Wear Resistance test on ASTM 440C Steel by Diffusion bonding with Nickel foil

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Abstract- *The main objective of this project is to improve the wear resistance of the ASTM 440C stainless steel by the diffusion bonding of nickel. When nickel is diffused with the stainless steel the surface of the stainless steel gets tough and thereby the wear resistance of the ASTM 440C stainless steel increased. As friction and wear are not simply materials parameters available in handbooks, they are unique characteristics of the tribological system, hence experimental evaluation of the sliding pair has been conducted.*

Keywords- ASTM 440C , Diffusion bonding, Tribological system

I. INTRODUCTION

Stainless steel is widely used in applications in which corrosion resistance is of high importance. In many end-uses, the material is also expected to have a hard, scratch-resistant surface. When improved wear resistance is required, surface engineering provides solution. Industrially proven processes are available that improve surface hardness, scratch and wear resistance. Surface hardening, a process that includes a wide variety of techniques, is used to improve the wear resistance of parts without affecting the interior part.

This combination of hard surface and resistance to breakage upon impact is useful in parts success a cam or ring gear, bearing or shafts, turbine applications, and automotive components that must have a very hard surface to resist wear, along with a tough interior to resist the impact that occurs during operation. Most surface treatment result in compressive residual stresses at the surface that reduce the probability of crack initiation and help arrest crack propagation at the case-core interface. Further, the surface hardening of steel can have an advantage over through hardening because less expensive low-carbon and medium-carbon steel can be surface hardened with minimal problems of thick sections.

II. ASTM 440C STAINLESS STEEL, NICKEL FOIL, PIN ON DISC

Grade 440C is capable of attaining, after heat treatment, the highest strength, hardness (Rockwell C 60) and wear resistance of all the stainless alloys. Its very high carbon content of 1.0% is responsible for these characteristics, which make 440C particularly suited to such applications as ball bearings and valve partsMechanical properties, the tensile strength of wrought, annealed nickel is about 450MPa (65 ksi), and the elongation is around 40%.Hard-rolled nickel strip has a tensile strength of 620-790 MPa (90-115 ksi), and an elongation of 15-10%.Instruments to obtain linear measures of wear should have asensitivity of 2.5 μm or better. Any balance used to measure themass. loss of the test specimen shall have a sensitivity of 0.1 mgor better; in low wear situations greater sensitivity may beneeded. Testing parameters are load,speed and distance.

III. STAGES OF FABRICATION, DIFFUSION BONDING PROCESS

A. Bonding Process

A diffusion bonding process provides a metallurgical bond between at least two metallic bodies having either iron or nickel as a component, utilizing a cobalt base alloy diffusion bondable to the metallic bodies at a temperature below the liquids of either body but sufficient to promote inter diffusion of the cobalt alloy and metallic bodies. The bodies and alloy are contacted and subjected to the bonding temperature, whereupon solid state diffusion bonding occurs, producing a metallurgical bond which has a strength equivalent to brazing

B. fabrication stages

The ASTM440C Stainless Steel with required length and diameter is machined. Then the nickel foil is diffused with the ASTM440C Stainless Steel by the diffusion process method. Then the excess of nickel foil above the stainless steel is machined by the grinding process. Then the work piece is tested for the wear resistance and the friction resistance by the pin on disc apparatus.

Figure 1. Nickel coated Specimen

IV. PERFORMANCE STUDY

This test method describes a laboratory procedure for determining the wear of materials during sliding using a pin-on-disk apparatus. Materials are tested in pairs under nominally non-abrasive conditions. The principal areas of experimental attention in using this type of apparatus to measure wear are described. The coefficient of friction may also be determined.

