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Quality Management- Customization for Qualification, Inspection and Testing During Automated Braze Welding of Austenitic Stainless Steel to Electrolytic Tough Pitch Copper for PFBR Sodium Purification Circuit Cold Traps

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Prototype Fast Breeder Reactor (PFBR) is sodium cooled, pool type, 500 MWe reactor which is at advanced stage of construction at Kalpakkam, Tamilnadu, India. The heat generated in the reactor core is removed by circulating sodium through the core. This sodium is called primary sodium and becomes radioactive as it passes through the core. The primary sodium then transfers its heat to secondary sodium in IHX which is non radioactive. Besides the primary and secondary circuit, safety grade decay heat removal (SGDHR) circuit also exists for removing the decay heat from the core. All these sodium circuits have cold traps for purifying the sodium. Cold traps works on the principle of temperature dependent solubility and by reducing the temperature of sodium, the main impurities in sodium i.e. Oxygen and hydrogen are removed as oxides and hydrides. All the cold traps are skirt supported (vertical) austenitic stainless steel vessels and consists of an inner shell and outer jacket. Between the inner shell and outer jacket air/nitrogen is used as the cooling medium for reducing the temperature of sodium. Copper fins are provided on the inner shell segment of cold traps for increasing the heat transfer area. These copper fins are distributed over the inner shell segment with very close pitch. Due to certain constraints in fabrication, braze welding of copper fins to stainless steel inner shell segment was adopted in place of brazing. The cold traps are thin walled components. These cold traps were manufactured as per stringent PFBR specification with SS 304 LN stainless steel as material of construction. Materials, Welding, Inspection and Testing of these vessels are more stringent than ASME. Since ASME doesn't provide exact details of braze welding qualifications, based on the functional requirements of cold traps, tensile test, bend test, IGC practice E, macro test and fracture test were stipulated in the Braze welding procedure specification. This paper brings out the Quality management methodologies adopted and customized during dissimilar welding i.e. braze welding of Sodium purification circuit cold traps for PFBR.

Key words: Sodium purification; Copper fins; Stainless steel, Braze welding, Quality management.

Prototype Fast Breeder Reactor (PFBR) is sodium cooled, pool type, 500 MWe reactor which is at advanced stage of construction at Kalpakkam, Tamilnadu, India. The heat generated in the reactor core is removed by circulating sodium through the core. This sodium is called primary sodium and becomes radioactive as it passes through the core. The primary sodium then transfers its heat to secondary sodium in IHX which is non radioactive. Besides the primary and

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secondary circuit, safety grade decay heat removal (SGDHR) circuit also exists for removing the decay heat from the core. All these sodium circuits have cold traps (Table-1) for purifying the sodium during the operation of the reactor and initial sodium purification circuit cold trap is used for purification of sodium before filling into the reactor main vessel. All the cold traps are skirt supported (vertical) and consists of an inner shell and outer jacket which are made of stainless steel. Between the inner shell and outer jacket, air/nitrogen is used as the cooling medium for reducing the temperature of sodium. Copper fins are provided on the inner shell segment of cold traps for increasing the heat transfer area. Copper fins are of 2 mm to 4 mm thickness and the stainless steel inner shell segment thickness ranges from 6 mm to 20 mm. These copper fins are fixed over the inner shell segment with very close pitch by braze welding.

Table 1. Cold Traps Details

S. No	Description of cold traps	Qty	Outer diameter (mm)	Height (mm)	Weight (MT)
1	Initial Sodium Purification Circuit (ISPC) Cold trap	1	Φ 3018	5900	23
2	Secondary Sodium Purification Circuit (SSPC) Cold trap	2	Φ 3018	5900	23
3	Primary Sodium Purification Circuit (PSPC) Cold trap	2	Φ 1452	5303	7.6
4	Safety Grade Decay Heat Removal Sodium Purification Circuit (SGHDR SPC) Cold trap	2	Φ728	3000	1.17

Description of Cold traps

Cold traps (Fig-1) are employed in sodium system of fast breeder reactors for maintaining the oxygen/ hydrogen levels in sodium within acceptable limits. Cold traps works on the principle of temperature dependent solubility and by reducing the temperature of sodium the main impurities in sodium ie. oxygen and hydrogen are removed as oxides and hydrides. These cold traps are manufactured as per stringent PFBR specification with SS 304 LN stainless steel as material of construction. Materials, welding, inspection and testing of these cold traps are more stringent than ASME. These cold traps are subjected to pneumatic test and helium leak test under vacuum.

