International Conference on Recent Innovations in Science, Engineering & Management
R.R. INSTITUTE OF TECHNOLOGY, Bengaluru (India)
10th - 11th May 2019 www.conferenceworld.in ISBN : 978-93-87793-87-3

A REVIEW ON INVESTIGATION OF MICROSTRUCTURAL ANALYSIS OF DUPLEX STAINLESS STEEL

Mr. Shridharmurthy H.N.[1], Dr. Arulmani L[2]., Mr. Madhu Kumar V[3], Mr. Nagesh S[4], Mr.Shrikanth Patil[5] , Mr. Mahesh Hukkeri[6]

[1]*Assistant Professor: Dept. of Mechanical Engineering, RRIT (VTU), Bengaluru, India*

[2]*Associate Professor: Dept. of Mechanical Engineering, RRIT (VTU), Bengaluru, India*

[3456]*B.E Students: Dept. of Mechanical Engineering, RRIT (VTU), Bengaluru, India*

ABSTRACT

Duplex stainless steels are the most recent family of stainless steels developed in the 1960's. Duplex stainless steel is one of the fastest growing material in the field of steels. It is an exiting area of interest for researchers, stainless steel producers, fabricators and end users. They present very diversified technical challenges and simultaneously attractive in-service properties at excellent cost/properties ratios, particularly in critical markets including oil and gas, chemical industry, pulp and paper industry, water systems, desalination plants, pollution control equipments, chemical tankers, etc.

Keywords: Corrosion resistance, Deformation, Hardness, Microstructure, Temperature.

INTRODUCTION

Stainless steels are alloys which containing 11% of chromium by weight. They have very good corrosion resistance property compared to other steels because of chromium oxide coated on the surface of stainless steel. The more the chromium oxide is added the corrosion resistance property will be higher. Stainless steels can be classified into five groups based on their microstructures ferritic, austenitic, martensitic, duplex and precipitation hardening stainless steels.

Ferrite and austenite are in equal proportions in Duplex stainless steels which have much better corrosion resistance and mechanical properties compared to single phase stainless steels. They even provide good resistance to chemical environment. These are the steels with higher strengths which can be used as alternatives for similar single phase austenite and ferrite steels. These steels are duplex in nature of d-ferrite and austenite. The 2205 duplex stainless steel has higher ferritic structure at about 1300ºC because its volume fraction increases at higher temperature. The duplex structure of these alloys under hot working temperatures could change hot deformation behavior.

LITERATURE

A. Momeni • K. Dehghani • X. X. Zhang [1]studied thatthe hot deformation characteristics of 2205 duplex stainless steel was analyzed by the constitutive equations and microstructural observations. The flow stress of the studied material is very well fitted by the constitutive equation of hyperbolic sine function at low and high deformation temperatures. The material constants of n, A, and a and the apparent activation energy are polynomial functions of strain. The polynomial relations are used in the hyperbolic constitutive equation to guess the flow curves of the studied duplex stainless steel. Dynamic recovery in ferrite accelerates at higher temperatures and is extended to continuous DRX.

A. Iza-mendia, Pin ol-juez, J.J. urcola, and I.Gutie rrez, [2] worked onthe ferrite develops sub-grain structure even if rotation take place of this sub-grain observed in as-cast steel. In the as-cast and wrought duplex stainless steel their different intial microstructure defines the mechanical behaviour of the duplex stainless steel. The strain can be divided in different ways in ferrit and in austenite some austenite areas act as hard non deforming particles, even for large strains.Damage at the ferrite/austenite interface is present when deforming at 1000ºC, associated with slightly deformed austenite areas.

Vahid A. Hosseinia, Leif Karlssona, Cemrnekc, [3] studied that a functionally graded microstructure was produced by the arc heat treatment of grade 2507 (UNS S32750) super duplex stainless steel under steady state conditions for 10 h. Microstructural analyses were performed and experimental results were compared to thermodynamic calculations. Due to solid state diffusion Nitrogen was depleted up to 1.2mm from the fusion boundary which affectes the ferrite/austenite balance and resulted in the formation of a fully ferritic microstructure in the region heat treated between 1150 °C and 1430 °C. Sigma phase formed between 630 °C and 1000 °C, chi phase at 560–1000 °C, chromium nitrides at 600–900 °C, R-phase at 560–660 °C, and presumably Mo-rich thin intergranular films at 560–660 °C. Evaluation of phase fractions in the graded microstructure revealed that equilibrium sigma and austenite fractions, as predicted by thermodynamic calculations, were approached at 750–880 °C, but not above 950 °C or below 750 °C.

