0
    0.0     0.0     0.0     0.0     0.0     0.0     0.0
0 0 0 0 0
0 1 1 0 0
0 1 1 1 0
0 1 1 0 0
0 0 0 0 0
    0     1     1     1     1     0     0     1     0     0     0     0
    0     0     0
    0.5    1.91    1.91    1.91 -5.734E5     0.0  1123.7     1.0
    0.0     0.0     0.0 1.36092  1000.0     1.0     0.0
    0.0     0.0     0.0     0.0     0.0
    0.0    1.91    1.91     0.0     0.0
    0.0    1.91    1.91    1.91     0.0
    0.0    1.91    1.91     0.0     0.0
    0.0     0.0     0.0     0.0     0.0
    0.0     0.0     0.0     0.0     0.0
    0.0    1.91    1.91     0.0     0.0
    0.0    1.91    1.91    1.91     0.0
    0.0    1.91    1.91     0.0     0.0
    0.0     0.0     0.0     0.0     0.0
    0.0     0.0     0.0     0.0     0.0
    0.0    1.91    1.91     0.0     0.0
    0.0    1.91    1.91    1.91     0.0
    0.0    1.91    1.91     0.0     0.0
    0.0     0.0     0.0     0.0     0.0
      0.0         0.0         0.0         0.0         0.0
      0.0  1.62094E5  7.53060E5         0.0         0.0
      0.0  4.82693E5  6.76361E5  8.50464E5        0.0
      0.0  2.38497E5  8.50464E5         0.0         0.0
      0.0         0.0         0.0         0.0         0.0
    0.0     0.0     0.0     0.0     0.0
    0.0  0.0722  1.3832     0.0     0.0
    0.0  1.4331  1.4450  2.0932     0.0
    0.0  0.7008  2.2127     0.0     0.0
    0.0     0.0     0.0     0.0     0.0
  0.015     0.0     0.0     0.0     0.0     0.0     0.0
   1.E9     0.0     0.0     0.0     0.0     0.0     0.0
  0
    1.0     0.0     0.0     0.0     0.0     0.0     0.0
  1.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
    0
    0     0     0     1
```

부록 2. EBR-II 7-집합체 입력특성

1) EBR-II 7-집합체 계산을 위한 MATRA-LMR 입력자료 (단일 집합체)

```
3000      0      0      1      0
   1      0 (EBR-II : Ass. 1 - 61pin, 0.53MW, 19474lmb/hr)
   1      0      0      0      0      3      1
   2      0      0      0      0      1      0      0
0.316  -0.25    0.0
  64.    -1.    0.0
   3     24
.0000  .0421  .1263  .1919  .2340  .2778  .3199  .3492  .3759  .4196
.4634  .4994  .5287  .5802  .6319  .6535  .6743  .7040  .7563  .7961
.8169  .8899  .9761 1.000
.0000  .0028  .0088  .0164  .0279  .0383  .0558  .0540 3.865  4.237
4.339  4.291  4.087  3.659  .0224  .0185  .0155  .0116  .0078  .0046
.0042  .0068  .0014  .0000
   4    120    120           0      0      0
   1  .0113  .3613  .3613    2  .0420  .1570    6  .0420  .1570    8  .0420  .1570
   2  .0113  .3613  .3613    3  .0420  .1570   11  .0420  .1570
   3  .0113  .3613  .3613    4  .0420  .1570   14  .0420  .1570
   4  .0113  .3613  .3613    5  .0420  .1570   17  .0420  .1570
   5  .0113  .3613  .3613    6  .0420  .1570   20  .0420  .1570
   6  .0113  .3613  .3613   23  .0420  .1570
   7  .0113  .3613  .3613    8  .0420  .1570   24  .0420  .1570   26  .0420  .1570
   8  .0113  .3613  .3613    9  .0420  .1570
   9  .0113  .3613  .3613   10  .0420  .1570   28  .0420  .1570
  10  .0113  .3613  .3613   11  .0420  .1570   31  .0420  .1570
  11  .0113  .3613  .3613   12  .0420  .1570
  12  .0113  .3613  .3613   13  .0420  .1570   33  .0420  .1570
  13  .0113  .3613  .3613   14  .0420  .1570   36  .0420  .1570
  14  .0113  .3613  .3613   15  .0420  .1570
  15  .0113  .3613  .3613   16  .0420  .1570   38  .0420  .1570
  16  .0113  .3613  .3613   17  .0420  .1570   41  .0420  .1570
  17  .0113  .3613  .3613   18  .0420  .1570
  18  .0113  .3613  .3613   19  .0420  .1570   43  .0420  .1570
  19  .0113  .3613  .3613   20  .0420  .1570   46  .0420  .1570
  20  .0113  .3613  .3613   21  .0420  .1570
  21  .0113  .3613  .3613   22  .0420  .1570   48  .0420  .1570
  22  .0113  .3613  .3613   23  .0420  .1570   51  .0420  .1570
  23  .0113  .3613  .3613   24  .0420  .1570
  24  .0113  .3613  .3613   53  .0420  .1570
  25  .0113  .3613  .3613   26  .0420  .1570   54  .0420  .1570   56  .0420  .1570
  26  .0113  .3613  .3613   27  .0420  .1570
  27  .0113  .3613  .3613   28  .0420  .1570   58  .0420  .1570
  28  .0113  .3613  .3613   29  .0420  .1570
  29  .0113  .3613  .3613   30  .0420  .1570   60  .0420  .1570
  30  .0113  .3613  .3613   31  .0420  .1570   63  .0420  .1570
  31  .0113  .3613  .3613   32  .0420  .1570
  32  .0113  .3613  .3613   33  .0420  .1570   65  .0420  .1570
  33  .0113  .3613  .3613   34  .0420  .1570
  34  .0113  .3613  .3613   35  .0420  .1570   67  .0420  .1570
  35  .0113  .3613  .3613   36  .0420  .1570   70  .0420  .1570
  36  .0113  .3613  .3613   37  .0420  .1570
  37  .0113  .3613  .3613   38  .0420  .1570   72  .0420  .1570
  38  .0113  .3613  .3613   39  .0420  .1570
  39  .0113  .3613  .3613   40  .0420  .1570   74  .0420  .1570
  40  .0113  .3613  .3613   41  .0420  .1570   77  .0420  .1570
  41  .0113  .3613  .3613   42  .0420  .1570
  42  .0113  .3613  .3613   43  .0420  .1570   79  .0420  .1570
  43  .0113  .3613  .3613   44  .0420  .1570
  44  .0113  .3613  .3613   45  .0420  .1570   81  .0420  .1570
  45  .0113  .3613  .3613   46  .0420  .1570   84  .0420  .1570
  46  .0113  .3613  .3613   47  .0420  .1570
```

47	.0113	.3613	.3613	48	.0420	.1570	86	.0420	.1570			
48	.0113	.3613	.3613	49	.0420	.1570						
49	.0113	.3613	.3613	50	.0420	.1570	88	.0420	.1570			
50	.0113	.3613	.3613	51	.0420	.1570	91	.0420	.1570			
51	.0113	.3613	.3613	52	.0420	.1570						
52	.0113	.3613	.3613	53	.0420	.1570	93	.0420	.1570			
53	.0113	.3613	.3613	54	.0420	.1570						
54	.0113	.3613	.3613	95	.0420	.1570						
55	.0113	.3613	.3613	56	.0420	.1570	96	.0420	.1570	97	.0420	.1799
56	.0113	.3613	.3613	57	.0420	.1570						
57	.0113	.3613	.3613	58	.0420	.1570	98	.0420	.1799			
58	.0113	.3613	.3613	59	.0420	.1570						
59	.0113	.3613	.3613	60	.0420	.1570	99	.0420	.1799			
60	.0113	.3613	.3613	61	.0420	.1570						
61	.0113	.3613	.3613	62	.0420	.1570	100	.0420	.1799			
62	.0113	.3613	.3613	63	.0420	.1570	101	.0420	.1799			
63	.0113	.3613	.3613	64	.0420	.1570						
64	.0113	.3613	.3613	65	.0420	.1570	102	.0420	.1799			
65	.0113	.3613	.3613	66	.0420	.1570						
66	.0113	.3613	.3613	67	.0420	.1570	103	.0420	.1799			
67	.0113	.3613	.3613	68	.0420	.1570						
68	.0113	.3613	.3613	69	.0420	.1570	104	.0420	.1799			
69	.0113	.3613	.3613	70	.0420	.1570	105	.0420	.1799			
70	.0113	.3613	.3613	71	.0420	.1570						
71	.0113	.3613	.3613	72	.0420	.1570	106	.0420	.1799			
72	.0113	.3613	.3613	73	.0420	.1570						
73	.0113	.3613	.3613	74	.0420	.1570	107	.0420	.1799			
74	.0113	.3613	.3613	75	.0420	.1570						
75	.0113	.3613	.3613	76	.0420	.1570	108	.0420	.1799			
76	.0113	.3613	.3613	77	.0420	.1570	109	.0420	.1799			
77	.0113	.3613	.3613	78	.0420	.1570						
78	.0113	.3613	.3613	79	.0420	.1570	110	.0420	.1799			
79	.0113	.3613	.3613	80	.0420	.1570						
80	.0113	.3613	.3613	81	.0420	.1570	111	.0420	.1799			
81	.0113	.3613	.3613	82	.0420	.1570						
82	.0113	.3613	.3613	83	.0420	.1570	112	.0420	.1799			
83	.0113	.3613	.3613	84	.0420	.1570	113	.0420	.1799			
84	.0113	.3613	.3613	85	.0420	.1570						
85	.0113	.3613	.3613	86	.0420	.1570	114	.0420	.1799			
86	.0113	.3613	.3613	87	.0420	.1570						
87	.0113	.3613	.3613	88	.0420	.1570	115	.0420	.1799			
88	.0113	.3613	.3613	89	.0420	.1570						
89	.0113	.3613	.3613	90	.0420	.1570	116	.0420	.1799			
90	.0113	.3613	.3613	91	.0420	.1570	117	.0420	.1799			
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92	.0113	.3613	.3613	93	.0420	.1570	118	.0420	.1799			
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94	.0113	.3613	.3613	95	.0420	.1570	119	.0420	.1799			
95	.0113	.3613	.3613	96	.0420	.1570						
96	.0113	.3613	.3613	120	.0420	.1799						
97	.0417	.7997	.4215	98	.0878	.2720	120	.0878	.4384			
98	.0344	.6333	.3613	99	.0878	.2720						
99	.0344	.6333	.3613	100	.0878	.2720						
100	.0417	.7997	.4215	101	.0878	.4384						
101	.0417	.7997	.4215	102	.0878	.2720						
102	.0344	.6333	.3613	103	.0878	.2720						
103	.0344	.6333	.3613	104	.0878	.2720						
104	.0417	.7997	.4215	105	.0878	.4384						
105	.0417	.7997	.4215	106	.0878	.2720						
106	.0344	.6333	.3613	107	.0878	.2720						
107	.0344	.6333	.3613	108	.0878	.2720						
108	.0417	.7997	.4215	109	.0878	.4384						
109	.0417	.7997	.4215	110	.0878	.2720						
110	.0344	.6333	.3613	111	.0878	.2720						
111	.0344	.6333	.3613	112	.0878	.2720						
112	.0417	.7997	.4215	113	.0878	.4384						
113	.0417	.7997	.4215	114	.0878	.2720						

114	.0344	.6333	.3613	115	.0878	.2720
115	.0344	.6333	.3613	116	.0878	.2720
116	.0417	.7997	.4215	117	.0878	.4384
117	.0417	.7997	.4215	118	.0878	.2720
118	.0344	.6333	.3613	119	.0878	.2720
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120	.0417	.7997	.4215			
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4	.0667	-.750	.250			
5	.0667	-.084	.584			
6	.0667	-.584	.084			
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8	.0667	-.417	.917			
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40	.0667	-.417	.917			
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45	.0667	-.250	.750			
46	.0667	-.084	.584			
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61	.0667	-.917	.417
62	.0667	-.750	.250
63	.0667	-.584	.084
64	.0667	-.917	.417
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66	.0667	-.584	.084
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145	.0667	-.250	.750
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147	.0667	-.084	.584
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149	.0667	-.250	.750
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151	.0667	-.417	.917
152	.0667	-.250	.750
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157	.0667	-1.00	
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159	.0667	-1.00	
160	.0667	-1.00	
161	.0667	-.917	
162	.0667	-.834	
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169	.0667	-.584	
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178	.0667	-.167	
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1	0	1	0	1	0	2	1	1	1
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8	61	61	0	0	0	0	0	0	0					
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2	.2300	.9971	1	.1667	6	.1667	7	.1667	8	.1667	23	.1667	24	.1667
3	.2300	.9917	1	.1667	2	.1667	8	.1667	9	.1667	10	.1667	11	.1667
4	.2300	.9954	2	.1667	3	.1667	11	.1667	12	.1667	13	.1667	14	.1667
5	.2300	1.006	3	.1667	4	.1667	14	.1667	15	.1667	16	.1667	17	.1667
6	.2300	1.012	4	.1667	5	.1667	17	.1667	18	.1667	19	.1667	20	.1667
7	.2300	1.007	5	.1667	6	.1667	20	.1667	21	.1667	22	.1667	23	.1667
8	.2300	.9922	7	.1667	24	.1667	25	.1667	26	.1667	53	.1667	54	.1667
9	.2300	.9877	7	.1667	8	.1667	9	.1667	26	.1667	27	.1667	28	.1667
10	.2300	.9821	9	.1667	10	.1667	28	.1667	29	.1667	30	.1667	31	.1667
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12	.2300	.9881	12	.1667	13	.1667	33	.1667	34	.1667	35	.1667	36	.1667
13	.2300	.9986	13	.1667	14	.1667	15	.1667	36	.1667	37	.1667	38	.1667
14	.2300	1.009	15	.1667	16	.1667	38	.1667	39	.1667	40	.1667	41	.1667
15	.2300	1.016	16	.1667	17	.1667	18	.1667	41	.1667	42	.1667	43	.1667
16	.2300	1.022	18	.1667	19	.1667	43	.1667	44	.1667	45	.1667	46	.1667
17	.2300	1.017	19	.1667	20	.1667	21	.1667	46	.1667	47	.1667	48	.1667
18	.2300	1.011	21	.1667	22	.1667	48	.1667	49	.1667	50	.1667	51	.1667
19	.2300	1.001	22	.1667	23	.1667	24	.1667	51	.1667	52	.1667	53	.1667
20	.2300	.9868	25	.1667	54	.1667	55	.1667	56	.1667	95	.1667	96	.1667
21	.2300	.9832	25	.1667	26	.1667	27	.1667	56	.1667	57	.1667	58	.1667
22	.2300	.9785	27	.1667	28	.1667	29	.1667	58	.1667	59	.1667	60	.1667
23	.2300	.9728	29	.1667	30	.1667	60	.1667	61	.1667	62	.1667	63	.1667
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25	.2300	.9780	32	.1667	33	.1667	34	.1667	65	.1667	66	.1667	67	.1667
26	.2300	.9799	34	.1667	35	.1667	67	.1667	68	.1667	69	.1667	70	.1667
27	.2300	.9905	35	.1667	36	.1667	37	.1667	70	.1667	71	.1667	72	.1667
28	.2300	1.001	37	.1667	38	.1667	39	.1667	72	.1667	73	.1667	74	.1667
29	.2300	1.013	39	.1667	40	.1667	74	.1667	75	.1667	76	.1667	77	.1667
30	.2300	1.020	40	.1667	41	.1667	42	.1667	77	.1667	78	.1667	79	.1667
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33	.2300	1.027	45	.1667	46	.1667	47	.1667	84	.1667	85	.1667	86	.1667
34	.2300	1.021	47	.1667	48	.1667	49	.1667	86	.1667	87	.1667	88	.1667
35	.2300	1.014	49	.1667	50	.1667	88	.1667	89	.1667	90	.1667	91	.1667
36	.2300	1.005	50	.1667	51	.1667	52	.1667	91	.1667	92	.1667	93	.1667
37	.2300	.9956	52	.1667	53	.1667	54	.1667	93	.1667	94	.1667	95	.1667
38	.2300	.9810	55	.1667	96	.1667	97	.3333	120	.3333				
39	.2300	.9782	55	.1667	56	.1667	57	.1667	97	.2500	98	.2500		
40	.2300	.9744	57	.1667	58	.1667	59	.1667	98	.2500	99	.2500		
41	.2300	.9696	59	.1667	60	.1667	61	.1667	99	.2500	100	.2500		
42	.2300	.9638	61	.1667	62	.1667	100	.3333	101	.3333				
43	.2300	.9661	62	.1667	63	.1667	64	.1667	101	.2500	102	.2500		
44	.2300	.9681	64	.1667	65	.1667	66	.1667	102	.2500	103	.2500		
45	.2300	.9696	66	.1667	67	.1667	68	.1667	103	.2500	104	.2500		
46	.2300	.9706	68	.1667	69	.1667	104	.3333	105	.3333				
47	.2300	.9814	69	.1667	70	.1667	71	.1667	105	.2500	106	.2500		
48	.2300	.9925	71	.1667	72	.1667	73	.1667	106	.2500	107	.2500		
49	.2300	1.004	73	.1667	74	.1667	75	.1667	107	.2500	108	.2500		
50	.2300	1.015	75	.1667	76	.1667	108	.3333	109	.3333				
51	.2300	1.024	76	.1667	77	.1667	78	.1667	109	.2500	110	.2500		
52	.2300	1.032	78	.1667	79	.1667	80	.1667	110	.2500	111	.2500		
53	.2300	1.038	80	.1667	81	.1667	82	.1667	111	.2500	112	.2500		
54	.2300	1.044	82	.1667	83	.1667	112	.3333	113	.3333				
55	.2300	1.038	83	.1667	84	.1667	85	.1667	113	.2500	114	.2500		
56	.2300	1.031	85	.1667	86	.1667	87	.1667	114	.2500	115	.2500		
57	.2300	1.024	87	.1667	88	.1667	89	.1667	115	.2500	116	.2500		
58	.2300	1.016	89	.1667	90	.1667	116	.3333	117	.3333				
59	.2300	1.007	90	.1667	91	.1667	92	.1667	117	.2500	118	.2500		
60	.2300	.9981	92	.1667	93	.1667	94	.1667	118	.2500	119	.2500		
61	.2300	.9894	94	.1667	95	.1667	96	.1667	119	.2500	120	.2500		
9	0	0	0	0	0	0								
55.2	0.		1.E-5	.0001								0.5		
138		200	200											
10	0	0	1	0	0	0								
0.01														

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0.5
11      1       1       0       0       0       0       0       0       0       0
14.7    699.8   1.465   0.1070
12      1       0       0       0       0       0       0       0
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2) EBR-II 7-집합체 계산을 위한 MATRA-LMR 입력자료 (다 집합체)

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   2      0      0      0      0      1      0      0
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  64.     -1.    0.0
   3     24      7
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.4634  .4994  .5287  .5802  .6319  .6535  .6743  .7040  .7563  .7961
.8169  .8899  .9761 1.000
.0000  .0028  .0088  .0164  .0279  .0383  .0558  .0540 3.865 4.237
4.339 4.291 4.087 3.659  .0224  .0185  .0155  .0116  .0078  .0046
.0042  .0068  .0014  .0000
.0000  .0706  .2211  .3789  .5300  .7175 1.057 1.026 2.640 3.283
3.401 3.357 3.185 2.782  .5091  .4380  .3763  .2962  .2056  .1241
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  1     12
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  1     12
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  1      9
  1     10
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    1      12
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81	.0667	-.417	.917
82	.0667	-.250	.750
83	.0667	-.584	.084
84	.0667	-.084	.584
85	.0667	-.417	.917
86	.0667	-.250	.750
87	.0667	-.084	.584
88	.0667	-.417	.917
89	.0667	-.250	.750
90	.0667	-.417	.917
91	.0667	-.917	.417
92	.0667	-.584	.084
93	.0667	-.250	.750
94	.0667	-.084	.584
95	.0667	-.917	.417
96	.0667	-.250	.750
97	.0667	-.084	.584
98	.0667	-.917	.417
99	.0667	-.250	.750
100	.0667	-.084	.584
101	.0667	-.917	.417
102	.0667	-.250	.750
103	.0667	-.750	.250
104	.0667	-.084	.584
105	.0667	-.917	.417
106	.0667	-.750	.250
107	.0667	-.084	.584
108	.0667	-.917	.417
109	.0667	-.750	.250

110	.0667	-.084	.584
111	.0667	-.917	.417
112	.0667	-.750	.250
113	.0667	-.084	.584
114	.0667	-.584	.084
115	.0667	-.917	.417
116	.0667	-.750	.250
117	.0667	-.584	.084
118	.0667	-.917	.417
119	.0667	-.750	.250
120	.0667	-.584	.084
121	.0667	-.917	.417
122	.0667	-.750	.250
123	.0667	-.584	.084
124	.0667	-.917	.417
125	.0667	-.417	.917
126	.0667	-.750	.250
127	.0667	-.584	.084
128	.0667	-.417	.917
129	.0667	-.750	.250
130	.0667	-.584	.084
131	.0667	-.417	.917
132	.0667	-.750	.250
133	.0667	-.584	.084
134	.0667	-.417	.917
135	.0667	-.750	.250
136	.0667	-.250	.750
137	.0667	-.584	.084
138	.0667	-.417	.917
139	.0667	-.250	.750
140	.0667	-.584	.084
141	.0667	-.417	.917
142	.0667	-.250	.750
143	.0667	-.584	.084
144	.0667	-.417	.917
145	.0667	-.250	.750
146	.0667	-.584	.084
147	.0667	-.084	.584
148	.0667	-.417	.917
149	.0667	-.250	.750
150	.0667	-.084	.584
151	.0667	-.417	.917
152	.0667	-.250	.750
153	.0667	-.084	.584
154	.0667	-.417	.917
155	.0667	-.250	.750
156	.0667	-.417	.917
157	.0667	-1.00	
158	.0667	.084	
159	.0667	-1.00	
160	.0667	-1.00	
161	.0667	-.917	
162	.0667	-.834	
163	.0667	-.834	
164	.0667	-.834	
165	.0667	-.750	
166	.0667	-.667	
167	.0667	-.667	
168	.0667	-.667	
169	.0667	-.584	
170	.0667	-.500	
171	.0667	-.500	
172	.0667	-.500	
173	.0667	-.417	
174	.0667	-.334	
175	.0667	-.334	
176	.0667	-.334	

177	.0667	-.250												
178	.0667	-.167												
179	.0667	-.167												
180	.0667	-.167												
1	0	1	0	1	0	1	0	1	0					
1	0	1	0	1	0	1	0	1	0					
1	0	1	0	1	0	1	0	1	0					
1	0	1	0	1	0	1	0	1	0					
1	0	1	0	1	0	1	0	1	0					
1	0	1	0	1	0	1	0	1	0					
1	0	1	0	1	0	1	0	1	0					
1	0	1	0	1	0	1	0	1	0					
1	0	1	0	1	0	1	0	1	0					
1	0	1	0	1	0	2	1	1	1					
1	1	1	1	0	0	0	0	0	0					
0	0	0	0	0	0	1	1	1	1					
8	7	0	0	0	0	0	0							
1	61	0												
1	.2300	1.002	1	.1667	2	.1667	3	.1667	4	.1667	5	.1667	6	.1667
2	.2300	.9971	1	.1667	6	.1667	7	.1667	8	.1667	23	.1667	24	.1667
3	.2300	.9917	1	.1667	2	.1667	8	.1667	9	.1667	10	.1667	11	.1667
4	.2300	.9954	2	.1667	3	.1667	11	.1667	12	.1667	13	.1667	14	.1667
5	.2300	1.006	3	.1667	4	.1667	14	.1667	15	.1667	16	.1667	17	.1667
6	.2300	1.012	4	.1667	5	.1667	17	.1667	18	.1667	19	.1667	20	.1667
7	.2300	1.007	5	.1667	6	.1667	20	.1667	21	.1667	22	.1667	23	.1667
8	.2300	.9922	7	.1667	24	.1667	25	.1667	26	.1667	53	.1667	54	.1667
9	.2300	.9877	7	.1667	8	.1667	9	.1667	26	.1667	27	.1667	28	.1667
10	.2300	.9821	9	.1667	10	.1667	28	.1667	29	.1667	30	.1667	31	.1667
11	.2300	.9853	10	.1667	11	.1667	12	.1667	31	.1667	32	.1667	33	.1667
12	.2300	.9881	12	.1667	13	.1667	33	.1667	34	.1667	35	.1667	36	.1667
13	.2300	.9986	13	.1667	14	.1667	15	.1667	36	.1667	37	.1667	38	.1667
14	.2300	1.009	15	.1667	16	.1667	38	.1667	39	.1667	40	.1667	41	.1667
15	.2300	1.016	16	.1667	17	.1667	18	.1667	41	.1667	42	.1667	43	.1667
16	.2300	1.022	18	.1667	19	.1667	43	.1667	44	.1667	45	.1667	46	.1667
17	.2300	1.017	19	.1667	20	.1667	21	.1667	46	.1667	47	.1667	48	.1667
18	.2300	1.011	21	.1667	22	.1667	48	.1667	49	.1667	50	.1667	51	.1667
19	.2300	1.001	22	.1667	23	.1667	24	.1667	51	.1667	52	.1667	53	.1667
20	.2300	.9868	25	.1667	54	.1667	55	.1667	56	.1667	95	.1667	96	.1667
21	.2300	.9832	25	.1667	26	.1667	27	.1667	56	.1667	57	.1667	58	.1667
22	.2300	.9785	27	.1667	28	.1667	29	.1667	58	.1667	59	.1667	60	.1667
23	.2300	.9728	29	.1667	30	.1667	60	.1667	61	.1667	62	.1667	63	.1667
24	.2300	.9756	30	.1667	31	.1667	32	.1667	63	.1667	64	.1667	65	.1667
25	.2300	.9780	32	.1667	33	.1667	34	.1667	65	.1667	66	.1667	67	.1667
26	.2300	.9799	34	.1667	35	.1667	67	.1667	68	.1667	69	.1667	70	.1667
27	.2300	.9905	35	.1667	36	.1667	37	.1667	70	.1667	71	.1667	72	.1667
28	.2300	1.001	37	.1667	38	.1667	39	.1667	72	.1667	73	.1667	74	.1667
29	.2300	1.013	39	.1667	40	.1667	74	.1667	75	.1667	76	.1667	77	.1667
30	.2300	1.020	40	.1667	41	.1667	42	.1667	77	.1667	78	.1667	79	.1667
31	.2300	1.027	42	.1667	43	.1667	44	.1667	79	.1667	80	.1667	81	.1667
32	.2300	1.033	44	.1667	45	.1667	81	.1667	82	.1667	83	.1667	84	.1667
33	.2300	1.027	45	.1667	46	.1667	47	.1667	84	.1667	85	.1667	86	.1667
34	.2300	1.021	47	.1667	48	.1667	49	.1667	86	.1667	87	.1667	88	.1667
35	.2300	1.014	49	.1667	50	.1667	88	.1667	89	.1667	90	.1667	91	.1667
36	.2300	1.005	50	.1667	51	.1667	52	.1667	91	.1667	92	.1667	93	.1667
37	.2300	.9956	52	.1667	53	.1667	54	.1667	93	.1667	94	.1667	95	.1667
38	.2300	.9810	55	.1667	96	.1667	97	.3333	120	.3333				
39	.2300	.9782	55	.1667	56	.1667	57	.1667	97	.2500	98	.2500		
40	.2300	.9744	57	.1667	58	.1667	59	.1667	98	.2500	99	.2500		
41	.2300	.9696	59	.1667	60	.1667	61	.1667	99	.2500	100	.2500		
42	.2300	.9638	61	.1667	62	.1667	100	.3333	101	.3333				
43	.2300	.9661	62	.1667	63	.1667	64	.1667	101	.2500	102	.2500		
44	.2300	.9681	64	.1667	65	.1667	66	.1667	102	.2500	103	.2500		
45	.2300	.9696	66	.1667	67	.1667	68	.1667	103	.2500	104	.2500		
46	.2300	.9706	68	.1667	69	.1667	104	.3333	105	.3333				
47	.2300	.9814	69	.1667	70	.1667	71	.1667	105	.2500	106	.2500		
48	.2300	.9925	71	.1667	72	.1667	73	.1667	106	.2500	107	.2500		
49	.2300	1.004	73	.1667	74	.1667	75	.1667	107	.2500	108	.2500		

50	.2300	1.015	75	.1667	76	.1667	108	.3333	109	.3333				
51	.2300	1.024	76	.1667	77	.1667	78	.1667	109	.2500	110	.2500		
52	.2300	1.032	78	.1667	79	.1667	80	.1667	110	.2500	111	.2500		
53	.2300	1.038	80	.1667	81	.1667	82	.1667	111	.2500	112	.2500		
54	.2300	1.044	82	.1667	83	.1667	112	.3333	113	.3333				
55	.2300	1.038	83	.1667	84	.1667	85	.1667	113	.2500	114	.2500		
56	.2300	1.031	85	.1667	86	.1667	87	.1667	114	.2500	115	.2500		
57	.2300	1.024	87	.1667	88	.1667	89	.1667	115	.2500	116	.2500		
58	.2300	1.016	89	.1667	90	.1667	116	.3333	117	.3333				
59	.2300	1.007	90	.1667	91	.1667	92	.1667	117	.2500	118	.2500		
60	.2300	.9981	92	.1667	93	.1667	94	.1667	118	.2500	119	.2500		
61	.2300	.9894	94	.1667	95	.1667	96	.1667	119	.2500	120	.2500		
2	7	0												
1	.7810	1.000	1	.1667	2	.1667	3	.1667	4	.1667	5	.1667	6	.1667
2	.7810	1.000	1	.1667	6	.1667	7	.3333	12	.3333				
3	.7810	1.000	1	.1667	2	.1667	7	.3333	8	.3333				
4	.7810	1.000	2	.1667	3	.1667	8	.3333	9	.3333				
5	.7810	1.000	3	.1667	4	.1667	9	.3333	10	.3333				
6	.7810	1.000	4	.1667	5	.1667	10	.3333	11	.3333				
7	.7810	1.000	5	.1667	6	.1667	11	.3333	12	.3333				
3	7	0												
1	.7810	1.000	1	.1667	2	.1667	3	.1667	4	.1667	5	.1667	6	.1667
2	.7810	1.000	1	.1667	6	.1667	7	.3333	12	.3333				
3	.7810	1.000	1	.1667	2	.1667	7	.3333	8	.3333				
4	.7810	1.000	2	.1667	3	.1667	8	.3333	9	.3333				
5	.7810	1.000	3	.1667	4	.1667	9	.3333	10	.3333				
6	.7810	1.000	4	.1667	5	.1667	10	.3333	11	.3333				
7	.7810	1.000	5	.1667	6	.1667	11	.3333	12	.3333				
4	7	0												
1	.7810	1.000	1	.1667	2	.1667	3	.1667	4	.1667	5	.1667	6	.1667
2	.7810	1.000	1	.1667	6	.1667	7	.3333	12	.3333				
3	.7810	1.000	1	.1667	2	.1667	7	.3333	8	.3333				
4	.7810	1.000	2	.1667	3	.1667	8	.3333	9	.3333				
5	.7810	1.000	3	.1667	4	.1667	9	.3333	10	.3333				
6	.7810	1.000	4	.1667	5	.1667	10	.3333	11	.3333				
7	.7810	1.000	5	.1667	6	.1667	11	.3333	12	.3333				
5	7	0												
1	.7810	1.000	1	.1667	2	.1667	3	.1667	4	.1667	5	.1667	6	.1667
2	.7810	1.000	1	.1667	6	.1667	7	.3333	12	.3333				
3	.7810	1.000	1	.1667	2	.1667	7	.3333	8	.3333				
4	.7810	1.000	2	.1667	3	.1667	8	.3333	9	.3333				
5	.7810	1.000	3	.1667	4	.1667	9	.3333	10	.3333				
6	.7810	1.000	4	.1667	5	.1667	10	.3333	11	.3333				
7	.7810	1.000	5	.1667	6	.1667	11	.3333	12	.3333				
6	7	0												
1	.7810	1.000	1	.1667	2	.1667	3	.1667	4	.1667	5	.1667	6	.1667
2	.7810	1.000	1	.1667	6	.1667	7	.3333	12	.3333				
3	.7810	1.000	1	.1667	2	.1667	7	.3333	8	.3333				
4	.7810	1.000	2	.1667	3	.1667	8	.3333	9	.3333				
5	.7810	1.000	3	.1667	4	.1667	9	.3333	10	.3333				
6	.7810	1.000	4	.1667	5	.1667	10	.3333	11	.3333				
7	.7810	1.000	5	.1667	6	.1667	11	.3333	12	.3333				
7	7	0												
1	.7810	1.000	1	.1667	2	.1667	3	.1667	4	.1667	5	.1667	6	.1667
2	.7810	1.000	1	.1667	6	.1667	7	.3333	12	.3333				
3	.7810	1.000	1	.1667	2	.1667	7	.3333	8	.3333				
4	.7810	1.000	2	.1667	3	.1667	8	.3333	9	.3333				
5	.7810	1.000	3	.1667	4	.1667	9	.3333	10	.3333				
6	.7810	1.000	4	.1667	5	.1667	10	.3333	11	.3333				
7	.7810	1.000	5	.1667	6	.1667	11	.3333	12	.3333				
9	0	0	0	0	0	0								
55.2	0.		1.E-5	.0001								0.5		
138		200	200											
10	0	0	1	0	0	0								
0.01														
0.5														
11	1	1	0	0	0	0	0	0	0	0				

14.7	699.8							
1.8082	0.056524	1.8921	2.1496	1.4062	1.2554	2.0490		
0.1070	0.0085851	0.28738	0.32648	0.21358	0.19068	0.31122		
12	1	0	0	0	0	0	0	0

3) EBR-II 7-집합체 계산을 위한 THI3D 입력자료 (단일 집합체)

