Welding Application

Experiences in the Manufacture of Monel Condensers

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1.0 Introduction

This paper deals with the experiences of the Central Workshops at B.A.R.C. in fabricating several condensers, constructed out of Monel. Stringent code requirements are met in this construction. Dissimilar metals welding, vacuum brazing of components are discussed. Monel metal was selected for construction because of superior corrosion resistance and superior strength at low temperatures involved in the operations.

2.0 Materials of Construction

2.1 Base Material

- Monel 400 in thicknesses ranging from 6 mm to 43 mm in the forms of plates and pipes.
- Stainless steel - 43 mm thick.
- OFHC Copper.

2.2 Welding Consumables

- ER Ni Cu 7, wire diameters 1.6 & 2.4 mm
- E Ni Cu 7 Electrodes, 3.15 & 4.0 diameters
- B Ag 8 wires and foils

3.0 Design Data

Design data for the monel condenser are as follows :

Design pressure	:	10 Bars
Design temperetures	:	-60^{o} to 100^{o}C
Hydraulic test pressure	:	13 Bars
Helium leak test	:	3×10^{-9} std. cc sec^{-1}
Weight	:	680 Kg.

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3.1 Codes and Processes used

Design and Construction	:	ASME section VIII Division 1
Welding and Brazing	:	ASME Sec. IX
Welding Process used	:	GTAW/SMAW/EBW
Brazing Process	:	Vacuum furnace brazing
NDE (LPT)	:	ASME Sec. V Article 6
Radiography	:	ASME Sec. V Article 2
Hydraulic test	:	ASME Sec. VIII Div. 1 UG 99.
Helium leak	:	ASME Sec. V Article T-1050

3.2 Weld Joint Features

Figure 1 gives the overall features of the Monel condensers. Molten Monel does not flow and wet the base metal as readily as carbon steel or stainless steels. Hence, wider groove angles (80^{o}) were opted to permit proper manipulation of torch and filler metal, using stringer beads. In U/J groove joints, bevel angles upto 20^{o} were used. In Figure 2, a permanent backing strip was opted for the shell to flange welding to ensure reliable and proper penetration. In this particular joint, due to the lack of access space for grinding, this feature was opted. Figure 3 gives the features of Monel to Stainless Steel joint. This has a double J (20^{o}) bevel joint.

4.0 Manufacture

The edge preparation of some of the shell plates was done by machining process and in most instances by electrical portable edge preparation machine. Each item was inspected for size, and correctness of edge preparation. The fit up of the rolled shell was done carefully to ensure proper root gap etc. and certified for further processing. Cleanliness of the fitment and consumables are of prime importance. Analytical grade acetone was used for cleaning,