Alberto Moreira Jorge Junior, Oscar Balancin [4] investigated thatthe mechanical behavior of duplex stainless steels when the microstructure was essentially ferritic during hot deformation and it is determined by the matrix and the plastic flow curve is typical of materials that undergo extended dynamic recovery. The austenite particles in the duplex stainless steel combines with the ferritic matrix inhibits deformation of the material, increasing the initial flow stress and the hardening rate. With the extended dynamic recovery of the matrix, there is loss of this coherence and thussoftening of the material.

Jithin M, Anees Abdul Hameed, Ben Jose, Anush Jacob [5]studied from the various tests it can be concluded that the mechanical properties vary depending upon the various heat treatment processes. Hence depending upon the properties and applications required we should go for a suitable heat treatment processes. They observed that, after hardening the hardness increases as the soaking time increases. Similarly the normalising heat treatment increases wear strength, and also the compressive yield strength of the Duplex stainless steel with the increasing soaking time. It reduces the strength of Duplex stainless steel. So hardening heat treatment can be used to improve the hardness of Duplex stainless steel. The tempering is used for increasing the impact strength. From the result obtained after tempering it is found that impact strength of the Duplex stainless steel also increases with increase in soaking time. But it is found that hardness of Duplex stainless steel steel reduces after tempering.

Mahesh B. Davanageri, Narendranath S, RavikiranKadoli, [6] observed that super duplex stainless steel AISI 2507 was aged at 850°C for 1 hour followed by water and oil quenching. The effects of sigma phase (σ) on hardness and wear properties were investigated. Microstructure of heat treated super duplex stainless steel showed that sigma ($\sigma\sigma$) phase was precipitated on high Cr-concentrated region of $\delta\delta$-ferrite. It was observed that at 850°Cabout 30% by volume fraction got precipitated.Hardness of the heat treated specimens was increased when compared to solution treated specimens due to secondary precipitation of sigma (σ) phase at 850°C.It was concluded that as the sliding distance increases the wear volume lost for the specimens were increased. However, it is lower in case of oil quenched specimens when compared to water quenched and solution treated specimens.

R. Jayachitra, K.Vijayalakshmi and V.Muthupandi, [7] studied Ultrasonic longitudinal velocity and attenuation characteristics in DSS heat-treated in two phase (α & γ) regions were studied. The results show that the attenuation is mainly decided by the grain size and attenuation increases with increase in grain size. The ultrasonic velocity is found to be dependent upon both ferrite-austenite ratio and the grain size.

A. Vinoth Jebaraj, L. Ajaykumar, C.R. Deepak, K.V.V. Aditya,[8] studied that Nickel enriched filler metal ER 2209 and nitrogen added shielding medium play a crucial role in forming the microstructure which contains larger amount of austenite phases in the DSS weld. Also, the addition of nitrogen through the shielding medium slows down the formation of intermetallic phases. The addition of Chromium beyond 22% in the weld filler leads to the formation of excessive ferrite phases in the DSS weld. DSS solidifies initially as delta ferrite and austenite nucleates in three different stages after welding. Grain boundary allotriomorphs, Widmanstatten structure, and intragranular austenite particles are the three forms of austenite phases present in the fusion zone. The zone next to the fusion line, i.e. HTHAZ, approaches close to the melting point which gives nearly 75–80% of ferrite phases due to the rapid cooling involved in this region.

Xun Wu**,** Baolei Li**,** Jie Li, Zhimin Ling [9] A certain corrosion rate of corroded steel bar can beobtained by electric accelerated test in a short period of time, and the degradation law that mechanical properties of duplex stainless steel bar after corrosion can be reflected well. The surface of corroded duplex stainless steel bar is not uniform after the test of electricity accelerated, appeared the concave and convex corrosion pits. And the maximum loss ratio of sectional area is used to characterize corrosion degree; According to the pattern of corrosion pits, the maximum loss of steel cross section is simplified to get the corresponding geometric model and the corrosion degree is obtained accurately by quantitative calculation. The results revealed that the corrosion rate appears first quick back slow trend with the electric corrosion time.

