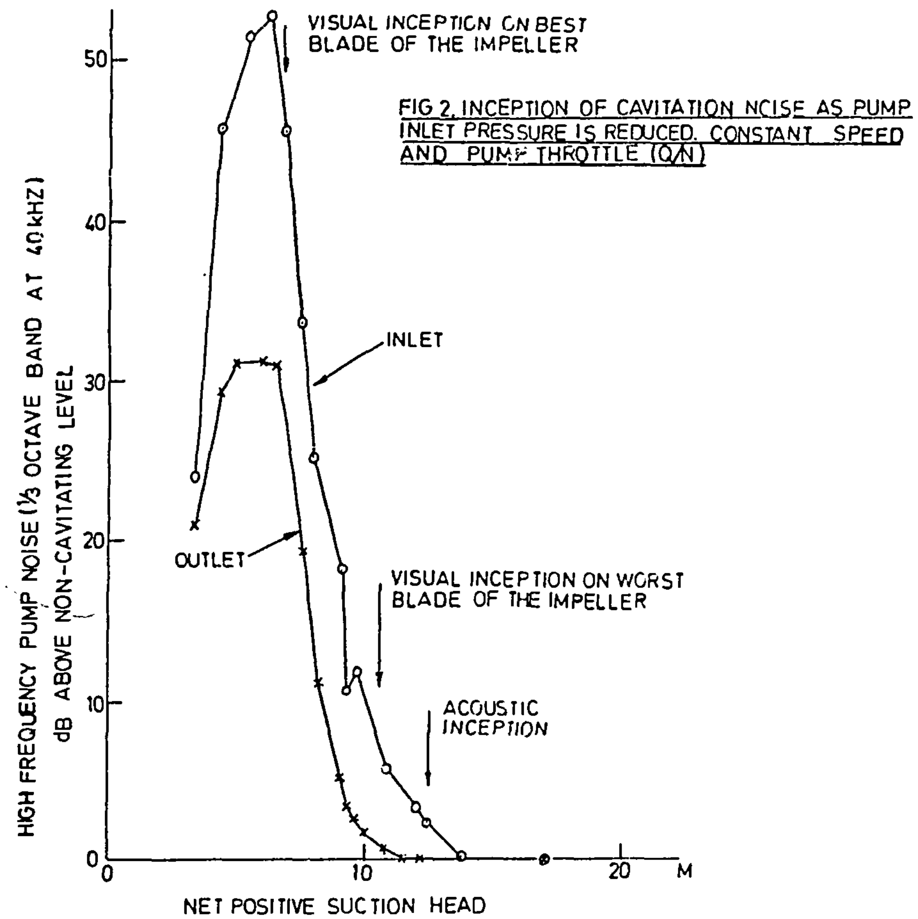


FIG 2. INCEPTION OF CAVITATION NOISE AS PUMP INLET PRESSURE IS REDUCED. CONSTANT SPEED AND PUMP THROTTLE (Q/N)

15 " Cavitation Work Conducted at Risley Engineering and Materials Laboratories, A.E. COLLINSON, U.K.A.E.A., U.K.

Cavitation in Reactor Components

It is important to minimise cavitation in PFR for two reasons: firstly to reduce the risk of damage from erosion and secondly to reduce the background noise when using acoustic diagnostic techniques for core protection. It is therefore necessary to determine the inception of cavitation noise for reactor components rather than the fall in hydraulic performance of common engineering usage, such as for a pump. In PFR most attention has been paid to two types of component; pressure dropping devices, including fuel sub-assemblies and the pump.

The investigation of cavitation in pressure droppers is described by Collinson (1) in a paper presented to this meeting. The method of acoustic detection used, for experiments in both water and sodium, is based on the count rate arising from the collapse of individual vapour bubbles. It was assumed that, in the absence of cavitation noise, erosion would not occur, and little effort has been devoted to the investigation of damage produced by cavitation.

For the PFR pump, the specification agreed with the manufacturer was that at the design point there should be no visible evidence of bubble formation on the impeller blades. The use of visual techniques is obviously not practicable in sodium and the alternative method of using acoustic listening methods has been investigated. In the earlier experiments, using water, results were confusing but by minimising spurious noise and attenuation effects, and by having a panoramic viewing system, it has been found that similar results could be obtained using acoustic and visual methods. This is illustrated in Figure 1 which shows the relation between noise (at 40kHz) and inlet pressure for one particular pump. An interesting feature of this curve is the steep rise in noise once cavitation starts. Thus if damage from cavitation erosion is important and if this noise curve is typical there may not be a clear criterion for its avoidance after the inception of cavitation. The degree of cavitation to accept from a sodium coolant pump is presently under review. Additional experiments have been carried out to locate cavitation sources on pumps using the triangulation techniques developed for stress wave emission measurents by Bentley et al(2). The first measurements were made on a stationary centrifugal pump with simulated cavitation sources and showed that despite the complexity of the transmission paths the sources could be uniquely located in the three dimensional structure. Further measurements have been made on an operating pump system. This readily distinguished pump from valve noise. Two sources were identified in the pump casing, one indicating cavitation over the impeller blades and the second stationary, indicating a leak from high to low pressure. The investigation is continuing with the development of specialised equipment for the source location of intense cavitation.