```
 EBR-II 7-ASSEMBLY PROBLEM (SINGLE CASE)   SEPTEMBER 30, 1999
 126     1   138     1   138     0     0     3     1    61     6     4
   0     2     1     0     0     2     1    20     1     0     2     1
   0     0     1     1   139     0     0     0     0     1     1     1
   0     0     0     0     0     0     0
  0.272      0.0  0.04576      6.0    0.042 0.20276 1.0464E5      1.23
   0.02   85.813    0.97     1.03      1.0     0.0     0.0      0.5
   0.02      0.0     0.0      0.0      0.0    0.01    0.01     0.01
   0.02     0.02    0.02      0.0      0.0     0.0     0.0      0.0
    0.0      0.0     0.0      0.0      0.0     0.0     0.0
3 3 3 3 5 3 3 3 3 5 3 3 3 3 5 3 3 3 3 5 3 3 3 3 5 3 3 3 3 5 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
   0     0     0     0     0     0     0     1     0     0     0     0
   0     0     0
     0.4    0.215    0.215    0.230 1.4705E6      0.0   1159.5      1.0
     0.0      0.0      0.0      1.0   1000.0      1.0      0.0
  0.0000   .00276   .00875   .01637   .02787   .03833   .05583   .05404
  3.8655   4.2371   4.3388   4.2907   4.0874   3.6585   .02244   .01845
  .01548   .01160   .00775   .00456   .00420   .00675   .00144   0.0000
 -0.001
   0.000    2.324    6.973    10.59    12.92    15.33    17.66    19.27
   20.75    23.16    25.58    27.57    29.18    32.03    34.88    36.07
   37.22    38.86    41.75    43.94    45.09    49.12    53.88    55.20
   .9810    .9894    .9981    1.007    1.016    1.024    1.031    1.038
   1.044    1.038    1.032    1.024    1.015    1.004    .9925    .9814
   .9706    .9696    .9681    .9661    .9638    .9696    .9744    .9782
   .9868    .9956    1.005    1.014    1.021    1.027    1.033    1.027
   1.020    1.013    1.001    .9905    .9799    .9780    .9756    .9728
   .9785    .9832    .9922    1.001    1.011    1.017    1.022    1.016
   1.009    .9986    .9881    .9853    .9821    .9877    .9971    1.007
   1.012    1.006    .9954    .9917    1.002
     0.5      0.5      0.5      0.5      0.5      0.5      0.5      0.5
 1 2 3 4 5 6 1 2 3 4 5 6 1 2 3 4 5 6 1 2 3 4 5 6
 1 2 3 4 5 6 1 2 3 4 5 6 1 2 3 4 5 6 1 2 3 4 5 6
 1 2 3 4 5 6 1 2 3 4 5 6 1 2 3 4 5 6 1 2 3 4 5 6
 1 2 3 4 5 6 1 2 3 4 5 6 1 2 3 4 5 6 1 2 3 4 5 6
 1 2 3 4 5 6 1 2 3 4 5 6 1 2 3 4 5 6 1 2 3 4 5 6
 1 2 3 4 5 6 1 2 3 4 5 6 1 2 3 4 5 6 1
  0  60 120 180 240 300
  1   0  90 150 240 300   0  60 180
  2   0  60 150 240 300   0  90 210
  3   0  60 150 210 300   0 120 240
  4   0  60 120 210 300   0 150 270
  5   0  60 120 210 270   0 180 300
  6   0  60 120 180 270   0 210 330
  7  60 120 180 270 330   0 240   0
  8  60 120 180 240 330   0 270  30
  9  30 120 180 240 330   0 300  60
 10  30 120 180 240 300   0 330  90
 11  30  90 180 240 300   0   0 120
 12   0  90 180 240 300   0  30 150
 13   0  60 120 180 240 300         1
  1   1  29  30   1  31  72   0
  2   2  31   1   2  33  32   0
  3   2  33   2   3  35  34   0
  4   2  35   3   4  37  36   0
  5   3  37   4   5   6  38   0
  6   4  39  38   6   7  40   0
  7   4  41  40   7   8  42   0
  8   4  43  42   8   9  44   0
  9   5  45  44   9  10  11   0
 10   6  47  46  45  11  12   0
```

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11   6  49  48  47  12  13   0
12   6  51  50  49  13  14   0
13   7  52  51  14  15  16   0
14   8  54  53  52  16  17   0
15   8  56  55  54  17  18   0
16   8  58  57  56  18  19   0
17   9  21  59  58  19  20   0
18  10  22  61  60  59  21   0
19  10  23  63  62  61  22   0
20  10  24  65  64  63  23   0
21  11  25  26  66  65  24   0
22  12  26  27  68  67  66   0
23  12  27  28  70  69  68   0
24  12  28  29  72  71  70   0
25  13  71  72  31  32  73 102
26  13  73  32  33  34  75  74
27  13  75  34  35  36  77  76
28  13  77  36  37  38  39  78
29  13  79  78  39  40  41  80
30  13  81  80  41  42  43  82
31  13  83  82  43  44  45  46
32  13  85  84  83  46  47  48
33  13  87  86  85  48  49  50
34  13  53  88  87  50  51  52
35  13  55  90  89  88  53  54
36  13  57  92  91  90  55  56
37  13  59  60  93  92  57  58
38  13  61  62  95  94  93  60
39  13  63  64  97  96  95  62
40  13  65  66  67  98  97  64
41  13  67  68  69 100  99  98
42  13  69  70  71 102 101 100
43  13 101 102  73  74 103 120
44  13 103  74  75  76 105 104
45  13 105  76  77  78  79 106
46  13 107 106  79  80  81 108
47  13 109 108  81  82  83  84
48  13 111 110 109  84  85  86
49  13  89 112 111  86  87  88
50  13  91 114 113 112  89  90
51  13  93  94 115 114  91  92
52  13  95  96 117 116 115  94
53  13  97  98  99 118 117  96
54  13  99 100 101 120 119 118
55  13 119 120 103 104 121 126
56  13 121 104 105 106 107 122
57  13 123 122 107 108 109 110
58  13 113 124 123 110 111 112
59  13 115 116 125 124 113 114
60  13 117 118 119 126 125 116
61  13 125 126 121 122 123 124
   1.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 1.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
   6   38   39   78   79  106  107  122  125  116  115   94
  93   60   59   21
   0    0    0    1    0
```

4) EBR-II 7-집합체 계산을 위한 THI3D 입력자료 (다 집합체)

```
EBR-II 7-ASSEMBLY PROBLEM (MULTI CASE)   SEPTEMBER 30, 1999
   5     5   138     1   138     0     0     2     1     7     1     0
   0     2     1     0     0     2     1    20     1     0     2     1
  -1     0     0     0     0     0     0     0     0     1     1     1
   0     0     0     0     0     0     0
   2.29      0.3    0.477      0.0       0.0    1.472 6.3289E5     1.23
   0.02   85.813     0.97     1.03       1.0      0.0      0.0      0.5
   0.02      0.0      0.0      0.0       0.0     2.01     0.01     0.01
   0.02     0.02     0.02      0.0       0.0      0.0      0.0      0.0
    0.0      0.0      0.0      0.0       0.0      0.0      0.0
0 0 0 0 0
0 1 1 0 0
0 1 1 1 0
0 1 1 0 0
0 0 0 0 0
   0     1     1     1     1     0     0     1     0     0     0     0
   0     0     0
    0.4     1.99     1.99     1.99-2.3263E6     0.0   1159.5      1.0
    0.0      0.0      0.0      1.0   1000.0     1.0      0.0
    0.0      0.0      0.0      0.0      0.0
    0.0     1.99     1.99      0.0      0.0
    0.0     1.99     1.99     1.99      0.0
    0.0     1.99     1.99      0.0      0.0
    0.0      0.0      0.0      0.0      0.0
    0.0      0.0      0.0      0.0      0.0
    0.0     1.99     1.99      0.0      0.0
    0.0     1.99     1.99     1.99      0.0
    0.0     1.99     1.99      0.0      0.0
    0.0      0.0      0.0      0.0      0.0
    0.0      0.0      0.0      0.0      0.0
    0.0     1.99     1.99      0.0      0.0
    0.0     1.99     1.99     1.99      0.0
    0.0     1.99     1.99      0.0      0.0
    0.0      0.0      0.0      0.0      0.0
       0.0         0.0         0.0         0.0         0.0
       0.0  1.37660E5   2.87393E6          0.0         0.0
       0.0  3.10685E6   1.95935E6   3.10554E6          0.0
       0.0  2.45648E6   2.64574E6          0.0         0.0
       0.0         0.0         0.0         0.0         0.0
    0.0      0.0      0.0      0.0      0.0
    0.0 0.037267  1.24750      0.0      0.0
    0.0  1.35094  1.19218  1.41727      0.0
    0.0  0.82771  0.92713      0.0      0.0
    0.0      0.0      0.0      0.0      0.0
  0.005      0.0      0.0      0.0      0.0      0.0      0.0
   1.E9      0.0      0.0      0.0      0.0      0.0      0.0
 0
    1.0      0.0      0.0      0.0      0.0      0.0      0.0
 1.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0
  0
  0     0     0     1     0
```

부록 3. TED 7-집합체 입력특성

1) TED 7-집합체 계산을 위한 MATRA-LMR 입력자료 (단일 집합체)

```
3000      0      0      1      0
   1      0 (TED (x494) : 61 pin, 0.62 MW, 39245 lbm/hr -> Single)
   1      0      0      0      0      3      2
   2      0      0      0      0      1      0      0
0.316  -0.25    0.0
  64.    -1.    0.0
   3     27
.0000  .0465  .1395  .2177  .2554  .2992  .3492  .3746  .3990  .4235
.4479  .4724  .4968  .5213  .5457  .5702  .5947  .6455  .6705  .6947
.7210  .7563  .8068  .8339  .8962  .9761 1.000
.0000  .0000  .0000  .0000  .0000  .0000  .0000  .9537 1.021 1.076
1.114 1.119  1.094 1.040  .9600  .8655  .7577  .0000  .0000  .0000
.0000  .0000  .0000  .0000  .0000  .0000  .0000
   4    120    120      0      0      0      0
   1  .0115  .3613  .3613      2  .0430  .1576      6  .0430  .1576      8  .0430  .1576
   2  .0115  .3613  .3613      3  .0430  .1576     11  .0430  .1576
   3  .0115  .3613  .3613      4  .0430  .1576     14  .0430  .1576
   4  .0115  .3613  .3613      5  .0430  .1576     17  .0430  .1576
   5  .0115  .3613  .3613      6  .0430  .1576     20  .0430  .1576
   6  .0115  .3613  .3613     23  .0430  .1576
   7  .0115  .3613  .3613      8  .0430  .1576     24  .0430  .1576     26  .0430  .1576
   8  .0115  .3613  .3613      9  .0430  .1576
   9  .0115  .3613  .3613     10  .0430  .1576     28  .0430  .1576
  10  .0115  .3613  .3613     11  .0430  .1576     31  .0430  .1576
  11  .0115  .3613  .3613     12  .0430  .1576
  12  .0115  .3613  .3613     13  .0430  .1576     33  .0430  .1576
  13  .0115  .3613  .3613     14  .0430  .1576     36  .0430  .1576
  14  .0115  .3613  .3613     15  .0430  .1576
  15  .0115  .3613  .3613     16  .0430  .1576     38  .0430  .1576
  16  .0115  .3613  .3613     17  .0430  .1576     41  .0430  .1576
  17  .0115  .3613  .3613     18  .0430  .1576
  18  .0115  .3613  .3613     19  .0430  .1576     43  .0430  .1576
  19  .0115  .3613  .3613     20  .0430  .1576     46  .0430  .1576
  20  .0115  .3613  .3613     21  .0430  .1576
  21  .0115  .3613  .3613     22  .0430  .1576     48  .0430  .1576
  22  .0115  .3613  .3613     23  .0430  .1576     51  .0430  .1576
  23  .0115  .3613  .3613     24  .0430  .1576
  24  .0115  .3613  .3613     53  .0430  .1576
  25  .0115  .3613  .3613     26  .0430  .1576     54  .0430  .1576     56  .0430  .1576
  26  .0115  .3613  .3613     27  .0430  .1576
  27  .0115  .3613  .3613     28  .0430  .1576     58  .0430  .1576
  28  .0115  .3613  .3613     29  .0430  .1576
  29  .0115  .3613  .3613     30  .0430  .1576     60  .0430  .1576
  30  .0115  .3613  .3613     31  .0430  .1576     63  .0430  .1576
  31  .0115  .3613  .3613     32  .0430  .1576
  32  .0115  .3613  .3613     33  .0430  .1576     65  .0430  .1576
  33  .0115  .3613  .3613     34  .0430  .1576
  34  .0115  .3613  .3613     35  .0430  .1576     67  .0430  .1576
  35  .0115  .3613  .3613     36  .0430  .1576     70  .0430  .1576
  36  .0115  .3613  .3613     37  .0430  .1576
  37  .0115  .3613  .3613     38  .0430  .1576     72  .0430  .1576
  38  .0115  .3613  .3613     39  .0430  .1576
  39  .0115  .3613  .3613     40  .0430  .1576     74  .0430  .1576
  40  .0115  .3613  .3613     41  .0430  .1576     77  .0430  .1576
  41  .0115  .3613  .3613     42  .0430  .1576
  42  .0115  .3613  .3613     43  .0430  .1576     79  .0430  .1576
  43  .0115  .3613  .3613     44  .0430  .1576
  44  .0115  .3613  .3613     45  .0430  .1576     81  .0430  .1576
  45  .0115  .3613  .3613     46  .0430  .1576     84  .0430  .1576
  46  .0115  .3613  .3613     47  .0430  .1576
```

47	.0115	.3613	.3613	48	.0430	.1576	86	.0430	.1576			
48	.0115	.3613	.3613	49	.0430	.1576						
49	.0115	.3613	.3613	50	.0430	.1576	88	.0430	.1576			
50	.0115	.3613	.3613	51	.0430	.1576	91	.0430	.1576			
51	.0115	.3613	.3613	52	.0430	.1576						
52	.0115	.3613	.3613	53	.0430	.1576	93	.0430	.1576			
53	.0115	.3613	.3613	54	.0430	.1576						
54	.0115	.3613	.3613	95	.0430	.1576						
55	.0115	.3613	.3613	56	.0430	.1576	96	.0430	.1576	97	.0430	.1577
56	.0115	.3613	.3613	57	.0430	.1576						
57	.0115	.3613	.3613	58	.0430	.1576	98	.0430	.1577			
58	.0115	.3613	.3613	59	.0430	.1576						
59	.0115	.3613	.3613	60	.0430	.1576	99	.0430	.1577			
60	.0115	.3613	.3613	61	.0430	.1576						
61	.0115	.3613	.3613	62	.0430	.1576	100	.0430	.1577			
62	.0115	.3613	.3613	63	.0430	.1576	101	.0430	.1577			
63	.0115	.3613	.3613	64	.0430	.1576						
64	.0115	.3613	.3613	65	.0430	.1576	102	.0430	.1577			
65	.0115	.3613	.3613	66	.0430	.1576						
66	.0115	.3613	.3613	67	.0430	.1576	103	.0430	.1577			
67	.0115	.3613	.3613	68	.0430	.1576						
68	.0115	.3613	.3613	69	.0430	.1576	104	.0430	.1577			
69	.0115	.3613	.3613	70	.0430	.1576	105	.0430	.1577			
70	.0115	.3613	.3613	71	.0430	.1576						
71	.0115	.3613	.3613	72	.0430	.1576	106	.0430	.1577			
72	.0115	.3613	.3613	73	.0430	.1576						
73	.0115	.3613	.3613	74	.0430	.1576	107	.0430	.1577			
74	.0115	.3613	.3613	75	.0430	.1576						
75	.0115	.3613	.3613	76	.0430	.1576	108	.0430	.1577			
76	.0115	.3613	.3613	77	.0430	.1576	109	.0430	.1577			
77	.0115	.3613	.3613	78	.0430	.1576						
78	.0115	.3613	.3613	79	.0430	.1576	110	.0430	.1577			
79	.0115	.3613	.3613	80	.0430	.1576						
80	.0115	.3613	.3613	81	.0430	.1576	111	.0430	.1577			
81	.0115	.3613	.3613	82	.0430	.1576						
82	.0115	.3613	.3613	83	.0430	.1576	112	.0430	.1577			
83	.0115	.3613	.3613	84	.0430	.1576	113	.0430	.1577			
84	.0115	.3613	.3613	85	.0430	.1576						
85	.0115	.3613	.3613	86	.0430	.1576	114	.0430	.1577			
86	.0115	.3613	.3613	87	.0430	.1576						
87	.0115	.3613	.3613	88	.0430	.1576	115	.0430	.1577			
88	.0115	.3613	.3613	89	.0430	.1576						
89	.0115	.3613	.3613	90	.0430	.1576	116	.0430	.1577			
90	.0115	.3613	.3613	91	.0430	.1576	117	.0430	.1577			
91	.0115	.3613	.3613	92	.0430	.1576						
92	.0115	.3613	.3613	93	.0430	.1576	118	.0430	.1577			
93	.0115	.3613	.3613	94	.0430	.1576						
94	.0115	.3613	.3613	95	.0430	.1576	119	.0430	.1577			
95	.0115	.3613	.3613	96	.0430	.1576						
96	.0115	.3613	.3613	120	.0430	.1577						
97	.0254	.7771	.4215	98	.0428	.2730	120	.0428	.4158			
98	.0223	.6343	.3613	99	.0428	.2730						
99	.0223	.6343	.3613	100	.0428	.2730						
100	.0254	.7771	.4215	101	.0428	.4158						
101	.0254	.7771	.4215	102	.0428	.2730						
102	.0223	.6343	.3613	103	.0428	.2730						
103	.0223	.6343	.3613	104	.0428	.2730						
104	.0254	.7771	.4215	105	.0428	.4158						
105	.0254	.7771	.4215	106	.0428	.2730						
106	.0223	.6343	.3613	107	.0428	.2730						
107	.0223	.6343	.3613	108	.0428	.2730						
108	.0254	.7771	.4215	109	.0428	.4158						
109	.0254	.7771	.4215	110	.0428	.2730						
110	.0223	.6343	.3613	111	.0428	.2730						
111	.0223	.6343	.3613	112	.0428	.2730						
112	.0254	.7771	.4215	113	.0428	.4158						
113	.0254	.7771	.4215	114	.0428	.2730						

