Experimentation Investigation of Wear Characteristics of Heat Treated 304 Austenitic Stainless Steel

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Abstract-

A heat treatment is the process of treating work piece to a certain temperature (i.e. below or above recrystallization temperature), socking for a certain time and subsequent cooling in a definite medium or rate, in order to get the improved or controlled mechanical properties, like strength, toughness, hardness, ductility, and internally developed residual stress. In addition to seeking enhanced mechanical properties, conventional heat treatment is also sought for its ability to improve corrosion resistance. To improve the service life of engineering element, the application of heat treatment has becomes necessary to deal with tool and die, automotive parts or aerospace parts. This paper focuses on the influences of various heat treatments in their dry sliding characteristics i.e. tribo-characteristics of SS 304.

KeyWords: SS 304, heat treatment, friction & wear, micro hardness.

1. INTRODUCTION

In fact, the term heat treatment applies just to the procedure where the warming, soaking and consequent cooling are performed for a particular reason of exchanging properties, yet the warming and cooling happens as accidental periods of other assembling forms, for example, hot shaping or welding. The material properties will be modified, in any case, similarly as through a universal heat treatment had been performed, and the outcome can be either advantageous of hurtful. Heat treat ought to be completely incorporated with the other assembling forms, whenever wanted outcome to be acquired.

The different kinds of heat treatment commonly connected to carbon and low alloy steels are as:

1) Stress relieving,
2) Normalizing,
3) Annealing,
4) Hardening,
5) Tempering,
6) Special heat treatment,
9) Case hardening,
10) Surface hardening

There are certain Objectives of heat treatments are as follows

- To improve hardness and strength by bulk hardening and case hardening for wear prevention.
- To upgrade softness by recrystallization annealing and ductility by tempering.
- Up gradation of toughness through tempering, recrystallization annealing.
- Recrystallization annealing, full annealing, normalizing to get fine grain size.

- Stress relief annealing is performed for refining internal stresses induced in deformation by cold working or sudden or uneven cooling from elevated temperature during various manufacturing processes (casting and welding).
- Improved machinability can be accomplished by full annealing and normalizing.
- Hardening and tempering is necessary for improvement in tool steels properties.
- Tempering, age hardening and recrystallization to enhance electrical properties.
- Phase transformation and hardening for improved magnetic properties.

Most commonly utilized AISI SS-304 a type of austenitic steel or18/8 steel for 18 percent of Cr and 8 percent of Ni. The second most basic austenite steel is the 316 evaluation, additionally termed as marine evaluation pure, utilized basically for its expanded protection from corrosion. A run of the mill piece of 18% chromium and 10% nickel, usually known as 18/10 pure, is frequently utilized in cryogenics, pharmaceuticals, cutlery and superb cookware [1].

The steel type AISI 410 (12 wt.% Cr, 0.1 wt.% C) is a champion among the most predominant materials inside this assessment of steels and is used in a wide grouping of employments when all is said in done structuring. New martensitic tempered steels, for instance, the XD15NWTM steel have been made with the expect to exchange AISI 440C for cryogenic flight bearing because of its improved tribological and exhaustion properties. The CX13VD steel is a carburizing solidified steel that is furthermore part of the flawless steels with 12 wt.% Cr and steels with the extension of nickel, molybdenum and vanadium. It is used in the aviation's and mechanical applications, such valve, ball screws, sharp edge propellers and riggings [2].

1.1 Effect of Heat Treatment on Tribological Properties

The study of friction and associated wear with that friction and associated lubrication in an interface in relative motion is the territory of tribology. For engineering product friction and wear plays a crucial role, so product quality and reliability depends on wear characteristics. The exterior of metals and metallic alloys characteristics plays a crucial role on many of the substrate's performance properties and resistance to wear. The surface properties are combinations of the physical and mechanical properties such as micro hardness, surface roughness, toughness, residual stress, etc. of the surface layer. Their properties and structure are changed in parity with the process of technological processing of surface layers. As the friction takes place in very thin layers of the surface. The force of friction depends on combination of' mechanical and physical properties of surfaces [3].

