



e-ISSN: 2319-8753 | p-ISSN: 2320-6710

IJRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 9, Issue 9, September 2020

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 7.512

9940 572 462

6381 907 438

ijirset@gmail.com

www.ijirset.com

Reduction of Welding Rework in T23/P23 and T91/P91 Boiler Panels

A.Andrews Cyril¹, K. Venkatesan¹, D. Noorullah¹, A. Baskaran²

Department of Metallurgical Engineering, Government College of Engineering, Salem, India¹

Department of Mechanical Engineering, Government College of Engineering, Srirangam, India²

ABSTRACT: Industrial boilers are one of the most valuable and important assets at most plants (thermal power) and refineries. It's an incredibly important factor in the power plant's efficiency. The panels are a part of boilers it's the combination of tubes and fins of T91/ T23 material. Thermal conductivity and thermal expansivity are the key properties to use this T91 material in boiler panels. T23 material gives good resistance to wet corrosion and also effective survival under high temperature, high stress service. While the manufacturing of boiler panels joining process play a predominant role. Joining processes generally used are submerged arc welding, gas metal arc welding & flux cored arc welding. The results of the visual inspection on the weldment these materials reveals some discontinuities. These defects are rectified by welding rework. This paper emphasizes about reducing the rework during the manufacturing of boiler panels using these materials. After finding out the major defects its root causes are analysed. Reduction of welding rework enables improvement of weld quality in the boiler manufacturing process so that the rework, cost and timing reduce.

KEYWORDS: Boiler Panels, Defects, Discontinuities, SMAW, GMAW, FCAW, Visual analyses, Welding Rework.

I. INTRODUCTION

The Reduction of Rework Welding in Boiler Panels. Panels are the major heat transmitting part in thermal power plants. Panels are combination of tubes and fins it is made from T91/ T23. The discontinuities were completely visually analysed while the manufacturing process of panels. The reduction of defects in panels is lead to reduce the rework in panels, increase the productivity, decrease the cost of rework & also increase the entire arrangement welding efficiency and joints life times of panels from prevention of dangerous activities. The discontinuities were evaluated throughout the welded area and estimated over in percentage.

1.1 Boiler

A boiler is an indoor vessel that gives a way for combustion and transfers heat to water until it becomes predicament or steam. The recent water or steam struggling is then usable for transferring the warmth to a process. Water is beneficial and cheap medium for transferring heat to a process. When water is boiled into steam its volume increases about 1,600 times, producing a force that's almost as explosive as gunpowder. This causes the boiler to be extremely dangerous equipment and will be treated carefully.

The boiler system comprises a feed-water system, steam system, and equipment. The feed-water system supplies treated water to the boiler and regulate it automatically to satisfy the steam demand. Various valves and controls are provided to access for maintenance and monitoring.

The steam system heats and vaporizes the feed water and controls steam produced within the boiler. Steam is directed through a piping system to the appliance. Throughout the system, steam pressure is regulated using valves and monitored with steam pressure gauges.

1.2 Panels

Panel consists of a number of tubes joined together using fins. The number of tubes, length and diameter of tubes used in a panel vary according to design requirement. Water wall panels are tubular in construction made from tubes and fins of different diameter and widths as per engineering requirements. These forms the walls of the boiler which carry steam through the tubes which is heated by the fuel and the panels form the water walls of the boiler. "The water wall is defined as the flue gas tight enclosure of furnace heat exchanger section of the boiler"



Fig: 1.3 Boiler Panels

It is the basic heat transfer surface in the boiler. It forms the enclosure where combustion takes place. It also acts as a passage for flue gas flow where other heat transfer surfaces are housed. Based on their spacing they are classified as

- First pass panel
 - I. Water wall panel
- Second pass panel
 - II. Steam cooled super heater panel

1.3 PANEL MATERIAL

There are two types of materials mostly used in the panel manufacturing.

1.3a T23/P23 (7CrWVMoNb9-6)

Grade T23/P23 is a ferritic/bainitic-martensitic (2.25 % chromium, 1.6 % tungsten, 0.2 % molybdenum) steel, micro-alloyed with vanadium and niobium and having controlled boron and nitrogen contents according to ASTM A 335, A 213 or to EN 10216-2 standard under the designation 7CrWVMoNb9-6. It was introduced into the ASME Code with Code Case 2199 in 1995.

