Characterization of Welded Duplex Stainless Steel for marine applications

Balasubramaniam N S #1**, Santhosh A N** #2**, Dr. Aprameyan S** #3

[1]*Assistant Professor, C.Byregowda Institute of Technology, Kolar, India*

[2]*Assistant Professor, C.Byregowda Institute of Technology, Kolar, India*

[3]*Professor C.Byregowda Institute of Technology, Kolar, India*

balu_me400@rediffmail.com#1

ansanthoshan@gmail.com#2

aprameyan2565@gmail.com#3

Abstract— **The purpose of this study is to subject the DSS with different intermediate thermal ageing temperatures such as 475°C and 375°C respectively and for the further study TIG welding is carried out in a view to understand how exactly the thermal ageing is influencing to the degree of brittleness in both developed and developed welded DSS. This investigation in turn helps to reduce the severity of brittleness and hence to avoid sudden failures at the hull of marines. The microstructure test reveals that DSS (475°C) behaves much harder with a lack of ferrite due to carbide precipitation and irregular grain orientations.**

Keywords—**Duplex Stainless Steel (DSS), thermal ageing, brittleness, microstructure, precipitation, grain orientations.**

I. INTRODUCTION

The duplex stainless steel (DSS) family was introduced commercially about 1920's mainly intended for the pulp and paper industry. Original duplex Alloys suffered from brittleness and low ductility. A second generation with improved Weld-ability, mainly due to higher additions of nitrogen, was developed in the early 80's. Duplex Stainless Steels are extremely corrosion resistant, work hardenable alloys.Their microstructures consist of a mixture of austenite and ferrite phases. This two- Phase structure of ferrite and austenite combines the beneficial effects of the phases and allows the steel to obtain high strength (ferrite) and toughness (austenite) even at low temperatures.

II. METHODOLOGY

The methodology involves the following to subject the developed and developed welded DSS into various mechanical tests to characterize its hardness, impact toughness and UTS results. Comparative study is also made between all those developed and developed welded grades to identify the grade, which exhibits better mechanical properties for applying at hulls of marines.

a. Development of DSS

Two categories of (Chromium-Nickel steels AISI 304) DSS blanks is manufactured by following heat treatment process for different thermal ageing temperatures such as 475°C and 375°C for first and second blanks respectively.

b. Welding of developed DSS

The welding parameters carried out for TIG welding process is carried out according to American Welding Society (AWS) such as plate thickness of 12mm, welding current of 55amp, electrode type as AWS E 316L.

Fig 1: Welded DSS (double V-groove TIG welded)

c. Evaluation of mechanical properties for DSS

The steps carried out for evaluation of mechanical properties for both developed DSS and developed welded DSS are same and are summarised as below:

Hardness Test

DSS falls under a family of soft ferrous metal. Hence in this work, it is suitable to select Rockwell hardness test for further determining hardness.

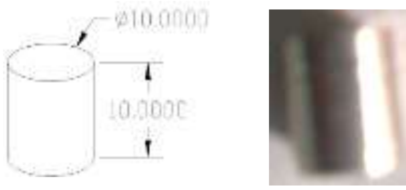


Fig 2: Hardness specimen specifications

Impact test

The main intention of conducting impact test for developed DSS and developed welded DSS, which is being applied at the hull of marines, is to measure materials ability to with stand shock loading due to waves.

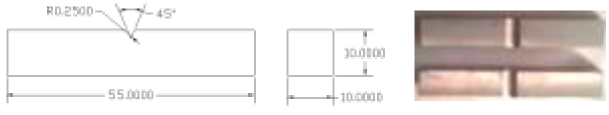


Fig 3: Impact test (Charpy) specimen specifications

Tensile Test

Tensile test is used to determine ultimate tensile strength and several other properties such as Young's Modulus, Yield Strength, Proof Strength of material This test in turn supports to study the fracture behavior of a material.

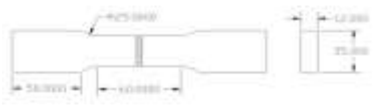
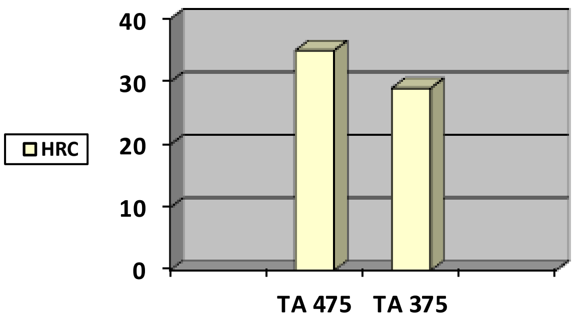


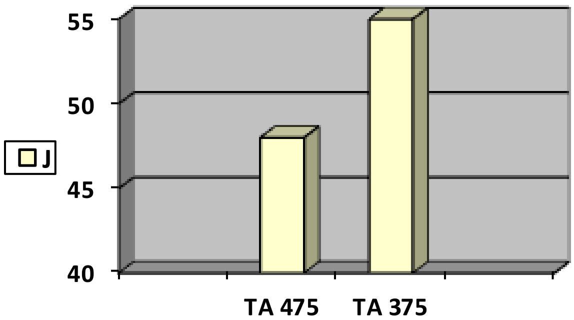

Fig 4: Tensile test specimen specifications

III. RESULTS & DISCUSSION

The results extracted from the current work on examining the influence of thermal ageing temperature on mechanical properties of both developed and developed welded DSS and serves as a basic for predicting the thermal ageing temperature at which their exhibits better mechanical properties. The results obtained from different tests have been shown below.