Ve´ronique Aubin, Philippe Quaegebeur, Suzanne Degallaix [10] Cyclic tests on a duplex stainless steel were carried out, which provide a better knowledge of the behavior of this steel under complex biaxial loadings. The influence of loading history was studied in terms of strain amplitude, mean strain and loading path. Despite its elongated microstructure in the rolling direction, the duplex stainless steel studied has a monotonic and cyclic isotropic behavior. Whatever the loading path, after a rapid hardening, the steel softens cyclically until stabilization in the range of the strain amplitudes studied. As austenitic stainless steels, the duplex stainless steel is sensitive to loading path, although the extra-hardening observed is lower for the duplex stainless steel. Three groups of loading paths are distinguished with increasing stress responses at the stabilized cycle: (i) tension compression, torsion and proportional 458 paths, (ii) clover path, (iii) square, circle and hourglass path.

N. Saliba and L. Gardner [11] An experimental and numerical programme investigating the structural behaviour of lean duplex stainless steel welded I-sections has been performed at Imperial College London. A total of 24 material tests, 4 stub column tests and 8 bending tests were conducted. The specimen geometries, including measurements of initial imperfections, and test results, including full load-deformation histories, have been fully reported. Numerical models were validated against the experimental results, after which parametric studies were carried out to generate further structural performance data on lean duplex stainless steel. The obtained results from both the experiments and the numerical analysis were used to evaluate the applicability of existing design approaches to lean duplex stainless steel. Further improvements in efficiency could be achieved using the continuous strength method. The test results on lean duplex stainless steel were also compared to results obtained from tests performedon austenitic, ferritic and duplex grades. The comparisons show that, on a normalized basis, the behaviour is similar to other stainless steel grades, and hence, lean duplex stainless steel can be added to future revisions of EN 1993-1-4. Overall, the high strength, good corrosion resistance and moderate cost of lean duplex stainless steel make this material an attractive choice for structural applications.

CONCLUSION

Without doubt duplex stainless steel is one of the high strength and good corrosive resistance material compared to other stainless steel. Its mixture of austenite and ferrite in equal proportion makes it more corrosion resistance and can have good mechanical behavior at higher temperature. The duplex nature of these steel can with stand stress and strain and even posses good properties under chemical environment. These steel offer higher heat conductivity and lower thermal expansion.

REFERENCES:

1. Momeni • K. Dehghani • X. X. Zhang, Mechanical and microstructural analysis of 2205 duplex stainless steel under hot working condition (2011) 2966–2974.
2. A. Iza-mendia, a. Pin ol-juez, j.j. urcola, and I. GUTIE RREZ, Microstructural and Mechanical Behavior of a Duplex Stainless Steel under Hot Working Conditions 1997 volume 29a, (2975-2986).
3. Vahid A. Hosseinia,b,, Leif Karlssona, Cem Örnekc,d, Pierfranco Reccagnie, Sten Wessmana, Dirk Engelberge Microstructure and functionality of a uniquely graded super duplex stainless steel designed by a novel arc heat treatment method.Materials Characterization 139 (2018) 390–400.
4. Alberto Moreira Jorge Júnior, Gedeon Silva Reis, Oscar Balancin, Influence of the microstructure on the plastic behaviour of duplex stainless steels.Materials Science and Engineering A 528 (2011) 2259–2264.
5. Jithin M, Anees Abdul Hameed, Ben Jose, Anush Jacob Influence Of Heat Treatment On Duplex Stainless Steel To Study The Material Properties.International journal of scientific & technology research volume 4, issue 02, february 2015 issn 2277-8616
6. Mahesh B. Davanageri1, Narendranath S, Ravikiran KadoliInfluence of Heat Treatment on Microstructure, Hardness and Wear Behavior of Super Duplex Stainless Steel AISI 2507 American Journal of Materials Science 2015, 5(3C): 48-52.
7. R. Jayachitra, k. Vijayalakshmi and v. Muthupandi. Microstructural Characterisation of SAF 2205 Duplex Stainless Steel Heat - Treated at 1300°C Material Science Research IndiaVol. 8(2),309-313 (2011).
8. A. Vinoth Jebaraj, L. Ajaykumar, C.R. Deepak, K.V.V. Aditya Weldability, machinability and surfacing of commercial duplex stainless steel AISI2205 for marine applications. Journal of Advanced Research (2017) 8, 183–199
9. Xun Wu, Baolei Li, Jie Li, Zhimin Ling Study on the Corrosion of Duplex Stainless Steel Bar. International Conference on Smart City and Systems Engineering(2016) 30-303
10. Ve´ronique Aubin, Philippe Quaegebeur, Suzanne Degallaix Cyclic plasticity of a duplex stainless steel under non-proportional loading.Materials Science and Engineering A346 (2003) 208-215.
11. N. Saliba and L. Gardner Cross-section stability of lean duplex stainless steel welded I-sections Journal of Constructional Steel Research. 80(1), 1–14.