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Evaluation of Duplex SS as a Substitute for Austenitic SS in the Manufacture of Pressure Vessels

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***Abstract*— Duplex stainless steel are family of grades having the combination of good corrosion resistance with high strength and ease of fabrication [1]. Their physical properties are between those of austenitic and ferritic stainless steels[1] but Our paper provides a detailed study of duplex stainless steel and its advantages in manufacturing of pressure vessel. This work assumes the reader already has experience with the fabrication of stainless steels; therefore, it provides data comparing the properties of duplex stainless steels to those of 300-series austenitic stainless steels and to carbon steel. Therefore, process equipment manufacturers and component suppliers can reduce lead times and provide better stainless steel equipment for critical service in industrial environments as a result of information developed in this study.**

***Index Terms*— Mechanical simulation, distortion, residual stress,**

I. Introduction

Problem Statement

this program involves two major areas of endeavor, interrelated and leading to a more fundamental understanding and comparison of the corrosion and distortion behavior of various grades of stainless steels as regards their fabrication. Therefore, process equipment manufacturers and component suppliers can reduce lead times and provide better stainless steel equipment for critical service in industrial environments as a result of information developed in this study.

The following goals have been defined for this project:

- Evaluation for duplex stainless steel materials and their welds, in comparison with their austenitic counterparts, regarding microstructure, corrosion resistance, weldability and welding distortion, and mechanical properties.
- Providing a solution to the problem of corrosion/erosion faced by the client through the comparative study conducted.

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II. Project Goal

To reduce the of corrosion/erosion and distortion problem of pressure vessel storing Ethylene Glucol and the distortion problem .

The keypoints of the problem definition are as follows :-

- Minimizing welding distortion through metallurgical evaluation of materials.
- Eradication of erosion and corrosion through metallurgical upgrade of material.

III. Overview

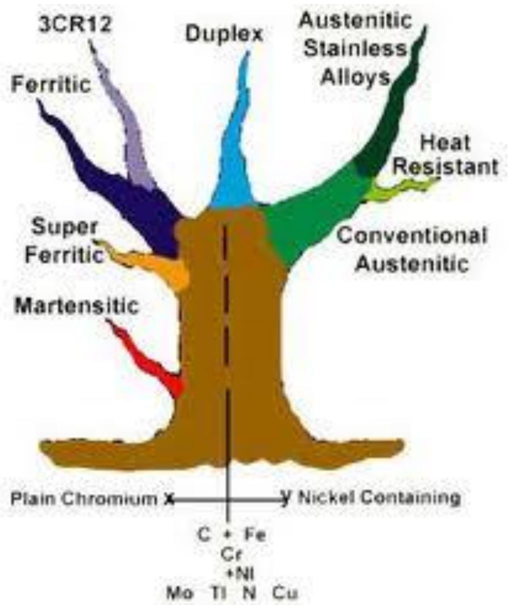

Figure 1.Tree diagram of stainless steel

In metallurgy stainless steel, also known as inox steel or inox from French "*inoxydable*", which has minimum of 10.5% chromium content by mass. Stainless steel does not corrode easily, rust or stain with water as ordinary steel does, but unlike the name it is not fully stain-proof, most notably under low-oxygen, high-salinity, or poor-circulation environments. In a case where both the properties of steel and resistance to corrosion are required, stainless steel is used. Stainless steel differs from carbon steel by the percentage of chromium present. When unprotected carbon steel exposed to air, it gets rusted easily and moisture. This iron oxide film (the rust) is active and helps to increse corrosion rate by forming more iron oxide. Stainless steels contain sufficient chromium to form a passive film of chromium oxide, which prevents further surface corrosion by blocking oxygen diffusion to the steel surface and blocks corrosion from spreading into the metal's internal structure, and due to the similar size of the steel and oxide ions they bond very strongly and remain attached to the surface. Passivation only takes place if the proportion of chromium is high enough and oxygen is present. Additions of a minimum of 13% (by weight) chromium gives high corrosion resistance and up to 26% is used for harsh environments. The chromium forms a passivation layer of chromium oxide (Cr_2O_3) when exposed to free air. The layer is too thin to be seen, and the metal retains the lusture and smoothness. The layer is impervious to water and air, protecting the metal beneath, and this layer quickly reforms when the surface is scratched. This phenomenon is called passivation and is seen in manyother metals, like aluminium and titanium. Corrosion resistance can have adverse effect when the component is used in a non-oxygenated environment, Stainless steel has high resistance to attack from acids, but this quality depends on the other factors such as kind and concentration of the acid, the surrounding temperature, and the type of steel.