114	.0223	.6343	.3613	115	.0428	.2730
115	.0223	.6343	.3613	116	.0428	.2730
116	.0254	.7771	.4215	117	.0428	.4158
117	.0254	.7771	.4215	118	.0428	.2730
118	.0223	.6343	.3613	119	.0428	.2730
119	.0223	.6343	.3613	120	.0428	.2730
120	.0254	.7771	.4215			
7	1	180	0	0	0	0
6.0	.23	.042	.273			
1	.0667	-.917	.417			
2	.0667	-.584	.084			
3	.0667	-.250	.750			
4	.0667	-.750	.250			
5	.0667	-.084	.584			
6	.0667	-.584	.084			
7	.0667	-.917	.417			
8	.0667	-.417	.917			
9	.0667	-.750	.250			
10	.0667	-.250	.750			
11	.0667	-.584	.084			
12	.0667	-.417	.917			
13	.0667	-.917	.417			
14	.0667	-.584	.084			
15	.0667	-.250	.750			
16	.0667	-.084	.584			
17	.0667	-.917	.417			
18	.0667	-.250	.750			
19	.0667	-.750	.250			
20	.0667	-.084	.584			
21	.0667	-.917	.417			
22	.0667	-.750	.250			
23	.0667	-.084	.584			
24	.0667	-.584	.084			
25	.0667	-.917	.417			
26	.0667	-.750	.250			
27	.0667	-.584	.084			
28	.0667	-.917	.417			
29	.0667	-.417	.917			
30	.0667	-.750	.250			
31	.0667	-.584	.084			
32	.0667	-.417	.917			
33	.0667	-.750	.250			
34	.0667	-.250	.750			
35	.0667	-.584	.084			
36	.0667	-.417	.917			
37	.0667	-.250	.750			
38	.0667	-.584	.084			
39	.0667	-.084	.584			
40	.0667	-.417	.917			
41	.0667	-.250	.750			
42	.0667	-.417	.917			
43	.0667	-.917	.417			
44	.0667	-.584	.084			
45	.0667	-.250	.750			
46	.0667	-.084	.584			
47	.0667	-.917	.417			
48	.0667	-.250	.750			
49	.0667	-.084	.584			
50	.0667	-.917	.417			
51	.0667	-.250	.750			
52	.0667	-.750	.250			
53	.0667	-.084	.584			
54	.0667	-.917	.417			
55	.0667	-.750	.250			
56	.0667	-.084	.584			
57	.0667	-.917	.417			
58	.0667	-.750	.250			

59	.0667	-.084	.584
60	.0667	-.584	.084
61	.0667	-.917	.417
62	.0667	-.750	.250
63	.0667	-.584	.084
64	.0667	-.917	.417
65	.0667	-.750	.250
66	.0667	-.584	.084
67	.0667	-.917	.417
68	.0667	-.417	.917
69	.0667	-.750	.250
70	.0667	-.584	.084
71	.0667	-.417	.917
72	.0667	-.750	.250
73	.0667	-.584	.084
74	.0667	-.417	.917
75	.0667	-.750	.250
76	.0667	-.250	.750
77	.0667	-.584	.084
78	.0667	-.417	.917
79	.0667	-.250	.750
80	.0667	-.584	.084
81	.0667	-.417	.917
82	.0667	-.250	.750
83	.0667	-.584	.084
84	.0667	-.084	.584
85	.0667	-.417	.917
86	.0667	-.250	.750
87	.0667	-.084	.584
88	.0667	-.417	.917
89	.0667	-.250	.750
90	.0667	-.417	.917
91	.0667	-.917	.417
92	.0667	-.584	.084
93	.0667	-.250	.750
94	.0667	-.084	.584
95	.0667	-.917	.417
96	.0667	-.250	.750
97	.0667	-.084	.584
98	.0667	-.917	.417
99	.0667	-.250	.750
100	.0667	-.084	.584
101	.0667	-.917	.417
102	.0667	-.250	.750
103	.0667	-.750	.250
104	.0667	-.084	.584
105	.0667	-.917	.417
106	.0667	-.750	.250
107	.0667	-.084	.584
108	.0667	-.917	.417
109	.0667	-.750	.250
110	.0667	-.084	.584
111	.0667	-.917	.417
112	.0667	-.750	.250
113	.0667	-.084	.584
114	.0667	-.584	.084
115	.0667	-.917	.417
116	.0667	-.750	.250
117	.0667	-.584	.084
118	.0667	-.917	.417
119	.0667	-.750	.250
120	.0667	-.584	.084
121	.0667	-.917	.417
122	.0667	-.750	.250
123	.0667	-.584	.084
124	.0667	-.917	.417
125	.0667	-.417	.917

126	.0667	-.750	.250
127	.0667	-.584	.084
128	.0667	-.417	.917
129	.0667	-.750	.250
130	.0667	-.584	.084
131	.0667	-.417	.917
132	.0667	-.750	.250
133	.0667	-.584	.084
134	.0667	-.417	.917
135	.0667	-.750	.250
136	.0667	-.250	.750
137	.0667	-.584	.084
138	.0667	-.417	.917
139	.0667	-.250	.750
140	.0667	-.584	.084
141	.0667	-.417	.917
142	.0667	-.250	.750
143	.0667	-.584	.084
144	.0667	-.417	.917
145	.0667	-.250	.750
146	.0667	-.584	.084
147	.0667	-.084	.584
148	.0667	-.417	.917
149	.0667	-.250	.750
150	.0667	-.084	.584
151	.0667	-.417	.917
152	.0667	-.250	.750
153	.0667	-.084	.584
154	.0667	-.417	.917
155	.0667	-.250	.750
156	.0667	-.417	.917
157	.0667	-1.00	
158	.0667	.084	
159	.0667	-1.00	
160	.0667	-1.00	
161	.0667	-.917	
162	.0667	-.834	
163	.0667	-.834	
164	.0667	-.834	
165	.0667	-.750	
166	.0667	-.667	
167	.0667	-.667	
168	.0667	-.667	
169	.0667	-.584	
170	.0667	-.500	
171	.0667	-.500	
172	.0667	-.500	
173	.0667	-.417	
174	.0667	-.334	
175	.0667	-.334	
176	.0667	-.334	
177	.0667	-.250	
178	.0667	-.167	
179	.0667	-.167	
180	.0667	-.167	

1	0	1	0	1	0	1	0	1	0
1	0	1	0	1	0	1	0	1	0
1	0	1	0	1	0	1	0	1	0
1	0	1	0	1	0	1	0	1	0
1	0	1	0	1	0	1	0	1	0
1	0	1	0	1	0	1	0	1	0
1	0	1	0	1	0	1	0	1	0
1	0	1	0	1	0	1	0	1	0
1	0	1	0	1	0	1	0	1	0
1	0	1	0	1	0	2	1	1	1
1	1	1	1	0	0	0	0	0	0
0	0	0	0	0	0	1	1	1	1

8	61	61	0	0	0	0	0	0	0					
1	.2300		1	.1667	2	.1667	3	.1667	4	.1667	5	.1667	6	.1667
2	.2300	1.223	1	.1667	6	.1667	7	.1667	8	.1667	23	.1667	24	.1667
3	.2300	1.215	1	.1667	2	.1667	8	.1667	9	.1667	10	.1667	11	.1667
4	.2300	1.218	2	.1667	3	.1667	11	.1667	12	.1667	13	.1667	14	.1667
5	.2300	1.236	3	.1667	4	.1667	14	.1667	15	.1667	16	.1667	17	.1667
6	.2300	1.222	4	.1667	5	.1667	17	.1667	18	.1667	19	.1667	20	.1667
7	.2300	1.234	5	.1667	6	.1667	20	.1667	21	.1667	22	.1667	23	.1667
8	.2300	1.204	7	.1667	24	.1667	25	.1667	26	.1667	53	.1667	54	.1667
9	.2300	1.193	7	.1667	8	.1667	9	.1667	26	.1667	27	.1667	28	.1667
10	.2300	1.196	9	.1667	10	.1667	28	.1667	29	.1667	30	.1667	31	.1667
11	.2300		10	.1667	11	.1667	12	.1667	31	.1667	32	.1667	33	.1667
12	.2300	1.199	12	.1667	13	.1667	33	.1667	34	.1667	35	.1667	36	.1667
13	.2300	1.206	13	.1667	14	.1667	15	.1667	36	.1667	37	.1667	38	.1667
14	.2300		15	.1667	16	.1667	38	.1667	39	.1667	40	.1667	41	.1667
15	.2300	1.246	16	.1667	17	.1667	18	.1667	41	.1667	42	.1667	43	.1667
16	.2300	1.236	18	.1667	19	.1667	43	.1667	44	.1667	45	.1667	46	.1667
17	.2300	1.243	19	.1667	20	.1667	21	.1667	46	.1667	47	.1667	48	.1667
18	.2300		21	.1667	22	.1667	48	.1667	49	.1667	50	.1667	51	.1667
19	.2300	1.220	22	.1667	23	.1667	24	.1667	51	.1667	52	.1667	53	.1667
20	.2300		25	.1667	54	.1667	55	.1667	56	.1667	95	.1667	96	.1667
21	.2300	1.199	25	.1667	26	.1667	27	.1667	56	.1667	57	.1667	58	.1667
22	.2300	1.189	27	.1667	28	.1667	29	.1667	58	.1667	59	.1667	60	.1667
23	.2300	1.173	29	.1667	30	.1667	60	.1667	61	.1667	62	.1667	63	.1667
24	.2300	1.182	30	.1667	31	.1667	32	.1667	63	.1667	64	.1667	65	.1667
25	.2300	1.200	32	.1667	33	.1667	34	.1667	65	.1667	66	.1667	67	.1667
26	.2300		34	.1667	35	.1667	67	.1667	68	.1667	69	.1667	70	.1667
27	.2300	1.224	35	.1667	36	.1667	37	.1667	70	.1667	71	.1667	72	.1667
28	.2300	1.227	37	.1667	38	.1667	39	.1667	72	.1667	73	.1667	74	.1667
29	.2300	1.249	39	.1667	40	.1667	74	.1667	75	.1667	76	.1667	77	.1667
30	.2300	1.253	40	.1667	41	.1667	42	.1667	77	.1667	78	.1667	79	.1667
31	.2300		42	.1667	43	.1667	44	.1667	79	.1667	80	.1667	81	.1667
32	.2300	1.266	44	.1667	45	.1667	81	.1667	82	.1667	83	.1667	84	.1667
33	.2300	1.260	45	.1667	46	.1667	47	.1667	84	.1667	85	.1667	86	.1667
34	.2300	1.245	47	.1667	48	.1667	49	.1667	86	.1667	87	.1667	88	.1667
35	.2300	1.241	49	.1667	50	.1667	88	.1667	89	.1667	90	.1667	91	.1667
36	.2300	1.223	50	.1667	51	.1667	52	.1667	91	.1667	92	.1667	93	.1667
37	.2300	1.206	52	.1667	53	.1667	54	.1667	93	.1667	94	.1667	95	.1667
38	.2300	1.190	55	.1667	96	.1667	97	.3333	120	.3333				
39	.2300	1.206	55	.1667	56	.1667	57	.1667	97	.2500	98	.2500		
40	.2300	1.179	57	.1667	58	.1667	59	.1667	98	.2500	99	.2500		
41	.2300	1.178	59	.1667	60	.1667	61	.1667	99	.2500	100	.2500		
42	.2300		61	.1667	62	.1667	100	.3333	101	.3333				
43	.2300	1.172	62	.1667	63	.1667	64	.1667	101	.2500	102	.2500		
44	.2300	1.174	64	.1667	65	.1667	66	.1667	102	.2500	103	.2500		
45	.2300	1.183	66	.1667	67	.1667	68	.1667	103	.2500	104	.2500		
46	.2300	1.190	68	.1667	69	.1667	104	.3333	105	.3333				
47	.2300	1.209	69	.1667	70	.1667	71	.1667	105	.2500	106	.2500		
48	.2300	1.228	71	.1667	72	.1667	73	.1667	106	.2500	107	.2500		
49	.2300	1.229	73	.1667	74	.1667	75	.1667	107	.2500	108	.2500		
50	.2300		75	.1667	76	.1667	108	.3333	109	.3333				
51	.2300	1.250	76	.1667	77	.1667	78	.1667	109	.2500	110	.2500		
52	.2300	1.263	78	.1667	79	.1667	80	.1667	110	.2500	111	.2500		
53	.2300	1.274	80	.1667	81	.1667	82	.1667	111	.2500	112	.2500		
54	.2300	1.272	82	.1667	83	.1667	112	.3333	113	.3333				
55	.2300	1.267	83	.1667	84	.1667	85	.1667	113	.2500	114	.2500		
56	.2300		85	.1667	86	.1667	87	.1667	114	.2500	115	.2500		
57	.2300	1.254	87	.1667	88	.1667	89	.1667	115	.2500	116	.2500		
58	.2300	1.241	89	.1667	90	.1667	116	.3333	117	.3333				
59	.2300		90	.1667	91	.1667	92	.1667	117	.2500	118	.2500		
60	.2300	1.211	92	.1667	93	.1667	94	.1667	118	.2500	119	.2500		
61	.2300	1.201	94	.1667	95	.1667	96	.1667	119	.2500	120	.2500		
9	0	0	0	0	0	0								
55.2	0.		1.E-5	.00001								0.5		
138		200	200											
10	0	0	1	0	0	0								
0.01														

```
0.5
11        1        1        0        0        0        0        0        0        0        0
14.696    699.8    3.55    .492957
```

2) TED 7-집합체 계산을 위한 MATRA-LMR 입력자료 (다 집합체)

```
3000      0      0      1      1
   1      0 (TED : X494 -> Multi)
   1      0      0      0      0      3      2
   2      0      0      0      0      1      0      0
0.316  -0.25    0.0
  64.    -1.    0.0
   3     27      2
.0000  .0465  .1395  .2177  .2554  .2992  .3492  .3746  .3990  .4235
.4479  .4724  .4968  .5213  .5457  .5702  .5947  .6455  .6705  .6947
.7210  .7563  .8068  .8339  .8962  .9761 1.000
.0000  .0000  .0000  .0000  .0000  .0000  .0000  .9537 1.021  1.076
1.114  1.119  1.094  1.040  .9600  .8655  .7577  .0000  .0000  .0000
.0000  .0000  .0000  .0000  .0000  .0000  .0000
.0000  .0000  .0000  .0000  .0000  .0000  .0000 1.000  1.000  1.000
1.000  1.000  1.000  1.000  1.000  1.000  1.000  .0000  .0000  .0000
.0000  .0000  .0000  .0000  .0000  .0000  .0000
   4      7      0      1
699.8   0.04  0.028  2.207   55.2    138
   1    120      1      0      0      0
   1  .0115  .3613  .3613      2  .0430  .1576      6  .0430  .1576      8  .0430  .1576
   2  .0115  .3613  .3613      3  .0430  .1576     11  .0430  .1576
   3  .0115  .3613  .3613      4  .0430  .1576     14  .0430  .1576
   4  .0115  .3613  .3613      5  .0430  .1576     17  .0430  .1576
   5  .0115  .3613  .3613      6  .0430  .1576     20  .0430  .1576
   6  .0115  .3613  .3613     23  .0430  .1576
   7  .0115  .3613  .3613      8  .0430  .1576     24  .0430  .1576     26  .0430  .1576
   8  .0115  .3613  .3613      9  .0430  .1576
   9  .0115  .3613  .3613     10  .0430  .1576     28  .0430  .1576
  10  .0115  .3613  .3613     11  .0430  .1576     31  .0430  .1576
  11  .0115  .3613  .3613     12  .0430  .1576
  12  .0115  .3613  .3613     13  .0430  .1576     33  .0430  .1576
  13  .0115  .3613  .3613     14  .0430  .1576     36  .0430  .1576
  14  .0115  .3613  .3613     15  .0430  .1576
  15  .0115  .3613  .3613     16  .0430  .1576     38  .0430  .1576
  16  .0115  .3613  .3613     17  .0430  .1576     41  .0430  .1576
  17  .0115  .3613  .3613     18  .0430  .1576
  18  .0115  .3613  .3613     19  .0430  .1576     43  .0430  .1576
  19  .0115  .3613  .3613     20  .0430  .1576     46  .0430  .1576
  20  .0115  .3613  .3613     21  .0430  .1576
  21  .0115  .3613  .3613     22  .0430  .1576     48  .0430  .1576
  22  .0115  .3613  .3613     23  .0430  .1576     51  .0430  .1576
  23  .0115  .3613  .3613     24  .0430  .1576
  24  .0115  .3613  .3613     53  .0430  .1576
  25  .0115  .3613  .3613     26  .0430  .1576     54  .0430  .1576     56  .0430  .1576
  26  .0115  .3613  .3613     27  .0430  .1576
  27  .0115  .3613  .3613     28  .0430  .1576     58  .0430  .1576
  28  .0115  .3613  .3613     29  .0430  .1576
  29  .0115  .3613  .3613     30  .0430  .1576     60  .0430  .1576
  30  .0115  .3613  .3613     31  .0430  .1576     63  .0430  .1576
  31  .0115  .3613  .3613     32  .0430  .1576
  32  .0115  .3613  .3613     33  .0430  .1576     65  .0430  .1576
  33  .0115  .3613  .3613     34  .0430  .1576
  34  .0115  .3613  .3613     35  .0430  .1576     67  .0430  .1576
  35  .0115  .3613  .3613     36  .0430  .1576     70  .0430  .1576
  36  .0115  .3613  .3613     37  .0430  .1576
  37  .0115  .3613  .3613     38  .0430  .1576     72  .0430  .1576
  38  .0115  .3613  .3613     39  .0430  .1576
  39  .0115  .3613  .3613     40  .0430  .1576     74  .0430  .1576
  40  .0115  .3613  .3613     41  .0430  .1576     77  .0430  .1576
  41  .0115  .3613  .3613     42  .0430  .1576
  42  .0115  .3613  .3613     43  .0430  .1576     79  .0430  .1576
  43  .0115  .3613  .3613     44  .0430  .1576
  44  .0115  .3613  .3613     45  .0430  .1576     81  .0430  .1576
  45  .0115  .3613  .3613     46  .0430  .1576     84  .0430  .1576
  46  .0115  .3613  .3613     47  .0430  .1576
  47  .0115  .3613  .3613     48  .0430  .1576     86  .0430  .1576
  48  .0115  .3613  .3613     49  .0430  .1576
  49  .0115  .3613  .3613     50  .0430  .1576     88  .0430  .1576
  50  .0115  .3613  .3613     51  .0430  .1576     91  .0430  .1576
  51  .0115  .3613  .3613     52  .0430  .1576
  52  .0115  .3613  .3613     53  .0430  .1576     93  .0430  .1576
  53  .0115  .3613  .3613     54  .0430  .1576
  54  .0115  .3613  .3613     95  .0430  .1576
  55  .0115  .3613  .3613     56  .0430  .1576     96  .0430  .1576     97  .0430  .1577
  56  .0115  .3613  .3613     57  .0430  .1576
  57  .0115  .3613  .3613     58  .0430  .1576     98  .0430  .1577
  58  .0115  .3613  .3613     59  .0430  .1576
  59  .0115  .3613  .3613     60  .0430  .1576     99  .0430  .1577
  60  .0115  .3613  .3613     61  .0430  .1576
  61  .0115  .3613  .3613     62  .0430  .1576    100  .0430  .1577
```

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 62   .0115   .3613   .3613    63   .0430   .1576   101   .0430   .1577
 63   .0115   .3613   .3613    64   .0430   .1576
 64   .0115   .3613   .3613    65   .0430   .1576   102   .0430   .1577
 65   .0115   .3613   .3613    66   .0430   .1576
 66   .0115   .3613   .3613    67   .0430   .1576   103   .0430   .1577
 67   .0115   .3613   .3613    68   .0430   .1576
 68   .0115   .3613   .3613    69   .0430   .1576   104   .0430   .1577
 69   .0115   .3613   .3613    70   .0430   .1576   105   .0430   .1577
 70   .0115   .3613   .3613    71   .0430   .1576
 71   .0115   .3613   .3613    72   .0430   .1576   106   .0430   .1577
 72   .0115   .3613   .3613    73   .0430   .1576
 73   .0115   .3613   .3613    74   .0430   .1576   107   .0430   .1577
 74   .0115   .3613   .3613    75   .0430   .1576
 75   .0115   .3613   .3613    76   .0430   .1576   108   .0430   .1577
 76   .0115   .3613   .3613    77   .0430   .1576   109   .0430   .1577
 77   .0115   .3613   .3613    78   .0430   .1576
 78   .0115   .3613   .3613    79   .0430   .1576   110   .0430   .1577
 79   .0115   .3613   .3613    80   .0430   .1576
 80   .0115   .3613   .3613    81   .0430   .1576   111   .0430   .1577
 81   .0115   .3613   .3613    82   .0430   .1576
 82   .0115   .3613   .3613    83   .0430   .1576   112   .0430   .1577
 83   .0115   .3613   .3613    84   .0430   .1576   113   .0430   .1577
 84   .0115   .3613   .3613    85   .0430   .1576
 85   .0115   .3613   .3613    86   .0430   .1576   114   .0430   .1577
 86   .0115   .3613   .3613    87   .0430   .1576
 87   .0115   .3613   .3613    88   .0430   .1576   115   .0430   .1577
 88   .0115   .3613   .3613    89   .0430   .1576
 89   .0115   .3613   .3613    90   .0430   .1576   116   .0430   .1577
 90   .0115   .3613   .3613    91   .0430   .1576   117   .0430   .1577
 91   .0115   .3613   .3613    92   .0430   .1576
 92   .0115   .3613   .3613    93   .0430   .1576   118   .0430   .1577
 93   .0115   .3613   .3613    94   .0430   .1576
 94   .0115   .3613   .3613    95   .0430   .1576   119   .0430   .1577
 95   .0115   .3613   .3613    96   .0430   .1576
 96   .0115   .3613   .3613   120   .0430   .1577
 97   .0254   .7771   .4215    98   .0428   .2730   120   .0428   .4158
 98   .0223   .6343   .3613    99   .0428   .2730
 99   .0223   .6343   .3613   100   .0428   .2730
100   .0254   .7771   .4215   101   .0428   .4158
101   .0254   .7771   .4215   102   .0428   .2730
102   .0223   .6343   .3613   103   .0428   .2730
103   .0223   .6343   .3613   104   .0428   .2730
104   .0254   .7771   .4215   105   .0428   .4158
105   .0254   .7771   .4215   106   .0428   .2730
106   .0223   .6343   .3613   107   .0428   .2730
107   .0223   .6343   .3613   108   .0428   .2730
108   .0254   .7771   .4215   109   .0428   .4158
109   .0254   .7771   .4215   110   .0428   .2730
110   .0223   .6343   .3613   111   .0428   .2730
111   .0223   .6343   .3613   112   .0428   .2730
112   .0254   .7771   .4215   113   .0428   .4158
113   .0254   .7771   .4215   114   .0428   .2730
114   .0223   .6343   .3613   115   .0428   .2730
115   .0223   .6343   .3613   116   .0428   .2730
116   .0254   .7771   .4215   117   .0428   .4158
117   .0254   .7771   .4215   118   .0428   .2730
118   .0223   .6343   .3613   119   .0428   .2730
119   .0223   .6343   .3613   120   .0428   .2730
120   .0254   .7771   .4215
3.55
  2     3     4     5     6     7
  4    97    98    99   100
  4   101   102   103   104
  4   105   106   107   108
  4   109   110   111   112
  4   113   114   115   116
  4   117   118   119   120
  2    12     2     0     0     0
  1   .0507  1.178  1.178   2   .0420   .4573   6   .0420   .4573   7   .0420   .4374
  2   .0507  1.178  1.178   3   .0420   .4573   8   .0420   .4374
  3   .0507  1.178  1.178   4   .0420   .4573   9   .0420   .4374
  4   .0507  1.178  1.178   5   .0420   .4573  10   .0420   .4374
  5   .0507  1.178  1.178   6   .0420   .4573  11   .0420   .4374
  6   .0507  1.178  1.178  12   .0420   .4374
  7   .1275  2.800  1.571   8   .0426  1.207   12   .0426  1.207
  8   .1275  2.800  1.571   9   .0426  1.207
  9   .1275  2.800  1.571  10   .0426  1.207
 10   .1275  2.800  1.571  11   .0426  1.207
 11   .1275  2.800  1.571  12   .0426  1.207
 12   .1275  2.800  1.571
5.2816
  0     0     3     1     7     0
  1     7
  1     8
```

```
  1      9
  1     10
  1     11
  1     12
  3     12      2       0       0       0
  1   .0507   1.178   1.178     2   .0420   .4573     6   .0420   .4573     7   .0420   .4374
  2   .0507   1.178   1.178     3   .0420   .4573     8   .0420   .4374
  3   .0507   1.178   1.178     4   .0420   .4573     9   .0420   .4374
  4   .0507   1.178   1.178     5   .0420   .4573    10   .0420   .4374
  5   .0507   1.178   1.178     6   .0420   .4573    11   .0420   .4374
  6   .0507   1.178   1.178    12   .0420   .4374
  7   .1275   2.800   1.571     8   .0426   1.207    12   .0426   1.207
  8   .1275   2.800   1.571     9   .0426   1.207
  9   .1275   2.800   1.571    10   .0426   1.207
 10   .1275   2.800   1.571    11   .0426   1.207
 11   .1275   2.800   1.571    12   .0426   1.207
 12   .1275   2.800   1.571
4.4725
  0      0       0       4       1       2
  1      7
  1      8
  1      9
  1     10
  1     11
  1     12
  4     12      2       0       0       0
  1   .0507   1.178   1.178     2   .0420   .4573     6   .0420   .4573     7   .0420   .4374
  2   .0507   1.178   1.178     3   .0420   .4573     8   .0420   .4374
  3   .0507   1.178   1.178     4   .0420   .4573     9   .0420   .4374
  4   .0507   1.178   1.178     5   .0420   .4573    10   .0420   .4374
  5   .0507   1.178   1.178     6   .0420   .4573    11   .0420   .4374
  6   .0507   1.178   1.178    12   .0420   .4374
  7   .1275   2.800   1.571     8   .0426   1.207    12   .0426   1.207
  8   .1275   2.800   1.571     9   .0426   1.207
  9   .1275   2.800   1.571    10   .0426   1.207
 10   .1275   2.800   1.571    11   .0426   1.207
 11   .1275   2.800   1.571    12   .0426   1.207
 12   .1275   2.800   1.571
4.8458
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  1      7
  1      8
  1      9
  1     10
  1     11
  1     12
  5     12      2       0       0       0
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  4   .0507   1.178   1.178     5   .0420   .4573    10   .0420   .4374
  5   .0507   1.178   1.178     6   .0420   .4573    11   .0420   .4374
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  7   .1275   2.800   1.571     8   .0426   1.207    12   .0426   1.207
  8   .1275   2.800   1.571     9   .0426   1.207
  9   .1275   2.800   1.571    10   .0426   1.207
 10   .1275   2.800   1.571    11   .0426   1.207
 11   .1275   2.800   1.571    12   .0426   1.207
 12   .1275   2.800   1.571
5.2851
  1      4       0       0       0       6
  1      7
  1      8
  1      9
  1     10
  1     11
  1     12
  6     12      2       0       0       0
  1   .0507   1.178   1.178     2   .0420   .4573     6   .0420   .4573     7   .0420   .4374
  2   .0507   1.178   1.178     3   .0420   .4573     8   .0420   .4374
  3   .0507   1.178   1.178     4   .0420   .4573     9   .0420   .4374
  4   .0507   1.178   1.178     5   .0420   .4573    10   .0420   .4374
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  7   .1275   2.800   1.571     8   .0426   1.207    12   .0426   1.207
  8   .1275   2.800   1.571     9   .0426   1.207
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 1     12
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 5  .0507  1.178  1.178      6  .0420  .4573     11  .0420  .4374
 6  .0507  1.178  1.178     12  .0420  .4374
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 9  .1275  2.800  1.571     10  .0426  1.207
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 3  .0667  -.250   .750
 4  .0667  -.750   .250
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28	.2300	1.227	37	.1667	38	.1667	39	.1667	72	.1667	73	.1667	74	.1667
29	.2300	1.249	39	.1667	40	.1667	74	.1667	75	.1667	76	.1667	77	.1667
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31	.2300		42	.1667	43	.1667	44	.1667	79	.1667	80	.1667	81	.1667