1.3a (I) Application

This grade can be used for:

- Boiler super heater and reheater tubes and water wall panels in complex fossil-fueled power plants and HRSG (Heat Recovery Steam Generators)
- Headers and steam piping in fossil-fueled power plants
- Repair and revamping projects involving the replacement of steels such as ASTM T/P22 (EN10216-2 10CrMo9-10), T/P12 (13CrMo4-5)

1.3a (II) Challenges

Grade T/P23 exhibits superior high-temperature strength and creep behavior compared to other low-alloy ferritic steels. Accordingly, the weight of boiler and piping components in this steel can be reduced and they possess increased resistance to thermal fatigue. Compared with austenitic steels, grade T23/P23 has higher heat transfer and lower thermal expansion coefficients. Low tube hardness in the as-welded condition cuts out the need for preheating and post-weld heat treatment.

1.3b T91/P91 (X10CrMoVNb9-1)

Grade T/P91 is a ferritic-martensitic (9 % chromium, 1 % molybdenum) steel micro-alloyed with vanadium and niobium, and has a controlled nitrogen content according to ASTM A 335, A 213 or to EN 10216-2 standard under the designation X10CrMoVNb9-1.

1.3b (I) Application

On fossil-fueled power plants, this grade is mainly used for high-temperature applications in super heater and reheater tubes, headers and steam piping.

1.3b (II) Challenges

Grade T/P91 exhibits excellent elevated-temperature strength and creep behavior up to 580 °C - 600 °C. Its 9 % chromium content offers better corrosion and oxidation resistance than grade 22. In addition, the reduced weight of boiler and piping components resulting from the steel's superior performance compared with other standard steels allows higher resistance to thermal fatigue. Compared with austenitic steels, grade T91/P91 has higher heat transfer and lower thermal expansion coefficient.

II. EXPERIMENTAL WORK

The major welding processes involved in panel formation are-SMAW - Shield Metal Arc Welding, FCAW- Flux Cored Arc Welding, GMAW - Gas Metal Arc Welding.

2.1 Shield Metal Arc Welding

SMAW welding may be a process which uses a consumable electrode which is roofed with a flux. The welding machine is attached to a power source which creates either alternating current (AC) or direct current (DC) to make an arc between the electrodes and therefore, the metal. The work piece and therefore, the electrode melts forming a pool of molten metal (weld pool) that cools to make a joint. Because the weld is laid, the flux coating of the electrode disintegrates, giving off vapors that function as a shielding gas and providing a layer of slag, both of which protect the weld area from atmospheric contamination. It dominates other welding processes within the maintenance and repair industry, and though flux-cored arc welding is growing in popularity, SMAW continues to be used extensively within the construction of heavy steel structures, and in industrial fabrication. The actual welding technique utilized depends on the electrode, the composition of the work piece, and therefore, the position of the joint being welded. The selection of electrode and welding position also determines the welding speed. Flat welds require the smallest amount operator skill, and may be through with electrodes that melt quickly but solidify slowly. This allows higher welding speeds.

2.2 Flux Cored Arc Welding

Flux cored arc welding, or FCAW, evolved from the gas metal arc welding, or GMAW process to enhance arc action, metal transfer, weld metal properties, and weld appearance. The Equipment used for FCAW is analogous thereto for GMAW. Some differences could be higher current capacity guns, lack of gas apparatus for self-shielded electrodes and knurled wire feed rolls. Like GMAW, FCAW uses a continuing voltage DC power supply. Depending upon the dimensions of electrode, the operation maybe DCEP or DCEN or both DCEP or DCEN. The flux cored arc welding process relatively good performance on contaminated surfaces and increased deposition rates have helped FCAW to exchange SMAW and GMAW process in many applications.

2.3 Gas Metal Arc Welding

Gas metal arc welding (GMAW), sometimes mentioned by its subtypes metal noble gas (MIG) welding or metal active gas (MAG) welding, may be a welding process during which an electrical arc forms between a consumable wire electrode and therefore, the work piece metals, which heats the work piece metals, causing them to melt, and join. GMAW requires only that the operator guide the welding gun with proper position and orientation along the work being welded. Keeping a uniform contact tip-to-work distance (the stick out distance) is vital, because an extended stick out distance can cause the electrode to overheat and also wastes shielding gas. Stick out distance varies for various GMAW weld processes and applications. The orientation of the gun is additionally important it should be held so on bisect the angle between the work piece that's, at 45 degrees for a fillet weld and 90 degrees for welding a flat surface. The travel angle, or lead angle, is the angle of the torch with reference to the direction of travel, and it should generally remain approximately vertical.

