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A Study of Surface Morphology and Wear Rate Prediction of Coated Inconel Specimen of 600, 625 and 718

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ABSTRACT

In the current work the coated Inconel specimens 600,618 and 625 are used to find the wear rate. and these three different grades Inconel specimen were tested for their wear rate calculation by using pin on disc wear machine by varying different loads and speeds and all these three different Inconel specimen wear rate values are calculated and are compared and it was found that among three different Inconel specimens 600, 625 and 718 the dominant type of specimen is Inconel 625 and is an important coating material property with regard to the wear rate behaviour under pin on disc test conditions and it is observed that well known Inconel specimen 625 is much more promising coating material and done details study of surface morphology of Inconel coated specimen 600, 625 and 718.

Keywords *– wear rate, pin, disc, load and speed.*

1. INTRODUCTION

The loss of material and deformation from its original position on a surface is known as wear. By the mechanical action of another surface, a tougher surface often removes material from a softer surface. or Wear refers to the material's deteriorating, sluggish removal or distortion at solid surfaces. Functional surfaces deteriorate due to wear in machine components and other processes including fatigue and creep, which finally results in material failure or functionality loss. wear can result from mechanical (such as erosion) or chemical factors (e.g., corrosion) Wear occurrence depends on applied load, geometry of the surface, rolling and sliding velocity, environmental condition, mechanical, thermal, chemical properties etc. Metallic wear is the term for the corrosion of metal surfaces brought on by plastic deformation. Many processes, including as chemical reactions, corrosion, erosion, and abrasion, can lead to wear. The processes of wear are studied in the field of tribology there are many types of wear Some of them include surface fatigue, fretting wear, erosive wear, adhesive wear, abrasive wear, and corrosion & oxidation wear.

Applications require for precautions against surface deterioration caused by oxidation, wear, and corrosion under tough circumstances of extreme load and heat, thermally sprayed Cr3C2-NiCr coating is applied using the D gun technique. In demanding working situations like at very high temperatures or in dangerous surroundings, for instance in turbine blades or in tubes of boiler for power generating and these coatings exhibit good qualities. These coatings used to extend the useful life of components operating at high temperatures and maintain their high wear and corrosion resistance up to 1253 K/W. Various studies show that Cr2O3 (layer covering oxide) preferentially forms at very high temperatures on the coated surface, preventing the coating's entire surface from oxidising. the purpose of this wear test under focused contact pressure is unavoidably to validate the material's dependability and safety for difficult total joint process and wear rate of all three different grade coated Inconel specimens 600, 625 and 718.

Chromium carbide coatings are frequently used on items that are worn and eroded at high temperatures [1] the carbide particles size, the distribution of the carbides inside the splats, and the cohesion between the splats, are typically thought to have a significant impact on how resistant they are to wear and erosion.[2][3][4][5]6]. It is possible to modify coating technique to fit particular surroundings. Numerous bulk materials, including ceramics, cermets, ferrous and non-ferrous metals, alloys, and sufficient resistance to wear, corrosion, and friction via coating as fresh European legislation about hazardous waste, the research of alternatives to hard chromium plating has increased in the galvanic industries.[7] When a product needs to be wear-resistant, thermal spray coatings with materials like chromium carbide appear to be an change to chrome plating.[8] Different techniques, including heat treatment, alloying procedures, and coatings, have been proposed to address these problems and to improve the material properties for certain purposes. Since coating layers can cut costs and ignore material scarcity because their thickness rarely exceeds micrometers, coating procedures among these have the largest percentage of material augmentation. As a result, less ingredients are required to build layers of coating on a significant amount of given materials. The features that coatings can have include better wettability, hydrophobicity, improved wettability, altered surface roughness, increased surface hardness, and others.[9]

2. EXPERIMENT METHOD

2.1 Wear Test Method and Material used

By using pin-on-disc machine, the wear test is conducted and the purpose of conducting wear test is to know the how much wear rate occurs from the coated three different Inconel specimens. in this experiment material is used is three different grades cylindrical Inconel specimen having size of 25mm length and 6mm diameter as shown in Figure 1.and The specimen's pin diameter is chosen in accordance with the pin-on-disc wear testing machine [10]. And considered as standard size (ASTM G-99)

