INIS-mf--808

[redacted]

FC-15

DESIGN AND FABRICATION OF REACTOR COMPONENTS-WELDING

K.V.Vannan
Power Projects Engineering Division

I. CONSUMABLE INSERT WELDING

Bore suck back posed a problem in the closure welds of RAPP-2 Steam Generators. It is difficult to measure the extent of suck back from radiographs, other than from mock up samples. Insert being an imported item, efforts should be made for the use of filler only. Insert can be eliminated from welds on all non-critical applications (eg) drain lines irrespective of the radioactivity or cost of fluid handled. Root and final pass L.P.I. should suffice and even radiography is unnecessary. Surprisingly there is no ASME Specifications for C.S. insert and filler wire.

II. WELD EDGE PREPARATION

If flame or arc process is used, formation of oxides, carbides and a brittle HAZ in the weld edge preparation is possible. To eliminate them 1/16" min. grinding is specified. In the case of plasma cutting of S.S., tests done for Dump Tank reveal that 0.010" grinding is adequate. Inview of possible carbide pick up, use of carbide grinding wheels on S.S. and especially at weld edge preparations should be avoided.

III. PREHEAT

For ready weldability "carbon equivalent" for C.S. = % C + % Mn/4

We regret that some of the pages in the microfiche copy of this report may not be up to the proper legibility standards, even though the best possible copy was used for preparing the master fiche.

should not exceed 0.45. In low alloy steels %C + % Mn/6 + % Ni/20 + % Cr/10 - % Mo/50 - % V/10 + % Cu/40 should not exceed 0.40. Less stringent figures are also quoted. C.E = % C + % Mn/20 + % Ni/15 + (% Cr + % Mo + % V)/10. For C.E. of 0.40, 0.50 and 0.60 preheat tempr. will be 50°C, 150°C and 250°C respectively. It is better to be stricter than code stipulations, to avoid risks since local segregation of C in parent metal could cause airhardening. Further the preheating keeps atmospheric moisture away from weld zone. Preheating of C.S. whenever thickness exceeds or equals 1" or C content exceeds or equals 0.30% is advisable.

IV. INTER PASS TEMPERATURE CONTROL

Large heat input causes grain coarsening and weld distortion. During the course of RAPP-2 steam generator fabrication, tests done on a specimen, weld repaired about 6 times showed no grain coarsening. This means that upper limit for interpass is not important in the case of carbon steel, but still is advisable to reduce distortion in the case of large thicknesses and to improve notch ductility. Control is a must in the case of S.S. inview of tendency for larger distortion.

V. WELD DISTORTION

Higher coeff. of thermal expn. and lower thermal conductivity cause larger shrinkage. Higher Y.S. causes rentention of shrinkage stress which results in subsequent distortion. Transverse shrinkage = 0.10 Aw/t. Aw = weld metal area within fusion line: sq. in, t = plate thickness: in. Sheet metal distortion can be rectified by flame shrinkage method (flame heating followed by water spray). This technique was adopted for the S.S.Liner of RAPP-1 Calandria Vault. In the case of field welding of shield tank assembly, steel spacers were used to maintain root gap. However, considerable difficulty was experienced in removing them due to high weld shrinkage. But in the case of welding of expansion joint to Calandria and Dump Tank, non-use of such spacers resulted in too much of weld shrinkage. After the 1st pass, the root gap closed due to weld shrinkage and consequently more back grinding had to be done to provide access for L.P.I. and further welding. This resulted in extra weld metal deposition aggravating the extent of shrinkage.