2.4 Welding Defect

The defects within the weld are often defined as irregularities within the weld metal produced due to incorrect welding parameters or wrong welding procedures or wrong combination of filler metal and parent metal. It can simply be defined as "Defects introduced during welding beyond the acceptance limit which will cause a weld to fail." A defect doesn't allow the finished joint to resist the desired strength (load). The panel defects were evaluated and represented in the pictorial view. There are four panel were evaluated throughout the welded area and they have shown in pie chart with tabulated of the panel discontinuities length, weldment length and percentage of the defect in the panel.

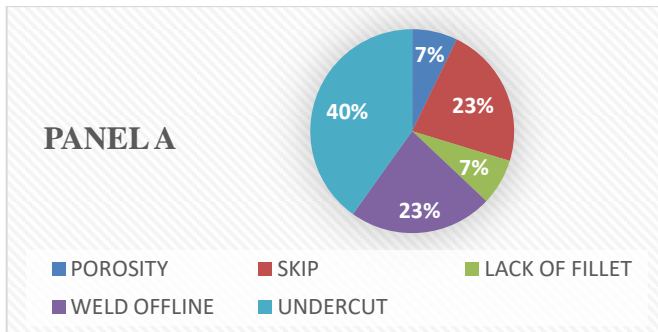


Fig: 2.1 Pie chart of Panel A defects percentage

Total Defect Length in Panel A	3550 mm
Total Weldment Length in Panel A	122472 mm
Total Percentage Defect in Panel A	5.79 %

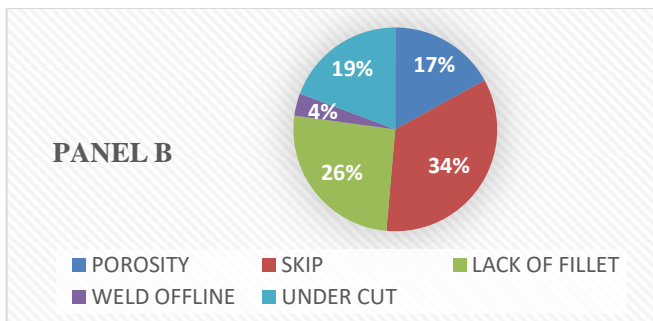


Fig: 2.1 Pie chart of Panel B defects percentage

Total Defect Length in Panel B	788 mm
Total Weldment Length in Panel B	115700 mm
Total Percentage Defect In Panel B	1.37 %

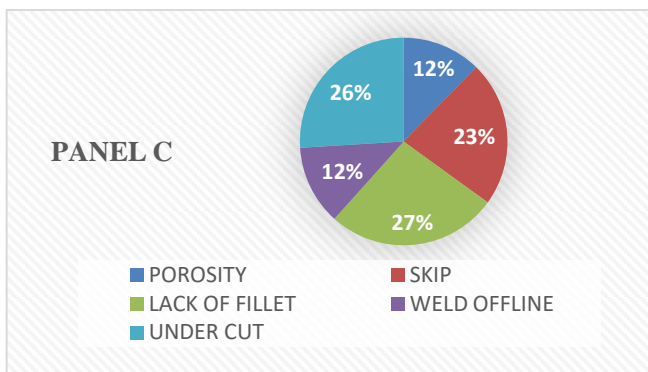


Fig: 2.1 Pie chart of Panel C defects percentage

Total Defect Length In Panel C	1032 mm
Total Weldment Length In Panel C	147445 mm
Total Percentage Defect In Panel C	1.39%

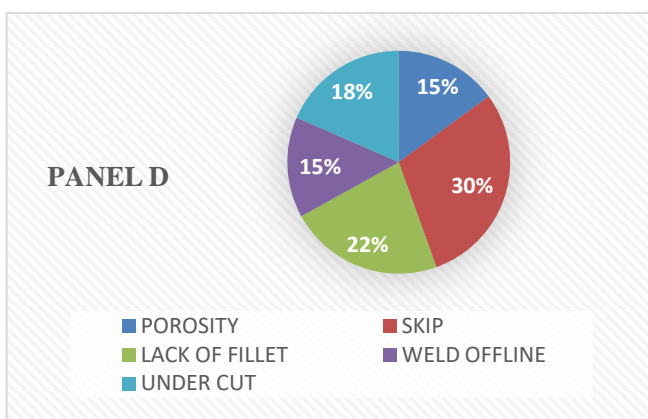


Fig: 2.1 Pie chart of Panel D defects percentage

Total Defect Length In Panel D	1204 mm
Total Weldment Length In Panel D	662400 mm
Total Percentage Defect In Panel D	0.18%