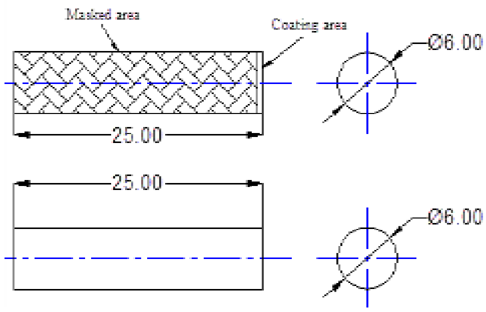

Fig 1 *Dimension of Coated Inconel Wear Specimen*

2.2 Pin-On-Disc Test Method

In experiment procedure, the test is conducted under constant parameters like load 10N, 20N and 30N, speed 200rpm, 300rpm and 400rpm, sliding distance 1000m, and sliding distance diameter 100mm and The revolving disc's counter face had a 100 mm wear track diameter, and the pin was fixed against it. the pin was loaded against the disc. Then wear test for all three different specimens was conducted under the varying normal loads of 10, 20 and 30N with speeds and for a total sliding distance of 1000 metres, wear tests were conducted under the same circumstances as previously mentioned [11]. Prior to the test, the surfaces of the pin samples were polished using emery papers to ensure that they made effective contact with the steel disc. The specimens were ultrasonically degreased with acetone after being cleaned with soap and water for five minutes at room temperature with a solution of 5% sulphuric acid. Additionally, based on the speed choice, the machine's running time is determined [12]. By using a single pan electronic weighing machine to weigh each specimen before and after the experiment, weight loss of each specimen was determined. and wear rate is calculated by using formula as volume loss/sliding distance table 1 shows the wear rate loss of all three Inconel specimen 600, 625 and 718 and Figure 2 shows wear test machine.

***Fig 2** wear test machine*

2.3 Wear Rate Loss

Below Table 1 gives the information that at speed 400rpm and load 10N wear rate or loss of the Inconel specimen 625 is 0.0027 it's very less as compared to other two Inconel specimen 600 and 718.

Table 1 Wear rate of Cr_3C_2-NiCr coated Inconel substrates for the varying load and speed

Expt No	Inconel	Speed (rpm)	Load (N)	Wear rate (10^{-6} mm^3/m)
1	Inconel 600	200	10	0.0084
2		200	20	0.0099
3		200	30	0.0141
4		300	10	0.0051
5		300	20	0.0069
6		300	30	0.0114
7		400	10	0.0043
8		400	20	0.0056
9		400	30	0.0065
10	Inconel 625	200	10	0.0042
11		200	20	0.0071
12		200	30	0.0095
13		300	10	0.0051
14		300	20	0.0062
15		300	30	0.0032
16		**400**	**10**	**0.0027**
17		400	20	0.0039
18		400	30	0.0051

19	Inconel 718	200	10	0.0069
20		200	20	0.0077
21		200	30	0.0068
22		300	10	0.0063
23		300	20	0.0070
24		300	30	0.0047
25		400	10	0.0043
26		400	20	0.0058
27		400	30	0.0043

3. DISCUSSION

The real actual area of contact would move closer to the nominal area as the load on the specimen increased, increasing the force between the two sliding surfaces. The applied load was increased from 10 to 30N, which confirm that, the wear rate increases as the load is increased [13]. As the load increased, the depth of penetration of the abrasives into the specimen increased resulting in an increased material loss. This resulted in higher wear rate at the high loads. The wear rate on the applied load the increased due to the number of Cr3C2 – NiCr grits in contact with the specimen as the load increases. This results in greater mass loss at high load since there would be more grits in contact with the specimen [14]. The wear rate was greater for high load compared to low load due to the increase in depth of penetration of the grits to the specimen as shown in Figure 3, 4 and 5 respectively.