Sliding velocity: 3m/s
Track Diameter: 40mm
Sliding distance: 1000m
Experiment duration: 333.33sec
Applied load: 30N
Disk speed: 263rpm

A. Wear graph

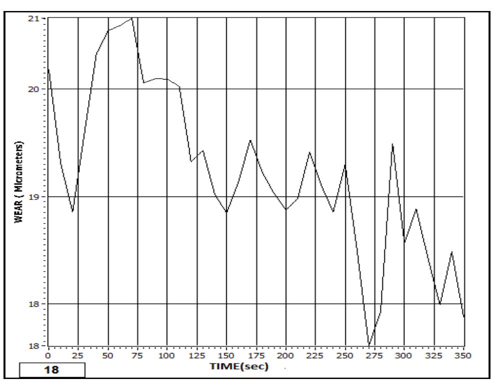

Figure 2.

B. Friction graph

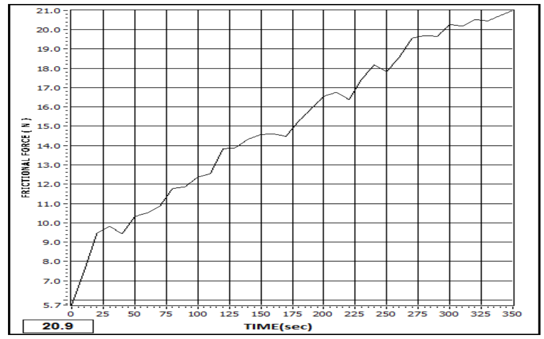

Figure 3.

Sliding velocity: 3m/s
Track diameter: 40mm
Sliding velocity: 3m/s
Track Diameter: 40mm
Sliding distance: 1000m
Experiment duration: 420.222sec
Applied load: 90N
Disk speed: 263rpm

A. Wear graph

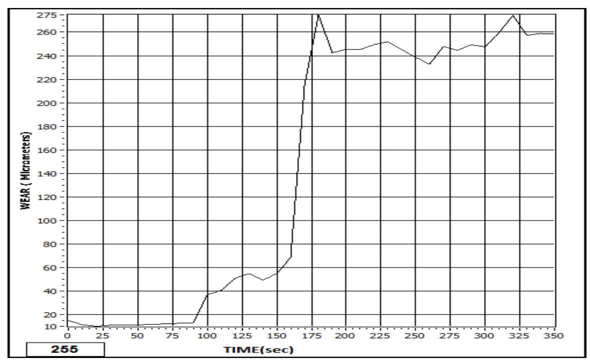

Figure 4.

B. Friction graph

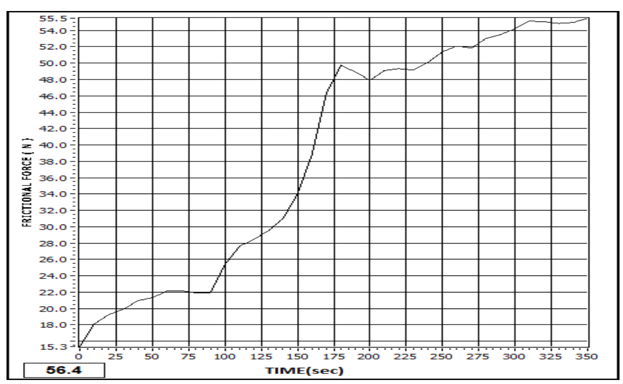

Figure 5.

A. Wear graph

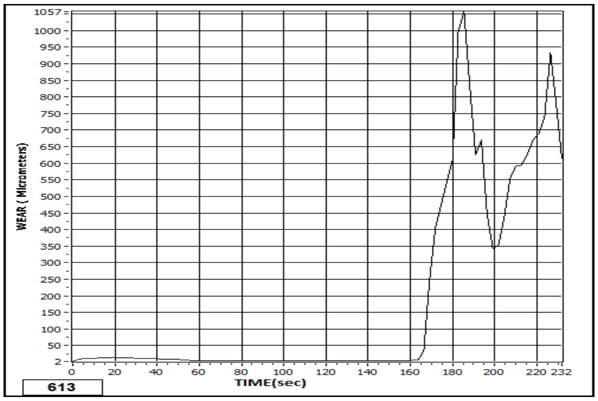

Figure 6.