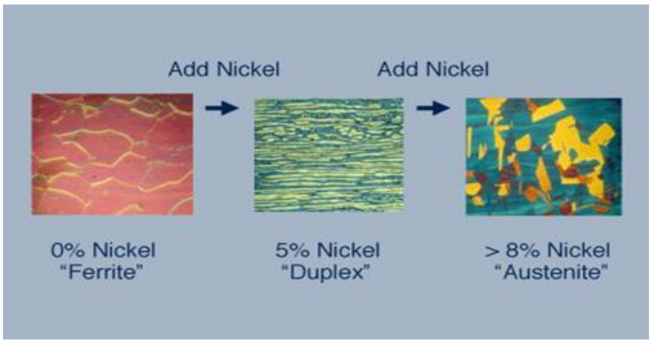

Figure 2.Phase indicating diagram

IV. THEORETICAL PERFORMANCE ANALYSIS

Grade	Density (kg/m^3)	Elastic modulus (GPa)	Mean coefficient of thermal expansion (μm/c)	Thermal conductivity (W/m-k)	Specific heat (J/kg-K)	Electrical Resistivity (nΩ-m)
SS304	8000	193	-	16.3	-	740
SS316	8000	193	15.9	16.3	500	740
Carbon Steel	8100	190	-	4.3	450	130-1250
DSS	7805	200	13.7	19	450	850

Grade	C	Mn	Si	P	S	Cr	Mo	Ni	N
304	0.08	2	1	0.045	0.03	18-20	0.03	8-10.5	2
316	0.08	2	0.75	0.045	0.03	18	3	14	0.1
CS	0.12	1.65	0.6	0.045	0.03	18	0.03	5	-
DSS	0.03	2	1	0.03	0.02	23	3.5	6.5	0.2

Duplex stainless steel is defined as the stainless steel that has two phase structure (ferrite and austenite) which are significantly present in the alloy. DSS possesses improved corrosion and mechanical properties over austenitic stainless steel , hence they are considered to have higher potential in extending life of components. DSS has been invented since early 1900. Publications of the research work can be found dated from 1930s.But since 1970s that came in the most growing alloy development and appliance.