2.4a Types of Defects Occur While Welding

1. Porosity
2. Undercut
3. Overlap
4. Burn through
5. Cracks
6. Spatter
7. Skip
8. Blow holes
9. Arc strike
10. Lack of fillet

2.5 Discontinuity

An interruption of the typical structure of a material, like an absence of homogeneity in its mechanical, metallurgical, or physical characteristics. A discontinuity is not necessarily a defect.

III. RESULT & ANALYSIS

After the formation of panel both sides of panel are visually inspected for defects and the length is being calculated. The major defects found are,

- a) Blow Holes
- b) Skip
- c) Under Cut
- d) Lack Of Fillet
- e) Porosity
- f) Weld Offline

The length of the following defects is being measured and percentage defect value per pass per shift has been calculated along with the percentage intensity of Individual defect is also measured.

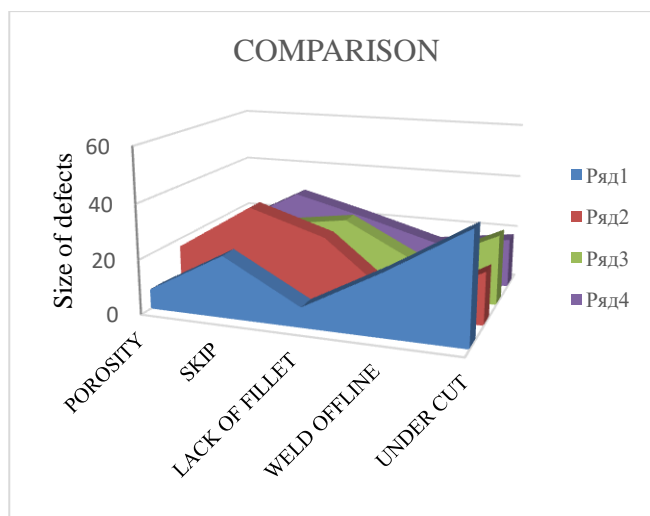


Fig: A Comparison graph of defects in panel

3.1 Comparison of Defects Panel Wise

Overall Graphical represent of panel defects & comparison shown on the graph Fig: A.

IV. DISCUSSION

During the manufacturing process of the panel there are many types of defects are occurring in each stages. Such as weld offline, undercut, blow holes, skip of welding, lack of fillets, porosity. The defects were completely visually analyses while the manufacturing process of panels. The defects were evaluated throughout the welded area and estimated over in percentage. That defects are major concern to increases the working time and reduces the welding strength. So, this work fully concentrated on minimizes the defects.

The way to reduce the welding defects are;

4.1 WELD OFFLINE

- a) Causes & Its Action Plan
 - i) Jerking of torch
 - Improve rigidity of torch mounting unit.
 - ii) Roller misalignments
 - Strictly follow the shop check list for avoid roller misalignments.
 - Third roller setting to be studied
 - iii) Start & stop at intermediate stage
 - Improve the torch rigidity
 - iv) Torch rigidity
 - Improve the torch rigidity
 - v) Angle of torch
 - Improve the torch rigidity
 - Rerouting of the cable arrangements.

