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Tribological Investigation of Detonation Sprayed Ni-Cr And Al_2O_3 $13Tio_2$ Coatings On Grey Cast Iron To Enhance Its Wear Resistance

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Abstract: This paper is concerned with the investigation of the capability of Detonation sprayed Ni-Cr And Al_2O_3 $13TiO_2$ coatings to improve the tribological and mechanical properties of grey cast iron. The present study describes and compares the mechanical and tribological properties of NiCr and Al_2O_3 $13TiO_2$ D-Sprayed coatings deposited on two different substrates (GI250 and GIHC) Experiments using a tribometer (pin on disc) is performed in order to evaluate the wear properties. The coating microstructures were characterised by SEM and EDAX. Cumulative weight analysis is done to compare the wear loss in weight and its concluded Al_2O_3 $13TiO_2$ form a good bond with GI250 using Detonation spray process.

Keywords: Al_2O_3 $13TiO_2$, Detonation, EDAX , Ni-Cr, SEM.

I. Introduction

Surface engineering is an economic method for the production of materials, tools and machine parts with required surface properties, such as wear and corrosion resistance [1]. Since many types of attack such as corrosion, friction, wear, heat, radiation occur on the surface of a component, or transferred via the surface into the component, surface protection is of a considerable significance as regards modern materials technology.

The purpose of surface technology including thermal spraying is to produce functionally effective surfaces [2]. The wear resistance in the case of brake disc rotors, wire drawing pulleys etc. can be improved by a wide range of coatings.

Thermal spray is a technique that produces a wide range of coatings for diverse applications. The principle of thermal spray is to melt material feedstock (wire or powder), to accelerate the melt to impact on a substrate where rapid solidification and deposit build-up occurs[3].

To reduce the wear problem, wear resistant coatings are deposited on the grey irons. Standard test methods for wear testing with pin-on disc apparatus are employed to study the wear behavior of the uncoated and coated grey irons as well. Thermal spray processes that have been considered to deposit the coatings are enlisted as: (1) Flame spraying with a powder or wire, (2) Electric arc wire spraying, (3) Plasma spraying, (4) Spray and fuse, (5) High Velocity Oxyfuel (HVOF) spraying, (6) Detonation Gun.

Among the commercially available thermal spray coating techniques, detonation spray (DS) is chosen to get hard, dense and consequently wear resistant coatings

II. Experimental Procedure

Two types of gray irons were studied: one Grade 250 (GI250), one high-carbon (GIHC), whose chemical compositions and basic mechanical properties are shown in Table 1.

Table 1
Chemical composition (wt.%) and mechanical properties of irons

	GI250	GIHC
C	3.54	3.73
Si	2.15	2.07
Mn	0.51	0.78
P	0.054	0.058
S	0.1	0.085
Ti	0.012	0.014
Cu	0.69	0.56
Cr	0.034	0.27
Sn	0.061	0.039
Hardness(HB)	195 ± 5	180 ± 5

Samples of cylindrical shape, with diameter 8mm and length 30mm were casted with the components of GI250 and GIHC. The casted samples were marked accordingly with sample numbers and The grinding of end faces (to be coated) of the pins is done using emery papers of five different grades 220, 400, 600, 800, 1000 in the same order . Grinding was followed by polishing with 1/0, 2/0, 3/0 and 4/0 grades polishing papers. Two types of coating powders namely (1)Ni-Cr (2) Al_2O_3-$13TiO_2$ are selected for Detonation Spray Coating Process after the literature survey. Powder Ni-Cr and Al_2O_3-$13TiO_2$ form hard dense and excellent bonded coatings on the samples. The wear tests were performed in a machine (Wear and Friction Monitor Tester TR-201) conforming to ASTM G 99 standard. The wear tests for coated as well as uncoated specimens were conducted under three normal loads of 30 N, 40 N and 50 N and a fixed sliding velocity of 1 m/s. A track diameter of D=40 mm, sliding speed v=1 m/s is kept. Wear tests have been carried out for a total sliding distance of 5400 m (6 cycles of 5min, 5min, 10min, 10min, 20min, 40min duration),so that only top coated surface was exposed for each detonation sprayed sample. Weight losses for pins were measured after each cycle to determine the wear loss.

The weight was measured by a micro balance to an accuracy of 0.0001 gm. The coefficient of friction has been determined from the friction force and the normal loads in all

the cases. The wear tracks produced in the coating were studied by SEM (FEI Quanta 200F), and
The EDAX genesis software indicates the elemental compositions (weight %) present at point/area of interest. The results of coating volume loss are reported.

