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EVALUATION OF WEAR AND CORROSION BEHAVIOR OF HEAT TREATED STAINLESS STEEL

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ABSTRACT

This paper discusses about the abrasive wear resistance and corrosion resistance of SS304. In the current work heat treated SS304 rectangular billets are subjected to abrasion using Dry Sand/Rubber Wheel Apparatus and adhesion wear for samples subjected to different heat treatment process. The steel billets are subjected to four types of cooling medium -furnace cooling, air cooling, ice cooling and oil cooling. The hardness for all the specimens is determined. The steel billets after heat treatment are also subjected to immersion corrosion test. It is seen that samples subjected to furnace cooling have shown superior corrosion and wear resistance when compared to the other counterparts.

Keywords: *Heat Treatment, SS304, Abrasion Wear, Adhesion Wear and Corrosion Resistance.*

1. Introduction

One of the challenging problems of today is to limit the rate of mechanical wear present in various mechanical parts. Mechanical wear of components overtime render the components useless and unfit to give the desired performance. Wear is related to interactions between surfaces and more specifically the removal and deformation of material on a surface as a result of mechanical action of the opposite surface. [7] The wear mechanisms are very complex, because of interlinked factors, which intensity of interaction depends on the conditions type of environment, in which the mechanical parts are used but also on the type and parameters of the work. Based on the analysis of parameters responsible for the wear of mechanical parts, about 50% (of the parts) works in abrasive wear, 15% - adhesive wear, 8% - erosion, 8% - fretting, 5% - wear is due to corrosion and about 14% is just a combination of abrasive, erosive and corrosive wear [1].

Type 304 stainless steel is a T 300 Series Stainless Steel austenitic. It has a minimum of 18% chromium and 8% nickel, combined with a maximum of 0.08% carbon. It is defined as a Chromium-Nickel austenitic alloy. Grade 304 is the standard "18/8" stainless that you will probably see in your pans and cookery tools. These are some of its characteristics:

- Forming and welding properties
- Corrosion / oxidation resistance thanks to the chromium content
- Deep drawing quality
- Excellent toughness, even down to cryogenic temperatures which are defined as very low temperatures
- Low temperature properties responding well to hardening by cold working
- Ease of cleaning, ease of fabrication, beauty of appearance [2]

Hence, wear resistance data for such a material such as SS304 would prove valuable.

Heat treating is a group of industrial and metalworking processes used to alter the physical, and sometimes chemical, properties of a material. The most common application is metallurgical. [8]. Heat treatment involves the use of heating or chilling, normally to extreme temperatures, to achieve a desired result such as hardening or softening of a material. [8]. Solution Treatment (Annealing) - Heat to 1010-1120°C and cool rapidly. These grades cannot be hardened by thermal treatment. [3]

Hardness test on the SS 304 specimen can be done. Hardness values only become relevant when comparisons are made within a family of steels, and this can be misleading at times. It is best therefore to dismiss any relationship between hardness and wear resistance. Actual chemical compositions and resulting metallurgical structures should be considered as criteria. The results of these considerations are manifested not in the hardness test but in the actual wear test such as ASTM G 65. [6]

The published literature on wear resistance of SS 304 is rather limited and there is also a lack of

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information about the wear resistance of SS 304 for different heat treatment processes. Therefore, it was thought worthwhile to study: (1) The microstructure of heat treated SS 304 specimen, and (2) To predict approximately the dependence of wear resistance on heat treatment processes.

2. Experimental Details

2.1 Heat treatment

Twenty five SS 304 billets have been used. Out of these five billets are not subjected to any heat treatment process. The remaining twenty specimens are heated to a temperature of 950 degree Celsius for the time period of two hours in a furnace. After two hours, the furnace is switched off and the 5 specimens are retained in the furnace for steady furnace cooling till the furnace temperature reaches the room temperature. Out of the remaining 15 specimens, 5 specimens each are cooled in air, ice and oil. After this procedure all specimens are subjected to the standard ASTM G 65 abrasion test.

2.2 Abrasion testing

Standard ASTM G65 procedure is performed by loading a rectangular test sample against a rotating rubber wheel and depositing sand of controlled grit size, composition, and flow rate between them. The wheel is rotated in the direction of the flow of sand. The mass of the test sample is recorded before and after conducting a test and the difference between the two values is the resultant mass loss due to dry sand abrasion [4].The experiment is performed by keeping speed of the rubber wheel at 200 rpm. The number of revolutions is set to 3000 revolution. Each specimen is therefore subjected to 15 minutes of abrasion. Under these constant conditions, the experiment is performed for each of the five set of specimen each corresponding five different load condition namely 0 kg, 1 kg, 2 kg, 3 kg and 4 kg. This load is to be applied by using appropriate weights on the load arm of the abrasion testing machine. As the lever ratio comes into play, the total actual load is calculated using equation (1)

2.3 Corrosion testing

Immersion test is conducted on these five heat treated specimens. These are weighed and immersed in sea water for a period of one week .Their final weight is noted down and the loss in weight is calculated.