VI. POST WELD HEAT TREATMENT

A lot of problems were faced in the stressrelief of the field welds of shield tank. Individual portions of the weld seam were subjected to varying hold times and varying soak temperatures. However, the integrated time at temperature was adequate to meet the intent of the code though not the letter. Local S/R should not be done under heavy restraint, since residual stress gets transferred to other areas causing distortion there as in the case of RAPP-1 End Shield Tube Sheet. For the same reason local S/R was waived for the welds between shield tank and lifting attachments. During the S/R of water cooled thermal shield which is a heavy walled vessel with minimum interspace, it was not possible to measure the tempr. of wall on the inside. Further furnace gas has no access to the inside. To ensure that the inside of vessel also had been adequately heated, the min. hold time corresponding to governing thickness for S/R was conservatively increased by 50%. In such cases, it is difficult to assess the soak time required accurately by calculations. Max. vessel and weld thicknessshould govern heating and cooling rates and hold time respectively. Code is not clear on this. ASME codes are silent on PWHT of aust. S.S. welds inview of controversies prevailing on this matter. But PWHT is advisable in critical S.S.components since high residual stresses can be present in S.S.due to higher coefft. of expansion and lower conductivity. It is reported that soaks at 1375°F and 1600°F result in stress reliefs of 50% and 90% respectively. Solution annealing from above 1800°F is desirable, but distortion and quenching stresses result. To relieve quenching stress, further S/R at about 1200°F will be required. Sensitisation problem still persists but is minimised in the case of low carbon S.S. Also PWHT requires an inert atmosphere to avoid pickling. It is claimed that since no martensite formation is involved when an S.S.weldment cools, there is no loss of ductility as in C.S.and hence no S/R is required.

VI. STORAGE OF ELECTRODES

No definite information is available about the shelf life of electrodes. However, it is advisable to restrict the same to

1 year. Inspection of the polythene packings for low H_2 electrodes shows that there is not 100% sealing, due to bad workmanship. So moisture pickup by electrodes cannot be ruled out. Since the extent of moisture pickup cannot be easily assessed always, it has been decided at MAPP Site to rebake all low H_2 electrodes at 700°F prior to transferring them to "holding" ovens in shops. Clear advice from manufacturers is lacking in this regard.

VIII. NON-DESTRUCTIVE TESTING

Tests done at MAPP Site show that the simple air soap bubble test is as effective as freon (halide torch/electronic detector) test in detecting a leak and that too in lesser time.

IX. SOCKET WELDING

Quite often socket weld fittings are specified for radioactive lines. The clearence between pipe and fittings amounts to a crevice where active particles can accumulate, posing a radiation hazard. In such cases butt weld fittings are recommended. Sockets afford easier fit up and hence ideal for field.

X. WELDING OF S.S. TYPES AISI 347, 309 AND 310

Large incidence of cracks in type 347 welds (due to formation of sigma phase, low melting Niobium silicate, etc.) is reported. Further this material in aust. S.S. group is most prone to stress corrosion cracking. Hence type 304 L should be preferred to type 347. While welding C.S. to S.S. the 1st layer due to type 309 filler will end up in Aust. + Martensite zone. To avoid M.phase, increase the content of 309 by lesser penetration (A.C.welding in M.M.A. or reduced current or R.P. in T.I.G.). Other alternative is to use type 310 for 1st layer. But type 310 being more austenitic is more prone to (sigma-phase) cracking.

XI. DEVELOPMENT ACTIVITIES TO BE UNDERTAKEN

N_2 may be used as a purging gas for S.S. even though this may result in some hardening of S.S. CO_2 may be used as shielding/purging gas for S.S./C.S. Deeper penetration is possible with CO_2. C.S. weldments made with CO_2 have mechl. properties comparable to those with He/Argon. S.S.weldments may show carbon pick up resulting in lesser corrosion resistance and ductility. But soundness of welds is better. CO_2 can be supplemented with flux to reduce arc spatter. Quite often demagnetisation after M.P.I. of steel components is specified. Demagnetisation is necessary in the case of electro magnetic Instrumentation items, components requiring subsequent machining (to prevent adherence of chipsto tool) and those handling process fluids (to avoid accumulation of Fe rust). In the case of piping and vessels, since M.P.I. is done on the outer surface only, the residual magnetism left on the inner surface might be quite low. It may not be necessary to insist on demagnetisation of each and every component. All above suggestions require further testing before taking a decision.

[redacted]