Influence Of Heat Treatment On Duplex Stainless Steel To Study The Material Properties

Jithin M, Anees Abdul Hameed, Ben Jose, Anush Jacob

Abstract: The various heat treatment processes are annealing, normalizing, hardening, tempering, spheroidising, surface hardening, flame and induction hardening, nitriding, cyaniding, carbonitriding, carburizing etc Heat treatment on duplex stainless steel is to improve ductility, toughness, strength, hardness and to relieve internal stress developed in the material. Here basically the experiment of hardness test, impact test, wear test and compression is done to get idea about heat treated duplex stainless steel, which has extensive uses in all industries and scientific research and development fields.

Index Terms: Heat Treatment,Duplex Stainless Steel,Wear,Impact.

1 INTRODUCTION

There is no one material called steel, just like none material is called plastic. There are enormous kinds of steel in present classification. Steel is the general name given to a large family of alloys of iron with carbon and a variety of different elements. Small differences in the composition of the steel can have a dramatic effect on its properties. One can alter the properties of the steel by different mechanical and heat treatments. Modern duplex stainless steel was used from the year 1980s which were developed from cast alloys. The material became so popular due to large booming properties like it provided high strength in nature also it acted high resistance to corrosion cracking. Heat Treatment[1] is the controlled heating and cooling of metals to alter their physical and mechanical properties without changing the product shape. Heat treatment is sometimes done in manufacturing processes to either heat or cool the metal such as welding or forming. Heat treatment is commonly associated with increasing the strength of material, but it can also be used to alter manufacturability objectives such as improve machining, formability, restore ductility after a cold working operation. Thus it holds good in enabling manufacturing process, but it also improves product performance by increasing strength or other desirable characteristics.

2 DUPLEX STAINLESS STEEL

Duplex stainless steels[2] are called “duplex” because of their two-phase microstructure consisting of grains of ferritic and austenitic stainless steel. When this material is melted it then solidifies from the liquid phase to a ferritic structure. when the material gets cools to room temperature, half of the ferritic grains transform to austenitic grains. The result is a microstructure of roughly 50% austenite and 50% ferrite.

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The composition of duplex stainless steel are characterized by high chromium (19–32%), lower nickel (up to %8), molybdenum (up to %4) and remaining will be nitrogen, carbon and other contents than austenitic stainless steels. There are two most common grades of duplex stainless steel are 2205 or UNS S31803 (22% Cr, , 3% Mo, 5% Ni & 0.15% N) and 2507 or UNS S32750 (25% Cr, , 4% Mo, 7% Ni & 0.25% N) Duplex stainless steels (DSSs), meaning those with a mixed microstructure of about equal proportions of austenite and ferrite. One of the first duplex grades developed specifically for improved resistance to chloride stress corrosion cracking was 3RE60. DSS of type 329 became well established after World War II and was used extensively for heat exchanger tubing for nitric-acid service. In the same years, both wrought and cast duplex grades have been used for a variety of processing industry applications including vessels, heat exchangers and pumps. These first type of duplex stainless steels provided good performance characteristics but had limitations in the as-welded condition.

Tables 1. Corrosion and Mechanical Properties of Some Stainless Steels: Duplex 2205, Austenitic Type 304, 316 and 317 and Duplex Developed Under the Patent of Ref. [11]

Alloy	Chemical Comp. (wt. %)		PCR	SCC	Mechanical Properties		
	Ni	Mo	CPT	CSCC	0.2 % PS	TS	El (%)
2205	4.5-6.5	2.5-3.5	35ºC	20ºC	450 MPa	620 MPa	25
Type 304*	8-10.5	--	--	-2.5ºC	205MPa	515 MPa	40.0
Type 316*	10-14	2-3	15ºC	-3ºC	205 MPa	515 MPa	40.0
Type 317*	11-15	3-4	19ºC	2ºC	206 MPa	517 MPa	35.0
US6551420B1(a)	3.0 - 4.0	1.5 - 2.0	31ºC	**	572 MPa	786 MPa	37

PCR: Pitting Corrosion Resistance; CPT: Critical Pitting Temperature (ASTMG-48A); CCCT: Crevice Corrosion Critical Temperature (ASTM G48B); 0.2%PS: 0.2% offset Proof Strength; TS: Tensile Strength;

3 HEAT TREATMENT

3.1 Annealing

The duplex stainless steel material was heated to 900^{0}c and is kept at this temperature for soaking for 3 different timings. The soaking conditions was varied from 30minutes, 45minutes, and 60minutes. The material after heating was made to cool very slowly. The cooling of the material after heating was done by placing the material in the sand which is a very slow cooling process.

3.2 Normalizing
The duplex stainless steel material was heated to 1100^{0}c and is kept at this temperature for soaking for 3 different timings. The soaking conditions was varied from 30minutes, 45minutes, and 60minutes. The material after heating was made to cool slowly. The cooling of the material after heating was done by placing the material in open air.

3.3 Tempering
The duplex stainless steel material was heated to 900^{0}c and is kept at this temperature for soaking for 3 different timings. The soaking conditions was varied from 30minutes, 45minutes, and 60minutes. The specimens after taking from oven was made to cool slowly. The cooling of the material after heating was done by placing the material in open air.

