

A Review of Superalloy Welding Experiments

Pavan Raj¹, Shivdatta D Bapat²

Student¹, Associate Professor²

Department of Mechanical Engineering

ATS's SBGI, Miraj

Corresponding Author's Email: -pavanraj005@gmail.com

Abstract

The fabrication of super alloy elements, followed by welding, is the subject of this study, which has a significant impact on the manufacturing business. Furthermore, numerous materials are used, one of which is P91. Many researchers have chosen P91 steel over the last two decades because of the key advantages it has, including its utilization in power plants, where it is common to have pipes that must sustain steam at temperatures between 570 and 600 °C and pressures between 170 and 230 bar. For most conventional steels, these operating conditions are important, needing higher high-temperature mechanical strength and strong creep resistance.

Keywords: *Welding, Tig welding, P91, A-Tig welding, Super alloys*

INTRODUCTION

The face-centred cubic gamma matrix was used to generate Super alloys. The colossal development of super alloys occurred during World War II; however, these alloys are one of the necessary classes of engineering elements because of their versatility of service contingencies in a wide range of environments and applications, such as corrosion resistance in both aqueous and high temperature, and

best corrosion resistance in both aqueous and high temperature.

Extra physical grounds include strength at room and airborne temperatures, malleability and toughness at low temperatures, and additional physical grounds.

Furthermore, compared to other commercial metallurgical alloys, super

alloys are highly exploited to their true melting point. Super alloys are divided into three categories: nickel base, cobalt base, and iron base, with a nickel-iron base subgroup.

The microstructure of those elements is mostly made up of cuboidal shaped ordered'-phase particles implanted in a disordered'-phase matrix. Mechanical components composed of super alloys function under high stress and temperature in a harsh environment during service life, and as a result, surface fractures can be seen, leading to unexpected rupture. Because mechanical components are so expensive, welding them outweighs the benefits of location; nonetheless, it is not a simple task. Furthermore, the welds must adhere to a set of stringent guidelines. They are I transforming as needed to conceive the original microstructure, (ii) not entering any relevant residual stress in the molten (MZ) and heat-affected (HAZ) zones, (iii) not producing cracks in the MZ and HAZ, (iv) not inducing massive surface segregation, and (v) to minimize elemental diffusion, which can change the chemical structure of and' phases.

Furthermore, P-91 was transformed into 9Cr-1Mo steel. P-91 manufactured structures and parts have a lot of merit in

the force and substance industry because of their amazing features like high-temperature stress erosion resistance and less vulnerability to warm weariness at high working temperatures. When it comes to the standard of living, It is excellent in terms of weld and surface completion of the manufactured structure of P91 when welded by Tungsten Inert Gas welding (TIG); however, in all cases, the cycle has a constraint in terms of weld infiltration. As a result, the completion of a welding cycle predominates in manufacturing with such a conglomeration of boundaries that provides the most extreme weld entrance and the smallest weld width. P91 creep resisting steel and comparable ASTM A335 grades have yield strength of 415 MPa (minimum), a tensile strength of 585 MPa (minimum), and longitudinal elongation of 20% (minimum), and a maximum hardness of HB 250 at room temperature. At 625°C, the minimum creep rupture strength is 68 MPa.

Objectives and Scope of the Study

The goal of this study is to provide optimal parameters for the welding of P91 using A-tig, and the following are the study's objectives:

- Welding super alloys requires the optimization of various welding

parameters. to shorten maintenance times

- Examine how these parameters affect the properties of the welding joint.
- To improve the welding quality

LITERATURE REVIEW

R. Montanari et al. found that the IN 792 DS super alloy exhibited no macro flaws such as cracks and pores but did reveal minor micro structural differences in the MZ and HAZ. The findings show that the criteria employed to distinguish seams ensure a wide range of welding and are useful for orienting the calibration of post-welding treatments.