3. Results and Discussion

The schematic representation of ASTMG-65 is shown in Fig. 1. The specimen weight before abrasion and after abrasion is noted down. The change in weight is calculated. This is shown in Table 1.

$$F = (W x 2.41) + (2.61) \quad (1)$$

Where F is the total weight, W is the weight in the hanger = 0, 1, 2, 3, 4 kg. 2.41 is the lever ratio and 2.61 is the self-weight of the hanger.

Table 1. Loss in weight due to abrasion is calculated for different loads on hanger

Heat Treatment Processes	Loss of weight when 0kg Load is on the hanger (g)	Loss of weight when 1kg Load is on the hanger (g)	Loss of weight when 2kg Load is on the hanger (g)	Loss of weight when 3kg Load is on the hanger (g)	Loss of weight when 4kg Load is on the hanger (g)	Weight loss due to Corrosion (g)
No heat treatment	0.398	0.785	1.189	1.411	2.346	0.02
Heat treated ice cooled	0.34	0.683	1.017	1.264	2.215	0.01
Heat treated air cooled	0.267	0.536	0.792	1.179	1.956	0.028
Heat treated oil cooled	0.249	0.458	0.778	1.111	1.976	0.02
Heat treated furnace cooled	0.152	0.432	0.676	0.944	1.87	0.006

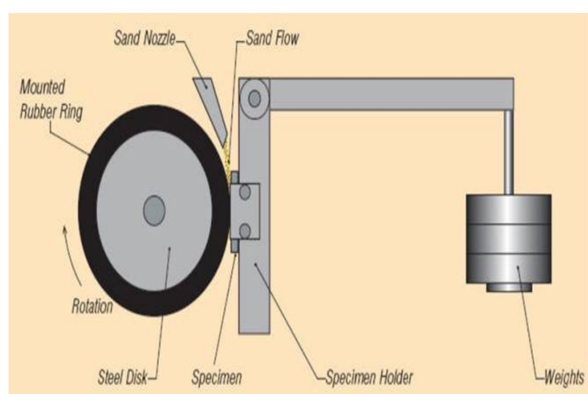

Fig. 1 ASTM G65 test machine [5]

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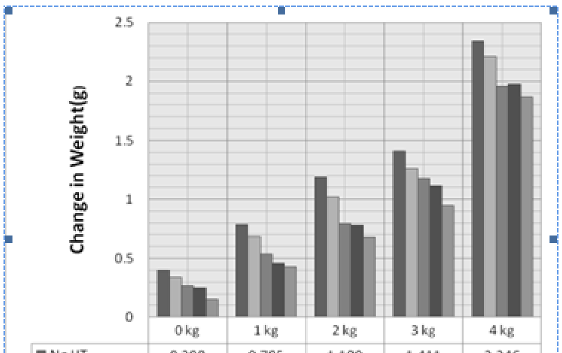

	0 kg	1 kg	2 kg	3 kg	4 kg
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Oil cooled	0.249	0.458	0.778	1.111	1.976
Furnace cooled	0.152	0.432	0.676	0.944	1.87

Fig. 2 Plot of change in weight and applied load

4. Conclusions

The wear resistance of SS 304 can be increased by heat treating the specimen up to 950 degree Celsius and cooling it very slowly to the room temperature like furnace cooling. Cooling it very fast like ice cooling actually decreases the wear resistance.

1. As the applied load increases the change in weight for all heat treatment processes increases.
2. For a particular applied load the change in weight is minimum for furnace cooled specimens and maximum for specimens without heat treatment. In fact the change in weight for any applied load varies as:
   a) No heat treatment > Ice cooled > Air cooled > Oil cooled > Furnace cooled
   b) This shows that as the rate of cooling decreases, the change in weight decreases and hence the wear increases.
3. The corrosion test is done by dipping the samples into a container containing salt water. The weight of all samples except the no heat treatment sample suffered weight loss. All samples got corroded and hence a decrease in weight was observed, while the no heat treatment sample gained weight due to the deposition of salt on its surface.
4. It can be concluded that furnace heat treated sample shows highest resistance to corrosion since it has undergone a least decrease in its weight.

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