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6	.7500	1.000	4	.1667	5	.1667	10	.3333	11	.3333				
7	.7500	1.000	5	.1667	6	.1667	11	.3333	12	.3333				
6	7	0												
1	.7500	1.000	1	.1667	2	.1667	3	.1667	4	.1667	5	.1667	6	.1667
2	.7500	1.000	1	.1667	6	.1667	7	.3333	12	.3333				
3	.7500	1.000	1	.1667	2	.1667	7	.3333	8	.3333				
4	.7500	1.000	2	.1667	3	.1667	8	.3333	9	.3333				
5	.7500	1.000	3	.1667	4	.1667	9	.3333	10	.3333				
6	.7500	1.000	4	.1667	5	.1667	10	.3333	11	.3333				
7	.7500	1.000	5	.1667	6	.1667	11	.3333	12	.3333				
7	7	0												
1	.7500	1.000	1	.1667	2	.1667	3	.1667	4	.1667	5	.1667	6	.1667
2	.7500	1.000	1	.1667	6	.1667	7	.3333	12	.3333				
3	.7500	1.000	1	.1667	2	.1667	7	.3333	8	.3333				
4	.7500	1.000	2	.1667	3	.1667	8	.3333	9	.3333				
5	.7500	1.000	3	.1667	4	.1667	9	.3333	10	.3333				
6	.7500	1.000	4	.1667	5	.1667	10	.3333	11	.3333				
7	.7500	1.000	5	.1667	6	.1667	11	.3333	12	.3333				
9	0	0	0	0	0	0								
55.2	0.		1.E-5	.0001								0.5		
138		200	200											
10	0	0	1	0	0	0								
0.01														
0.5														

11	1	1	0	0	0	0	0	0	0	0
14.7	699.8									
2.1247	2.3539	2.3831	1.4450	2.5379	0.084683	2.4927				
0.492957	1.44157	1.45947	0.88494	1.55426	0.0518655	1.52661				
12	1	0	0	0	0	0	0	0		

3) TED 7-집합체 계산을 위한 THI3D 입력자료 (다 집합체)

```
 TED (X494) 7-ASSEMBLY PROBLEM (MULTI CASE)   OCTOBER 26, 1999
    5     5   138     1   138     0     0     2     1     7     1     0
    0     2     1     0     0     2     1    20     1     0     2     1
   -1     0     0     0     0     0     0     0     0     1     1     1
    0     0     0     0     0     0     0
    2.29      0.3     0.477       0.0       0.0     1.472  8.001E5      1.23
    0.02   85.813      0.97      1.03       1.0       0.0       0.0       0.5
    0.02      0.0       0.0       0.0       0.0      2.01      0.01      0.01
    0.02     0.02      0.02       0.0       0.0       0.0       0.0       0.0
     0.0      0.0       0.0       0.0       0.0       0.0       0.0
0 0 0 0 0
0 1 1 0 0
0 1 1 1 0
0 1 1 0 0
0 0 0 0 0
    0     1     1     1     1     0     0     1     0     0     0     0
    0     0     0
     0.4     1.99      1.99      1.99-3.4910E6      0.0    1159.5       1.0
     0.0      0.0       0.0       1.0   1000.0       1.0       0.0
     0.0      0.0       0.0       0.0       0.0
     0.0     1.99      1.99       0.0       0.0
     0.0     1.99      1.99      1.99       0.0
     0.0     1.99      1.99       0.0       0.0
     0.0      0.0       0.0       0.0       0.0
     0.0      0.0       0.0       0.0       0.0
     0.0     1.99      1.99       0.0       0.0
     0.0     1.99      1.99      1.99       0.0
     0.0     1.99      1.99       0.0       0.0
     0.0      0.0       0.0       0.0       0.0
     0.0      0.0       0.0       0.0       0.0
     0.0     1.99      1.99       0.0       0.0
     0.0     1.99      1.99      1.99       0.0
     0.0     1.99      1.99       0.0       0.0
     0.0      0.0       0.0       0.0       0.0
         0.0         0.0         0.0          0.0         0.0
         0.0   3.94570E6   3.34120E6          0.0         0.0
         0.0   5.04400E6   3.94860E6    3.62010E6         0.0
         0.0   5.90400E5   3.94830E6          0.0         0.0
         0.0         0.0         0.0          0.0         0.0
     0.0      0.0       0.0       0.0       0.0
     0.0  1.22770   1.24290       0.0       0.0
     0.0  1.30000   1.10810   0.75360       0.0
     0.0 0.044166   1.32360       0.0       0.0
     0.0      0.0       0.0       0.0       0.0
   0.005      0.0       0.0       0.0       0.0      0.0       0.0
    1.E9      0.0       0.0       0.0       0.0      0.0       0.0
  0
     1.0      0.0       0.0       0.0       0.0      0.0       0.0
  1.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0
   0
   0     0     0     1     0
```

부록 4. KALIMER 7-집합체 입력특성

1) DR0302 7-집합체 계산을 위한 MATRA-LMR 입력자료 (단일 집합체)

```
 30000      0      0      1      0
     1      0 (D4SH120 / 271 pin / DR 0302, 7.44 MWth, 39.80 kg/sec)
     1      0      0      0      0      3      2
     2      0      0      0      0      1      0      0
 0.316  -0.25    0.0
   64.     -1.    0.0
     3     81
 0.00000  0.00643  0.01929  0.03216  0.04502  0.05788  0.07074  0.08361  0.09647  0.10933
 0.12219  0.13506  0.14792  0.16078  0.17364  0.18650  0.19937  0.21223  0.22509  0.23795
 0.25082  0.26368  0.27654  0.28932  0.30201  0.31471  0.32740  0.34009  0.35278  0.36548
 0.37817  0.39086  0.40356  0.41625  0.42894  0.44163  0.45433  0.46702  0.47971  0.49241
 0.50510  0.51779  0.53049  0.54318  0.55587  0.56856  0.58126  0.59395  0.60664  0.61933
 0.63201  0.64470  0.65728  0.66974  0.68220  0.69466  0.70713  0.71959  0.73205  0.74451
 0.75698  0.76944  0.78190  0.79437  0.80683  0.81929  0.83175  0.84422  0.85668  0.86914
 0.88160  0.89407  0.90653  0.91899  0.93146  0.94392  0.95638  0.96884  0.98131  0.99377
 1.00000
 0.00000  0.00015  0.00036  0.00058  0.00084  0.00115  0.00153  0.00200  0.00257  0.00328
 0.00413  0.00516  0.00639  0.00782  0.00945  0.01127  0.01321  0.01518  0.01701  0.01843
 0.01907  0.01836  0.01563  2.07146  2.29435  2.56883  2.84849  3.11350  3.26484  3.47169
 3.64852  3.79209  3.90012  3.94016  3.97384  3.97036  3.92956  3.85209  3.78681  3.63518
 3.44867  3.22982  2.98195  2.79549  2.48695  2.16155  1.83456  1.53952  0.00398  0.00420
 0.00422  0.00408  0.00395  0.00379  0.00366  0.00352  0.00337  0.00321  0.00304  0.00286
 0.00268  0.00249  0.00231  0.00213  0.00195  0.00178  0.00162  0.00147  0.00132  0.00118
 0.00105  0.00093  0.00081  0.00070  0.00059  0.00049  0.00039  0.00030  0.00020  0.00011
 0.00000
     4    540    540      0      0      0      0
     1  .0200  .4607  .4607      2  .0591  .2035      6  .0591  .2035      8  .0591  .2035
     2  .0200  .4607  .4607      3  .0591  .2035     11  .0591  .2035
     3  .0200  .4607  .4607      4  .0591  .2035     14  .0591  .2035
     4  .0200  .4607  .4607      5  .0591  .2035     17  .0591  .2035
     5  .0200  .4607  .4607      6  .0591  .2035     20  .0591  .2035
     6  .0200  .4607  .4607     23  .0591  .2035
     7  .0200  .4607  .4607      8  .0591  .2035     24  .0591  .2035     26  .0591  .2035
     8  .0200  .4607  .4607      9  .0591  .2035
     9  .0200  .4607  .4607     10  .0591  .2035     28  .0591  .2035
    10  .0200  .4607  .4607     11  .0591  .2035     31  .0591  .2035
    11  .0200  .4607  .4607     12  .0591  .2035
    12  .0200  .4607  .4607     13  .0591  .2035     33  .0591  .2035
    13  .0200  .4607  .4607     14  .0591  .2035     36  .0591  .2035
    14  .0200  .4607  .4607     15  .0591  .2035
    15  .0200  .4607  .4607     16  .0591  .2035     38  .0591  .2035
    16  .0200  .4607  .4607     17  .0591  .2035     41  .0591  .2035
    17  .0200  .4607  .4607     18  .0591  .2035
    18  .0200  .4607  .4607     19  .0591  .2035     43  .0591  .2035
    19  .0200  .4607  .4607     20  .0591  .2035     46  .0591  .2035
    20  .0200  .4607  .4607     21  .0591  .2035
    21  .0200  .4607  .4607     22  .0591  .2035     48  .0591  .2035
    22  .0200  .4607  .4607     23  .0591  .2035     51  .0591  .2035
    23  .0200  .4607  .4607     24  .0591  .2035
    24  .0200  .4607  .4607     53  .0591  .2035
    25  .0200  .4607  .4607     26  .0591  .2035     54  .0591  .2035     56  .0591  .2035
    26  .0200  .4607  .4607     27  .0591  .2035
    27  .0200  .4607  .4607     28  .0591  .2035     58  .0591  .2035
    28  .0200  .4607  .4607     29  .0591  .2035
    29  .0200  .4607  .4607     30  .0591  .2035     60  .0591  .2035
    30  .0200  .4607  .4607     31  .0591  .2035     63  .0591  .2035
    31  .0200  .4607  .4607     32  .0591  .2035
    32  .0200  .4607  .4607     33  .0591  .2035     65  .0591  .2035
    33  .0200  .4607  .4607     34  .0591  .2035
    34  .0200  .4607  .4607     35  .0591  .2035     67  .0591  .2035
    35  .0200  .4607  .4607     36  .0591  .2035     70  .0591  .2035
```

36	.0200	.4607	.4607	37	.0591	.2035						
37	.0200	.4607	.4607	38	.0591	.2035	72	.0591	.2035			
38	.0200	.4607	.4607	39	.0591	.2035						
39	.0200	.4607	.4607	40	.0591	.2035	74	.0591	.2035			
40	.0200	.4607	.4607	41	.0591	.2035	77	.0591	.2035			
41	.0200	.4607	.4607	42	.0591	.2035						
42	.0200	.4607	.4607	43	.0591	.2035	79	.0591	.2035			
43	.0200	.4607	.4607	44	.0591	.2035						
44	.0200	.4607	.4607	45	.0591	.2035	81	.0591	.2035			
45	.0200	.4607	.4607	46	.0591	.2035	84	.0591	.2035			
46	.0200	.4607	.4607	47	.0591	.2035						
47	.0200	.4607	.4607	48	.0591	.2035	86	.0591	.2035			
48	.0200	.4607	.4607	49	.0591	.2035						
49	.0200	.4607	.4607	50	.0591	.2035	88	.0591	.2035			
50	.0200	.4607	.4607	51	.0591	.2035	91	.0591	.2035			
51	.0200	.4607	.4607	52	.0591	.2035						
52	.0200	.4607	.4607	53	.0591	.2035	93	.0591	.2035			
53	.0200	.4607	.4607	54	.0591	.2035						
54	.0200	.4607	.4607	95	.0591	.2035						
55	.0200	.4607	.4607	56	.0591	.2035	96	.0591	.2035	98	.0591	.2035
56	.0200	.4607	.4607	57	.0591	.2035						
57	.0200	.4607	.4607	58	.0591	.2035	100	.0591	.2035			
58	.0200	.4607	.4607	59	.0591	.2035						
59	.0200	.4607	.4607	60	.0591	.2035	102	.0591	.2035			
60	.0200	.4607	.4607	61	.0591	.2035						
61	.0200	.4607	.4607	62	.0591	.2035	104	.0591	.2035			
62	.0200	.4607	.4607	63	.0591	.2035	107	.0591	.2035			
63	.0200	.4607	.4607	64	.0591	.2035						
64	.0200	.4607	.4607	65	.0591	.2035	109	.0591	.2035			
65	.0200	.4607	.4607	66	.0591	.2035						
66	.0200	.4607	.4607	67	.0591	.2035	111	.0591	.2035			
67	.0200	.4607	.4607	68	.0591	.2035						
68	.0200	.4607	.4607	69	.0591	.2035	113	.0591	.2035			
69	.0200	.4607	.4607	70	.0591	.2035	116	.0591	.2035			
70	.0200	.4607	.4607	71	.0591	.2035						
71	.0200	.4607	.4607	72	.0591	.2035	118	.0591	.2035			
72	.0200	.4607	.4607	73	.0591	.2035						
73	.0200	.4607	.4607	74	.0591	.2035	120	.0591	.2035			
74	.0200	.4607	.4607	75	.0591	.2035						
75	.0200	.4607	.4607	76	.0591	.2035	122	.0591	.2035			
76	.0200	.4607	.4607	77	.0591	.2035	125	.0591	.2035			
77	.0200	.4607	.4607	78	.0591	.2035						
78	.0200	.4607	.4607	79	.0591	.2035	127	.0591	.2035			
79	.0200	.4607	.4607	80	.0591	.2035						
80	.0200	.4607	.4607	81	.0591	.2035	129	.0591	.2035			
81	.0200	.4607	.4607	82	.0591	.2035						
82	.0200	.4607	.4607	83	.0591	.2035	131	.0591	.2035			
83	.0200	.4607	.4607	84	.0591	.2035	134	.0591	.2035			
84	.0200	.4607	.4607	85	.0591	.2035						
85	.0200	.4607	.4607	86	.0591	.2035	136	.0591	.2035			
86	.0200	.4607	.4607	87	.0591	.2035						
87	.0200	.4607	.4607	88	.0591	.2035	138	.0591	.2035			
88	.0200	.4607	.4607	89	.0591	.2035						
89	.0200	.4607	.4607	90	.0591	.2035	140	.0591	.2035			
90	.0200	.4607	.4607	91	.0591	.2035	143	.0591	.2035			
91	.0200	.4607	.4607	92	.0591	.2035						
92	.0200	.4607	.4607	93	.0591	.2035	145	.0591	.2035			
93	.0200	.4607	.4607	94	.0591	.2035						
94	.0200	.4607	.4607	95	.0591	.2035	147	.0591	.2035			
95	.0200	.4607	.4607	96	.0591	.2035						
96	.0200	.4607	.4607	149	.0591	.2035						
97	.0200	.4607	.4607	98	.0591	.2035	150	.0591	.2035	152	.0591	.2035
98	.0200	.4607	.4607	99	.0591	.2035						
99	.0200	.4607	.4607	100	.0591	.2035	154	.0591	.2035			
100	.0200	.4607	.4607	101	.0591	.2035						
101	.0200	.4607	.4607	102	.0591	.2035	156	.0591	.2035			
102	.0200	.4607	.4607	103	.0591	.2035						

103	.0200	.4607	.4607	104	.0591	.2035	158	.0591	.2035			
104	.0200	.4607	.4607	105	.0591	.2035						
105	.0200	.4607	.4607	106	.0591	.2035	160	.0591	.2035			
106	.0200	.4607	.4607	107	.0591	.2035	163	.0591	.2035			
107	.0200	.4607	.4607	108	.0591	.2035						
108	.0200	.4607	.4607	109	.0591	.2035	165	.0591	.2035			
109	.0200	.4607	.4607	110	.0591	.2035						
110	.0200	.4607	.4607	111	.0591	.2035	167	.0591	.2035			
111	.0200	.4607	.4607	112	.0591	.2035						
112	.0200	.4607	.4607	113	.0591	.2035	169	.0591	.2035			
113	.0200	.4607	.4607	114	.0591	.2035						
114	.0200	.4607	.4607	115	.0591	.2035	171	.0591	.2035			
115	.0200	.4607	.4607	116	.0591	.2035	174	.0591	.2035			
116	.0200	.4607	.4607	117	.0591	.2035						
117	.0200	.4607	.4607	118	.0591	.2035	176	.0591	.2035			
118	.0200	.4607	.4607	119	.0591	.2035						
119	.0200	.4607	.4607	120	.0591	.2035	178	.0591	.2035			
120	.0200	.4607	.4607	121	.0591	.2035						
121	.0200	.4607	.4607	122	.0591	.2035	180	.0591	.2035			
122	.0200	.4607	.4607	123	.0591	.2035						
123	.0200	.4607	.4607	124	.0591	.2035	182	.0591	.2035			
124	.0200	.4607	.4607	125	.0591	.2035	185	.0591	.2035			
125	.0200	.4607	.4607	126	.0591	.2035						
126	.0200	.4607	.4607	127	.0591	.2035	187	.0591	.2035			
127	.0200	.4607	.4607	128	.0591	.2035						
128	.0200	.4607	.4607	129	.0591	.2035	189	.0591	.2035			
129	.0200	.4607	.4607	130	.0591	.2035						
130	.0200	.4607	.4607	131	.0591	.2035	191	.0591	.2035			
131	.0200	.4607	.4607	132	.0591	.2035						
132	.0200	.4607	.4607	133	.0591	.2035	193	.0591	.2035			
133	.0200	.4607	.4607	134	.0591	.2035	196	.0591	.2035			
134	.0200	.4607	.4607	135	.0591	.2035						
135	.0200	.4607	.4607	136	.0591	.2035	198	.0591	.2035			
136	.0200	.4607	.4607	137	.0591	.2035						
137	.0200	.4607	.4607	138	.0591	.2035	200	.0591	.2035			
138	.0200	.4607	.4607	139	.0591	.2035						
139	.0200	.4607	.4607	140	.0591	.2035	202	.0591	.2035			
140	.0200	.4607	.4607	141	.0591	.2035						
141	.0200	.4607	.4607	142	.0591	.2035	204	.0591	.2035			
142	.0200	.4607	.4607	143	.0591	.2035	207	.0591	.2035			
143	.0200	.4607	.4607	144	.0591	.2035						
144	.0200	.4607	.4607	145	.0591	.2035	209	.0591	.2035			
145	.0200	.4607	.4607	146	.0591	.2035						
146	.0200	.4607	.4607	147	.0591	.2035	211	.0591	.2035			
147	.0200	.4607	.4607	148	.0591	.2035						
148	.0200	.4607	.4607	149	.0591	.2035	213	.0591	.2035			
149	.0200	.4607	.4607	150	.0591	.2035						
150	.0200	.4607	.4607	215	.0591	.2035						
151	.0200	.4607	.4607	152	.0591	.2035	216	.0591	.2035	218	.0591	.2035
152	.0200	.4607	.4607	153	.0591	.2035						
153	.0200	.4607	.4607	154	.0591	.2035	220	.0591	.2035			
154	.0200	.4607	.4607	155	.0591	.2035						
155	.0200	.4607	.4607	156	.0591	.2035	222	.0591	.2035			
156	.0200	.4607	.4607	157	.0591	.2035						
157	.0200	.4607	.4607	158	.0591	.2035	224	.0591	.2035			
158	.0200	.4607	.4607	159	.0591	.2035						
159	.0200	.4607	.4607	160	.0591	.2035	226	.0591	.2035			
160	.0200	.4607	.4607	161	.0591	.2035						
161	.0200	.4607	.4607	162	.0591	.2035	228	.0591	.2035			
162	.0200	.4607	.4607	163	.0591	.2035	231	.0591	.2035			
163	.0200	.4607	.4607	164	.0591	.2035						
164	.0200	.4607	.4607	165	.0591	.2035	233	.0591	.2035			
165	.0200	.4607	.4607	166	.0591	.2035						
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435	.0200	.4607	.4607	436	.0591	.2035	513	.0591	.2086			
436	.0200	.4607	.4607	437	.0591	.2035	514	.0591	.2086			
437	.0200	.4607	.4607	438	.0591	.2035						

438	.0200	.4607	.4607	439	.0591	.2035	515	.0591	.2086
439	.0200	.4607	.4607	440	.0591	.2035			
440	.0200	.4607	.4607	441	.0591	.2035	516	.0591	.2086
441	.0200	.4607	.4607	442	.0591	.2035			
442	.0200	.4607	.4607	443	.0591	.2035	517	.0591	.2086
443	.0200	.4607	.4607	444	.0591	.2035			
444	.0200	.4607	.4607	445	.0591	.2035	518	.0591	.2086
445	.0200	.4607	.4607	446	.0591	.2035			
446	.0200	.4607	.4607	447	.0591	.2035	519	.0591	.2086
447	.0200	.4607	.4607	448	.0591	.2035			
448	.0200	.4607	.4607	449	.0591	.2035	520	.0591	.2086
449	.0200	.4607	.4607	450	.0591	.2035			
450	.0200	.4607	.4607	451	.0591	.2035	521	.0591	.2086
451	.0200	.4607	.4607	452	.0591	.2035			
452	.0200	.4607	.4607	453	.0591	.2035	522	.0591	.2086
453	.0200	.4607	.4607	454	.0591	.2035	523	.0591	.2086
454	.0200	.4607	.4607	455	.0591	.2035			
455	.0200	.4607	.4607	456	.0591	.2035	524	.0591	.2086
456	.0200	.4607	.4607	457	.0591	.2035			
457	.0200	.4607	.4607	458	.0591	.2035	525	.0591	.2086
458	.0200	.4607	.4607	459	.0591	.2035			
459	.0200	.4607	.4607	460	.0591	.2035	526	.0591	.2086
460	.0200	.4607	.4607	461	.0591	.2035			
461	.0200	.4607	.4607	462	.0591	.2035	527	.0591	.2086
462	.0200	.4607	.4607	463	.0591	.2035			
463	.0200	.4607	.4607	464	.0591	.2035	528	.0591	.2086
464	.0200	.4607	.4607	465	.0591	.2035			
465	.0200	.4607	.4607	466	.0591	.2035	529	.0591	.2086
466	.0200	.4607	.4607	467	.0591	.2035			
467	.0200	.4607	.4607	468	.0591	.2035	530	.0591	.2086
468	.0200	.4607	.4607	469	.0591	.2035			
469	.0200	.4607	.4607	470	.0591	.2035	531	.0591	.2086
470	.0200	.4607	.4607	471	.0591	.2035	532	.0591	.2086
471	.0200	.4607	.4607	472	.0591	.2035			
472	.0200	.4607	.4607	473	.0591	.2035	533	.0591	.2086
473	.0200	.4607	.4607	474	.0591	.2035			
474	.0200	.4607	.4607	475	.0591	.2035	534	.0591	.2086
475	.0200	.4607	.4607	476	.0591	.2035			
476	.0200	.4607	.4607	477	.0591	.2035	535	.0591	.2086
477	.0200	.4607	.4607	478	.0591	.2035			
478	.0200	.4607	.4607	479	.0591	.2035	536	.0591	.2086
479	.0200	.4607	.4607	480	.0591	.2035			
480	.0200	.4607	.4607	481	.0591	.2035	537	.0591	.2086
481	.0200	.4607	.4607	482	.0591	.2035			
482	.0200	.4607	.4607	483	.0591	.2035	538	.0591	.2086
483	.0200	.4607	.4607	484	.0591	.2035			
484	.0200	.4607	.4607	485	.0591	.2035	539	.0591	.2086
485	.0200	.4607	.4607	486	.0591	.2035			
486	.0200	.4607	.4607	540	.0591	.2086			
487	.0479	1.002	.5375	488	.0672	.3524	540	.0672	.5411
488	.0416	.8131	.4607	489	.0672	.3524			
489	.0416	.8131	.4607	490	.0672	.3524			
490	.0416	.8131	.4607	491	.0672	.3524			
491	.0416	.8131	.4607	492	.0672	.3524			
492	.0416	.8131	.4607	493	.0672	.3524			
493	.0416	.8131	.4607	494	.0672	.3524			
494	.0416	.8131	.4607	495	.0672	.3524			
495	.0479	1.002	.5375	496	.0672	.5411			
496	.0479	1.002	.5375	497	.0672	.3524			
497	.0416	.8131	.4607	498	.0672	.3524			
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499	.0416	.8131	.4607	500	.0672	.3524			
500	.0416	.8131	.4607	501	.0672	.3524			
501	.0416	.8131	.4607	502	.0672	.3524			
502	.0416	.8131	.4607	503	.0672	.3524			
503	.0416	.8131	.4607	504	.0672	.3524			
504	.0479	1.002	.5375	505	.0672	.5411			