III. Results and Discussion

Cumulative weight loss for samples are compared in Figure 1 and The FE-SEM micrograph for Detonation sprayed Ni-Cr and Al_2O_3-13TiO_2 coatings on GI250 and GIHC along with micrograph for uncoated sample are shown in Figure 2.

Cumulative weight loss figure shows the loss in weight for each sample after a cycle of 5400m at a load of 40N. From the table it is clear that weight loss in case of coated samples is very less as compared to uncoated samples. In case of first and second sample (Ni-Cr coating on GIHC) and (Ni-Cr coating on GI250) if we compare it is found that weight loss in case of first sample is higher than the later, this means Ni-Cr coating is more compatible with GI250 but coated GI250 and GIHC sample as compared to uncoated samples clearly illustrates that wear is negligible. In case of third and fourth sample (AL_2O_3 13TiO_2 coating on GIHC) and (AL_2O_3 13TiO_2 coating on GI250) it is predicted that AL_2O_3 13TiO_2 is good wear resistant as it shows negligible wear as compared to uncoated GI250 and GIHC samples.

And if uncoated samples are compared it is found that GI250 is more wear resistant than GIHC mainly due to its higher hardness than GIHC

The FE-SEM micrographs in general indicate that the coatings are uniform, homogeneous and free from surface cracks. The Al_2O_3-13TiO_2 coatings have small size splats whereas the splats are coarse for Ni-Cr coating. More surface roughness is visible on micrographs of uncoated samples of GI250 and GIHC.

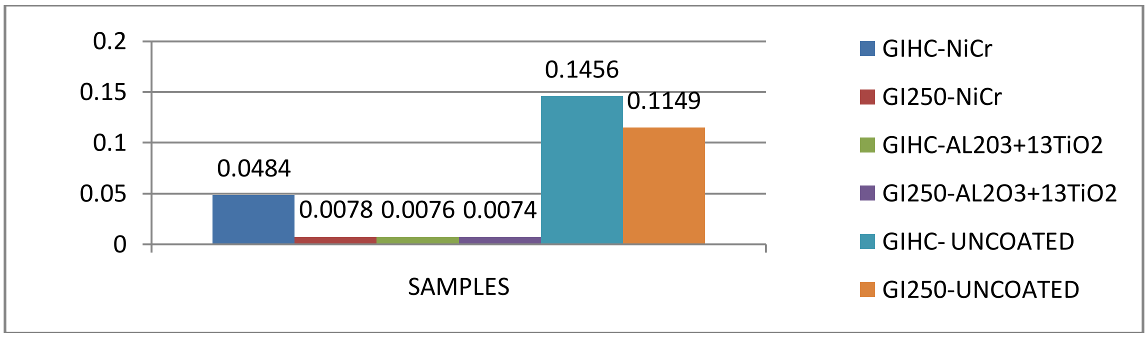
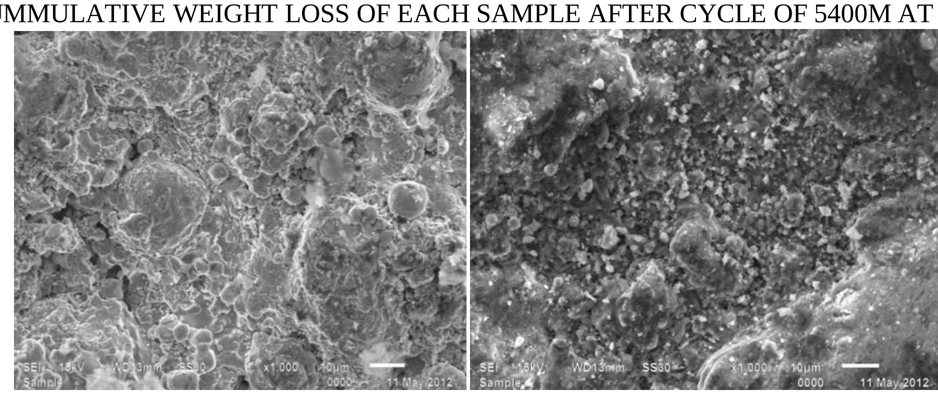


Figure 1: CUMMULATIVE WEIGHT LOSS OF EACH SAMPLE AFTER CYCLE OF 5400M AT 40 N LOADS.