According to M.B. Henderson et al., various factors influence defect propensity, including composition grain size, pre-and post-weld heat treatment, and the welding process itself (control of heat input and traverse speed). In a variety of gas turbine components, including nickel-based rotor discs and turbine blades, electron beam welding and laser powder deposition methods are widely employed to achieve high integrity-high attainment weldments.

Min-Yi Chen et al. show that a fully austenitic weld should have a very low

concentration of impurities to prevent hot cracking during welding; as a result, a drastic contrast in composition in the diluted zone around the weld interface occurs, resulting in a change in solidification mode from primary ferrite to primary austenite in a dissimilar metal weld. As a result, it was expected that impurities from the substrate would cause hot cracks at the weld interface.

Pedro Alvarez et al. demonstrate that the hot cracking susceptibility of alloy 718 is bounded by the Varestraint test and increases when LBW is used, which is higher than TIG welding circumstances. In the end, welding parameters were chosen to produce sound welds and meet industrial welding quality criteria, notably in terms of minimum weld width (W_m), under fill, overhang, and porosity.

K Mageshkumar et al. demonstrate that the PCGTAW's rapid cooling rate results in a refined microstructure and narrow HAZ in the fusion zone. The existence of carbide phases in the interdendritic regions was explained by SEM/EDS; yet, the presence of carbide phases boosted the strength by reducing dislocation motion during deformation. There were no cracks or other abnormalities in the fusion zone after the bend test.

M.T. Rush et al. demonstrate that when welding nickel-based super alloys, liquation cracking occurs first, followed by strain-age cracking. Furthermore, welding power affects both the incidence and amplitude of cracking. Low powers limit cracking with small spot sizes, and high powers minimize cracking with large spot sizes, demonstrating that the weld bead geometry influences cracking occurrence.

On the basis of mechanical properties and microstructural analyses, H Kazempour-Lias et al. determined that the four-stage PWHT cycle, despite being longer than the two-stage PWHT cycle, was more suitable for IN939 welding because the secondary ' particles built upon the four-stage heat treatment cycle could enhance the tensile properties. As a result, by using the best pre-and post-weld heat treatment cycles, the maximum joint efficiency of 79 per cent was achieved.

From micro structural measurements and X-ray diffraction, SaibCherif et al. show that the microstructure of the Ni-base super alloy INC738LC is exceedingly confusing since it includes many phases: γ , γ' particles, and carbides. The fusion zone has a different microstructure from the rest of the welded joint, which contains some precipitates.

Q. Wang et al. [9] demonstrate that the heat input surges as the welding speed are increased, and the welding current is increased. As a result, it can cause the welding pool to broaden and deepen, columnar crystals to decrease, and free dendritic crystals to increase in the seam; additionally, it can cause the strength and elongation of welded joints to increase initially and then decrease.

Sumit Mahajan et al. Demonstrate that the tensile properties of welds made with laboratory-developed electrodes were less severe than those of the equivalent base metal P91 but more significant than those of the base metal SS304L. Welds made using laboratory-developed electrodes (E7, E16) had better conforming transverse and longitudinal tensile characteristics than welds fabricated using commercial electrodes (CE). Tensile specimens from the base P91 side have shattered in the instance of E7 and E16DMW.

Shuangqun Zhao et al. demonstrate that the primary instabilities in the creation of INCONEL alloy 740 during long-term ageing include γ_2 coarsening, a high number of generation, and a high fraction of G phase existence at grain boundaries.

Serrated grain frames have little effect on the initial and subsequent creep behaviours, as demonstrated by An-Chou Yeh et al. However, it can dramatically reduce the creep strain rate in the tertiary creep zone and extend the creep rupture life. A modest adjustment to the solution heat treatment process can significantly improve the creation of serrated grain boundaries in IN718 and result in a 30% increase in creep rupture life.

Zhaokuang Chu et al. Demonstrate that there is a strong correlation between the two figures of strength and ductility, such that an increase in yield and tensile strengths correspond to a decrease in ductility throughout the same temperature range.