505	.0479	1.002	.5375	506	.0672	.3524
506	.0416	.8131	.4607	507	.0672	.3524
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511	.0416	.8131	.4607	512	.0672	.3524
512	.0416	.8131	.4607	513	.0672	.3524
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519	.0416	.8131	.4607	520	.0672	.3524
520	.0416	.8131	.4607	521	.0672	.3524
521	.0416	.8131	.4607	522	.0672	.3524
522	.0479	1.002	.5375	523	.0672	.5411
523	.0479	1.002	.5375	524	.0672	.3524
524	.0416	.8131	.4607	525	.0672	.3524
525	.0416	.8131	.4607	526	.0672	.3524
526	.0416	.8131	.4607	527	.0672	.3524
527	.0416	.8131	.4607	528	.0672	.3524
528	.0416	.8131	.4607	529	.0672	.3524
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530	.0416	.8131	.4607	531	.0672	.3524
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532	.0479	1.002	.5375	533	.0672	.3524
533	.0416	.8131	.4607	534	.0672	.3524
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539	.0416	.8131	.4607	540	.0672	.3524
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3	.0485	-.250	.750			
4	.0485	-.750	.250			
5	.0485	-.084	.584			
6	.0485	-.584	.084			
7	.0485	-.917	.417			
8	.0485	-.417	.917			
9	.0485	-.750	.250			
10	.0485	-.250	.750			
11	.0485	-.584	.084			
12	.0485	-.417	.917			
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14	.0485	-.584	.084			
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16	.0485	-.084	.584			
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25	.0485	-.917	.417			
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23	.2933	1.000	29	.1667	30	.1667	60	.1667	61	.1667	62	.1667	63	.1667
24	.2933	1.000	30	.1667	31	.1667	32	.1667	63	.1667	64	.1667	65	.1667
25	.2933	1.000	32	.1667	33	.1667	34	.1667	65	.1667	66	.1667	67	.1667
26	.2933	1.000	34	.1667	35	.1667	67	.1667	68	.1667	69	.1667	70	.1667
27	.2933	1.000	35	.1667	36	.1667	37	.1667	70	.1667	71	.1667	72	.1667
28	.2933	1.000	37	.1667	38	.1667	39	.1667	72	.1667	73	.1667	74	.1667
29	.2933	1.000	39	.1667	40	.1667	74	.1667	75	.1667	76	.1667	77	.1667
30	.2933	1.000	40	.1667	41	.1667	42	.1667	77	.1667	78	.1667	79	.1667
31	.2933	1.000	42	.1667	43	.1667	44	.1667	79	.1667	80	.1667	81	.1667
32	.2933	1.000	44	.1667	45	.1667	81	.1667	82	.1667	83	.1667	84	.1667
33	.2933	1.000	45	.1667	46	.1667	47	.1667	84	.1667	85	.1667	86	.1667
34	.2933	1.000	47	.1667	48	.1667	49	.1667	86	.1667	87	.1667	88	.1667
35	.2933	1.000	49	.1667	50	.1667	88	.1667	89	.1667	90	.1667	91	.1667

36	.2933	1.000	50	.1667	51	.1667	52	.1667	91	.1667	92	.1667	93	.1667
37	.2933	1.000	52	.1667	53	.1667	54	.1667	93	.1667	94	.1667	95	.1667
38	.2933	1.000	55	.1667	96	.1667	97	.1667	98	.1667	149	.1667	150	.1667
39	.2933	1.000	55	.1667	56	.1667	57	.1667	98	.1667	99	.1667	100	.1667
40	.2933	1.000	57	.1667	58	.1667	59	.1667	100	.1667	101	.1667	102	.1667
41	.2933	1.000	59	.1667	60	.1667	61	.1667	102	.1667	103	.1667	104	.1667
42	.2933	1.000	61	.1667	62	.1667	104	.1667	105	.1667	106	.1667	107	.1667
43	.2933	1.000	62	.1667	63	.1667	64	.1667	107	.1667	108	.1667	109	.1667
44	.2933	1.000	64	.1667	65	.1667	66	.1667	109	.1667	110	.1667	111	.1667
45	.2933	1.000	66	.1667	67	.1667	68	.1667	111	.1667	112	.1667	113	.1667
46	.2933	1.000	68	.1667	69	.1667	113	.1667	114	.1667	115	.1667	116	.1667
47	.2933	1.000	69	.1667	70	.1667	71	.1667	116	.1667	117	.1667	118	.1667
48	.2933	1.000	71	.1667	72	.1667	73	.1667	118	.1667	119	.1667	120	.1667
49	.2933	1.000	73	.1667	74	.1667	75	.1667	120	.1667	121	.1667	122	.1667
50	.2933	1.000	75	.1667	76	.1667	122	.1667	123	.1667	124	.1667	125	.1667
51	.2933	1.000	76	.1667	77	.1667	78	.1667	125	.1667	126	.1667	127	.1667
52	.2933	1.000	78	.1667	79	.1667	80	.1667	127	.1667	128	.1667	129	.1667
53	.2933	1.000	80	.1667	81	.1667	82	.1667	129	.1667	130	.1667	131	.1667
54	.2933	1.000	82	.1667	83	.1667	131	.1667	132	.1667	133	.1667	134	.1667
55	.2933	1.000	83	.1667	84	.1667	85	.1667	134	.1667	135	.1667	136	.1667
56	.2933	1.000	85	.1667	86	.1667	87	.1667	136	.1667	137	.1667	138	.1667
57	.2933	1.000	87	.1667	88	.1667	89	.1667	138	.1667	139	.1667	140	.1667
58	.2933	1.000	89	.1667	90	.1667	140	.1667	141	.1667	142	.1667	143	.1667
59	.2933	1.000	90	.1667	91	.1667	92	.1667	143	.1667	144	.1667	145	.1667
60	.2933	1.000	92	.1667	93	.1667	94	.1667	145	.1667	146	.1667	147	.1667
61	.2933	1.000	94	.1667	95	.1667	96	.1667	147	.1667	148	.1667	149	.1667
62	.2933	1.000	97	.1667	150	.1667	151	.1667	152	.1667	215	.1667	216	.1667
63	.2933	1.000	97	.1667	98	.1667	99	.1667	152	.1667	153	.1667	154	.1667
64	.2933	1.000	99	.1667	100	.1667	101	.1667	154	.1667	155	.1667	156	.1667
65	.2933	1.000	101	.1667	102	.1667	103	.1667	156	.1667	157	.1667	158	.1667
66	.2933	1.000	103	.1667	104	.1667	105	.1667	158	.1667	159	.1667	160	.1667
67	.2933	1.000	105	.1667	106	.1667	160	.1667	161	.1667	162	.1667	163	.1667
68	.2933	1.000	106	.1667	107	.1667	108	.1667	163	.1667	164	.1667	165	.1667
69	.2933	1.000	108	.1667	109	.1667	110	.1667	165	.1667	166	.1667	167	.1667
70	.2933	1.000	110	.1667	111	.1667	112	.1667	167	.1667	168	.1667	169	.1667
71	.2933	1.000	112	.1667	113	.1667	114	.1667	169	.1667	170	.1667	171	.1667
72	.2933	1.000	114	.1667	115	.1667	171	.1667	172	.1667	173	.1667	174	.1667
73	.2933	1.000	115	.1667	116	.1667	117	.1667	174	.1667	175	.1667	176	.1667
74	.2933	1.000	117	.1667	118	.1667	119	.1667	176	.1667	177	.1667	178	.1667
75	.2933	1.000	119	.1667	120	.1667	121	.1667	178	.1667	179	.1667	180	.1667
76	.2933	1.000	121	.1667	122	.1667	123	.1667	180	.1667	181	.1667	182	.1667
77	.2933	1.000	123	.1667	124	.1667	182	.1667	183	.1667	184	.1667	185	.1667
78	.2933	1.000	124	.1667	125	.1667	126	.1667	185	.1667	186	.1667	187	.1667
79	.2933	1.000	126	.1667	127	.1667	128	.1667	187	.1667	188	.1667	189	.1667
80	.2933	1.000	128	.1667	129	.1667	130	.1667	189	.1667	190	.1667	191	.1667
81	.2933	1.000	130	.1667	131	.1667	132	.1667	191	.1667	192	.1667	193	.1667
82	.2933	1.000	132	.1667	133	.1667	193	.1667	194	.1667	195	.1667	196	.1667
83	.2933	1.000	133	.1667	134	.1667	135	.1667	196	.1667	197	.1667	198	.1667
84	.2933	1.000	135	.1667	136	.1667	137	.1667	198	.1667	199	.1667	200	.1667
85	.2933	1.000	137	.1667	138	.1667	139	.1667	200	.1667	201	.1667	202	.1667
86	.2933	1.000	139	.1667	140	.1667	141	.1667	202	.1667	203	.1667	204	.1667
87	.2933	1.000	141	.1667	142	.1667	204	.1667	205	.1667	206	.1667	207	.1667
88	.2933	1.000	142	.1667	143	.1667	144	.1667	207	.1667	208	.1667	209	.1667
89	.2933	1.000	144	.1667	145	.1667	146	.1667	209	.1667	210	.1667	211	.1667
90	.2933	1.000	146	.1667	147	.1667	148	.1667	211	.1667	212	.1667	213	.1667
91	.2933	1.000	148	.1667	149	.1667	150	.1667	213	.1667	214	.1667	215	.1667
92	.2933	1.000	151	.1667	216	.1667	217	.1667	218	.1667	293	.1667	294	.1667
93	.2933	1.000	151	.1667	152	.1667	153	.1667	218	.1667	219	.1667	220	.1667
94	.2933	1.000	153	.1667	154	.1667	155	.1667	220	.1667	221	.1667	222	.1667
95	.2933	1.000	155	.1667	156	.1667	157	.1667	222	.1667	223	.1667	224	.1667
96	.2933	1.000	157	.1667	158	.1667	159	.1667	224	.1667	225	.1667	226	.1667
97	.2933	1.000	159	.1667	160	.1667	161	.1667	226	.1667	227	.1667	228	.1667
98	.2933	1.000	161	.1667	162	.1667	228	.1667	229	.1667	230	.1667	231	.1667
99	.2933	1.000	162	.1667	163	.1667	164	.1667	231	.1667	232	.1667	233	.1667
100	.2933	1.000	164	.1667	165	.1667	166	.1667	233	.1667	234	.1667	235	.1667
101	.2933	1.000	166	.1667	167	.1667	168	.1667	235	.1667	236	.1667	237	.1667
102	.2933	1.000	168	.1667	169	.1667	170	.1667	237	.1667	238	.1667	239	.1667

103	.2933	1.000	170	.1667	171	.1667	172	.1667	239	.1667	240	.1667	241	.1667
104	.2933	1.000	172	.1667	173	.1667	241	.1667	242	.1667	243	.1667	244	.1667
105	.2933	1.000	173	.1667	174	.1667	175	.1667	244	.1667	245	.1667	246	.1667
106	.2933	1.000	175	.1667	176	.1667	177	.1667	246	.1667	247	.1667	248	.1667
107	.2933	1.000	177	.1667	178	.1667	179	.1667	248	.1667	249	.1667	250	.1667
108	.2933	1.000	179	.1667	180	.1667	181	.1667	250	.1667	251	.1667	252	.1667
109	.2933	1.000	181	.1667	182	.1667	183	.1667	252	.1667	253	.1667	254	.1667
110	.2933	1.000	183	.1667	184	.1667	254	.1667	255	.1667	256	.1667	257	.1667
111	.2933	1.000	184	.1667	185	.1667	186	.1667	257	.1667	258	.1667	259	.1667
112	.2933	1.000	186	.1667	187	.1667	188	.1667	259	.1667	260	.1667	261	.1667
113	.2933	1.000	188	.1667	189	.1667	190	.1667	261	.1667	262	.1667	263	.1667
114	.2933	1.000	190	.1667	191	.1667	192	.1667	263	.1667	264	.1667	265	.1667
115	.2933	1.000	192	.1667	193	.1667	194	.1667	265	.1667	266	.1667	267	.1667
116	.2933	1.000	194	.1667	195	.1667	267	.1667	268	.1667	269	.1667	270	.1667
117	.2933	1.000	195	.1667	196	.1667	197	.1667	270	.1667	271	.1667	272	.1667
118	.2933	1.000	197	.1667	198	.1667	199	.1667	272	.1667	273	.1667	274	.1667
119	.2933	1.000	199	.1667	200	.1667	201	.1667	274	.1667	275	.1667	276	.1667
120	.2933	1.000	201	.1667	202	.1667	203	.1667	276	.1667	277	.1667	278	.1667
121	.2933	1.000	203	.1667	204	.1667	205	.1667	278	.1667	279	.1667	280	.1667
122	.2933	1.000	205	.1667	206	.1667	280	.1667	281	.1667	282	.1667	283	.1667
123	.2933	1.000	206	.1667	207	.1667	208	.1667	283	.1667	284	.1667	285	.1667
124	.2933	1.000	208	.1667	209	.1667	210	.1667	285	.1667	286	.1667	287	.1667
125	.2933	1.000	210	.1667	211	.1667	212	.1667	287	.1667	288	.1667	289	.1667
126	.2933	1.000	212	.1667	213	.1667	214	.1667	289	.1667	290	.1667	291	.1667
127	.2933	1.000	214	.1667	215	.1667	216	.1667	291	.1667	292	.1667	293	.1667
128	.2933	1.000	217	.1667	294	.1667	295	.1667	296	.1667	383	.1667	384	.1667
129	.2933	1.000	217	.1667	218	.1667	219	.1667	296	.1667	297	.1667	298	.1667
130	.2933	1.000	219	.1667	220	.1667	221	.1667	298	.1667	299	.1667	300	.1667
131	.2933	1.000	221	.1667	222	.1667	223	.1667	300	.1667	301	.1667	302	.1667
132	.2933	1.000	223	.1667	224	.1667	225	.1667	302	.1667	303	.1667	304	.1667
133	.2933	1.000	225	.1667	226	.1667	227	.1667	304	.1667	305	.1667	306	.1667
134	.2933	1.000	227	.1667	228	.1667	229	.1667	306	.1667	307	.1667	308	.1667
135	.2933	1.000	229	.1667	230	.1667	308	.1667	309	.1667	310	.1667	311	.1667
136	.2933	1.000	230	.1667	231	.1667	232	.1667	311	.1667	312	.1667	313	.1667
137	.2933	1.000	232	.1667	233	.1667	234	.1667	313	.1667	314	.1667	315	.1667
138	.2933	1.000	234	.1667	235	.1667	236	.1667	315	.1667	316	.1667	317	.1667
139	.2933	1.000	236	.1667	237	.1667	238	.1667	317	.1667	318	.1667	319	.1667
140	.2933	1.000	238	.1667	239	.1667	240	.1667	319	.1667	320	.1667	321	.1667
141	.2933	1.000	240	.1667	241	.1667	242	.1667	321	.1667	322	.1667	323	.1667
142	.2933	1.000	242	.1667	243	.1667	323	.1667	324	.1667	325	.1667	326	.1667
143	.2933	1.000	243	.1667	244	.1667	245	.1667	326	.1667	327	.1667	328	.1667
144	.2933	1.000	245	.1667	246	.1667	247	.1667	328	.1667	329	.1667	330	.1667
145	.2933	1.000	247	.1667	248	.1667	249	.1667	330	.1667	331	.1667	332	.1667
146	.2933	1.000	249	.1667	250	.1667	251	.1667	332	.1667	333	.1667	334	.1667
147	.2933	1.000	251	.1667	252	.1667	253	.1667	334	.1667	335	.1667	336	.1667
148	.2933	1.000	253	.1667	254	.1667	255	.1667	336	.1667	337	.1667	338	.1667
149	.2933	1.000	255	.1667	256	.1667	338	.1667	339	.1667	340	.1667	341	.1667
150	.2933	1.000	256	.1667	257	.1667	258	.1667	341	.1667	342	.1667	343	.1667
151	.2933	1.000	258	.1667	259	.1667	260	.1667	343	.1667	344	.1667	345	.1667
152	.2933	1.000	260	.1667	261	.1667	262	.1667	345	.1667	346	.1667	347	.1667
153	.2933	1.000	262	.1667	263	.1667	264	.1667	347	.1667	348	.1667	349	.1667
154	.2933	1.000	264	.1667	265	.1667	266	.1667	349	.1667	350	.1667	351	.1667
155	.2933	1.000	266	.1667	267	.1667	268	.1667	351	.1667	352	.1667	353	.1667
156	.2933	1.000	268	.1667	269	.1667	353	.1667	354	.1667	355	.1667	356	.1667
157	.2933	1.000	269	.1667	270	.1667	271	.1667	356	.1667	357	.1667	358	.1667
158	.2933	1.000	271	.1667	272	.1667	273	.1667	358	.1667	359	.1667	360	.1667
159	.2933	1.000	273	.1667	274	.1667	275	.1667	360	.1667	361	.1667	362	.1667
160	.2933	1.000	275	.1667	276	.1667	277	.1667	362	.1667	363	.1667	364	.1667
161	.2933	1.000	277	.1667	278	.1667	279	.1667	364	.1667	365	.1667	366	.1667
162	.2933	1.000	279	.1667	280	.1667	281	.1667	366	.1667	367	.1667	368	.1667
163	.2933	1.000	281	.1667	282	.1667	368	.1667	369	.1667	370	.1667	371	.1667
164	.2933	1.000	282	.1667	283	.1667	284	.1667	371	.1667	372	.1667	373	.1667
165	.2933	1.000	284	.1667	285	.1667	286	.1667	373	.1667	374	.1667	375	.1667
166	.2933	1.000	286	.1667	287	.1667	288	.1667	375	.1667	376	.1667	377	.1667
167	.2933	1.000	288	.1667	289	.1667	290	.1667	377	.1667	378	.1667	379	.1667
168	.2933	1.000	290	.1667	291	.1667	292	.1667	379	.1667	380	.1667	381	.1667
169	.2933	1.000	292	.1667	293	.1667	294	.1667	381	.1667	382	.1667	383	.1667

170	.2933	1.000	295	.1667	384	.1667	385	.1667	386	.1667	485	.1667	486	.1667
171	.2933	1.000	295	.1667	296	.1667	297	.1667	386	.1667	387	.1667	388	.1667
172	.2933	1.000	297	.1667	298	.1667	299	.1667	388	.1667	389	.1667	390	.1667
173	.2933	1.000	299	.1667	300	.1667	301	.1667	390	.1667	391	.1667	392	.1667
174	.2933	1.000	301	.1667	302	.1667	303	.1667	392	.1667	393	.1667	394	.1667
175	.2933	1.000	303	.1667	304	.1667	305	.1667	394	.1667	395	.1667	396	.1667
176	.2933	1.000	305	.1667	306	.1667	307	.1667	396	.1667	397	.1667	398	.1667
177	.2933	1.000	307	.1667	308	.1667	309	.1667	398	.1667	399	.1667	400	.1667
178	.2933	1.000	309	.1667	310	.1667	400	.1667	401	.1667	402	.1667	403	.1667
179	.2933	1.000	310	.1667	311	.1667	312	.1667	403	.1667	404	.1667	405	.1667
180	.2933	1.000	312	.1667	313	.1667	314	.1667	405	.1667	406	.1667	407	.1667
181	.2933	1.000	314	.1667	315	.1667	316	.1667	407	.1667	408	.1667	409	.1667
182	.2933	1.000	316	.1667	317	.1667	318	.1667	409	.1667	410	.1667	411	.1667
183	.2933	1.000	318	.1667	319	.1667	320	.1667	411	.1667	412	.1667	413	.1667
184	.2933	1.000	320	.1667	321	.1667	322	.1667	413	.1667	414	.1667	415	.1667
185	.2933	1.000	322	.1667	323	.1667	324	.1667	415	.1667	416	.1667	417	.1667
186	.2933	1.000	324	.1667	325	.1667	417	.1667	418	.1667	419	.1667	420	.1667
187	.2933	1.000	325	.1667	326	.1667	327	.1667	420	.1667	421	.1667	422	.1667
188	.2933	1.000	327	.1667	328	.1667	329	.1667	422	.1667	423	.1667	424	.1667
189	.2933	1.000	329	.1667	330	.1667	331	.1667	424	.1667	425	.1667	426	.1667
190	.2933	1.000	331	.1667	332	.1667	333	.1667	426	.1667	427	.1667	428	.1667
191	.2933	1.000	333	.1667	334	.1667	335	.1667	428	.1667	429	.1667	430	.1667
192	.2933	1.000	335	.1667	336	.1667	337	.1667	430	.1667	431	.1667	432	.1667
193	.2933	1.000	337	.1667	338	.1667	339	.1667	432	.1667	433	.1667	434	.1667
194	.2933	1.000	339	.1667	340	.1667	434	.1667	435	.1667	436	.1667	437	.1667
195	.2933	1.000	340	.1667	341	.1667	342	.1667	437	.1667	438	.1667	439	.1667
196	.2933	1.000	342	.1667	343	.1667	344	.1667	439	.1667	440	.1667	441	.1667
197	.2933	1.000	344	.1667	345	.1667	346	.1667	441	.1667	442	.1667	443	.1667
198	.2933	1.000	346	.1667	347	.1667	348	.1667	443	.1667	444	.1667	445	.1667
199	.2933	1.000	348	.1667	349	.1667	350	.1667	445	.1667	446	.1667	447	.1667
200	.2933	1.000	350	.1667	351	.1667	352	.1667	447	.1667	448	.1667	449	.1667
201	.2933	1.000	352	.1667	353	.1667	354	.1667	449	.1667	450	.1667	451	.1667
202	.2933	1.000	354	.1667	355	.1667	451	.1667	452	.1667	453	.1667	454	.1667
203	.2933	1.000	355	.1667	356	.1667	357	.1667	454	.1667	455	.1667	456	.1667
204	.2933	1.000	357	.1667	358	.1667	359	.1667	456	.1667	457	.1667	458	.1667
205	.2933	1.000	359	.1667	360	.1667	361	.1667	458	.1667	459	.1667	460	.1667
206	.2933	1.000	361	.1667	362	.1667	363	.1667	460	.1667	461	.1667	462	.1667
207	.2933	1.000	363	.1667	364	.1667	365	.1667	462	.1667	463	.1667	464	.1667
208	.2933	1.000	365	.1667	366	.1667	367	.1667	464	.1667	465	.1667	466	.1667
209	.2933	1.000	367	.1667	368	.1667	369	.1667	466	.1667	467	.1667	468	.1667
210	.2933	1.000	369	.1667	370	.1667	468	.1667	469	.1667	470	.1667	471	.1667
211	.2933	1.000	370	.1667	371	.1667	372	.1667	471	.1667	472	.1667	473	.1667
212	.2933	1.000	372	.1667	373	.1667	374	.1667	473	.1667	474	.1667	475	.1667
213	.2933	1.000	374	.1667	375	.1667	376	.1667	475	.1667	476	.1667	477	.1667
214	.2933	1.000	376	.1667	377	.1667	378	.1667	477	.1667	478	.1667	479	.1667
215	.2933	1.000	378	.1667	379	.1667	380	.1667	479	.1667	480	.1667	481	.1667
216	.2933	1.000	380	.1667	381	.1667	382	.1667	481	.1667	482	.1667	483	.1667
217	.2933	1.000	382	.1667	383	.1667	384	.1667	483	.1667	484	.1667	485	.1667
218	.2933	1.000	385	.1667	486	.1667	487	.3333	540	.3333				
219	.2933	1.000	385	.1667	386	.1667	387	.1667	487	.2500	488	.2500		
220	.2933	1.000	387	.1667	388	.1667	389	.1667	488	.2500	489	.2500		
221	.2933	1.000	389	.1667	390	.1667	391	.1667	489	.2500	490	.2500		
222	.2933	1.000	391	.1667	392	.1667	393	.1667	490	.2500	491	.2500		
223	.2933	1.000	393	.1667	394	.1667	395	.1667	491	.2500	492	.2500		
224	.2933	1.000	395	.1667	396	.1667	397	.1667	492	.2500	493	.2500		
225	.2933	1.000	397	.1667	398	.1667	399	.1667	493	.2500	494	.2500		
226	.2933	1.000	399	.1667	400	.1667	401	.1667	494	.2500	495	.2500		
227	.2933	1.000	401	.1667	402	.1667	495	.3333	496	.3333				
228	.2933	1.000	402	.1667	403	.1667	404	.1667	496	.2500	497	.2500		
229	.2933	1.000	404	.1667	405	.1667	406	.1667	497	.2500	498	.2500		
230	.2933	1.000	406	.1667	407	.1667	408	.1667	498	.2500	499	.2500		
231	.2933	1.000	408	.1667	409	.1667	410	.1667	499	.2500	500	.2500		
232	.2933	1.000	410	.1667	411	.1667	412	.1667	500	.2500	501	.2500		
233	.2933	1.000	412	.1667	413	.1667	414	.1667	501	.2500	502	.2500		
234	.2933	1.000	414	.1667	415	.1667	416	.1667	502	.2500	503	.2500		
235	.2933	1.000	416	.1667	417	.1667	418	.1667	503	.2500	504	.2500		
236	.2933	1.000	418	.1667	419	.1667	504	.3333	505	.3333				

237	.2933	1.000	419	.1667	420	.1667	421	.1667	505	.2500	506	.2500
238	.2933	1.000	421	.1667	422	.1667	423	.1667	506	.2500	507	.2500
239	.2933	1.000	423	.1667	424	.1667	425	.1667	507	.2500	508	.2500
240	.2933	1.000	425	.1667	426	.1667	427	.1667	508	.2500	509	.2500
241	.2933	1.000	427	.1667	428	.1667	429	.1667	509	.2500	510	.2500
242	.2933	1.000	429	.1667	430	.1667	431	.1667	510	.2500	511	.2500
243	.2933	1.000	431	.1667	432	.1667	433	.1667	511	.2500	512	.2500
244	.2933	1.000	433	.1667	434	.1667	435	.1667	512	.2500	513	.2500
245	.2933	1.000	435	.1667	436	.1667	513	.3333	514	.3333		
246	.2933	1.000	436	.1667	437	.1667	438	.1667	514	.2500	515	.2500
247	.2933	1.000	438	.1667	439	.1667	440	.1667	515	.2500	516	.2500
248	.2933	1.000	440	.1667	441	.1667	442	.1667	516	.2500	517	.2500
249	.2933	1.000	442	.1667	443	.1667	444	.1667	517	.2500	518	.2500
250	.2933	1.000	444	.1667	445	.1667	446	.1667	518	.2500	519	.2500
251	.2933	1.000	446	.1667	447	.1667	448	.1667	519	.2500	520	.2500
252	.2933	1.000	448	.1667	449	.1667	450	.1667	520	.2500	521	.2500
253	.2933	1.000	450	.1667	451	.1667	452	.1667	521	.2500	522	.2500
254	.2933	1.000	452	.1667	453	.1667	522	.3333	523	.3333		
255	.2933	1.000	453	.1667	454	.1667	455	.1667	523	.2500	524	.2500
256	.2933	1.000	455	.1667	456	.1667	457	.1667	524	.2500	525	.2500
257	.2933	1.000	457	.1667	458	.1667	459	.1667	525	.2500	526	.2500
258	.2933	1.000	459	.1667	460	.1667	461	.1667	526	.2500	527	.2500
259	.2933	1.000	461	.1667	462	.1667	463	.1667	527	.2500	528	.2500
260	.2933	1.000	463	.1667	464	.1667	465	.1667	528	.2500	529	.2500
261	.2933	1.000	465	.1667	466	.1667	467	.1667	529	.2500	530	.2500
262	.2933	1.000	467	.1667	468	.1667	469	.1667	530	.2500	531	.2500
263	.2933	1.000	469	.1667	470	.1667	531	.3333	532	.3333		
264	.2933	1.000	470	.1667	471	.1667	472	.1667	532	.2500	533	.2500
265	.2933	1.000	472	.1667	473	.1667	474	.1667	533	.2500	534	.2500
266	.2933	1.000	474	.1667	475	.1667	476	.1667	534	.2500	535	.2500
267	.2933	1.000	476	.1667	477	.1667	478	.1667	535	.2500	536	.2500
268	.2933	1.000	478	.1667	479	.1667	480	.1667	536	.2500	537	.2500
269	.2933	1.000	480	.1667	481	.1667	482	.1667	537	.2500	538	.2500
270	.2933	1.000	482	.1667	483	.1667	484	.1667	538	.2500	539	.2500
271	.2933	1.000	484	.1667	485	.1667	486	.1667	539	.2500	540	.2500
9	0	0	0	0	0	0						
156.33	0.0			.0001								0.5
397		300	300									
10	0	0	1	0	0	0						
0.01												
0.5												
11	1	1	0	0	0	0	0	0	0	0		
14.696	727.16	3.99487	.10051									
12	0	1	0	0	0	0	0	0				
1												