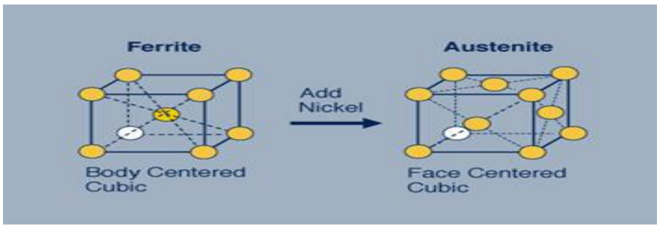

Figure 3. Geometry of Ferrite and Austenite

V. SIMULATION RESULT

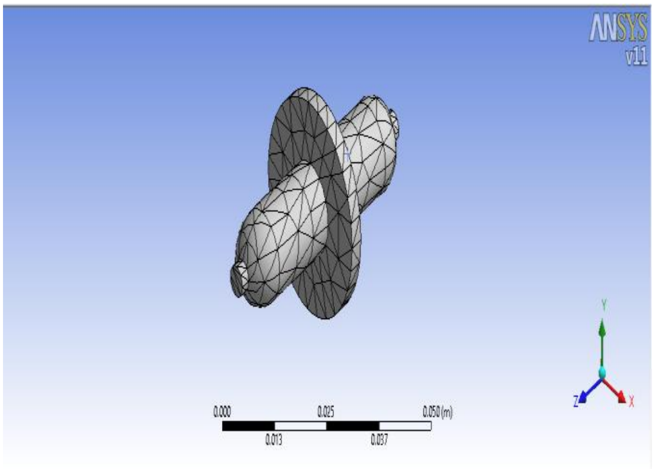

Figure 4. Meshing Model

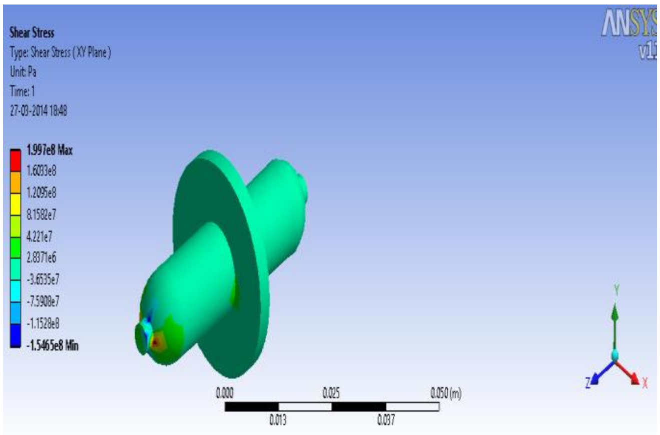

Figure 5.Ansys Result

VI. CONCLUSION

A review has been carried out of the corrosion performance of austenitic and duplex stainless steels as container materials for the storage of ethylene glycol in pressure vessel. Two grades have been selected as representative of each family, namely 304 and 316 austenitic stainless steels and 2205 duplex stainless steel. In general, the duplex stainless steel offer a number of advantages over the austenitic stainless steels, including: increased resistance of duplex alloys to localised corrosion due to the higher N content and, in some cases, higher Cr and Mo contents than "corresponding" austenitic stainless steels. Owing to its combination of high initial hardness, work hardenability and corrosion resistance. Duplex stainless steel displays very good resistance under such erosion and corrosion condition. The lower coefficient of thermal expansion of duplex stainless steel, compared to austenitic stainless steel, reduces the distortion and the associated stress.

These advantages should provide additional assurance of accepting duplex stainless steel for manufacturing of Pressure Vessel containing Ethylene Glycol.

ACKNOWLEDGEMENT

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[3]Figure 2-https://www.google.co.in/search?q=composition+of+duplex+stainless+steel&source=lnms&tbm=isch&sa=X&ei=Uzt2U6v9DoejugSNhYK4CA&ved=0CAYQ_AUoAQ&biw=1366&bih=667#q=phases+of+duplex+stainless+steel&tbm=isch&facrc=_&imgdii=_&imgrc=w12PLdanBdKeBM%253A%3BTf--ChN2t11W3M%3Bhttp%253A%252F%252Fwww.keytometals.com%252Fimages%252FArticles%252Fkts%252FFig208_2.jpg%3Bhttp%253A%252F%252Fwww.keytometals.com%252Fpage.aspx%253FID%253DCheckArticle%2526site%253Dkts%2526NM%253D208%3B421%3B257

[4]Figure 3-https://www.google.co.in/search?q=composition+of+duplex+stainless+steel&source=lnms&tbm=isch&sa=X&ei=Uzt2U6v9DoejugSNhYK4CA&ved=0CAYQ_AUoAQ&biw=1366&bih=667#q=phases+of+duplex+stainless+steel&tbm=isch&facrc=_&imgdii=_&imgrc=Vx7G90xTY1i_4M%253A%3BTf--ChN2t11W3M%3Bhttp%253A%252F%252Fwww.keytometals.com%252Fimages%252FArticles%252Fkts%252FFig208_1.jpg%3Bhttp%253A%252F%252Fwww.keytometals.com%252Fpage.aspx%253FID%253DCheckArticle%2526site%253Dkts%2526NM%253D208%3B352%3B214.

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