Detection of Gas Bubbles

Cavitation behaviour can be influenced by the numbers of free background gas bubbles in the system. It is necessary to define both size spectrum and total volume fraction of bubbles in order to characterise the background gas level. An instrument for the detection of entrained gas bubbles has been developed at REML relying on the Doppler effect on high frequency sound scattered by bubbles in a flowing liquid. The device is outlined in Figs 2 and 3.

References

1. 'The Onset of Cavitation in Pressure Dropping Devices in Water and Sodium' by A E Collinson

2. 'Instrumentation for Acoustic Emission' by P G Bentley et al TRG Report 2482(R) United Kingdom Atomic Energy Authority, Risley, Warrington, Cheshire.

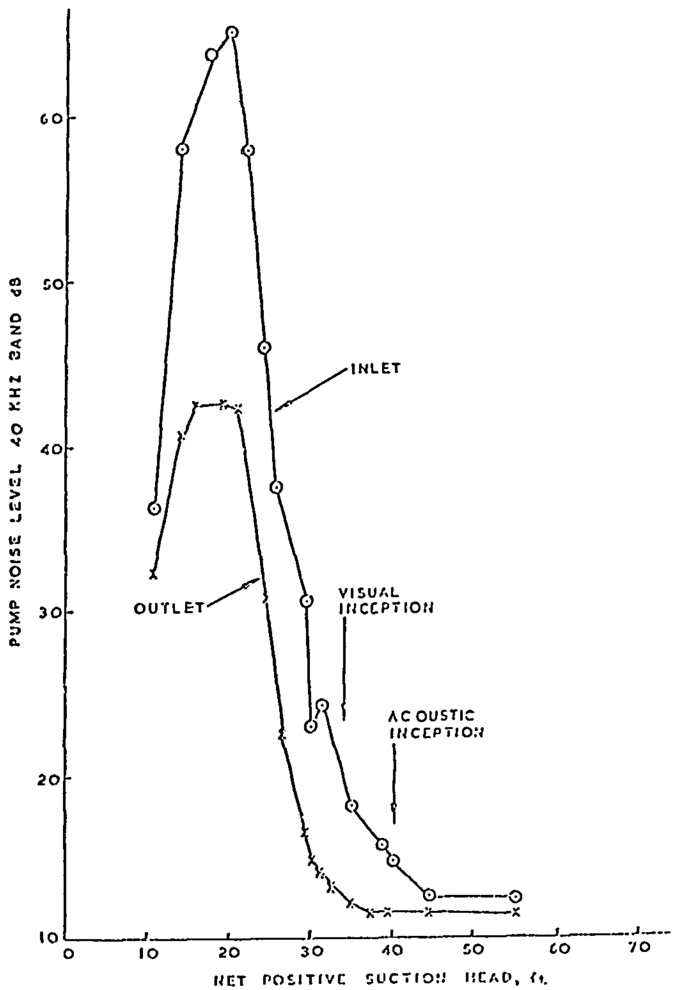
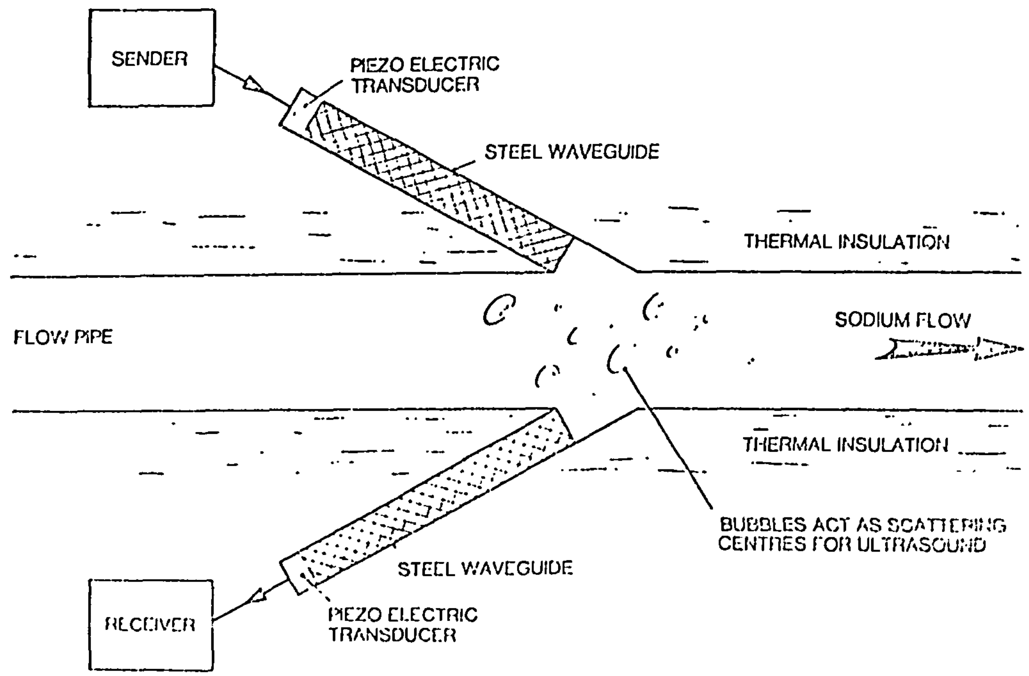