3.4 Hardening
The duplex stainless steel material was heated to 1100^{0}c and is kept at this temperature for soaking for 3 different timings. The soaking was varied from 30minutes, 45minutes, and 60minutes. The material after heating was cooled very fast . The material after heating was cooled by oil cooling. The oil used for cooling is SAE 20-40 oil which is used mostly for automobiles.

4 WEAR TEST
Wear[3] test is carried out to predict the wear performance and to investigate the wear mechanism. Inorder to determine the situations a specific material can handle in different specific rate condition the importance of wear the importance of wear testing is significant. When we consider surface enginnering point, wear test is carried out to evaluate the potential of using a certain surface engineering technology to reduce wear for a specific application, and to investigate the effect of treatment conditions on the wear performance, so that optimised surface treatment conditions can be realised.

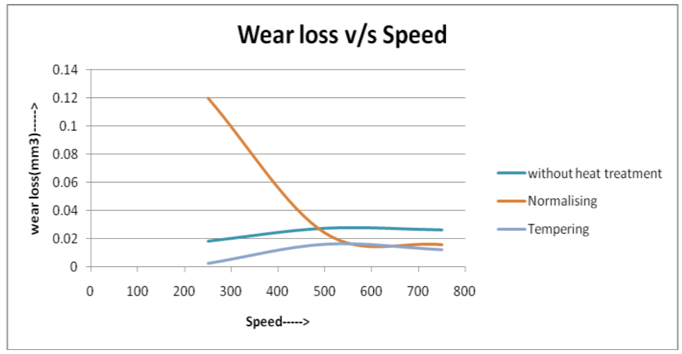
5 IMPACT TEST

5.1 Charpy Impact Test
The Charpy impact[4] test, also known as the Charpy u-notch test, is a standardized high strain-rate test which determines the amount of energy absorbed by a material during fracture. This energy so absorbed is the measure of a given material's toughness and acts as a tool to study temperature-dependent characters. The usage of this test is so wide, because it is easy to prepare and conduct. But the limitation is that all results are only comparative.

6 HARDNESS TEST

6.1 Brinell Hardness Test
The brinell hardness testing machine is one of the popular types of machine used for measuring hardness. It provides hardness value known as brinell hardness number (BHN) in kilograms per square millions meter based on the load applied to the hardened ball in kilograms and divided by the area of the impression left by the ball on the specimen in square millimeters.The diameter of the steel ball is 5mm or 10mm.A standard load in the range of 500kg to 3000kg is generally applied and maintained for 10 to 30 seconds.The diameter of the indentation is measured by using a low resolution microscope.

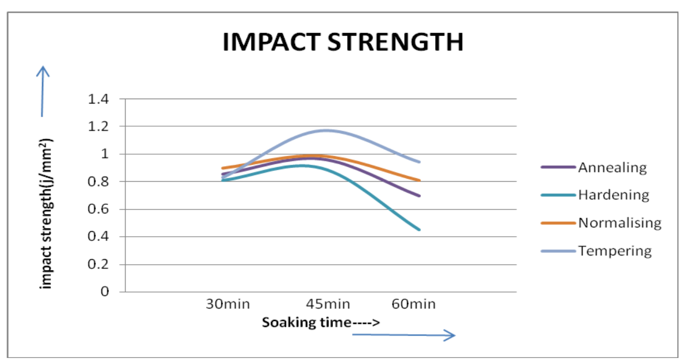
7 RESULTS



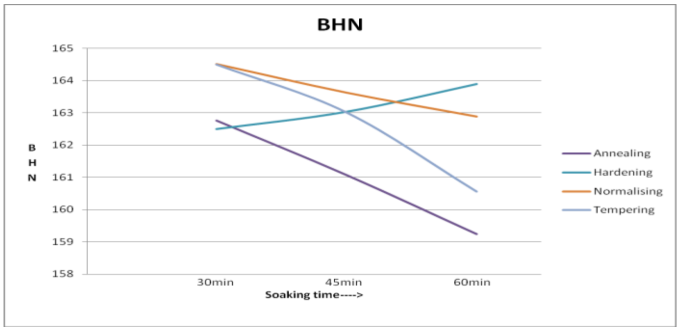
Fig(i) *Wear loss v/s Speed*

Fig(ii) *Wear loss v/s Distance*

Fig(iii) *Wear loss v/s Load*



Fig(iv) *impact strength v/s soaking time*



Fig(v) *BHN v/s soaking time*

7 CONCLUSION

From the various results obtained during the testing, 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. It is found from the observation 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. But the impact strength of Duplex stainless steel is reduced. Hence hardening heat treatment can be used to improve the hardness of Duplex stainless steel. The tempering is used for increasing the impact strength, of materials after tempering. 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. The normalising heat treatment is carried out mainly to improve strength with some ductility. From the results obtained after normalising it is found that hardness, wear strength, impact strength and yield strength of Duplex stainless steel increases with increase in soaking time to some extent. The annealing heat treatment process is carried out to reduce hardness, to improve machinability and to facilitate cold working. From the results obtained after annealing it is found that hardness, wear strength and compressive yield strength of Duplex stainless steel decreases with increase in soaking time and impact strength increases with increase in soaking time.Annealing doesn't make the material harder.

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