Huge numbers of the surfaces are chemically responsive. Except for noble metals, all metals furthermore, combinations and numerous nonmetals structure, oxide layers over the surface, and in different conditions which are probably going to shape different layers (like nitrides, sulfides, and chlorides). Other than the synthetic consumption coating, some adsorbed coatings are created either by physisorption or chemisorption of hydrocarbons, steam, and O_2, on earth. Every so often, there will be an oily or thin film got from nature. These coatings are found both on the metal surfaces as well as nonmetallic exterior.

The metallurgical attributes of the exterior of the metal, composite can change notably from the parent composition of the manufacturing path followed for example type of machining (Intermittent or continuous), grinding, honing, lapping like super finishing processes the exterior, the exterior layers are deformed in plastic nature either a temperature gradient and becomes intensely stressed. Remaining weight can release of satisfactory significance to impacted stability in dimension.

Work hardened exterior surface termed as the twisted film and basic part of material exterior. The friction may also been the cause of to produce distorted surface.

For the most part it is found grains in smaller sizes in the disfigured region from recrystallization zones of the grains. Moreover, with interface scouring the individual crystal can order themselves at the surface. The character of the distorted layers can be fully not quite the identical as the strengthened bulk material. In like manner, mechanical appearances are also impacted by the total and profundity of disfigurement of exterior [4].

2. LITERATURE SURVEY

2.1 Friction and Wear of SS 304 Austenitic Stainless Steel

With regards to the present investigation, a writing overview is prepared. This study covers the associations occurring at the interactive surface between at least two surfaces under relative movement controls the tribological behavior of both the materials are engaged with such collaboration.

Austenitic stainless steel, type 304 (18Cr–8Ni) is an iron-nickel-chromium alloy and can't be heat hardened further. However, annealing is possible and annealed 304 stainless steel has wide application as a structural material under the severe conditions such as the nuclear power plants and the chemical plants, refrigeration and processing plants like paper, food, beverage, cryogenics transportation, machinery parts, car headers, architecture etc. industries because of high corrosion resistance, good toughness and ductility [5]. And those properties are greatly influenced by heat treatment ad discussed in following section, not only heat treatments above recrystallization temperature but also sub-zero are treatments gaining much more attractions of researchers.

Investigations are completed when diverse sorts of stick, for example Al, Cu, Gun metal Against SS - 304 plate. Examinations are directed at typical burden 10N, 15N and 20 N, sliding speed sets of 1, 1.5 and 2 m/s, span of 30 minute when relative humidity 70 percent. Varieties of frictional coefficient and wear at various combinations of typical burden and relative speed are explored. Results demonstrate that friction coefficient changes with length of scouring, typical burden and sliding speed as a rule, contact coefficient increments for a specific span of scouring and then it stays steady for next remainder of the exploratory span. The acquired outcomes uncover that coefficient friction diminishes in terms of expansion in ordinary burden for each tried sets.

2. EXPERIMENTAL ANALYSIS

it has been discussed, what is tribology and different tribological parameters that include friction, wear lubrication and there related various parameters, types of stainless steels and their preliminary properties and alloying elements and type of heat treatment can be done to achieve desirable mechanical properties. After a detailed study on heat treatment techniques and desirable materials properties employed in tribology, it was found that a comparative study is necessary to find an alternative for austenitic stainless steels.

2.1 Sample Preparation

The work has been started by designing our pins made of Austenitic stainless steels 304 and Martensitic stainless steels 410 of diameter 6 mm and length of 30 mm and a disc of 8 mm thickness made of EN24 of 100 mm diameter as per need of the tribometer available in our laboratory.