Copper fins braze welding for PFBR Cold traps and constraints

As per the design requirements, silver bearing oxygen free (OFE) copper, C 10400 grade according to SB-152 shall be used as the copper fins. These copper fins shall be longitudinally brazed over the stainless steel inner shell segment by using AWS, SFA 5.8, BAg8 as the filler material. One test coupon shall be executed after completion of 10 nos of fins brazing and the test coupon shall have the same brazing parameters as that of the actual production. Brazing procedure qualification is as per ASME Section- IX. The copper fins details are given in the Table-2.

Table 2. Copper fin Details

S. No	Cold Trap	Fin Qty	Fin Thickness (mm)	Fin length (mm)	Pitch (mm)
1	ISPC Cold trap	280	4	3000	32
2	SSPC Cold trap	280	4	3000	32
3	PSPC Cold trap	111	2	2300	37
4	SGHDR SPC Cold trap	60	2	850	32

Since the copper fins length of the cold traps are very long as shown in the above table, ensuring a gap of 0.025 mm to 0.127 mm (0.001 inches to 0.005 inches) over the entire length of copper strip to provide capillary action during brazing and that too in the close pitch is not practical. Hence braze welding methodology was developed and demonstrated vide various mock-

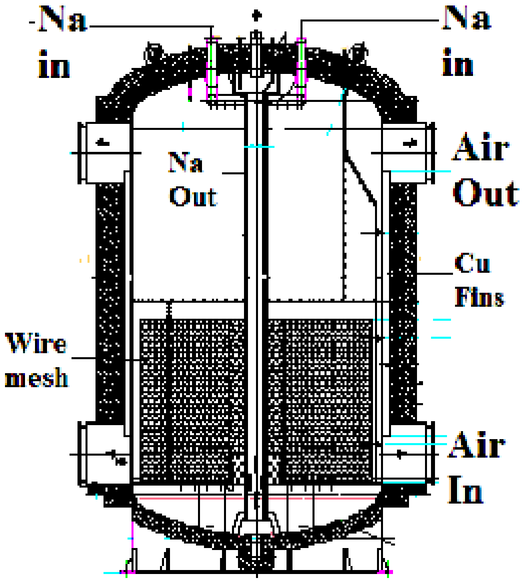

Fig. 1. Test pad configurations

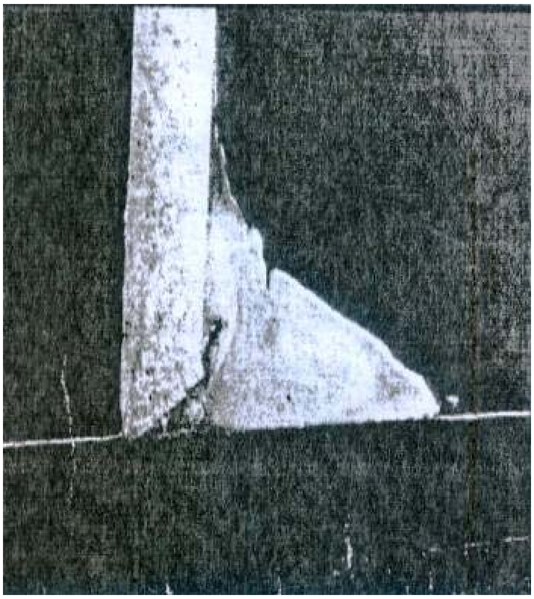

Fig. 2. Crack observed

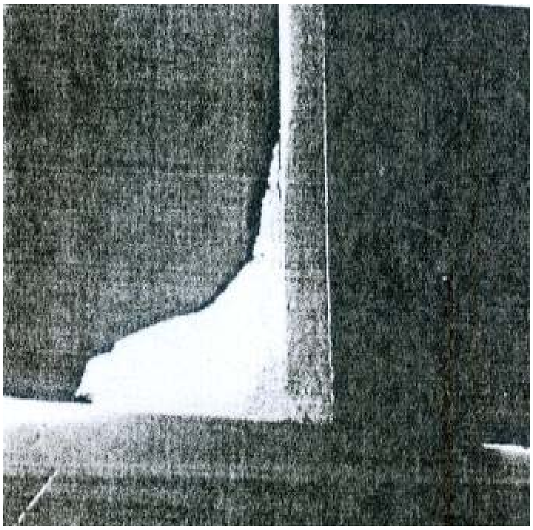

Fig. 3. Lack of fusion

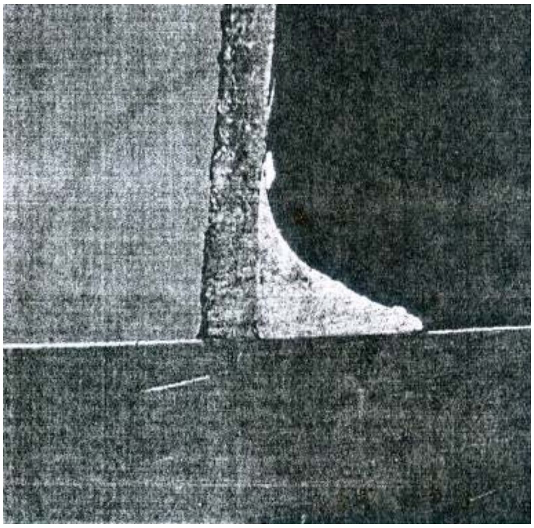

Fig. 4. Improved bead

Fig. 5. Braze welded fins in SSPC cold traps along with automation set up

ups and actual job was done successfully. Based on the market availability, Electrolytic tough pitch (ETP) copper, C 11000 according to SB 152 was selected as the copper fin material in place of OFE copper. C 11000 copper is similar to OFE copper in terms of thermal conductivity and specific heat capacity. Filler metal SFA 5.8, RBCu Zn-B was selected in place of BAg8 as the later is mostly used only in furnace brazing applications. Moreover BAg8 is very fluid and may flow out over the work surface during some brazing/ braze welding applications. RBCuZn-B can be used for torch brazing, induction brazing and furnace brazing.