4.2 POROSITY

- a) Causes & Its Action Plan
 - i) Using moisture fin
 - Functioning of heating elements to be checked and ensure the good condition of hopper.
 - Add one more heating elements for improving the heating of the fin.
 - ii) Using rusted fin
 - Proper functioning of the grit blasting to be ensured.
 - Ensure the rust free packing and storage.
 - Rusted fin can be rejected and send for other uses.
 - iii) Using rusted Tube
 - Rusted tubes to be sent for re-ROTO blasting
 - Scheduling and loading strictly adhered as per the plan
 - Inter Bay material movement arrangement is tube made in between Bay
 - Easy movement and right quantity just in time.
 - iv) Improper fit-up
 - Fin tacking unit to be checked
 - Shop made fixture to be made for fit up of panels.
 - Distortion Control
 - v) Fin
 - Sufficient quantity of the fin bar support plate to be ensured
 - Additional set of pressing rollers are to be beaded to avoid the opening of the panels, if it is Possible
 - vi) Filler wire interruption
 - Filler wire guide tubes are to be changed in line with PEMA arrangement.
 - Uniform rotation of wire spool to be ensured for uniform feeding of wire.
 - To ensure sufficient supply of quality contact Tips
 - vii) Using rusted filler wire
 - Rust free storage of filler wire to be ensured.
 - viii) Change in parameters
 - Improve rigidity of torch mounting unit.
 - ix) Spooling is not uniform
 - Check and ensure free rotation.

- x) Torch jerking
 - Modification is required to improve the torch rigidity.

4.3 SKIP OFF WELDING

I. Causes & Its Action Plan

i) While changing wire

- Improve the quality of hose.
- Provide proper sheave arrangement to avoid blocking of flux
- Provide proper flux feeding hose.

ii) Re-Starting

- Unavoidable (minimize wherever possible)

iii) Power failure

- Use an standby power system to avoid the failure

iv) Metal drip

- Metal drip can be avoided by the proper fit-up.

4.4 UNDER CUT

i) Torch angle

- Improve rigidity of torch mounting unit.

ii) Travel speed variation

- Follow the Welding procedure specification

iii) Improper parameter

- The welding procedure is properly to follow by employee

iv) Stick out (Torch distance)

- Maintain the proper distance over the material

4.5 For better welding result in GMAW

Use a CO₂ shielding gas corresponding to ANSI/AWS A5.32/A5.32M SG-C or an equipment CO₂ gas purified for welding.

Control the mixing ratio of Ar and CO₂ in Ar-CO₂ admixture shielding gas because fluctuation of the mixing ratio affects the usability of a solid wire.

Adjust the shielding gas flow rate in the 20 to 25 I/min range.

Use a wind screen in welding in a windy area because a strong wind causes blowholes.

Use a correct ventilating system at where general ventilation is insufficient.

Keep the tip-to-work distance at around 15 mm with welding currents less than 250A and at around 20 to 25 mm with welding currents over 250A.

The use of excessively low arc voltage may generate a large sound in spray arc welding with an Ar-CO₂ shielding gas. In such a case increase the arc voltage to prevent blowholes.

Torch angle, welding speed, wire diameter, and welding current markedly affect bead appearance and penetration; therefore, adjust such welding parameters consistent with the application.

4.6 For better welding result in SMAW

Slag and fumes on tack weld beats absorb moisture; therefore, they must be removed right after tack welding to prevent adverse effects on the subsequent main welding.

When wind velocity is more than 3m/sec in field welding, use a wind screen, or nitrogen in the wind decreases X-ray soundness and impact value of the weld.

In welding medium and heavy thick mild steels by using non-low-hydrogen electrodes, keep the work at appropriate preheat and interpass temperature to remove diffusible hydrogen and thereby prevent cracking in the weld.

In order to get better impact values, it is effective to lay each weld layer as thin as possible.

Many stick electrodes can be used with both AC and DC power sources. Low-hydrogen type electrodes, however, should be tested on mechanical properties beforehand, because DC current causes a little lower strength of the weld metal.

Low-hydrogen type electrodes are more suitable for surface finishing and repair welding of gas shielded metal arc and self-shielded metal arc welded deposits in order to prevent pits and blowholes.

It is recommended to strike an arc on the groove face and transfer the arc to root of the groove, maintaining the arc in stable condition.

4.7 For better welding result in FCAW

In flat butt welding, backhand technique is better for stable penetration. In horizontal and overhead fillet welding, forehand technique is best for flat bead appearance.

In vertical down fillet welding, the first layer run should be straight and keep the welding speed faster to avoid slag inclusions and to get better penetration. For the second and subsequent layers, remove the slag of preceding beads and avoid weaving.

In one side welding, welding parameters should carefully be selected to forestall welding defects like as hot cracking.

In horizontal fillet welding of primer-coated plates, porosity defects such as pit and gas hole are apt to occur; therefore, the selection of proper wires and welding parameters suitable for welding primer-coated plates are essential.

