Wear Analysis of Nickel Coated Piston and Al8011 using Cryogenic Process

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Abstract**—**Piston is considered as an important device for improvement in efficiency. In this paper, wear behavior of piston is analyzed using ANSYS software. The wear rate also plays an important role in the amount of the total wear happen in engine block. It also depends on the hardness of material of piston. In most cases, piston is made of cast alloy which will accept mostly all type of coating. This will improve the properties with respect to what the type of coating done on it. After finding the wear behavior for piston, the properties of materials can be improved in a cryogenic and coating. This will also lead to improvement in the life time and efficiency of piston.

Keywords—ANSYS, Piston, Cryogenic treatment, Nickel coating, Wear Rate, Testing

I. Introduction

At present Aluminum Alloy offer attractive performance as weight saving alternatives for a wide range of applications, starting from toys to high performance required areas like automobile industry and aerospace industry, as they can provide highly beneficial characteristics over existing materials. In view of further enhancing the properties of these composites, in addition to producing composites supplementary processes like heat treatment, surface treatment may be required to carry out. In other hand cryogenic treatment also known as subzero treating is very old process and is widely used for high precision parts especially for ferrous alloys. The use of extreme cold to strengthen metals has been used since long time ago for centuries. Presently cryogenic treatment has been widely utilized in many industries such as aerospace, automotive, electronic and mechanical engineering to improve mechanical strength and dimensional stability of components. For the past few decades, interest has been shown in the effect of applying low temperature heat treatment on aluminum and magnesium alloys for improvement of their properties.

Microstructures and mechanical properties of metals and alloys in cryogenic treatment drew attention of the researchers. Few researchers showed the beneficial effects of cryogenic treatment on improved performance of a Non-ferrous alloy. The effects of cryogenic treatment on the wear performance of copper alloy showed least significant changes focused on the effect of cryogenic treatment on the strength, hardness and toughness of aluminum alloy and increased mechanical properties with cryogenic treatment. However this is a field of engineering that is growing rapidly and is used by many manufacturers.

Piston is converted into a work piece by stir casting method and by knowing the characteristic and advantages of Al8011 it is selected for the process. Both are then cryogenic treated for different timing process. After that pin on disc wear test experiment is conducted for both materials with that result which has only minimum wear rate it selected for coating. Here the nickel coating is done for some different timing and it again wear tested to get the result. After all this the piston cad model is created using model software and imported into Ansys for getting how the temperature distribution takes place inside the engine block in piston.

II. Experimentl Procedure

A. Preparation of work piece

The raw material used in this study was an Al8011 and Automobile piston which is converted into required work piece by casting process. Here the Al8011 will be available in market with what size we required or it can be machined with required dimension then the other is piston material by using the stir casting process it is converted from piston to work piece then it is machined to get the finishing.

B. Cryogenic treatment

Cryogenic treatment of samples has been performed by placing the specimens in an isolated alumina chamber. The top of the chamber was covered by insulator glass wool after placing the samples in the chamber. This chamber was progressively immersed in a liquid nitrogen reservoir. The sample temperature was monitored by a K type thermocouple which was used to operate a step motor which lowered the sample and maintained a temperature decline at the rate of 1 °C/min. Steps were about 4 h was taken to reach to about −196 ◦C. This pain staking method eliminates the probability of thermal shock and micro-cracking. Specimens were held at −196 ◦C for 12,24and 48 hours timing and then slowly brought up to approximately + 25 °C. The three different timing treatments were conducted to determine whether there were any time-independent effects.

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C. Nickel coating

Electroless nickel plating improves corrosion resistance, increases the surface hardness of the material, provides a uniform and dense coating, and, in many cases, maintains the same surface finish the material had before plating. The specimens are cleaned by a series of cleaning chemicals such as bases and acids to have good adhesion. Each chemical pre-treatment is followed by water rinsing to remove the chemical that adheres to the surface. Degreasing removes oil from surface and acid cleaning removes scaling. Electroless nickel plating consists of the deposition of a nickel-phosphorous alloy onto the metal surface by a electrodes or external electrical charges. This permits the plating of hard to reach surfaces, such as small or deep bores and intricate shapes. Since electroless nickel plating provides a higher hardness, the performance is substantially improved. A harder surface reduces the coefficient of friction and the adhesive force substantially, resulting in lower wear and longer life. Where it is difficult or impossible to produce a uniform chrome plate using electrodes, such as in small or deep bores, the electroless nickel plating process is used. For rotary or reciprocating service where increased wear resistance is desired, the coating is hardened. This coating is done for about some 10 & 15min timing at 45 to 60^0C temperature. Advantages: High corrosion resistance in the as-deposited condition; maintains better uniform thickness and surface finish; can plate small diameters, deep bores and intricate shapes.