R. K. Sidhu et al. demonstrate that the UMT pre-weld heat treatment, which includes material ageing, reliably reduces the material's susceptibility to HAZ cracking, regardless of the filler material used. Intergranular liquation cracking occurred in all welds but was limited to the HAZs.

Anup Kulkarni et al. [15] demonstrate that by using inter layers, compositional adjustments can be accomplished in A-TIG welding. As a result of the use of inter

layers, an increase in chromium and nickel equivalents was observed. Without interlayer, an untempered martensitic structure was achieved at the weld zone. The interlayer of incoloy 800 resulted in a martensitic-austenitic structure in the weld zone, whereas the interlayer of Inconel 600 resulted in a completely austenitic structure.

Contrary to previous dissimilar metal welds P22yP91, Russel Fuchs et al. [16] demonstrate that the special carbon developing elements V, Nb, and Ti either prevent or reduce the degree of C-diffusion, regardless of whether the same weld metals are preferred for low alloyed pipe steels or higher alloyed elements.

According to A.H. Yaghi et al., the greatest tensile stresses occur closer to the interior cover of the pipe in thin walls and closer to the pipe's exterior surface in thick walls. Peak compressive stresses occurred closer to the pipe's outside surface in thin walls, and closer to the pipe's inside surface in thick walls.

According to Huijun Li et al., virgin P91 steel has a heterogeneous microstructure of tempered martensite laths with a mean diameter of 0.4 μ m. Some dislocation structures are included in this.

According to Chandan Pandey et al. [19], P91 and P92 steel plates of thickness 8 mm are joined favourably using autogenous tungsten inert gas (ATIG) (weld 2) and gas tungsten arc (GTA) welding (weld 1) with filler process.

According to Kamal H. Dhandha et al., arc constriction is the mechanism responsible for an increase in depth of penetration and a decrease in weld bead width. 3. Heat input increases when activated fluxes are used.

C. Pandey et al. demonstrate microstructure evolution in P91 steel base and weld metal under various heat exposure conditions and their impact on material performance. The virgin state (N&T) microstructure was composed of tempered martensitic microstructures that were stable due to precipitation hardening, solid solution hardening, and sub-grain hardening.

S. Krishnan et al. demonstrate that GMAW-P allows for more precise control of the heat input per unit length when compared to conventional GMAW, as well as a faster rate of electrode deposition than GTAW with external electrode wire, and does not have the flux-related issues that SMAW, FCAW, and SAW processes do.

According to J Brozda et al., when welding steel P91 to 10H2M, there is a chance that a narrow area of lower impact strength will develop in the transition zone of P91 due to the presence of the carbon-enriched structure of the HAZ and a decarburized zone within the weld.

Anup Kulkarni et al. demonstrate that tensile test specimens flunked from the P22 steel base metal in both cases, indicating that the weld is stronger than the base metals. In both as-welded and PWHT conditions, the ultimate tensile strength was 522 MPa and 491 MPa, respectively.

According to Jayant Gopal Thakare et al., the DWJ determines the heterogeneous microstructure in the as-welded state, with untempered lath martensite, PAGBS, lath packets, and negligible precipitates in the weld fusion zone, coarse grain with complete dissolution of precipitates near fusion boundary along P91 side, fine PAGs with partially dissolved precipitates, partially tempered martensite, and recently developed untempered marten

CONCLUSION

The following are some of the primary conclusions gained from the review of experimental welding of super alloys:

- Composition, grain size, pre-and post-weld heat treatment, as well as the

welding process itself, i.e. control of heat input and transverse speed, are all elements that influence defect likelihood.

- Identification of process parameters is still essentially experimental, and complete knowledge of joining processes is contingent on the development and implementation of more advanced numerical modelling approaches.
- The arc voltage fluctuations during welding were investigated, as well as the dissolved oxygen level in the weld zone. However, it can be determined that arc constriction performed a minor influence in boosting penetration depth, while the reversing Marangoni convention played a substantial role.
- Using A-tig welding, we were able to weld different metals in a single pass.

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