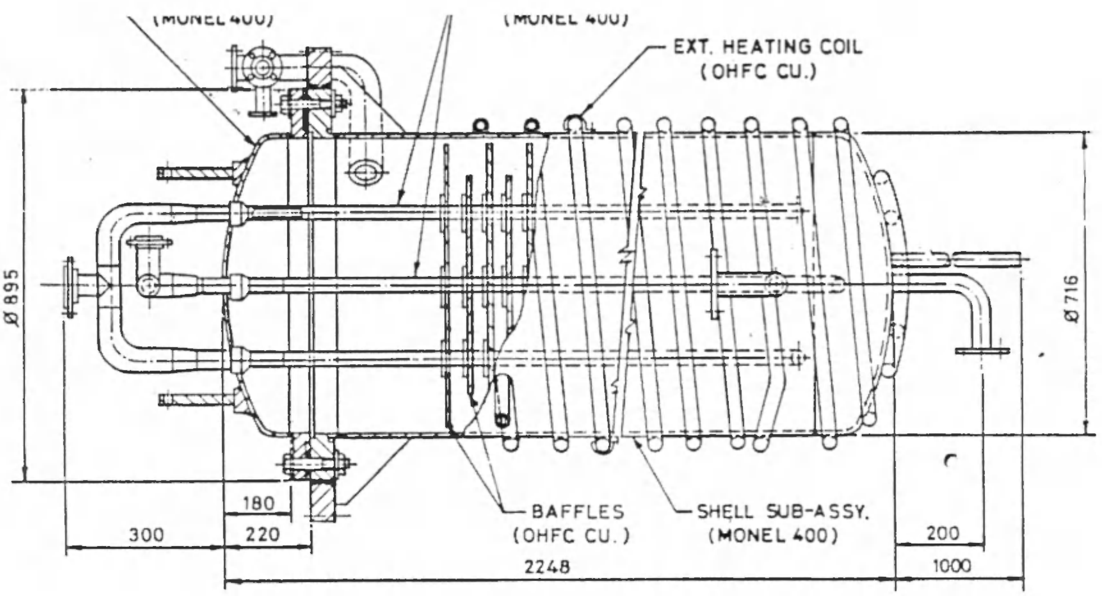

Fig. 1 *General view of the condenser assembly*

care was taken to avoid "Refilled" acetone readily available in the market. Stainless steel rotary wire brush was used. All welding was done by qualified welders only, using approved qualified procedures, as per codes. Mostly, GTAW process was used. The shells were rerolled for correcting the ovalities and radiographed subsequently.

4.1 Dished Ends to Shell

Prior to welding of the dished ends to the shells, all the dished ends were carefully inspected for ovalities. The data thus generated was used for matching the dished ends with the shell diameters. Wherever corrections are called for precise matching, the dished ends were manually corrected to get the fitments as precisely as possible. Spider and Copper backing strip was used for welding the dished end to the shell. Welding was by GTAW process, DCSP mode at 120 to 130 amps welding current, welding speed of about 150 mm/minute. Figure 4 shows the weld details of shell to dished end and figure 5 shows the longitudinal weld joint of shell.

4.2 Flange to Shell

Figure 2 gives the details of the flange to shell weld joint. Permanent backing strip was provided at the rear, to ensure high integrity of the joint. In the absence of this backing strip, grinding operation to repair the weld would have been impossible for want of access. Dissimilar thicknesses were involved in these two members. Therefore, by machining proper matching of the thicknesses was done, to facilitate proper heat distribution while welding.