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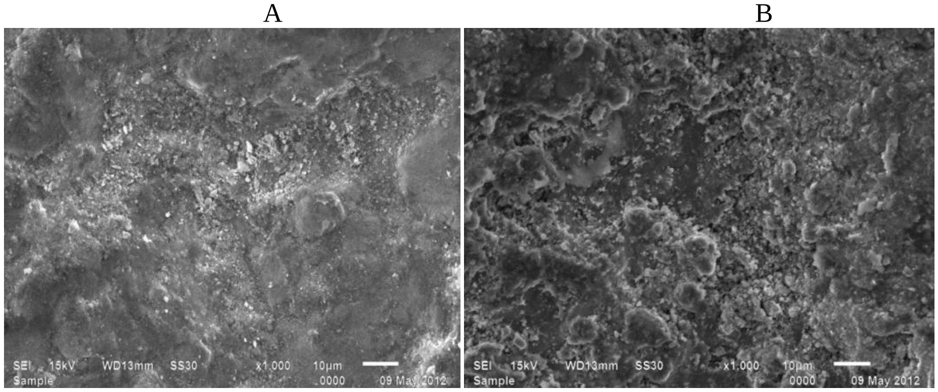

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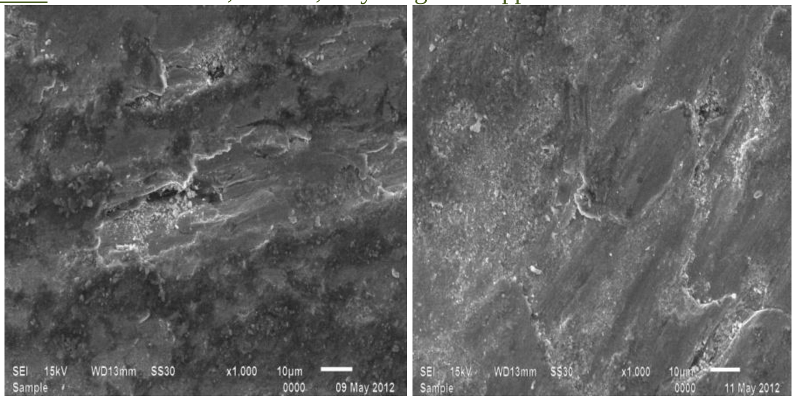

E F

Fig. 2.: SEM Micrographs Of Worn Out Samples Of (A) Ni-Cr Coating On GIHC (B) Al_2O_3+13tio$_2$ Coating On GIHC (C) Ni-Cr Coating On GI250 (D) Al_2O_3+13tio$_2$ Coating On GI250 (E) Uncoated GIHC Sample (F) Uncoated GI250 Sample At 40N Load

As reported by Astakhov, (2008) [4] that it is possible to deposit almost any material on any substrate without change in the properties of base material by D-gun spray process to considerably extend the life of parts, it is observed in the present study that the NiCr, Al_2O_3-13TiO$_2$ coatings powders have been successfully deposited on GI250 and GIHC substrates by the detonation spray process. It was further confirmed by characterization of coatings using EDAX analysis of as coated specimens. obtained in the study have been supported by the findings of Mohanty et al., (1996)[5]; Sahraoui et al., (2003)[6] and Bolelli et al.,(2006). [7]

The detonation sprayed NiCr, Al_2O_3-13TiO$_2$ coated GI250 and GIHC specimens showed significantly lower cumulative weight loss (Figure 1) as compared to bare GI250 and GIHC materials under the normal load of 40N. It was investigated with the help of Pin-on-Disk Wear Test Rig according to ASTM G99-03 Standard. There are many studies ; Murthy & Venkataraman (2006)[8], Sundarajan et al.(2005)[9] which support the above finding that Detonation sprayed coatings reduces the wear loss.

IV. Conclusion

- Detonation Sprayed NiCr, Al_2O_3-13TiO$_2$ coatings have successfully been deposited on GI250 and GIHC grades of grey cast iron.
- The detonation sprayed NiCr, Al_2O_3-13TiO$_2$ coated GI250 and GIHC specimens showed significantly lower cumulative weight loss as compared to uncoated GI250 and GIHC materials.
- Cumulative weight loss for detonation sprayed NiCr, Al_2O_3-13TiO$_2$ coated as well as bare GI250 and GIHC specimens increases with increase in load.
- The Cumulative weight loss for Al_2O_3-13TiO$_2$ coating was observed to be minimum in the present study.
- The $Al_2O_3$13TiO$_2$ GI250 coating substrate combination has shown minimum Cumulative weight loss among all the combinations. The wear resistance for coating–substrate combinations in their decreasing order (at 40N) is Al_2O_3 13TiO2-GI250 > Al_2O_3 13TiO$_2$-GIHC > NiCr-GI250 >NiCr - GIHC > Uncoated GI250 > Uncoated GIHC

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