2) DR0302 7-집합체 계산을 위한 MATRA-LMR 입력자료 (다 집합체)

```
 30000       0       0       1       1
     1       0 (D48H120 / Multi / DR 0302, 7.44 MWth, 39.80 kg/sec)
     1       0       0       0       0       3       2
     2       0       0       0       0       1       0       0
 0.316   -0.25     0.0
  64.      -1.     0.0
     3      81       4
0.00000 0.00643 0.01929 0.03216 0.04502 0.05788 0.07074 0.08361 0.09647 0.10933
0.12219 0.13506 0.14792 0.16078 0.17364 0.18650 0.19937 0.21223 0.22509 0.23795
0.25082 0.26368 0.27654 0.28932 0.30201 0.31471 0.32740 0.34009 0.35278 0.36548
0.37817 0.39086 0.40356 0.41625 0.42894 0.44163 0.45433 0.46702 0.47971 0.49241
0.50510 0.51779 0.53049 0.54318 0.55587 0.56856 0.58126 0.59395 0.60664 0.61933
0.63201 0.64470 0.65728 0.66974 0.68220 0.69466 0.70713 0.71959 0.73205 0.74451
0.75698 0.76944 0.78190 0.79437 0.80683 0.81929 0.83175 0.84422 0.85668 0.86914
0.88160 0.89407 0.90653 0.91899 0.93146 0.94392 0.95638 0.96884 0.98131 0.99377
1.00000
0.00000 0.00015 0.00036 0.00058 0.00084 0.00115 0.00153 0.00200 0.00257 0.00328
0.00413 0.00516 0.00639 0.00782 0.00945 0.01127 0.01321 0.01518 0.01701 0.01843
0.01907 0.01836 0.01563 2.07146 2.29435 2.56883 2.84849 3.11350 3.26484 3.47169
3.64852 3.79209 3.90012 3.94016 3.97384 3.97036 3.92956 3.85209 3.78681 3.63518
3.44867 3.22982 2.98195 2.79549 2.48695 2.16155 1.83456 1.53952 0.00398 0.00420
0.00422 0.00408 0.00395 0.00379 0.00366 0.00352 0.00337 0.00321 0.00304 0.00286
0.00268 0.00249 0.00231 0.00213 0.00195 0.00178 0.00162 0.00147 0.00132 0.00118
0.00105 0.00093 0.00081 0.00070 0.00059 0.00049 0.00039 0.00030 0.00020 0.00011
0.00000
0.00000 0.00015 0.00035 0.00057 0.00083 0.00113 0.00150 0.00196 0.00252 0.00321
0.00405 0.00506 0.00626 0.00766 0.00925 0.01103 0.01292 0.01485 0.01664 0.01805
0.01871 0.01812 0.01561 2.08066 2.30292 2.57346 2.84970 3.11215 3.26316 3.46885
3.64488 3.78789 3.89548 3.93562 3.96921 3.96587 3.92548 3.84868 3.78349 3.63294
3.44765 3.23030 2.98431 2.79925 2.49347 2.17053 1.84336 1.53650 0.00377 0.00389
0.00387 0.00377 0.00373 0.00366 0.00358 0.00346 0.00332 0.00316 0.00299 0.00281
0.00263 0.00245 0.00227 0.00209 0.00192 0.00175 0.00159 0.00144 0.00130 0.00116
0.00103 0.00091 0.00080 0.00069 0.00058 0.00048 0.00039 0.00029 0.00020 0.00011
0.00000
0.00000 0.00057 0.00136 0.00221 0.00319 0.00437 0.00580 0.00756 0.00973 0.01239
0.01563 0.01953 0.02416 0.02957 0.03575 0.04264 0.05003 0.05757 0.06464 0.07030
0.07316 0.07122 0.06163 1.74646 2.03020 2.31628 2.58838 2.84170 3.38034 3.60003
3.78425 3.93331 4.04694 4.24811 4.28655 4.28361 4.23993 4.15456 3.83374 3.67937
3.49232 3.27234 3.01873 2.39391 2.12474 1.84020 1.54317 1.24869 0.01112 0.01146
0.01140 0.01111 0.01043 0.01024 0.01000 0.00967 0.00928 0.00883 0.00834 0.00783
0.00732 0.00680 0.00630 0.00580 0.00532 0.00486 0.00442 0.00400 0.00360 0.00323
0.00287 0.00253 0.00221 0.00191 0.00162 0.00134 0.00107 0.00081 0.00056 0.00031
0.00000
0.00000 0.00065 0.00155 0.00252 0.00365 0.00500 0.00665 0.00868 0.01119 0.01427
0.01802 0.02255 0.02793 0.03423 0.04144 0.04948 0.05812 0.06694 0.07523 0.08187
0.08519 0.08275 0.07120 1.83574 2.07999 2.33970 2.59545 2.83996 3.39648 3.61598
3.80111 3.95154 4.06672 4.27960 4.31842 4.31434 4.26775 4.17758 3.82305 3.66318
3.47061 3.24465 2.98419 2.29631 2.03033 1.75298 1.46727 1.19060 0.01141 0.01187
0.01193 0.01170 0.01105 0.01094 0.01079 0.01053 0.01017 0.00974 0.00926 0.00874
0.00820 0.00764 0.00709 0.00654 0.00601 0.00550 0.00501 0.00453 0.00408 0.00366
0.00326 0.00287 0.00251 0.00217 0.00184 0.00152 0.00122 0.00093 0.00064 0.00036
0.00000
     4       7       0       1
727.16  0.1465  0.1583  5.9213  156.33     397
     1     540       1       0       0       0
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     2   .0200   .4607   .4607       3   .0591   .2035      11   .0591   .2035
     3   .0200   .4607   .4607       4   .0591   .2035      14   .0591   .2035
     4   .0200   .4607   .4607       5   .0591   .2035      17   .0591   .2035
     5   .0200   .4607   .4607       6   .0591   .2035      20   .0591   .2035
     6   .0200   .4607   .4607      23   .0591   .2035
     7   .0200   .4607   .4607       8   .0591   .2035      24   .0591   .2035      26   .0591   .2035
     8   .0200   .4607   .4607       9   .0591   .2035
     9   .0200   .4607   .4607      10   .0591   .2035      28   .0591   .2035
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35	.0200	.4607	.4607	36	.0591	.2035	70	.0591	.2035			
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9	496	497	498	499	500	501	502	503	504
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 9   532   533   534   535   536   537   538   539   540
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 3 .2774 3.286 3.286     4 .0550 1.240     9 .0550 1.170
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 5 .2774 3.286 3.286     6 .0550 1.240    11 .0550 1.170
 6 .2774 3.286 3.286    12 .0550 1.170
 7 .7075 7.682 4.381     8 .0551 3.271    12 .0551 3.271
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12 .7075 7.682 4.381
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 6 .2774 3.286 3.286    12 .0550 1.170
 7 .7075 7.682 4.381     8 .0551 3.271    12 .0551 3.271
 8 .7075 7.682 4.381     9 .0551 3.271
 9 .7075 7.682 4.381    10 .0551 3.271
10 .7075 7.682 4.381    11 .0551 3.271
11 .7075 7.682 4.381    12 .0551 3.271
12 .7075 7.682 4.381
2.41738
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 1    7
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 1   11
 1   12
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 2 .2774 3.286 3.286     3 .0550 1.240     8 .0550 1.170
 3 .2774 3.286 3.286     4 .0550 1.240     9 .0550 1.170
 4 .2774 3.286 3.286     5 .0550 1.240    10 .0550 1.170
 5 .2774 3.286 3.286     6 .0550 1.240    11 .0550 1.170
 6 .2774 3.286 3.286    12 .0550 1.170
 7 .7075 7.682 4.381     8 .0551 3.271    12 .0551 3.271
 8 .7075 7.682 4.381     9 .0551 3.271
 9 .7075 7.682 4.381    10 .0551 3.271
10 .7075 7.682 4.381    11 .0551 3.271
11 .7075 7.682 4.381    12 .0551 3.271
12 .7075 7.682 4.381
2.41738
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 9    .7075   7.682   4.381   10   .0551   3.271
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2.34966
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 1     12
 7     12       4       0     0      0
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12    .7075   7.682   4.381
2.34966
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 2    .0485   -.584    .084
 3    .0485   -.250    .750
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27	.0485	-.584	.084
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29	.0485	-.417	.917
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128	.2933	1.000	217	.1667	294	.1667	295	.1667	296	.1667	383	.1667	384	.1667
129	.2933	1.000	217	.1667	218	.1667	219	.1667	296	.1667	297	.1667	298	.1667
130	.2933	1.000	219	.1667	220	.1667	221	.1667	298	.1667	299	.1667	300	.1667
131	.2933	1.000	221	.1667	222	.1667	223	.1667	300	.1667	301	.1667	302	.1667
132	.2933	1.000	223	.1667	224	.1667	225	.1667	302	.1667	303	.1667	304	.1667
133	.2933	1.000	225	.1667	226	.1667	227	.1667	304	.1667	305	.1667	306	.1667
134	.2933	1.000	227	.1667	228	.1667	229	.1667	306	.1667	307	.1667	308	.1667
135	.2933	1.000	229	.1667	230	.1667	308	.1667	309	.1667	310	.1667	311	.1667
136	.2933	1.000	230	.1667	231	.1667	232	.1667	311	.1667	312	.1667	313	.1667
137	.2933	1.000	232	.1667	233	.1667	234	.1667	313	.1667	314	.1667	315	.1667
138	.2933	1.000	234	.1667	235	.1667	236	.1667	315	.1667	316	.1667	317	.1667
139	.2933	1.000	236	.1667	237	.1667	238	.1667	317	.1667	318	.1667	319	.1667
140	.2933	1.000	238	.1667	239	.1667	240	.1667	319	.1667	320	.1667	321	.1667
141	.2933	1.000	240	.1667	241	.1667	242	.1667	321	.1667	322	.1667	323	.1667
142	.2933	1.000	242	.1667	243	.1667	323	.1667	324	.1667	325	.1667	326	.1667

143	.2933	1.000	243	.1667	244	.1667	245	.1667	326	.1667	327	.1667	328	.1667
144	.2933	1.000	245	.1667	246	.1667	247	.1667	328	.1667	329	.1667	330	.1667
145	.2933	1.000	247	.1667	248	.1667	249	.1667	330	.1667	331	.1667	332	.1667
146	.2933	1.000	249	.1667	250	.1667	251	.1667	332	.1667	333	.1667	334	.1667
147	.2933	1.000	251	.1667	252	.1667	253	.1667	334	.1667	335	.1667	336	.1667
148	.2933	1.000	253	.1667	254	.1667	255	.1667	336	.1667	337	.1667	338	.1667
149	.2933	1.000	255	.1667	256	.1667	338	.1667	339	.1667	340	.1667	341	.1667
150	.2933	1.000	256	.1667	257	.1667	258	.1667	341	.1667	342	.1667	343	.1667
151	.2933	1.000	258	.1667	259	.1667	260	.1667	343	.1667	344	.1667	345	.1667
152	.2933	1.000	260	.1667	261	.1667	262	.1667	345	.1667	346	.1667	347	.1667
153	.2933	1.000	262	.1667	263	.1667	264	.1667	347	.1667	348	.1667	349	.1667
154	.2933	1.000	264	.1667	265	.1667	266	.1667	349	.1667	350	.1667	351	.1667
155	.2933	1.000	266	.1667	267	.1667	268	.1667	351	.1667	352	.1667	353	.1667
156	.2933	1.000	268	.1667	269	.1667	353	.1667	354	.1667	355	.1667	356	.1667
157	.2933	1.000	269	.1667	270	.1667	271	.1667	356	.1667	357	.1667	358	.1667
158	.2933	1.000	271	.1667	272	.1667	273	.1667	358	.1667	359	.1667	360	.1667
159	.2933	1.000	273	.1667	274	.1667	275	.1667	360	.1667	361	.1667	362	.1667
160	.2933	1.000	275	.1667	276	.1667	277	.1667	362	.1667	363	.1667	364	.1667
161	.2933	1.000	277	.1667	278	.1667	279	.1667	364	.1667	365	.1667	366	.1667
162	.2933	1.000	279	.1667	280	.1667	281	.1667	366	.1667	367	.1667	368	.1667
163	.2933	1.000	281	.1667	282	.1667	368	.1667	369	.1667	370	.1667	371	.1667
164	.2933	1.000	282	.1667	283	.1667	284	.1667	371	.1667	372	.1667	373	.1667
165	.2933	1.000	284	.1667	285	.1667	286	.1667	373	.1667	374	.1667	375	.1667
166	.2933	1.000	286	.1667	287	.1667	288	.1667	375	.1667	376	.1667	377	.1667
167	.2933	1.000	288	.1667	289	.1667	290	.1667	377	.1667	378	.1667	379	.1667
168	.2933	1.000	290	.1667	291	.1667	292	.1667	379	.1667	380	.1667	381	.1667
169	.2933	1.000	292	.1667	293	.1667	294	.1667	381	.1667	382	.1667	383	.1667
170	.2933	1.000	295	.1667	384	.1667	385	.1667	386	.1667	485	.1667	486	.1667
171	.2933	1.000	295	.1667	296	.1667	297	.1667	386	.1667	387	.1667	388	.1667
172	.2933	1.000	297	.1667	298	.1667	299	.1667	388	.1667	389	.1667	390	.1667
173	.2933	1.000	299	.1667	300	.1667	301	.1667	390	.1667	391	.1667	392	.1667
174	.2933	1.000	301	.1667	302	.1667	303	.1667	392	.1667	393	.1667	394	.1667
175	.2933	1.000	303	.1667	304	.1667	305	.1667	394	.1667	395	.1667	396	.1667
176	.2933	1.000	305	.1667	306	.1667	307	.1667	396	.1667	397	.1667	398	.1667
177	.2933	1.000	307	.1667	308	.1667	309	.1667	398	.1667	399	.1667	400	.1667
178	.2933	1.000	309	.1667	310	.1667	400	.1667	401	.1667	402	.1667	403	.1667
179	.2933	1.000	310	.1667	311	.1667	312	.1667	403	.1667	404	.1667	405	.1667
180	.2933	1.000	312	.1667	313	.1667	314	.1667	405	.1667	406	.1667	407	.1667
181	.2933	1.000	314	.1667	315	.1667	316	.1667	407	.1667	408	.1667	409	.1667
182	.2933	1.000	316	.1667	317	.1667	318	.1667	409	.1667	410	.1667	411	.1667
183	.2933	1.000	318	.1667	319	.1667	320	.1667	411	.1667	412	.1667	413	.1667
184	.2933	1.000	320	.1667	321	.1667	322	.1667	413	.1667	414	.1667	415	.1667
185	.2933	1.000	322	.1667	323	.1667	324	.1667	415	.1667	416	.1667	417	.1667
186	.2933	1.000	324	.1667	325	.1667	417	.1667	418	.1667	419	.1667	420	.1667
187	.2933	1.000	325	.1667	326	.1667	327	.1667	420	.1667	421	.1667	422	.1667
188	.2933	1.000	327	.1667	328	.1667	329	.1667	422	.1667	423	.1667	424	.1667
189	.2933	1.000	329	.1667	330	.1667	331	.1667	424	.1667	425	.1667	426	.1667
190	.2933	1.000	331	.1667	332	.1667	333	.1667	426	.1667	427	.1667	428	.1667
191	.2933	1.000	333	.1667	334	.1667	335	.1667	428	.1667	429	.1667	430	.1667
192	.2933	1.000	335	.1667	336	.1667	337	.1667	430	.1667	431	.1667	432	.1667
193	.2933	1.000	337	.1667	338	.1667	339	.1667	432	.1667	433	.1667	434	.1667
194	.2933	1.000	339	.1667	340	.1667	434	.1667	435	.1667	436	.1667	437	.1667
195	.2933	1.000	340	.1667	341	.1667	342	.1667	437	.1667	438	.1667	439	.1667
196	.2933	1.000	342	.1667	343	.1667	344	.1667	439	.1667	440	.1667	441	.1667
197	.2933	1.000	344	.1667	345	.1667	346	.1667	441	.1667	442	.1667	443	.1667
198	.2933	1.000	346	.1667	347	.1667	348	.1667	443	.1667	444	.1667	445	.1667
199	.2933	1.000	348	.1667	349	.1667	350	.1667	445	.1667	446	.1667	447	.1667
200	.2933	1.000	350	.1667	351	.1667	352	.1667	447	.1667	448	.1667	449	.1667
201	.2933	1.000	352	.1667	353	.1667	354	.1667	449	.1667	450	.1667	451	.1667
202	.2933	1.000	354	.1667	355	.1667	451	.1667	452	.1667	453	.1667	454	.1667
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205	.2933	1.000	359	.1667	360	.1667	361	.1667	458	.1667	459	.1667	460	.1667
206	.2933	1.000	361	.1667	362	.1667	363	.1667	460	.1667	461	.1667	462	.1667
207	.2933	1.000	363	.1667	364	.1667	365	.1667	462	.1667	463	.1667	464	.1667
208	.2933	1.000	365	.1667	366	.1667	367	.1667	464	.1667	465	.1667	466	.1667
209	.2933	1.000	367	.1667	368	.1667	369	.1667	466	.1667	467	.1667	468	.1667

210	.2933	1.000	369	.1667	370	.1667	468	.1667	469	.1667	470	.1667	471	.1667
211	.2933	1.000	370	.1667	371	.1667	372	.1667	471	.1667	472	.1667	473	.1667
212	.2933	1.000	372	.1667	373	.1667	374	.1667	473	.1667	474	.1667	475	.1667
213	.2933	1.000	374	.1667	375	.1667	376	.1667	475	.1667	476	.1667	477	.1667
214	.2933	1.000	376	.1667	377	.1667	378	.1667	477	.1667	478	.1667	479	.1667
215	.2933	1.000	378	.1667	379	.1667	380	.1667	479	.1667	480	.1667	481	.1667
216	.2933	1.000	380	.1667	381	.1667	382	.1667	481	.1667	482	.1667	483	.1667
217	.2933	1.000	382	.1667	383	.1667	384	.1667	483	.1667	484	.1667	485	.1667
218	.2933	1.000	385	.1667	486	.1667	487	.3333	540	.3333				
219	.2933	1.000	385	.1667	386	.1667	387	.1667	487	.2500	488	.2500		
220	.2933	1.000	387	.1667	388	.1667	389	.1667	488	.2500	489	.2500		
221	.2933	1.000	389	.1667	390	.1667	391	.1667	489	.2500	490	.2500		
222	.2933	1.000	391	.1667	392	.1667	393	.1667	490	.2500	491	.2500		
223	.2933	1.000	393	.1667	394	.1667	395	.1667	491	.2500	492	.2500		
224	.2933	1.000	395	.1667	396	.1667	397	.1667	492	.2500	493	.2500		
225	.2933	1.000	397	.1667	398	.1667	399	.1667	493	.2500	494	.2500		
226	.2933	1.000	399	.1667	400	.1667	401	.1667	494	.2500	495	.2500		
227	.2933	1.000	401	.1667	402	.1667	495	.3333	496	.3333				
228	.2933	1.000	402	.1667	403	.1667	404	.1667	496	.2500	497	.2500		
229	.2933	1.000	404	.1667	405	.1667	406	.1667	497	.2500	498	.2500		
230	.2933	1.000	406	.1667	407	.1667	408	.1667	498	.2500	499	.2500		
231	.2933	1.000	408	.1667	409	.1667	410	.1667	499	.2500	500	.2500		
232	.2933	1.000	410	.1667	411	.1667	412	.1667	500	.2500	501	.2500		
233	.2933	1.000	412	.1667	413	.1667	414	.1667	501	.2500	502	.2500		
234	.2933	1.000	414	.1667	415	.1667	416	.1667	502	.2500	503	.2500		
235	.2933	1.000	416	.1667	417	.1667	418	.1667	503	.2500	504	.2500		
236	.2933	1.000	418	.1667	419	.1667	504	.3333	505	.3333				
237	.2933	1.000	419	.1667	420	.1667	421	.1667	505	.2500	506	.2500		
238	.2933	1.000	421	.1667	422	.1667	423	.1667	506	.2500	507	.2500		
239	.2933	1.000	423	.1667	424	.1667	425	.1667	507	.2500	508	.2500		
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241	.2933	1.000	427	.1667	428	.1667	429	.1667	509	.2500	510	.2500		
242	.2933	1.000	429	.1667	430	.1667	431	.1667	510	.2500	511	.2500		
243	.2933	1.000	431	.1667	432	.1667	433	.1667	511	.2500	512	.2500		
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245	.2933	1.000	435	.1667	436	.1667	513	.3333	514	.3333				
246	.2933	1.000	436	.1667	437	.1667	438	.1667	514	.2500	515	.2500		
247	.2933	1.000	438	.1667	439	.1667	440	.1667	515	.2500	516	.2500		
248	.2933	1.000	440	.1667	441	.1667	442	.1667	516	.2500	517	.2500		
249	.2933	1.000	442	.1667	443	.1667	444	.1667	517	.2500	518	.2500		
250	.2933	1.000	444	.1667	445	.1667	446	.1667	518	.2500	519	.2500		
251	.2933	1.000	446	.1667	447	.1667	448	.1667	519	.2500	520	.2500		
252	.2933	1.000	448	.1667	449	.1667	450	.1667	520	.2500	521	.2500		
253	.2933	1.000	450	.1667	451	.1667	452	.1667	521	.2500	522	.2500		
254	.2933	1.000	452	.1667	453	.1667	522	.3333	523	.3333				
255	.2933	1.000	453	.1667	454	.1667	455	.1667	523	.2500	524	.2500		
256	.2933	1.000	455	.1667	456	.1667	457	.1667	524	.2500	525	.2500		
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263	.2933	1.000	469	.1667	470	.1667	531	.3333	532	.3333				
264	.2933	1.000	470	.1667	471	.1667	472	.1667	532	.2500	533	.2500		
265	.2933	1.000	472	.1667	473	.1667	474	.1667	533	.2500	534	.2500		
266	.2933	1.000	474	.1667	475	.1667	476	.1667	534	.2500	535	.2500		
267	.2933	1.000	476	.1667	477	.1667	478	.1667	535	.2500	536	.2500		
268	.2933	1.000	478	.1667	479	.1667	480	.1667	536	.2500	537	.2500		
269	.2933	1.000	480	.1667	481	.1667	482	.1667	537	.2500	538	.2500		
270	.2933	1.000	482	.1667	483	.1667	484	.1667	538	.2500	539	.2500		
271	.2933	1.000	484	.1667	485	.1667	486	.1667	539	.2500	540	.2500		
2	7	0												
1	2.092	1.000	1	.1667	2	.1667	3	.1667	4	.1667	5	.1667	6	.1667
2	2.092	1.000	1	.1667	6	.1667	7	.3333	12	.3333				
3	2.092	1.000	1	.1667	2	.1667	7	.3333	8	.3333				
4	2.092	1.000	2	.1667	3	.1667	8	.3333	9	.3333				

5	2.092	1.000	3	.1667	4	.1667	9	.3333	10	.3333				
6	2.092	1.000	4	.1667	5	.1667	10	.3333	11	.3333				
7	2.092	1.000	5	.1667	6	.1667	11	.3333	12	.3333				
3	7	0												
1	2.092	1.000	1	.1667	2	.1667	3	.1667	4	.1667	5	.1667	6	.1667
2	2.092	1.000	1	.1667	6	.1667	7	.3333	12	.3333				
3	2.092	1.000	1	.1667	2	.1667	7	.3333	8	.3333				
4	2.092	1.000	2	.1667	3	.1667	8	.3333	9	.3333				
5	2.092	1.000	3	.1667	4	.1667	9	.3333	10	.3333				
6	2.092	1.000	4	.1667	5	.1667	10	.3333	11	.3333				
7	2.092	1.000	5	.1667	6	.1667	11	.3333	12	.3333				
4	7	0												
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2	2.092	1.000	1	.1667	6	.1667	7	.3333	12	.3333				
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4	2.092	1.000	2	.1667	3	.1667	8	.3333	9	.3333				
5	2.092	1.000	3	.1667	4	.1667	9	.3333	10	.3333				
6	2.092	1.000	4	.1667	5	.1667	10	.3333	11	.3333				
7	2.092	1.000	5	.1667	6	.1667	11	.3333	12	.3333				
5	7	0												
1	2.092	1.000	1	.1667	2	.1667	3	.1667	4	.1667	5	.1667	6	.1667
2	2.092	1.000	1	.1667	6	.1667	7	.3333	12	.3333				
3	2.092	1.000	1	.1667	2	.1667	7	.3333	8	.3333				
4	2.092	1.000	2	.1667	3	.1667	8	.3333	9	.3333				
5	2.092	1.000	3	.1667	4	.1667	9	.3333	10	.3333				
6	2.092	1.000	4	.1667	5	.1667	10	.3333	11	.3333				
7	2.092	1.000	5	.1667	6	.1667	11	.3333	12	.3333				
6	7	0												
1	2.092	1.000	1	.1667	2	.1667	3	.1667	4	.1667	5	.1667	6	.1667
2	2.092	1.000	1	.1667	6	.1667	7	.3333	12	.3333				
3	2.092	1.000	1	.1667	2	.1667	7	.3333	8	.3333				
4	2.092	1.000	2	.1667	3	.1667	8	.3333	9	.3333				
5	2.092	1.000	3	.1667	4	.1667	9	.3333	10	.3333				
6	2.092	1.000	4	.1667	5	.1667	10	.3333	11	.3333				
7	2.092	1.000	5	.1667	6	.1667	11	.3333	12	.3333				
7	7	0												
1	2.092	1.000	1	.1667	2	.1667	3	.1667	4	.1667	5	.1667	6	.1667
2	2.092	1.000	1	.1667	6	.1667	7	.3333	12	.3333				
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4	2.092	1.000	2	.1667	3	.1667	8	.3333	9	.3333				
5	2.092	1.000	3	.1667	4	.1667	9	.3333	10	.3333				
6	2.092	1.000	4	.1667	5	.1667	10	.3333	11	.3333				
7	2.092	1.000	5	.1667	6	.1667	11	.3333	12	.3333				
9	0	0	0	0	0	0								
156.33	0.0			.0001								0.5		
397		300	300											
10	0	0	1	0	0	0								
0.01														
0.5														
11	1	1	0	0	0	0	0	0	0	0				
14.696	727.16													
27.2473	27.2922	7.52139	7.52139	27.2922	7.39595	7.39595								
0.10051	0.54658	0.15063	0.15063	0.54658	0.14812	0.14812								
12	0	1	0	0	0	0	0	0						
1														

3) RB0602 7-집합체 계산을 위한 MATRA-LMR 입력자료 (단일 집합체)

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 30000      0      0      1      0
     1      0 (D48H120 / 127 pin / RB 0602, 1.44 MWth, 8.70 kg/sec)
     1      0      0      0      0      3      2
     2      0      0      0      0      1      0      0
 0.316  -0.25    0.0
   64.     -1.    0.0
     3     81
 0.00000 0.00643 0.01929 0.03216 0.04502 0.05788 0.07074 0.08361 0.09647 0.10933
 0.12219 0.13506 0.14792 0.16078 0.17364 0.18650 0.19937 0.21223 0.22509 0.23795
 0.25082 0.26368 0.27654 0.28932 0.30201 0.31471 0.32740 0.34009 0.35278 0.36548
 0.37817 0.39086 0.40356 0.41625 0.42894 0.44163 0.45433 0.46702 0.47971 0.49241
 0.50510 0.51779 0.53049 0.54318 0.55587 0.56856 0.58126 0.59395 0.60664 0.61933
 0.63201 0.64470 0.65728 0.66974 0.68220 0.69466 0.70713 0.71959 0.73205 0.74451
 0.75698 0.76944 0.78190 0.79437 0.80683 0.81929 0.83175 0.84422 0.85668 0.86914
 0.88160 0.89407 0.90653 0.91899 0.93146 0.94392 0.95638 0.96884 0.98131 0.99377
 1.00000
 0.00000 0.00053 0.00126 0.00205 0.00296 0.00404 0.00535 0.00696 0.00894 0.01136
 0.01430 0.01782 0.02200 0.02686 0.03241 0.03857 0.04516 0.05184 0.05807 0.06294
 0.06513 0.06268 0.05290 1.97058 2.01556 2.27281 2.53026 2.77735 3.37232 3.59589
 3.78350 3.93572 4.05272 4.27825 4.31925 4.31724 4.27289 4.18518 3.83414 3.67792
 3.49018 3.27027 3.01730 2.35119 2.09387 1.83067 1.57096 1.34697 0.01170 0.01268
 0.01297 0.01268 0.01174 0.01127 0.01080 0.01032 0.00982 0.00930 0.00877 0.00823
 0.00769 0.00715 0.00663 0.00612 0.00563 0.00515 0.00470 0.00427 0.00386 0.00346
 0.00309 0.00273 0.00240 0.00207 0.00176 0.00146 0.00117 0.00089 0.00062 0.00035
 0.00000
     4    252    252      0      0      0      0
     1  .0258  .7471  .7471      2  .0390  .2971      6  .0390  .2971      8  .0390  .2971
     2  .0258  .7471  .7471      3  .0390  .2971     11  .0390  .2971
     3  .0258  .7471  .7471      4  .0390  .2971     14  .0390  .2971
     4  .0258  .7471  .7471      5  .0390  .2971     17  .0390  .2971
     5  .0258  .7471  .7471      6  .0390  .2971     20  .0390  .2971
     6  .0258  .7471  .7471     23  .0390  .2971
     7  .0258  .7471  .7471      8  .0390  .2971     24  .0390  .2971     26  .0390  .2971
     8  .0258  .7471  .7471      9  .0390  .2971
     9  .0258  .7471  .7471     10  .0390  .2971     28  .0390  .2971
    10  .0258  .7471  .7471     11  .0390  .2971     31  .0390  .2971
    11  .0258  .7471  .7471     12  .0390  .2971
    12  .0258  .7471  .7471     13  .0390  .2971     33  .0390  .2971
    13  .0258  .7471  .7471     14  .0390  .2971     36  .0390  .2971
    14  .0258  .7471  .7471     15  .0390  .2971
    15  .0258  .7471  .7471     16  .0390  .2971     38  .0390  .2971
    16  .0258  .7471  .7471     17  .0390  .2971     41  .0390  .2971
    17  .0258  .7471  .7471     18  .0390  .2971
    18  .0258  .7471  .7471     19  .0390  .2971     43  .0390  .2971
    19  .0258  .7471  .7471     20  .0390  .2971     46  .0390  .2971
    20  .0258  .7471  .7471     21  .0390  .2971
    21  .0258  .7471  .7471     22  .0390  .2971     48  .0390  .2971
    22  .0258  .7471  .7471     23  .0390  .2971     51  .0390  .2971
    23  .0258  .7471  .7471     24  .0390  .2971
    24  .0258  .7471  .7471     53  .0390  .2971
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    27  .0258  .7471  .7471     28  .0390  .2971     58  .0390  .2971
    28  .0258  .7471  .7471     29  .0390  .2971
    29  .0258  .7471  .7471     30  .0390  .2971     60  .0390  .2971
    30  .0258  .7471  .7471     31  .0390  .2971     63  .0390  .2971
    31  .0258  .7471  .7471     32  .0390  .2971
    32  .0258  .7471  .7471     33  .0390  .2971     65  .0390  .2971
    33  .0258  .7471  .7471     34  .0390  .2971
    34  .0258  .7471  .7471     35  .0390  .2971     67  .0390  .2971
    35  .0258  .7471  .7471     36  .0390  .2971     70  .0390  .2971
    36  .0258  .7471  .7471     37  .0390  .2971
    37  .0258  .7471  .7471     38  .0390  .2971     72  .0390  .2971
    38  .0258  .7471  .7471     39  .0390  .2971
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42	.0258	.7471	.7471	43	.0390	.2971	79	.0390	.2971			
43	.0258	.7471	.7471	44	.0390	.2971						
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66	.0258	.7471	.7471	67	.0390	.2971	111	.0390	.2971			
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162	.0258	.7471	.7471	163	.0390	.2971	223	.0390	.2918			
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171	.0258	.7471	.7471	172	.0390	.2971						
172	.0258	.7471	.7471	173	.0390	.2971	228	.0390	.2918			

173	.0258	.7471	.7471	174	.0390	.2971	229	.0390	.2918
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208	.0258	.7471	.7471	209	.0390	.2971	248	.0390	.2918
209	.0258	.7471	.7471	210	.0390	.2971			
210	.0258	.7471	.7471	211	.0390	.2971	249	.0390	.2918
211	.0258	.7471	.7471	212	.0390	.2971			
212	.0258	.7471	.7471	213	.0390	.2971	250	.0390	.2918
213	.0258	.7471	.7471	214	.0390	.2971			
214	.0258	.7471	.7471	215	.0390	.2971	251	.0390	.2918
215	.0258	.7471	.7471	216	.0390	.2971			
216	.0258	.7471	.7471	252	.0390	.2918			
217	.0653	1.536	.8716	218	.0488	.5146	252	.0488	.7892
218	.0586	1.262	.7471	219	.0488	.5146			
219	.0586	1.262	.7471	220	.0488	.5146			
220	.0586	1.262	.7471	221	.0488	.5146			
221	.0586	1.262	.7471	222	.0488	.5146			
222	.0653	1.536	.8716	223	.0488	.7892			
223	.0653	1.536	.8716	224	.0488	.5146			
224	.0586	1.262	.7471	225	.0488	.5146			
225	.0586	1.262	.7471	226	.0488	.5146			
226	.0586	1.262	.7471	227	.0488	.5146			
227	.0586	1.262	.7471	228	.0488	.5146			
228	.0653	1.536	.8716	229	.0488	.7892			
229	.0653	1.536	.8716	230	.0488	.5146			
230	.0586	1.262	.7471	231	.0488	.5146			
231	.0586	1.262	.7471	232	.0488	.5146			
232	.0586	1.262	.7471	233	.0488	.5146			
233	.0586	1.262	.7471	234	.0488	.5146			
234	.0653	1.536	.8716	235	.0488	.7892			
235	.0653	1.536	.8716	236	.0488	.5146			
236	.0586	1.262	.7471	237	.0488	.5146			
237	.0586	1.262	.7471	238	.0488	.5146			
238	.0586	1.262	.7471	239	.0488	.5146			
239	.0586	1.262	.7471	240	.0488	.5146			

240	.0653	1.536	.8716	241	.0488	.7892
241	.0653	1.536	.8716	242	.0488	.5146
242	.0586	1.262	.7471	243	.0488	.5146
243	.0586	1.262	.7471	244	.0488	.5146
244	.0586	1.262	.7471	245	.0488	.5146
245	.0586	1.262	.7471	246	.0488	.5146
246	.0653	1.536	.8716	247	.0488	.7892
247	.0653	1.536	.8716	248	.0488	.5146
248	.0586	1.262	.7471	249	.0488	.5146
249	.0586	1.262	.7471	250	.0488	.5146
250	.0586	1.262	.7471	251	.0488	.5146
251	.0586	1.262	.7471	252	.0488	.5146
252	.0653	1.536	.8716			
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11.8858	.47559	.03780	.51457			
1	.0485	-.917	.417			
2	.0485	-.584	.084			
3	.0485	-.250	.750			
4	.0485	-.750	.250			
5	.0485	-.084	.584			
6	.0485	-.584	.084			
7	.0485	-.917	.417			
8	.0485	-.417	.917			
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10	.0485	-.250	.750			
11	.0485	-.584	.084			
12	.0485	-.417	.917			
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16	.0485	-.084	.584			
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23	.4756	1.000	29	.1667	30	.1667	60	.1667	61	.1667	62	.1667	63	.1667	
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32	.4756	1.000	44	.1667	45	.1667	81	.1667	82	.1667	83	.1667	84	.1667	
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37	.4756	1.000	52	.1667	53	.1667	54	.1667	93	.1667	94	.1667	95	.1667	
38	.4756	1.000	55	.1667	96	.1667	97	.1667	98	.1667	149	.1667	150	.1667	
39	.4756	1.000	55	.1667	56	.1667	57	.1667	98	.1667	99	.1667	100	.1667	
40	.4756	1.000	57	.1667	58	.1667	59	.1667	100	.1667	101	.1667	102	.1667	
41	.4756	1.000	59	.1667	60	.1667	61	.1667	102	.1667	103	.1667	104	.1667	
42	.4756	1.000	61	.1667	62	.1667	104	.1667	105	.1667	106	.1667	107	.1667	
43	.4756	1.000	62	.1667	63	.1667	64	.1667	107	.1667	108	.1667	109	.1667	
44	.4756	1.000	64	.1667	65	.1667	66	.1667	109	.1667	110	.1667	111	.1667	
45	.4756	1.000	66	.1667	67	.1667	68	.1667	111	.1667	112	.1667	113	.1667	
46	.4756	1.000	68	.1667	69	.1667	113	.1667	114	.1667	115	.1667	116	.1667	
47	.4756	1.000	69	.1667	70	.1667	71	.1667	116	.1667	117	.1667	118	.1667	
48	.4756	1.000	71	.1667	72	.1667	73	.1667	118	.1667	119	.1667	120	.1667	
49	.4756	1.000	73	.1667	74	.1667	75	.1667	120	.1667	121	.1667	122	.1667	

50	.4756	1.000	75	.1667	76	.1667	122	.1667	123	.1667	124	.1667	125	.1667
51	.4756	1.000	76	.1667	77	.1667	78	.1667	125	.1667	126	.1667	127	.1667
52	.4756	1.000	78	.1667	79	.1667	80	.1667	127	.1667	128	.1667	129	.1667
53	.4756	1.000	80	.1667	81	.1667	82	.1667	129	.1667	130	.1667	131	.1667
54	.4756	1.000	82	.1667	83	.1667	131	.1667	132	.1667	133	.1667	134	.1667
55	.4756	1.000	83	.1667	84	.1667	85	.1667	134	.1667	135	.1667	136	.1667
56	.4756	1.000	85	.1667	86	.1667	87	.1667	136	.1667	137	.1667	138	.1667
57	.4756	1.000	87	.1667	88	.1667	89	.1667	138	.1667	139	.1667	140	.1667
58	.4756	1.000	89	.1667	90	.1667	140	.1667	141	.1667	142	.1667	143	.1667
59	.4756	1.000	90	.1667	91	.1667	92	.1667	143	.1667	144	.1667	145	.1667
60	.4756	1.000	92	.1667	93	.1667	94	.1667	145	.1667	146	.1667	147	.1667
61	.4756	1.000	94	.1667	95	.1667	96	.1667	147	.1667	148	.1667	149	.1667
62	.4756	1.000	97	.1667	150	.1667	151	.1667	152	.1667	215	.1667	216	.1667
63	.4756	1.000	97	.1667	98	.1667	99	.1667	152	.1667	153	.1667	154	.1667
64	.4756	1.000	99	.1667	100	.1667	101	.1667	154	.1667	155	.1667	156	.1667
65	.4756	1.000	101	.1667	102	.1667	103	.1667	156	.1667	157	.1667	158	.1667
66	.4756	1.000	103	.1667	104	.1667	105	.1667	158	.1667	159	.1667	160	.1667
67	.4756	1.000	105	.1667	106	.1667	160	.1667	161	.1667	162	.1667	163	.1667
68	.4756	1.000	106	.1667	107	.1667	108	.1667	163	.1667	164	.1667	165	.1667
69	.4756	1.000	108	.1667	109	.1667	110	.1667	165	.1667	166	.1667	167	.1667
70	.4756	1.000	110	.1667	111	.1667	112	.1667	167	.1667	168	.1667	169	.1667
71	.4756	1.000	112	.1667	113	.1667	114	.1667	169	.1667	170	.1667	171	.1667
72	.4756	1.000	114	.1667	115	.1667	171	.1667	172	.1667	173	.1667	174	.1667
73	.4756	1.000	115	.1667	116	.1667	117	.1667	174	.1667	175	.1667	176	.1667
74	.4756	1.000	117	.1667	118	.1667	119	.1667	176	.1667	177	.1667	178	.1667
75	.4756	1.000	119	.1667	120	.1667	121	.1667	178	.1667	179	.1667	180	.1667
76	.4756	1.000	121	.1667	122	.1667	123	.1667	180	.1667	181	.1667	182	.1667
77	.4756	1.000	123	.1667	124	.1667	182	.1667	183	.1667	184	.1667	185	.1667
78	.4756	1.000	124	.1667	125	.1667	126	.1667	185	.1667	186	.1667	187	.1667
79	.4756	1.000	126	.1667	127	.1667	128	.1667	187	.1667	188	.1667	189	.1667
80	.4756	1.000	128	.1667	129	.1667	130	.1667	189	.1667	190	.1667	191	.1667
81	.4756	1.000	130	.1667	131	.1667	132	.1667	191	.1667	192	.1667	193	.1667
82	.4756	1.000	132	.1667	133	.1667	193	.1667	194	.1667	195	.1667	196	.1667
83	.4756	1.000	133	.1667	134	.1667	135	.1667	196	.1667	197	.1667	198	.1667
84	.4756	1.000	135	.1667	136	.1667	137	.1667	198	.1667	199	.1667	200	.1667
85	.4756	1.000	137	.1667	138	.1667	139	.1667	200	.1667	201	.1667	202	.1667
86	.4756	1.000	139	.1667	140	.1667	141	.1667	202	.1667	203	.1667	204	.1667
87	.4756	1.000	141	.1667	142	.1667	204	.1667	205	.1667	206	.1667	207	.1667
88	.4756	1.000	142	.1667	143	.1667	144	.1667	207	.1667	208	.1667	209	.1667
89	.4756	1.000	144	.1667	145	.1667	146	.1667	209	.1667	210	.1667	211	.1667
90	.4756	1.000	146	.1667	147	.1667	148	.1667	211	.1667	212	.1667	213	.1667
91	.4756	1.000	148	.1667	149	.1667	150	.1667	213	.1667	214	.1667	215	.1667
92	.4756	1.000	151	.1667	216	.1667	217	.3333	252	.3333				
93	.4756	1.000	151	.1667	152	.1667	153	.1667	217	.2500	218	.2500		
94	.4756	1.000	153	.1667	154	.1667	155	.1667	218	.2500	219	.2500		
95	.4756	1.000	155	.1667	156	.1667	157	.1667	219	.2500	220	.2500		
96	.4756	1.000	157	.1667	158	.1667	159	.1667	220	.2500	221	.2500		
97	.4756	1.000	159	.1667	160	.1667	161	.1667	221	.2500	222	.2500		
98	.4756	1.000	161	.1667	162	.1667	222	.3333	223	.3333				
99	.4756	1.000	162	.1667	163	.1667	164	.1667	223	.2500	224	.2500		
100	.4756	1.000	164	.1667	165	.1667	166	.1667	224	.2500	225	.2500		
101	.4756	1.000	166	.1667	167	.1667	168	.1667	225	.2500	226	.2500		
102	.4756	1.000	168	.1667	169	.1667	170	.1667	226	.2500	227	.2500		
103	.4756	1.000	170	.1667	171	.1667	172	.1667	227	.2500	228	.2500		
104	.4756	1.000	172	.1667	173	.1667	228	.3333	229	.3333				
105	.4756	1.000	173	.1667	174	.1667	175	.1667	229	.2500	230	.2500		
106	.4756	1.000	175	.1667	176	.1667	177	.1667	230	.2500	231	.2500		
107	.4756	1.000	177	.1667	178	.1667	179	.1667	231	.2500	232	.2500		
108	.4756	1.000	179	.1667	180	.1667	181	.1667	232	.2500	233	.2500		
109	.4756	1.000	181	.1667	182	.1667	183	.1667	233	.2500	234	.2500		
110	.4756	1.000	183	.1667	184	.1667	234	.3333	235	.3333				
111	.4756	1.000	184	.1667	185	.1667	186	.1667	235	.2500	236	.2500		
112	.4756	1.000	186	.1667	187	.1667	188	.1667	236	.2500	237	.2500		
113	.4756	1.000	188	.1667	189	.1667	190	.1667	237	.2500	238	.2500		
114	.4756	1.000	190	.1667	191	.1667	192	.1667	238	.2500	239	.2500		
115	.4756	1.000	192	.1667	193	.1667	194	.1667	239	.2500	240	.2500		
116	.4756	1.000	194	.1667	195	.1667	240	.3333	241	.3333				

117	.4756	1.000	195	.1667	196	.1667	197	.1667	241	.2500	242	.2500
118	.4756	1.000	197	.1667	198	.1667	199	.1667	242	.2500	243	.2500
119	.4756	1.000	199	.1667	200	.1667	201	.1667	243	.2500	244	.2500
120	.4756	1.000	201	.1667	202	.1667	203	.1667	244	.2500	245	.2500
121	.4756	1.000	203	.1667	204	.1667	205	.1667	245	.2500	246	.2500
122	.4756	1.000	205	.1667	206	.1667	246	.3333	247	.3333		
123	.4756	1.000	206	.1667	207	.1667	208	.1667	247	.2500	248	.2500
124	.4756	1.000	208	.1667	209	.1667	210	.1667	248	.2500	249	.2500
125	.4756	1.000	210	.1667	211	.1667	212	.1667	249	.2500	250	.2500
126	.4756	1.000	212	.1667	213	.1667	214	.1667	250	.2500	251	.2500
127	.4756	1.000	214	.1667	215	.1667	216	.1667	251	.2500	252	.2500
9	0	0	0	0	0	0						
156.33	0.0			.0001								0.5
397		300	300									
10	0	0	1	0	0	0						
0.01												
0.5												
11	1	1	0	0	0	0	0	0	0	0		
14.696	727.16	1.30480	.025684									
12	0	0	0	0	0	0	0	0				

4) RB0602 7-집합체 계산을 위한 MATRA-LMR 입력자료 (다 집합체)