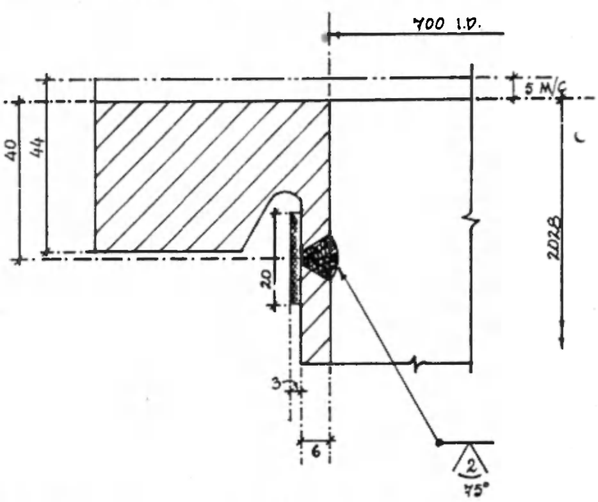

Fig. 2 *The weld joint details of shell to flange.*

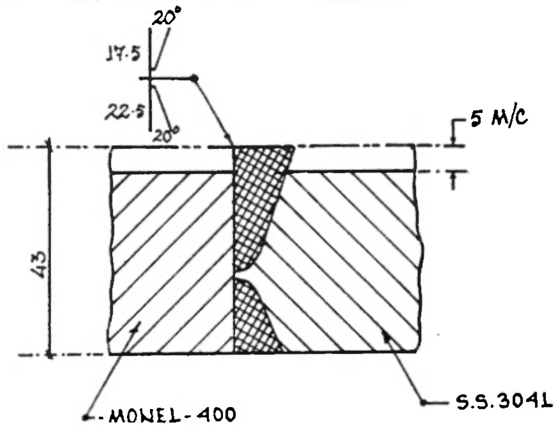

Fig. 3 *Flange to lug weld joint,*

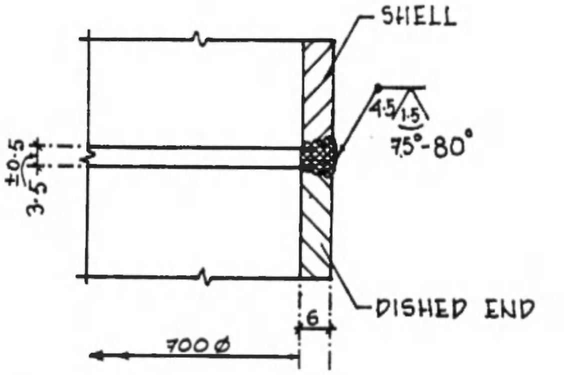

Fig. 4. *The weld joint details of the shell to dished end.*

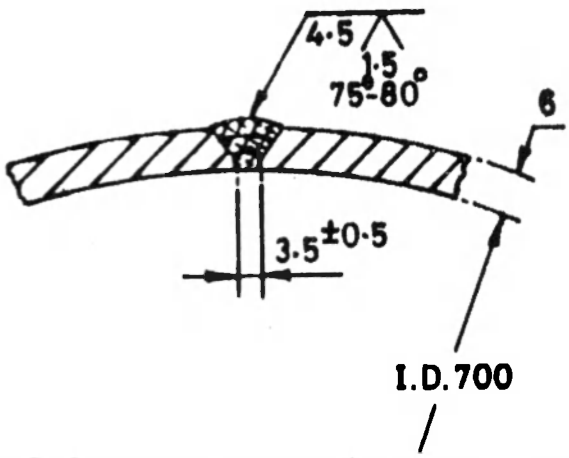

Fig. 5 *Longitudinal weld joint of the shell.*

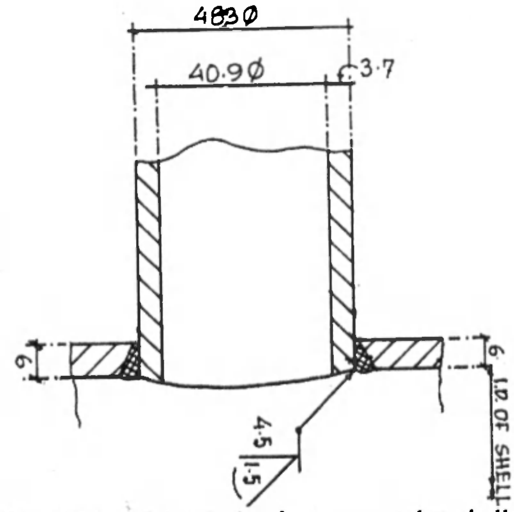

Fig. 6 (a) *Joint design for top nozzel to shell*

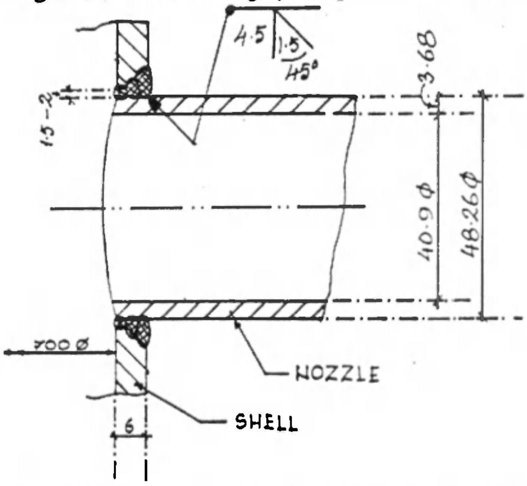

Fig. 6 (b) *Joint design for bottom nozzle to shell*

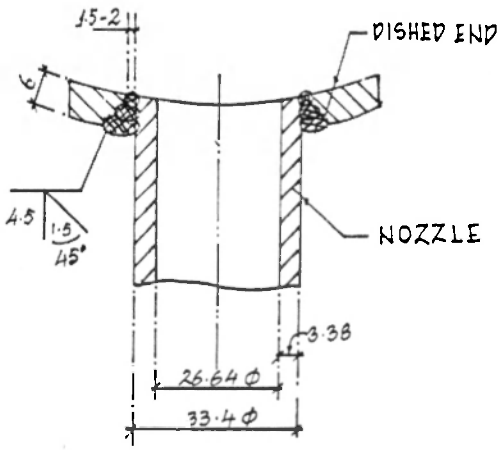

Fig. 6 (c) *Joint design for drain nozzle to dished end.*

4.3 Stainless Steel Lugs to Monel Flange

Four Stainless Steel lugs were welded to the flange as per figure 3. First three passes were done by GTAW, alternating between the two sides. After liquid penetrant test clearance, SMAW process was adapted, alternating the sides after each pass.