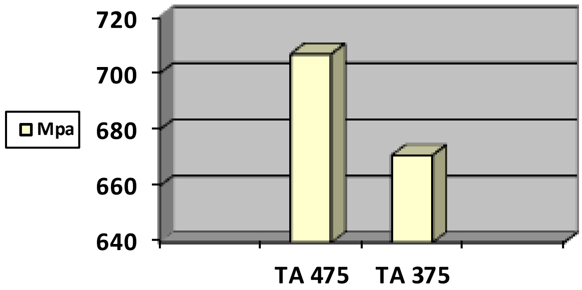


Hardness test results explains that the ductility in TA375 is more and thus TA375 possesses more load bearing capacity before fracture in contrast with TA475.



From impact test, it is evident that impact toughness of fracture energy for TA375 is higher than TA475 when tested under Charpy scale. It has been observed that TA375 absorbs more impact energy compared with TA475.This feature is very much essential for the hulls of marines in order to withstand impact loads due to waves and winds.

Hence it can be concluded that TA375 possesses more ductility and thus it can absorb more energy under impact loads before fracture in contrast with TA475.



Tensile test is reveals that the UTS for TA375 is lesser than TA475. It signifies thatTA375 will withstand relatively lesser load in comparison with TA475 before fracture. It is also clearly identified that percentage of elongation for TA375 is more compared to TA475.

CONCLUSIONS

From the comparative study among the two of developed DSS grades of TA475 and TA375, followed by welding yield the following conclusions:

- The results of Hardness test reveals that, TA375 and welded TA375 exhibits less hardness value among the other grade and this shows the sign of reduced embrittlement, which is desirable in the hull of marines.
- Impact test explains thatTA375 and welded TA375 can sustain more loads (due to waves) before fracture in comparison with TA475 and welded TA475 due to more toughness.
- Tensile test results TA375 and welded TA375 had lesser UTS and also show more percent of elongation among other grade. The lesser value of UTS proves the loss of embrittlement.

REFERENCES

1) Rue Colonel, International Stainless Steel Forum120 B-1140 Brussels Belgium,

2) Bengt Wallem and Avesta Sheffield A.B, Research and Development, SE-774 80

3) D.Dyja, Z.Stradomski, Microstructural Evolution in a Duplex Cast Steel after Quench Ageing, Archives of Materials Science and Engineering, Vol. 28(9), September 2007, pp. 557-564.

4) M.Shafy, Embrittlement Prediction of Aged Austenitic Stainless Steel Welded Components Using Hardness Measurements, Egypt. J. Solids, Vol. 28(2), 2005, pp. 325-335.

5) P.Labanowski, Stress Corrosion Cracking Susceptibility of Dissimilar Weld Joints, Achievements in Materials and Manufacturing engineering, Gdansk, Poland, Vol. 20(1-2), Jan-Feb 2007, pp. 255-258.

6) S.Topolska, J.Labanowski, Effect of Microstructure on Impact Toughness of Duplex and Super Duplex Stainless Steels, Achievements in Materials and Manufacturing engineering, Gdansk, Poland, Vol. 36(2), October 2009, pp. 142-149.

7) Janos Dobranszky and Janos Ginsztler, Microstructural Stability of Duplex Stainless Steel Weldments, Research Group for Metals Technology of the Hungarian Academy of Sciences Goldmann ter 3, Budapest 1118, Hungary, Vol. 561-565, 2007, pp. 2119-2122.

8) Iris Alvarez-Armas, Duplex Stainless Steels: Brief History and Some Recent Alloys, Instituto De Física Rosario - CONICET,

Universidad Nacional De Rosario, Bv. 27 de Febrero 210 bis - 2000 Rosario – Argentina, Vol. 1(1), 2008, pp. 51-57.
9) J.W.Abtibol Menezes, H.Abreu, S.Kundu, H.K.D.H.Bhadeshia and P.M.Kelly, Crystallography of Widmanstatten Austenite in Duplex Stainless Steel Weld Metal, Science and Technology of Welding and Joining, Vol. 14(1), 2009, pp. 4-10.
10) W.Dietzel, Fracture Mechanics Approach to Stress Corrosion Cracking, Anales de Mecánica De La Fractura, Geesthacht, Germany, Vol. 18, 2001, pp 1-7.