Heat treatments were done in a muffle furnace with a maximum temperature capacity of 1100 degree centigrade. As earlier discussed by some researcher SS 304 cannot be hardened further but can be soften. Five different heat treatment were selected based on feasibility of achieving their process parameters, these heat treatment are discussed in following section [6].

2.2 Experimental Parameters

In this investigation a Pin-on-Disc tribotester is utilized to quantify the tribological property, for example, frictional coefficient, friction force, rate of wear between two interactive surfaces. Pin on-disc device comprise of a stationary pin stacked against a pivoting plate under a connected load. Particular pin and disc for current experiment were made of stainless steel 304 and 410 and EN 24 separately. The string and pulley framework were utilized for loading by dead loads. Frictional coefficient can be determined from the estimation of power of friction and connected burden on the pin. Now from the literature it has been selected some parameters for the wear test as, the dead load for the experiment used is 50 N, revolution per minute of the disc of EN 24 is 500, the track diameter on which the pin will rub is 50mm and the estimated time for wear test is 5 minutes. To measure the temperature variation of the pin a thermocouple is used. The wear test setup have collected 60 data samples per minute which is used to analyze result for wear versus time, frictional force versus time and temperature versus time.

3.2 Instruments Specification

A muffle furnace was utilized for heat treatment of the stainless steel samples as given in the figure

1. The microcontroller controlled furnace has a maximum temperature capacity of 1100 °C with hearth dimensions of 10 ″ × 5 ″ × 5 ″.

Figure 1 Muffle Furnace

Figure 2 SS410 Sample after Process Annealing

(Ø 6 x 30 lengths)

Vickers Micro hardness of the stainless steels samples were determined in a Micro Vickers hardness Tester (Economet VH-1 MD) under a fixed load of 50 N.

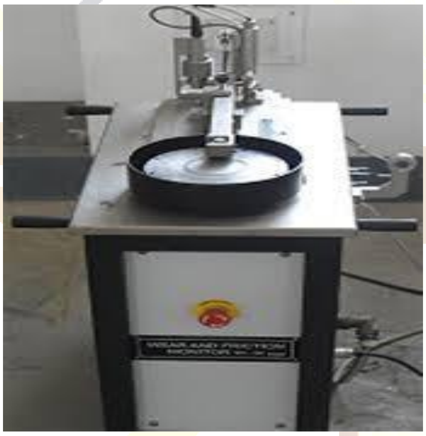
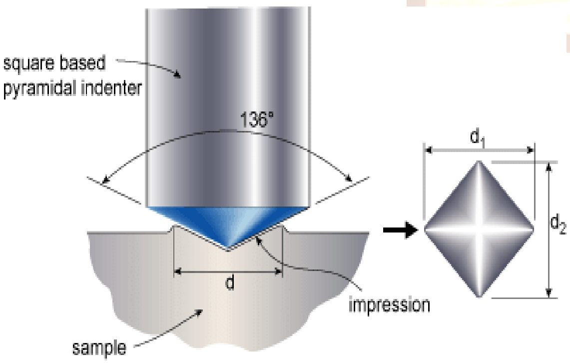


Figure 3. Micro Vickers hardness Tester (Economet VH-1 MD)



Tribological properties, for example, friction and associated wear, temperature rise of Stainless steel

Figure 4 Vickers Indentations

Figure 5 DUCOM TR201E Pin-on-disc Tribometer arrangements

Specimen before and after heat treatment are estimated utilizing Pin against disc tribotester. A typical setup of a Pin-on-disc is appeared in figure 5 and 6.

Figure 6 DUCOM TR201E Pin-on-disc Tribometer setup with computer

3. RESULTS AND DISCUSSION

The discussion about the result has been obtained in the Micro hardness testing and the comparison of tribological properties of Austenitic stainless steel 304 and Martensitic stainless steel 410 experimented in a Pin on Disc tribometer. The result incudes investigation of wear versus time, frictional force against time and temperature versus time for individual steels and a similar report were done between two steels by picking the best outcome from these.