4.4 Nozzles

The pipes to be bent needed special attention, particularly because of the bending radius being sharp. Special dies for bending were made. The pipe lengths were appropriately cut, keeping necessary excess lengths to be cut off, subsequent to the bending operation. The pipe was filled tightly with fine sand and the ends were plugged. Bendingwas manually carried out very slowly. Lubricants were generously used on the die surfaces. After cutting off the excess lengths and thorough cleaning, the end flanges were welded using GTAW, with Argon purging by the qualified welders. These nozzles were welded by GTAW onto the shell cut outs by providing local Argon purging pockets. Each assembly, on its completion, underwent hydraulic pressure testing and MSLD for defective joints, if any. Different joint designs for nozzle welding are shown in Fig. 6 (a) to (d)

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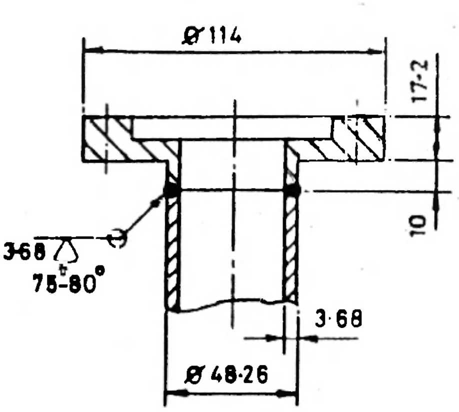

Fig. 6 (d) *Joint design for nozzle to CF64 flange (Monel 400)*

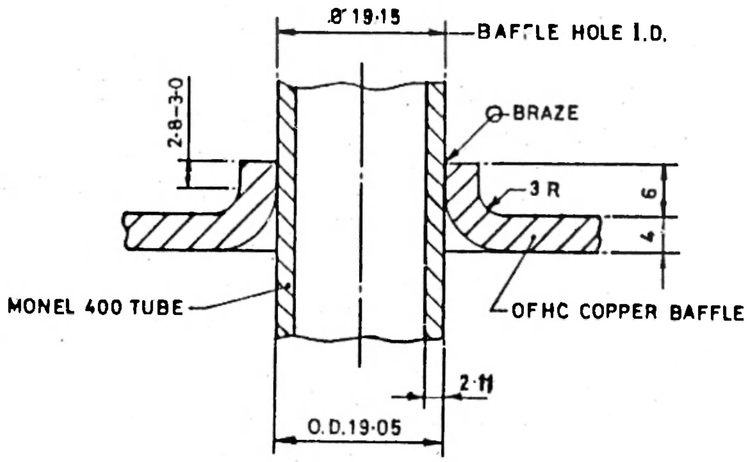

Fig. 7 *Joint design for vacuum brazing of baffle to tube.*

5.0 Vacuum Furnace Brazing

The typical joint configuration is shown in figure 7. The baffle holes were made by punching. The tube ovalities were considerable. Also the tubes were bent into U shape. Assembly of all the baffles and the U tube bundles were brazed in assembled condition. All these restrictions created problems for getting proper brazing gaps. Therefore, it was decided to flare the baffle holes oversize and assemble the tubes. The generous gaps now available were used to fill up with the selected brazing alloy in foil form. Having placed the foils in the gaps, with suitably designed and shaped tools, the gaps were crimped tight, manually. Vacuum brazing was successfully done at MIDHANI, Hyderabad at 796° C under a vacuum of 10^{-4} Torr.

6.0 Conclusion

Central Workshop at BARC, is essentially a jobbing shop catering to a wide spectrum of jobs. Great significance is attached to quality assurance at all stages of work. Several condensers have been fabricated successfully because of wide experience gained over the years and the data collected through R & D work.

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Welding Journal. Feb. '89:pp. 25.

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