D. Wear test

A tribometer is an instrument that measures tribological quantities, such as coefficient of friction, friction force, and wear volume, between two surfaces in contact. It was invented by the 18th century Dutch scientist Musschenbroek. A tribotester is the general name given to a machine or device used to perform tests and simulations of wear, friction and lubrication which are the subject of the study of tribology. Often tribotesters are extremely specific in their function and are fabricated by manufacturers who desire to test and analyze the long-term performance of their products. A pin on disc tribometer consists of a stationary "pin" under an applied load in contact with a rotating disc. The pin can have any shape to simulate a specific contact, but spherical tips are often used to simplify the contact geometry. Coefficient of friction is determined by the ratio of the frictional force to the loading force on the pin. The pin on disc test has proved useful in providing a simple wear and friction test.

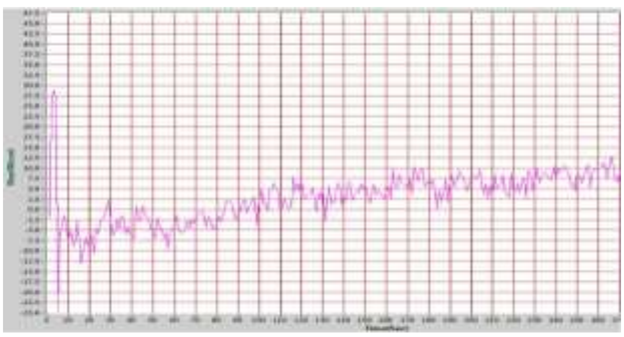
Pin-on-disc tests were carried out to examine the wear properties. The tests were operated under dry lubricated conditions air with room temperature of 25°C. The specimen was loaded with a normal force of 1Kg against the disc with a sliding velocity of 0.5 m/s.

III. RESULT AND DISCUSSION

Here we have different results with Al8011 of some have not been Ni coated but cryogenic treated and other is both Ni coated as well as cryogenic treated. In that table the wear rate is mentioned in microns and also how much load applied to each test experiment with sliding velocity is represented.

TEST NO.	MATERIAL	RPM	TIME DURATION	SLIDING VELOCITY (m/s)	WEAR IN (micro n)
T1	AL8011	500	5min (300sec)	1.309	26.0
T2	AL8011	600	5min (300sec)	1.571	45.0
T3	AL8011	700	5min (300sec)	1.832	48.5
T4	AL8011+ nickel (10 min)	500	5min (300sec)	1.309	12.5
T5	AL8011+ nickel (10 min)	600	5min (300sec)	1.571	43.0
T6	AL8011+ nickel (10 min)	700	5min (300sec)	1.832	28.0
T7	AL8011+ nickel (15 min)	500	5min (300sec)	1.309	50.0
T8	AL8011+ nickel (15 min)	600	5min (300sec)	1.571	55.0
T9	AL8011+ nickel (15 min)	700	5min (300sec)	1.832	50.0

The above result is from the graph format then the graph shows that minimum wear rate occurs during 10mins of Ni coated for 500RPM speed at 1.309 m/s of sliding velocity. It has only 12.5 microns wear rate and this is the best experiment in our project. With the same value of input for non Ni coated has 26microns of wear rate. The only cryo treated both piston and Al8011 with that the wear rate is taken for choosing which has to be Ni coated. In that we got Al8011 has less wear rate when compare to piston material so that the Al8011 is chosen for nickel coating.



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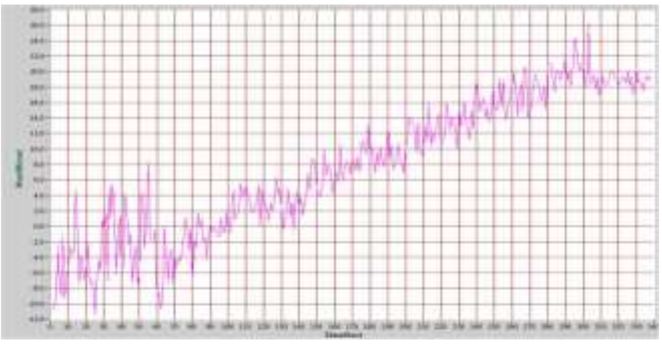

IV. CONCLUSION

Cryogenic treatment is a recent tread in the 21st century to enhance the properties of the conventional Alloys. Cryogenic treatment has a wide filed of application in tool making and the manufacture of inserts for the tool. When it comes to the application of this technique for the Aluminium alloys, very little work has been done. Complete information of the properties of these alloys at cryogenic temperature is still not known. In this approach the review on the effect of cryogenic treatment on the mechanical properties of aluminium alloys was done and following were the outcomes. The variation of the behavior of these alloys for cryo treatment is not the same for all alloys of Aluminium. Some alloys shows greater variation and some show very less influence of this treatment. A marginal improvement in the mechanical properties was observed after cryogenic treatment for most of the alloys. Hence in this process, the study of the application of cryo treatment for many other Al alloys is strongly recommended to enhance the commercial application of this process.

- With this experiment the wear rate has been increased with increase in mechanical properties
- Both Ni coated and cryogenic treated materials have shown some positive results.

Earlier research reported on electroless coatings are largely on the process and practically no attention has been paid to the mechanical properties. Even now considerable attention is being paid to the electroless process; however, some work has also been directed towards the studies on physicochemical and mechanical properties of electroless coatings. Studies have observed an increase in hardness of electroless nickel coating.

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