B. Friction Graph

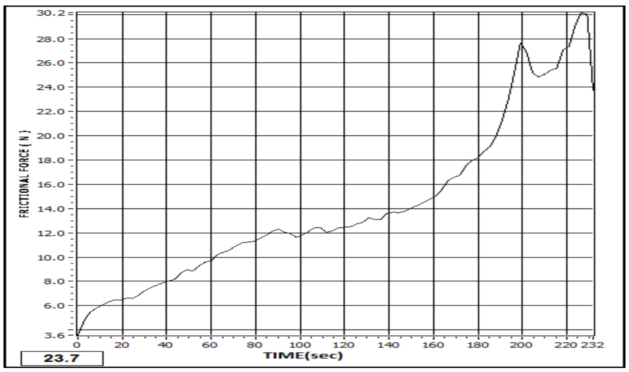

Figure 7.

V. COMPARISION OF WEAR RESISTANCE GRAPH WITH AND WITHOUT NICKEL FOIL

A. Without Nickel foil

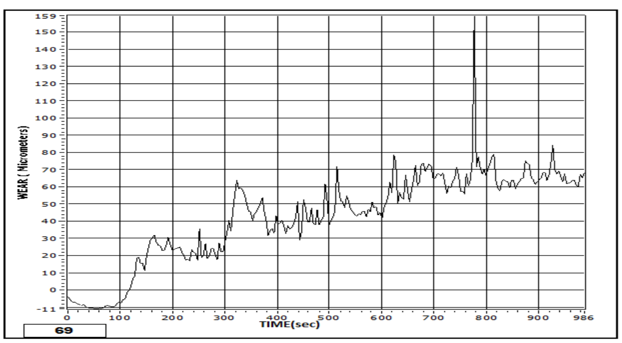

Figure 8.

B. With Nickel foil

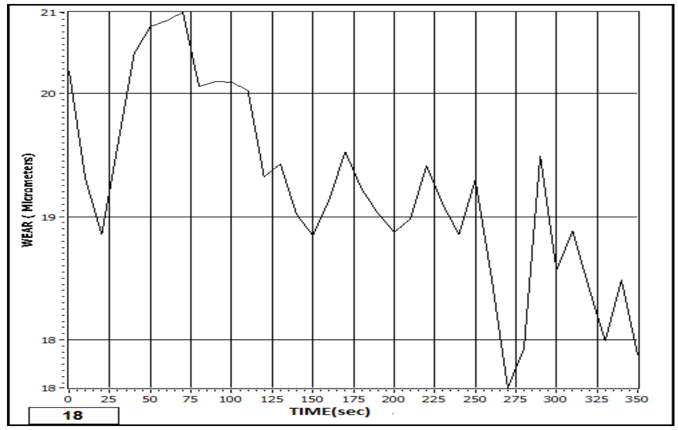

Figure 9.

By comparing the above graphs it is studied that wear rate is less in stainless steel with nickel foil than the stainless steel without nickel foil.

VI. CONCLUSION

Table 1.

SPECIMEN	LOAD (N)	CONDITION	WEAR (µm)	FRICTION (N)	COEFFICIENT OF FRICTION
1	30	Without Nickel foil	26	14	0.41
		With Nickel foil	20	9	0.3
2	90	Without Nickel foil	70	24	0.72
		With Nickel foil	65	21	0.53

The above indicates the comparison values of with and without nickel foil in 30N and 90N.

It proves that the tribological behavior of "ASTM440C Steel with diffusion bonding of Nickel Foil" is found to be better than the plain ASTM440C Steel under dry sliding condition.

After studying the mechanical and wear properties of diffusion of nickel foil with ASTM 440c stainless steel, the following works are suggested to be carried out in the future:

The evaluation types of wear like adhesive wear, Erosive wear and corrosive wear, may be conducted.

Dry sliding abrasive wear behavior can also be performed by varying its speed, load, sliding distance and lubrication condition.

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