So from the above comparison it is clearly noticed that austenitic stainless steel AISI 304 have better tribological properties in case of dry sliding. In case of SS 304 it is getting better wear performance that is less wear in annealing and sensitizing samples rather than oil quenching and solution annealing specimens as the hardness of oil quenching and solution annealing specimens are not exactly too higher, annealed and sensitized examples. Ferrite and austenite stages dominating

Part of the segments of oil quenching and solution

annealing examples. Where in case of SS 410 the

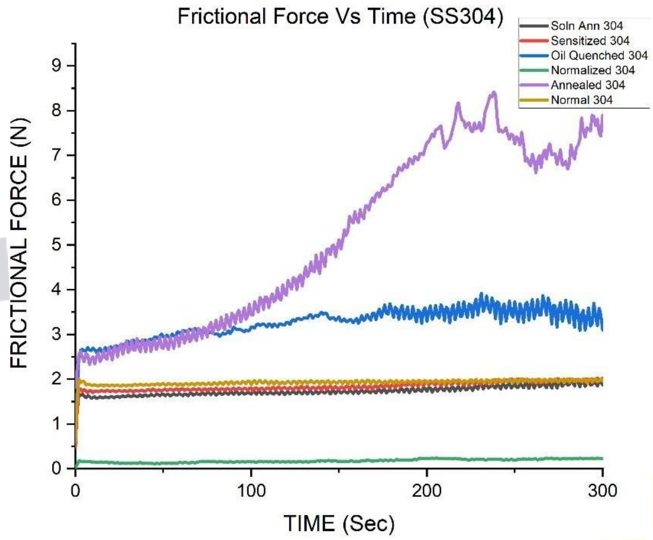


Figure 7 Frictional Force versus Time graph for SS304

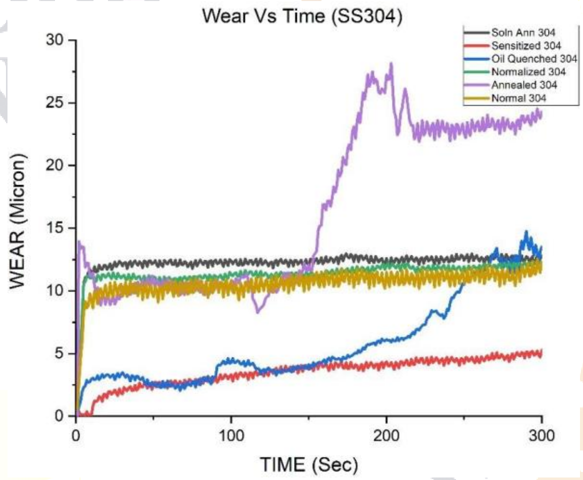


Figure 8 Wear versus Time graph for SS304

hardened steels followed by tempering at 650 ^{o}C exhibits best hardness value as well as best wear resistance properties.

Conclusion

This trial consider enlightens that the sensitized in case of SS-304 and annealed sample in case of SS-410 example is related with most minimal wear among other sort of heat treated samples.

Wear results for both the steels have been perfectly fooled their hardness properties. So, Heat treatment is an exact activity and needs much consideration and control of temperature observing. Maximum temperature of heating, Soaking and subsequent cooling medium are exceptionally significant processes parameters to be considered fundamentally for the ideal result.

- The main mechanisms for wear for SS-304 are abrasion and delamination; where in case of SS-410 the wear mechanisms are adhesion and ploughing or abrasion.
- Air quenched or normalized SS-304 samples and in case of SS-410 annealed samples exhibits lowest frictional resistance.
- There is no such fluctuation in temperature in SS-304 but in case of SS-410 it is prominent due to difference in their hardness.
- Tempering temperature for martensitic steels have a great influence on their hardness characteristics.
- Normalized and annealed samples for SS-304 and Annealed samples shows a stable trend in wear characteristics.

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