V. CONCLUSIONS

Through the continuous feedback to production engineer responsible for the maintenance & working of machine, the defect level decreased at a large rate. The reduction in defect percentage from 1st panel to 4th panel is observed.

Over the detailed analysis it is found that in panel formation following defects are occurring frequently, so following measures should be taken to reduce the percentage of defects.

To reduce defects following points should be avoided.

A) Porosity

- Improper (coating on the) electrode
- Pressure variation of shielding gas
- Longer arcs
- Faster arc travel speeds
- Too low and too high arc currents
- Incorrect welding technique
- Electrodes with damp and damaged coating
- Scale, rust, oil, grease, moisture, etc. if present on the job surface, unclean job surface
- Improper base metal composition

B) Weld off Line

- Improve rigidity of torch mounting unit.
- Strictly follow the shop checklist for avoiding roller misalignments.

C) Undercut

- Wrong manipulation and inclination of electrode and excessive weaving
- Too large electrode diameter
- Higher currents
- Longer arcs
- Faster arc travel speeds
- Magnetic arc blow
- Rusty and scaly job surfaces

D) Skip of Welding

- Metal drip is a cause for skip which can be avoided by proper fit up.
- By improving the quality of hose.

Defects is not a 100% avoidable one it's only can be reduced. By knowing the defects formation we can easily do the remedy and overcome for the defect formation and it's can get reduce the rework in panels.

REFERENCES

- [1] Victor Kislovsky, Warren T. Moss, Richard Wayne Rohaus, Process and apparatus for boiler tube panel welding and straightening, US 7,028,882 patent, Apr. 18, 2006.
- [2] Gorti B. Sarma, Steven J. Pawel and Preet M. Singh. Modeling of Recovery Boiler Tube Wall Panels to Investigate the Effect of Attachment Welds on Stress-Assisted Corrosion.



- [3] Ivan Samardžić, Božo Despotović, Štefanija Klarić. Automatic Pipe Butt Welding Processes in Steam Boilers Production.
- [4] N. Jeyapakash, R. Prabhakaran, G. Murugesan. Weldability Analysis of T23 Material for Superheater Coil, e-ISSN: 2278-1684, p-ISSN: 2320-334X, Volume 11, Issue 6 Ver. I (Nov- Dec. 2014), PP 01-04.
- [5] WANG Yi-xiang, YANG Bi-ying, XIA Hong-wei, CHEN Lei, HUXue-fei, REN Jian-hui (Anhui Special Equipment Inst., Hefei 230051, China). Technology Control on Welding Deformation in Splicing Tube Panels of High-temperature Super heater Made of T91 Steel. Equipment Manufacturing Technology, 2011-04.
- [6] Kamil Sieczkowski, Agnieszka Szczotok. Effect of Preheating before Welding on the Microstructure and the Properties of SA213 T12 and SA387Gr11CL2 Steels Joints on the Example of a Sheet Piling. ISSN: 1662-9779, Vol. 246, pp 201-206, 2016.
- [7] Gabrel, J, Lefebvre, Bo, Vaillant, J C, and Vandenberghe, B. Workability and development of T/P23 (2.25%Cr-1.6W-Nb-V steel) for fossil boiler and combined cycle applications. Germany: N. p., 2002.
- [8] Rutash Mittal, Ashutosh Gupta, Karan Pratap, Pratyush Shukla, Shyam Gupta, Shanurrahman. Microstructural and mechanical behavior in dissimilar T91/T22 welded pipes.
- [9] Marian Zeman, Mirosław Łomozik & Jerzy Brózda. Problems with welding steel T24 intended for membrane walls of boilers. Welding International, 28:11, 831-840, 05 Mar 2013.
- [10] S. A. David, J. A. Siefert and Z. Feng. Welding and weldability of candidate ferritic alloys for future advanced ultra-supercritical fossil power plants. Science and Technology of Welding and Joining, 19 June 2013.
- [11] J.C. Vaillant, B. Vandenberghe, B. Hahn, H. Heuser, C. Jochum. T/P23, 24, 911 and 92: New grades for advanced coal-fired power plants - Properties and experience. International Journal of Pressure Vessels and Piping 85 (2008) 38-46.



INNO SPACE
SJIF Scientific Journal Impact Factor

**Impact Factor:
7.512**

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

 9940 572 462  6381 907 438  ijirset@gmail.com



www.ijirset.com

Scan to save the contact details