```
 30000       0       0       1       1
     1       0 (D48H120 / Multi / RB 0602, 1.44 MWth, 8.70 kg/sec)
     1       0       0       0       0       3       2
     2       0       0       0       0       1       0       0
 0.316   -0.25     0.0
   64.      -1.     0.0
     3      81       7
0.00000 0.00643 0.01929 0.03216 0.04502 0.05788 0.07074 0.08361 0.09647 0.10933
0.12219 0.13506 0.14792 0.16078 0.17364 0.18650 0.19937 0.21223 0.22509 0.23795
0.25082 0.26368 0.27654 0.28932 0.30201 0.31471 0.32740 0.34009 0.35278 0.36548
0.37817 0.39086 0.40356 0.41625 0.42894 0.44163 0.45433 0.46702 0.47971 0.49241
0.50510 0.51779 0.53049 0.54318 0.55587 0.56856 0.58126 0.59395 0.60664 0.61933
0.63201 0.64470 0.65728 0.66974 0.68220 0.69466 0.70713 0.71959 0.73205 0.74451
0.75698 0.76944 0.78190 0.79437 0.80683 0.81929 0.83175 0.84422 0.85668 0.86914
0.88160 0.89407 0.90653 0.91899 0.93146 0.94392 0.95638 0.96884 0.98131 0.99377
1.00000
0.00000 0.00053 0.00126 0.00205 0.00296 0.00404 0.00535 0.00696 0.00894 0.01136
0.01430 0.01782 0.02200 0.02686 0.03241 0.03857 0.04516 0.05184 0.05807 0.06294
0.06513 0.06268 0.05290 1.97058 2.01556 2.27281 2.53026 2.77735 3.37232 3.59589
3.78350 3.93572 4.05272 4.27825 4.31925 4.31724 4.27289 4.18518 3.83414 3.67792
3.49018 3.27027 3.01730 2.35119 2.09387 1.83067 1.57096 1.34697 0.01170 0.01268
0.01297 0.01268 0.01174 0.01127 0.01080 0.01032 0.00982 0.00930 0.00877 0.00823
0.00769 0.00715 0.00663 0.00612 0.00563 0.00515 0.00470 0.00427 0.00386 0.00346
0.00309 0.00273 0.00240 0.00207 0.00176 0.00146 0.00117 0.00089 0.00062 0.00035
0.00000
0.00000 0.00014 0.00033 0.00054 0.00078 0.00106 0.00141 0.00183 0.00236 0.00299
0.00376 0.00469 0.00579 0.00706 0.00851 0.01013 0.01185 0.01359 0.01520 0.01646
0.01704 0.01646 0.01418 2.02721 2.26547 2.54360 2.82197 3.08379 3.25955 3.46498
3.64063 3.78342 3.89106 3.94036 3.97468 3.97237 3.93340 3.85842 3.78068 3.63367
3.45283 3.24092 3.00134 2.79562 2.50221 2.19348 1.88423 1.60759 0.00428 0.00459
0.00466 0.00453 0.00439 0.00418 0.00398 0.00378 0.00358 0.00338 0.00318 0.00297
0.00277 0.00258 0.00238 0.00220 0.00202 0.00185 0.00168 0.00152 0.00138 0.00123
0.00110 0.00097 0.00085 0.00074 0.00063 0.00052 0.00042 0.00032 0.00022 0.00012
0.00000
0.00000 0.00073 0.00173 0.00282 0.00406 0.00554 0.00734 0.00954 0.01223 0.01551
0.01949 0.02426 0.02989 0.03644 0.04390 0.05217 0.06103 0.07005 0.07851 0.08528
0.08862 0.08596 0.07354 1.89072 2.06580 2.28710 2.52150 2.75492 3.32923 3.54701
3.73083 3.88076 3.99698 4.22749 4.26910 4.26742 4.22297 4.13478 3.77741 3.62268
3.43851 3.22427 2.97966 2.34861 2.10732 1.87154 1.65691 1.50539 0.01779 0.01936
0.01984 0.01943 0.01805 0.01731 0.01655 0.01578 0.01500 0.01420 0.01339 0.01258
0.01178 0.01098 0.01020 0.00943 0.00869 0.00798 0.00729 0.00663 0.00600 0.00540
0.00483 0.00428 0.00376 0.00325 0.00277 0.00230 0.00185 0.00141 0.00098 0.00055
0.00000
0.00000 0.00108 0.00257 0.00418 0.00603 0.00822 0.01087 0.01411 0.01807 0.02289
0.02872 0.03568 0.04388 0.05339 0.06416 0.07605 0.08870 0.10144 0.11324 0.12244
0.12660 0.12207 0.10358 1.95012 2.04623 2.22854 2.44604 2.67637 3.28466 3.51125
3.70247 3.85887 3.98160 4.23762 4.28340 4.28239 4.23482 4.13969 3.74786 3.58554
3.39541 3.17561 2.92541 2.27404 2.04206 1.83227 1.66990 1.61455 0.02583 0.02842
0.02942 0.02918 0.02751 0.02662 0.02564 0.02458 0.02347 0.02230 0.02110 0.01988
0.01865 0.01742 0.01621 0.01502 0.01386 0.01274 0.01165 0.01061 0.00961 0.00866
0.00774 0.00687 0.00603 0.00523 0.00445 0.00371 0.00298 0.00228 0.00158 0.00090
0.00000
0.00000 0.00073 0.00174 0.00284 0.00409 0.00559 0.00740 0.00962 0.01235 0.01568
0.01971 0.02454 0.03026 0.03691 0.04448 0.05287 0.06182 0.07088 0.07926 0.08577
0.08855 0.08490 0.07110 1.84486 2.01246 2.23901 2.48202 2.72537 3.34214 3.57106
3.76302 3.91912 4.04043 4.28586 4.32990 4.32839 4.28185 4.18909 3.81028 3.64900
3.45775 3.23474 2.97848 2.30167 2.05153 1.80791 1.58715 1.43560 0.01655 0.01819
0.01877 0.01847 0.01721 0.01656 0.01590 0.01522 0.01450 0.01376 0.01299 0.01222
0.01144 0.01066 0.00990 0.00915 0.00843 0.00773 0.00706 0.00642 0.00581 0.00522
0.00466 0.00413 0.00362 0.00314 0.00267 0.00222 0.00178 0.00136 0.00094 0.00053
0.00000
0.00000 0.00014 0.00033 0.00054 0.00078 0.00107 0.00141 0.00184 0.00236 0.00300
0.00378 0.00471 0.00582 0.00710 0.00857 0.01019 0.01193 0.01369 0.01533 0.01662
0.01725 0.01676 0.01456 2.03382 2.27135 2.54819 2.82717 3.09121 3.26339 3.47139
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```
3.64921  3.79373  3.90275  3.95061  3.98539  3.98296  3.94322  3.86684  3.79100  3.64150
3.45772  3.24223  2.99821  2.79469  2.49386  2.17514  1.84875  1.53320  0.00370  0.00382
0.00383  0.00378  0.00380  0.00377  0.00369  0.00358  0.00343  0.00325  0.00307  0.00288
0.00269  0.00250  0.00231  0.00213  0.00196  0.00179  0.00163  0.00148  0.00133  0.00119
0.00106  0.00094  0.00082  0.00071  0.00060  0.00050  0.00040  0.00030  0.00021  0.00011
0.00000
0.00000  0.00014  0.00032  0.00053  0.00076  0.00104  0.00138  0.00179  0.00230  0.00293
0.00368  0.00459  0.00567  0.00693  0.00837  0.00996  0.01166  0.01339  0.01500  0.01627
0.01690  0.01643  0.01429  2.02799  2.27277  2.55439  2.83605  3.10093  3.26438  3.47091
3.64739  3.79067  3.89852  3.94295  3.97707  3.97452  3.93522  3.85985  3.78916  3.64092
3.45828  3.24385  3.00087  2.80619  2.50387  2.18215  1.85175  1.53305  0.00365  0.00376
0.00376  0.00369  0.00368  0.00363  0.00354  0.00342  0.00327  0.00310  0.00293  0.00274
0.00256  0.00238  0.00220  0.00202  0.00186  0.00170  0.00154  0.00140  0.00126  0.00113
0.00100  0.00089  0.00078  0.00067  0.00057  0.00047  0.00038  0.00029  0.00020  0.00010
0.00000
     4        7        0        1
727.16   0.1465   0.1583   5.9213   156.33   397
     1      252        1        0        0        0
     1    .0258    .7471    .7471        2    .0390    .2971        6    .0390    .2971        8    .0390    .2971
     2    .0258    .7471    .7471        3    .0390    .2971       11    .0390    .2971
     3    .0258    .7471    .7471        4    .0390    .2971       14    .0390    .2971
     4    .0258    .7471    .7471        5    .0390    .2971       17    .0390    .2971
     5    .0258    .7471    .7471        6    .0390    .2971       20    .0390    .2971
     6    .0258    .7471    .7471       23    .0390    .2971
     7    .0258    .7471    .7471        8    .0390    .2971       24    .0390    .2971       26    .0390    .2971
     8    .0258    .7471    .7471        9    .0390    .2971
     9    .0258    .7471    .7471       10    .0390    .2971       28    .0390    .2971
    10    .0258    .7471    .7471       11    .0390    .2971       31    .0390    .2971
    11    .0258    .7471    .7471       12    .0390    .2971
    12    .0258    .7471    .7471       13    .0390    .2971       33    .0390    .2971
    13    .0258    .7471    .7471       14    .0390    .2971       36    .0390    .2971
    14    .0258    .7471    .7471       15    .0390    .2971
    15    .0258    .7471    .7471       16    .0390    .2971       38    .0390    .2971
    16    .0258    .7471    .7471       17    .0390    .2971       41    .0390    .2971
    17    .0258    .7471    .7471       18    .0390    .2971
    18    .0258    .7471    .7471       19    .0390    .2971       43    .0390    .2971
    19    .0258    .7471    .7471       20    .0390    .2971       46    .0390    .2971
    20    .0258    .7471    .7471       21    .0390    .2971
    21    .0258    .7471    .7471       22    .0390    .2971       48    .0390    .2971
    22    .0258    .7471    .7471       23    .0390    .2971       51    .0390    .2971
    23    .0258    .7471    .7471       24    .0390    .2971
    24    .0258    .7471    .7471       53    .0390    .2971
    25    .0258    .7471    .7471       26    .0390    .2971       54    .0390    .2971       56    .0390    .2971
    26    .0258    .7471    .7471       27    .0390    .2971
    27    .0258    .7471    .7471       28    .0390    .2971       58    .0390    .2971
    28    .0258    .7471    .7471       29    .0390    .2971
    29    .0258    .7471    .7471       30    .0390    .2971       60    .0390    .2971
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221	.0586	1.262	.7471	222	.0488	.5146			
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245	.0586	1.262	.7471	246	.0488	.5146			
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247	.0653	1.536	.8716	248	.0488	.5146			
248	.0586	1.262	.7471	249	.0488	.5146			
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    6    223     224     225   226   227   228
    6    229     230     231   232   233   234
    6    235     236     237   238   239   240
    6    241     242     243   244   245   246
    6    247     248     249   250   251   252
    2     12       2       0     0     0
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    6  .2508   3.324   3.324    12  .0380  1.169
    7  .6423   7.733   4.432     8  .0371  3.281    12  .0371  3.281
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    9  .6423   7.733   4.432    10  .0371  3.281
   10  .6423   7.733   4.432    11  .0371  3.281
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   12  .6423   7.733   4.432
5.75844
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    1      7
    1      8
    1      9
    1     10
    1     11
    1     12
    3     12       3       0     0     0
    1  .2508   3.324   3.324     2  .0380  1.244     6  .0380  1.244     7  .0380  1.169
    2  .2508   3.324   3.324     3  .0380  1.244     8  .0380  1.169
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    4  .2508   3.324   3.324     5  .0380  1.244    10  .0380  1.169
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    7  .6423   7.733   4.432     8  .0371  3.281    12  .0371  3.281
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   10  .6423   7.733   4.432    11  .0371  3.281
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1.02373
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    1     12
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    6  .2508   3.324   3.324    12  .0380  1.169
    7  .6423   7.733   4.432     8  .0371  3.281    12  .0371  3.281
    8  .6423   7.733   4.432     9  .0371  3.281
    9  .6423   7.733   4.432    10  .0371  3.281
   10  .6423   7.733   4.432    11  .0371  3.281
   11  .6423   7.733   4.432    12  .0371  3.281
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    1       12
    6       12      6       0       0       0
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    4   .2508   3.324   3.324   5   .0380   1.244   10  .0380   1.169
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   10   .6423   7.733   4.432   11  .0371   3.281
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17	.4756	1.000	19	.1667	20	.1667	21	.1667	46	.1667	47	.1667	48	.1667
18	.4756	1.000	21	.1667	22	.1667	48	.1667	49	.1667	50	.1667	51	.1667
19	.4756	1.000	22	.1667	23	.1667	24	.1667	51	.1667	52	.1667	53	.1667
20	.4756	1.000	25	.1667	54	.1667	55	.1667	56	.1667	95	.1667	96	.1667
21	.4756	1.000	25	.1667	26	.1667	27	.1667	56	.1667	57	.1667	58	.1667
22	.4756	1.000	27	.1667	28	.1667	29	.1667	58	.1667	59	.1667	60	.1667
23	.4756	1.000	29	.1667	30	.1667	60	.1667	61	.1667	62	.1667	63	.1667
24	.4756	1.000	30	.1667	31	.1667	32	.1667	63	.1667	64	.1667	65	.1667
25	.4756	1.000	32	.1667	33	.1667	34	.1667	65	.1667	66	.1667	67	.1667
26	.4756	1.000	34	.1667	35	.1667	67	.1667	68	.1667	69	.1667	70	.1667
27	.4756	1.000	35	.1667	36	.1667	37	.1667	70	.1667	71	.1667	72	.1667
28	.4756	1.000	37	.1667	38	.1667	39	.1667	72	.1667	73	.1667	74	.1667
29	.4756	1.000	39	.1667	40	.1667	74	.1667	75	.1667	76	.1667	77	.1667
30	.4756	1.000	40	.1667	41	.1667	42	.1667	77	.1667	78	.1667	79	.1667
31	.4756	1.000	42	.1667	43	.1667	44	.1667	79	.1667	80	.1667	81	.1667
32	.4756	1.000	44	.1667	45	.1667	81	.1667	82	.1667	83	.1667	84	.1667
33	.4756	1.000	45	.1667	46	.1667	47	.1667	84	.1667	85	.1667	86	.1667
34	.4756	1.000	47	.1667	48	.1667	49	.1667	86	.1667	87	.1667	88	.1667
35	.4756	1.000	49	.1667	50	.1667	88	.1667	89	.1667	90	.1667	91	.1667
36	.4756	1.000	50	.1667	51	.1667	52	.1667	91	.1667	92	.1667	93	.1667
37	.4756	1.000	52	.1667	53	.1667	54	.1667	93	.1667	94	.1667	95	.1667
38	.4756	1.000	55	.1667	96	.1667	97	.1667	98	.1667	149	.1667	150	.1667
39	.4756	1.000	55	.1667	56	.1667	57	.1667	98	.1667	99	.1667	100	.1667
40	.4756	1.000	57	.1667	58	.1667	59	.1667	100	.1667	101	.1667	102	.1667
41	.4756	1.000	59	.1667	60	.1667	61	.1667	102	.1667	103	.1667	104	.1667
42	.4756	1.000	61	.1667	62	.1667	104	.1667	105	.1667	106	.1667	107	.1667
43	.4756	1.000	62	.1667	63	.1667	64	.1667	107	.1667	108	.1667	109	.1667
44	.4756	1.000	64	.1667	65	.1667	66	.1667	109	.1667	110	.1667	111	.1667
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46	.4756	1.000	68	.1667	69	.1667	113	.1667	114	.1667	115	.1667	116	.1667
47	.4756	1.000	69	.1667	70	.1667	71	.1667	116	.1667	117	.1667	118	.1667
48	.4756	1.000	71	.1667	72	.1667	73	.1667	118	.1667	119	.1667	120	.1667
49	.4756	1.000	73	.1667	74	.1667	75	.1667	120	.1667	121	.1667	122	.1667
50	.4756	1.000	75	.1667	76	.1667	122	.1667	123	.1667	124	.1667	125	.1667
51	.4756	1.000	76	.1667	77	.1667	78	.1667	125	.1667	126	.1667	127	.1667
52	.4756	1.000	78	.1667	79	.1667	80	.1667	127	.1667	128	.1667	129	.1667
53	.4756	1.000	80	.1667	81	.1667	82	.1667	129	.1667	130	.1667	131	.1667
54	.4756	1.000	82	.1667	83	.1667	131	.1667	132	.1667	133	.1667	134	.1667
55	.4756	1.000	83	.1667	84	.1667	85	.1667	134	.1667	135	.1667	136	.1667
56	.4756	1.000	85	.1667	86	.1667	87	.1667	136	.1667	137	.1667	138	.1667
57	.4756	1.000	87	.1667	88	.1667	89	.1667	138	.1667	139	.1667	140	.1667
58	.4756	1.000	89	.1667	90	.1667	140	.1667	141	.1667	142	.1667	143	.1667
59	.4756	1.000	90	.1667	91	.1667	92	.1667	143	.1667	144	.1667	145	.1667