FIG. 1

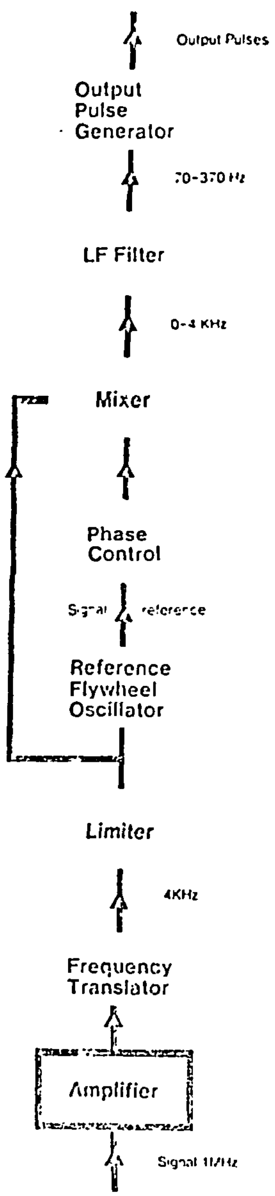
INCEPTION OF CAVITATION IN A PUMP

DETECTION OF ENTRAINED GAS BUBBLES WITH ULTRASONICS

GAS BUBBLES in a liquid can be detected by scattering high frequency sound off them. The amount of scattered energy is a measure of the bubble size. If the liquid is moving, the bubbles can be counted as they pass the detector. Ultrasonic transducers needed to send and receive the sound signals, are damaged by heat. So, if the liquid is hot sodium, solid steel waveguides are used to conduct sound in and out of the liquid. This results in the sender and receiver being strongly coupled through the metal structure of the detector. The bubbles can still be detected, however, because of DOPPLER EFFECT, which changes the frequency of the scattered sound.



THE REML ULTRASONIC DOPPLER SCATTERING GAS DETECTOR



Output Pulse Generator — The output consists of one pulse for each bubble detected The amplitude of the pulse is proportional to bubble radius

LF Filter — The pulses originate as broad band impulses centred on the doppler shift frequency. The actual filter band is selected for minimum noise and may not include the actual doppler frequency.

Mixer — Low frequency impulses are obtained by mixing the signal with a reference at the sending frequency.

Phase Control — The phase of the mixed signal is adjusted to 0 or 180°. The system is then insensitive to phase modulations caused by the complex structure of the sodium loop.

Reference Flywheel Oscillator — The reference is derived from the signal itself to eliminate phase drift due to the wave guide temperatures.

Limiter — A limiter is used to eliminate amplitude disturbances to the signal. The use of a limiter modifies the performance considerably. Doppler signals are detected only by the transient phase changes caused by discrete bubbles.

Frequency Translator — A frequency translater converts the signal to a convenient low frequency which is independant of the sending frequency

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16 " NERATOOM Work on Pump Development ", C.J. HOORNWEG, NERATOOM, Holland.

Summary

The prototype pump has been manufactured by Stork Engineerings Works at Hengelo in 1969. The full-scale test on water has been carried out as part of the procedures of acceptance. Tests on sodium have been carried out in the pumptestfacility of Interatom at Bensberg (W.Germany); these tests started in March 1971 and were finished in October 1972. During that period nearly 6000 hours of pump testing were accomplished, of which 150 hours the pump was subjected to cavitation. During 30 hours the pump was subjected to a cavitation intensity of more then 3% loss of delivery head. At some occasions the loss of delivery head was 7%.

The measured NPSH with the tests on sodium was 10 m, whereas the NPSH obtained with the tests on water was 9 m. Attempts have been made to account for this difference of NPSH-setting on the two liquids concerned.

At the end of the tests on sodium (that is after the excecution of the cavitation tests) the delivery head of the pump was 2 m.l.c. less than the rated value. After dismantling the pump it appeared that the surface of the impeller vanes was roughened, especially at those parts where the original sand cast surface had not been polished.

Based on the testresults and not being contradicted by calculation-results so far, our opinion is that cavitation in sodium of reactor temperature (550°C) most probably is of the same order of magnitude as it is in water of roomtemperature under the same conditions of NPSH, provided the same pump operates in systems that are exact replica of one another.

Introduction

As reported previously at the Cavitation Conference at Edinburgh (1974) [1], Neratoom participates in a joint venture with Germany and Belgium in the construction of a LMFBR with a capacity of 300 MW_e (called the SNR-300) to be built at Kalkar. It is of the loop-type design with three primary loops and three secondary loops. Before starting the design of the original pumps to be built for