Braze welding qualification and mock-up

Since ASME doesn't provide exact details of braze welding qualifications, based on the functional requirements of cold traps, tensile test, bend test, IGC practice E, macro test and fracture test were stipulated in the Braze welding procedure specification.

Based on the approved Braze welding procedure, mock-up was carried out in 1G position with 0.8 mm ¦ & 1.2 mm ¦ filler metal. Preheating temperature was maintained at 120 ºC. Argon purity of 99.995 % was ensured along with the flow rate as 8 to 10 LPM. DC (+) current in the amps range 180-220 and voltage range 20-22 was tried. SS wire brush was used for cleaning the job. Initially some problems were faced in terms of crack and lack of fusion. By optimizing the parameters and by training of welders, mock up was successful (Fig 2 to 4).

Braze welding automation

Since the number of fins to be welded were more i.e. 1182 fins covering 3.1 km it was decided to go for automated braze welding. The mock-ups were carried out in automated braze welding also and job was successfully completed well ahead of time and that too without any quality issues. The actual braze welded fins in ISPC cold trap with automation schematic and set up is shown in Fig 5.

CONCLUSION

Manufacturing of thin walled large diameter stainless components according to stringent PFBR requirements is really a challenging task. Enhanced reliability of welded components can be achieved mainly through best engineering practices, innovative fabrication techniques, quality control and quality assurance procedures in addition to design and metallurgy.

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