60	.4756	1.000	92	.1667	93	.1667	94	.1667	145	.1667	146	.1667	147	.1667
61	.4756	1.000	94	.1667	95	.1667	96	.1667	147	.1667	148	.1667	149	.1667
62	.4756	1.000	97	.1667	150	.1667	151	.1667	152	.1667	215	.1667	216	.1667
63	.4756	1.000	97	.1667	98	.1667	99	.1667	152	.1667	153	.1667	154	.1667
64	.4756	1.000	99	.1667	100	.1667	101	.1667	154	.1667	155	.1667	156	.1667
65	.4756	1.000	101	.1667	102	.1667	103	.1667	156	.1667	157	.1667	158	.1667
66	.4756	1.000	103	.1667	104	.1667	105	.1667	158	.1667	159	.1667	160	.1667
67	.4756	1.000	105	.1667	106	.1667	160	.1667	161	.1667	162	.1667	163	.1667
68	.4756	1.000	106	.1667	107	.1667	108	.1667	163	.1667	164	.1667	165	.1667
69	.4756	1.000	108	.1667	109	.1667	110	.1667	165	.1667	166	.1667	167	.1667
70	.4756	1.000	110	.1667	111	.1667	112	.1667	167	.1667	168	.1667	169	.1667
71	.4756	1.000	112	.1667	113	.1667	114	.1667	169	.1667	170	.1667	171	.1667
72	.4756	1.000	114	.1667	115	.1667	171	.1667	172	.1667	173	.1667	174	.1667
73	.4756	1.000	115	.1667	116	.1667	117	.1667	174	.1667	175	.1667	176	.1667
74	.4756	1.000	117	.1667	118	.1667	119	.1667	176	.1667	177	.1667	178	.1667
75	.4756	1.000	119	.1667	120	.1667	121	.1667	178	.1667	179	.1667	180	.1667
76	.4756	1.000	121	.1667	122	.1667	123	.1667	180	.1667	181	.1667	182	.1667
77	.4756	1.000	123	.1667	124	.1667	182	.1667	183	.1667	184	.1667	185	.1667
78	.4756	1.000	124	.1667	125	.1667	126	.1667	185	.1667	186	.1667	187	.1667
79	.4756	1.000	126	.1667	127	.1667	128	.1667	187	.1667	188	.1667	189	.1667
80	.4756	1.000	128	.1667	129	.1667	130	.1667	189	.1667	190	.1667	191	.1667
81	.4756	1.000	130	.1667	131	.1667	132	.1667	191	.1667	192	.1667	193	.1667
82	.4756	1.000	132	.1667	133	.1667	193	.1667	194	.1667	195	.1667	196	.1667
83	.4756	1.000	133	.1667	134	.1667	135	.1667	196	.1667	197	.1667	198	.1667
84	.4756	1.000	135	.1667	136	.1667	137	.1667	198	.1667	199	.1667	200	.1667
85	.4756	1.000	137	.1667	138	.1667	139	.1667	200	.1667	201	.1667	202	.1667
86	.4756	1.000	139	.1667	140	.1667	141	.1667	202	.1667	203	.1667	204	.1667
87	.4756	1.000	141	.1667	142	.1667	204	.1667	205	.1667	206	.1667	207	.1667
88	.4756	1.000	142	.1667	143	.1667	144	.1667	207	.1667	208	.1667	209	.1667
89	.4756	1.000	144	.1667	145	.1667	146	.1667	209	.1667	210	.1667	211	.1667
90	.4756	1.000	146	.1667	147	.1667	148	.1667	211	.1667	212	.1667	213	.1667
91	.4756	1.000	148	.1667	149	.1667	150	.1667	213	.1667	214	.1667	215	.1667
92	.4756	1.000	151	.1667	216	.1667	217	.3333	252	.3333				
93	.4756	1.000	151	.1667	152	.1667	153	.1667	217	.2500	218	.2500		
94	.4756	1.000	153	.1667	154	.1667	155	.1667	218	.2500	219	.2500		
95	.4756	1.000	155	.1667	156	.1667	157	.1667	219	.2500	220	.2500		
96	.4756	1.000	157	.1667	158	.1667	159	.1667	220	.2500	221	.2500		
97	.4756	1.000	159	.1667	160	.1667	161	.1667	221	.2500	222	.2500		
98	.4756	1.000	161	.1667	162	.1667	222	.3333	223	.3333				
99	.4756	1.000	162	.1667	163	.1667	164	.1667	223	.2500	224	.2500		
100	.4756	1.000	164	.1667	165	.1667	166	.1667	224	.2500	225	.2500		
101	.4756	1.000	166	.1667	167	.1667	168	.1667	225	.2500	226	.2500		
102	.4756	1.000	168	.1667	169	.1667	170	.1667	226	.2500	227	.2500		
103	.4756	1.000	170	.1667	171	.1667	172	.1667	227	.2500	228	.2500		
104	.4756	1.000	172	.1667	173	.1667	228	.3333	229	.3333				
105	.4756	1.000	173	.1667	174	.1667	175	.1667	229	.2500	230	.2500		
106	.4756	1.000	175	.1667	176	.1667	177	.1667	230	.2500	231	.2500		
107	.4756	1.000	177	.1667	178	.1667	179	.1667	231	.2500	232	.2500		
108	.4756	1.000	179	.1667	180	.1667	181	.1667	232	.2500	233	.2500		
109	.4756	1.000	181	.1667	182	.1667	183	.1667	233	.2500	234	.2500		
110	.4756	1.000	183	.1667	184	.1667	234	.3333	235	.3333				
111	.4756	1.000	184	.1667	185	.1667	186	.1667	235	.2500	236	.2500		
112	.4756	1.000	186	.1667	187	.1667	188	.1667	236	.2500	237	.2500		
113	.4756	1.000	188	.1667	189	.1667	190	.1667	237	.2500	238	.2500		
114	.4756	1.000	190	.1667	191	.1667	192	.1667	238	.2500	239	.2500		
115	.4756	1.000	192	.1667	193	.1667	194	.1667	239	.2500	240	.2500		
116	.4756	1.000	194	.1667	195	.1667	240	.3333	241	.3333				
117	.4756	1.000	195	.1667	196	.1667	197	.1667	241	.2500	242	.2500		
118	.4756	1.000	197	.1667	198	.1667	199	.1667	242	.2500	243	.2500		
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120	.4756	1.000	201	.1667	202	.1667	203	.1667	244	.2500	245	.2500		
121	.4756	1.000	203	.1667	204	.1667	205	.1667	245	.2500	246	.2500		
122	.4756	1.000	205	.1667	206	.1667	246	.3333	247	.3333				
123	.4756	1.000	206	.1667	207	.1667	208	.1667	247	.2500	248	.2500		
124	.4756	1.000	208	.1667	209	.1667	210	.1667	248	.2500	249	.2500		
125	.4756	1.000	210	.1667	211	.1667	212	.1667	249	.2500	250	.2500		
126	.4756	1.000	212	.1667	213	.1667	214	.1667	250	.2500	251	.2500		

127	.4756	1.000	214	.1667	215	.1667	216	.1667	251	.2500	252	.2500	
2	7	0	.										
1	2.116	1.000	1	.1667	2	.1667	3	.1667	4	.1667	5	.1667	6 .1667
2	2.116	1.000	1	.1667	6	.1667	7	.3333	12	.3333			
3	2.116	1.000	1	.1667	2	.1667	7	.3333	8	.3333			
4	2.116	1.000	2	.1667	3	.1667	8	.3333	9	.3333			
5	2.116	1.000	3	.1667	4	.1667	9	.3333	10	.3333			
6	2.116	1.000	4	.1667	5	.1667	10	.3333	11	.3333			
7	2.116	1.000	5	.1667	6	.1667	11	.3333	12	.3333			
3	7	0											
1	2.116	1.000	1	.1667	2	.1667	3	.1667	4	.1667	5	.1667	6 .1667
2	2.116	1.000	1	.1667	6	.1667	7	.3333	12	.3333			
3	2.116	1.000	1	.1667	2	.1667	7	.3333	8	.3333			
4	2.116	1.000	2	.1667	3	.1667	8	.3333	9	.3333			
5	2.116	1.000	3	.1667	4	.1667	9	.3333	10	.3333			
6	2.116	1.000	4	.1667	5	.1667	10	.3333	11	.3333			
7	2.116	1.000	5	.1667	6	.1667	11	.3333	12	.3333			
4	7	0											
1	2.116	1.000	1	.1667	2	.1667	3	.1667	4	.1667	5	.1667	6 .1667
2	2.116	1.000	1	.1667	6	.1667	7	.3333	12	.3333			
3	2.116	1.000	1	.1667	2	.1667	7	.3333	8	.3333			
4	2.116	1.000	2	.1667	3	.1667	8	.3333	9	.3333			
5	2.116	1.000	3	.1667	4	.1667	9	.3333	10	.3333			
6	2.116	1.000	4	.1667	5	.1667	10	.3333	11	.3333			
7	2.116	1.000	5	.1667	6	.1667	11	.3333	12	.3333			
5	7	0											
1	2.116	1.000	1	.1667	2	.1667	3	.1667	4	.1667	5	.1667	6 .1667
2	2.116	1.000	1	.1667	6	.1667	7	.3333	12	.3333			
3	2.116	1.000	1	.1667	2	.1667	7	.3333	8	.3333			
4	2.116	1.000	2	.1667	3	.1667	8	.3333	9	.3333			
5	2.116	1.000	3	.1667	4	.1667	9	.3333	10	.3333			
6	2.116	1.000	4	.1667	5	.1667	10	.3333	11	.3333			
7	2.116	1.000	5	.1667	6	.1667	11	.3333	12	.3333			
6	7	0											
1	2.116	1.000	1	.1667	2	.1667	3	.1667	4	.1667	5	.1667	6 .1667
2	2.116	1.000	1	.1667	6	.1667	7	.3333	12	.3333			
3	2.116	1.000	1	.1667	2	.1667	7	.3333	8	.3333			
4	2.116	1.000	2	.1667	3	.1667	8	.3333	9	.3333			
5	2.116	1.000	3	.1667	4	.1667	9	.3333	10	.3333			
6	2.116	1.000	4	.1667	5	.1667	10	.3333	11	.3333			
7	2.116	1.000	5	.1667	6	.1667	11	.3333	12	.3333			
7	7	0											
1	2.116	1.000	1	.1667	2	.1667	3	.1667	4	.1667	5	.1667	6 .1667
2	2.116	1.000	1	.1667	6	.1667	7	.3333	12	.3333			
3	2.116	1.000	1	.1667	2	.1667	7	.3333	8	.3333			
4	2.116	1.000	2	.1667	3	.1667	8	.3333	9	.3333			
5	2.116	1.000	3	.1667	4	.1667	9	.3333	10	.3333			
6	2.116	1.000	4	.1667	5	.1667	10	.3333	11	.3333			
7	2.116	1.000	5	.1667	6	.1667	11	.3333	12	.3333			
9	0	0	0	0	0	0							
156.33	0.0			.0001								0.5	
397		300	300										
10	0	0	1	0	0	0							
0.01													
0.5													
11	1	1	0	0	0	0	0	0	0	0			
14.696	727.16												
5.29102	19.0953	2.96685	1.75581	3.25611	20.93226	23.63285							
0.025684	0.37805	0.058737	0.034761	0.064464	0.41441	0.46788							
12	0	1	0	0	0	0	0	0					
1													

서 지 정 보 양 식			
수행기관보고서번호	위탁기관보고서번호	표준보고서번호	INIS 주제코드
KAERI/TR-1595/2000			

제목/부제	집합체간 열전달을 고려한 액체금속로 노심 열수력 해석
연구책임자 및 부서명 (TR, AR인 경우 주저자)	김원석 (KALIMER 기술개발팀)
연 구 자 및 부 서 명	김영균, 김영일 (KALIMER 기술개발팀)

출 판 지	대 전	발행기관	한국원자력연구소	발행년	2000. 6.
페 이 지	184 p.	도 표	있음(V), 없음( )	크 기	26 Cm.
참고사항	2000 중장기 과제				
비밀여부	공개(V), 대외비( ), __ 급비밀		보고서종류	기술보고서	
연구위탁기관			계약 번호		

초록 (15-20줄내외)

냉각재로 소듐을 사용하는 액체금속로에서는 피복재 온도나 핵연료의 최대온도에 설계 제한조건을 두게 된다. 이러한 설계요건을 만족하면서 냉각재 분배효율을 높이기 위해서는 노심의 온도분포를 정확히 예측할 필요가 있다.

소듐의 높은 열전도로 인하여 노심내 집합체간 열전달 현상이 집합체내 온도분포에 적지않은 영향을 미친다. 특히 이웃한 집합체간 온도차가 큰 경우에는 더 심하다. 따라서 액체금속로 노심 열수력 설계 및 해석시 집합체간 열전달 영향에 대한 고려는 필요하다. 현재 단일 집합체내에서의 온도분포 및 유량분포 계산이 가능한 MATRA-LMR 코드를 이러한 집합체간 열전달 영향을 고려하여 여러 집합체 계산 즉, 전체노심 해석이 가능하도록 개선작업을 수행하고 있다. 현재까지의 개발상태를 평가하기 위하여 여러 7-집합체 모의에 적용하여 계산을 수행하였고, 그 결과를 SLTHEN 및 THI3D 코드와 비교· 분석하였다. 계산결과, 집합체 평균 냉각재 출구온도는 집합체간 열전달 영향에 의해 변화하였으며, 최대 온도변화는 핵연료 집합체에서 보다 비 핵연료 집합체에서 그 영향이 크게 나타났다.

주제명키워드 (10단어내외)	액체금속로, 부수로해석, MATRA-LMR, 집합체간 열전달, 전체노심해석

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Abstract (15-20 Lines)

It is essential to have an accurate prediction of core coolant and fuel temperature distribution in the liquid metal reactor (LMR) core thermal hydraulic design, because of the design limits are imposed on the maximum temperatures of claddings and fuel pins in the sodium cooled LMRs.

Due to the high thermal conductivity of the sodium, the transverse interassembly heat transfer may have a significant effect on the temperature profile within the subassembly, especially when it is adjacent to considerably hotter or colder subassemblies. Therefore, the interassembly heat transfer calculation should be considered in the LMR core thermal hydraulic design and analysis. For multi-assembly analysis, the interassembly heat transfe model was added in the MATRA-LMR code and the code was extended a single assembly analysis to multi-assembly analysis, i.e., a whole core code. For the assessment of the development status with interassembly heat transfer, the benchmark calculations were performed with SLTHE and THI3D codes using the 7-assembly problems. It is founded that the subassembly mixed mean coolant temperature has been changed as an effect of the interassembly heat transfer. And the maximum temperature change was found in the non-fueled subassembly which is considerabl colder than the fueled subassemblies.

Subject Keywords (About 10 words)	LMR, Subchannel analysis, MATRA-LMR, COBRA, Interassembly heat transfer, Whole core analysis