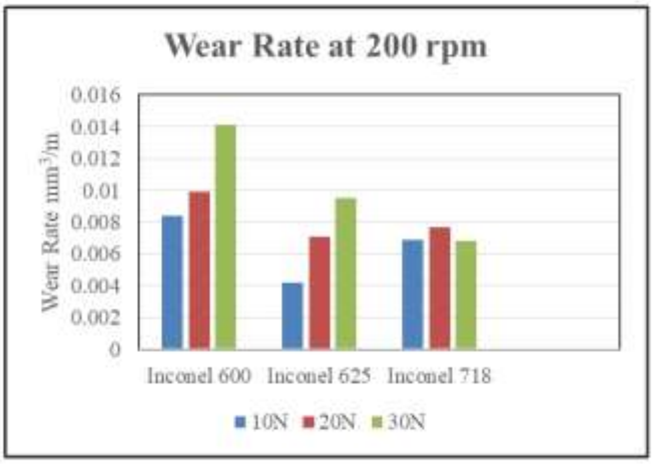

***Fig 3**. Wear rate at 200 rpm*

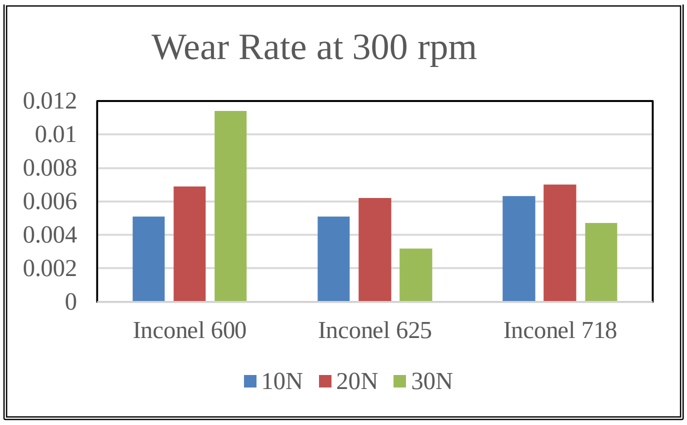

***Fig 4** Wear rate at 300 rpm*

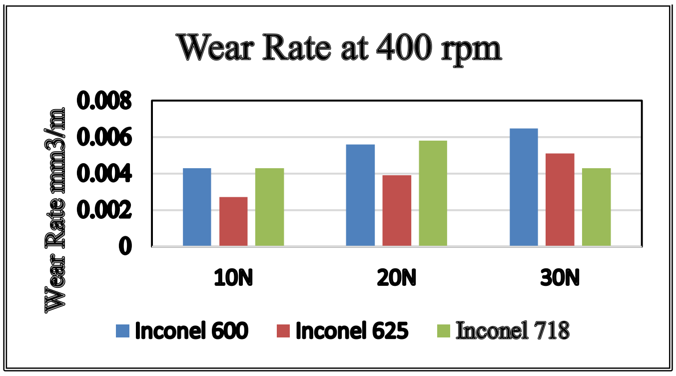

Fig 5 *Wear rate at 400 rpm*

4. Surface Morphology of worn Inconel 600, 625 and 718 - Cr_3C_2-NiCr coated specimens

The worn-out surfaces for the Inconel 600, Cr_3C_2-NiCr coatings for the speed of 200 rpm and load of 20N. Visual inspection reveals that dark areas gradually developed throughout the wearing process. As the coating thickness increased, more dark areas emerged. As the sliding distance increased, the dark layer's area grew as well as shown in Figure 6.

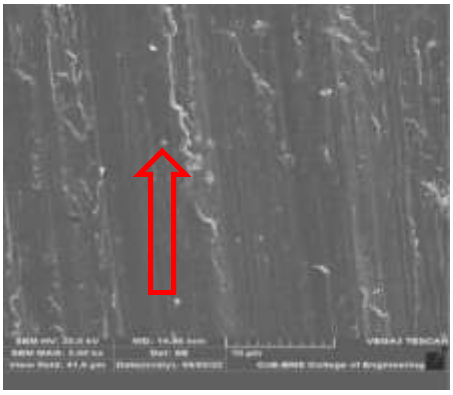

Fig 6 *worn out surfaces for the Inconel 600- Cr_3C_2-NiCr coatings for the speed of 200 rpm and load of 20N*

The worn-out surfaces for the Inconel 600 - Cr_3C_2-NiCr coatings for a load of 20 N and a speed of 300 rpm. High shear pressures on sliding surfaces generate fatigue loads to start subsurface cracks that spread, which causes material to be lost from the worn surfaces as shown in Figure 7.

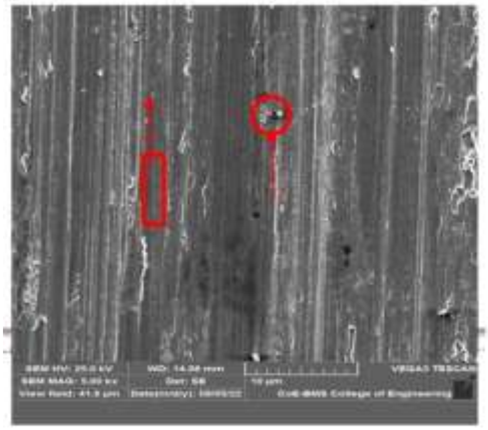

Fig 7 *worn-out surfaces for the Inconel 600- Cr_3C_2-NiCr coatings for the speed of 300 rpm and load of 20N*

In Figure 8, Typical features of the worn surfaces of Inconel 600- Cr_3C_2-NiCr coatings. The existence of grooves in the sliding direction and the creation of extensive lips along the groove walls in the tested coatings indicate a high degree of flexibility [15]. There were also a few little cracks running parallel to the sliding direction on the bottom of the grooves. It is also clear that the grooves made by 20N at 400 rpm have a wider groove width than the grooves created by 20N at 300 rpm.

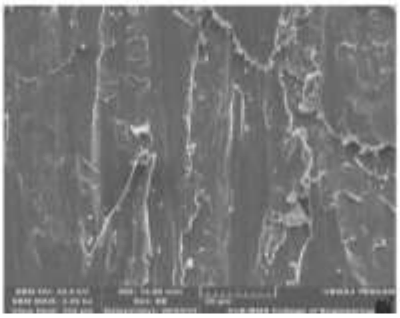

Fig 8 *worn-out surfaces for the Inconel 600- Cr_3C_2-NiCr coatings for the speed of 400 rpm and load of 20N*

The wear is severe as the speed is increased from zero to 200 rpm, the wear increases steadily and roughly linearly with speed. This could be a plausible explanation for what was stated earlier. In other words, the first low speed phase is a brief period of abruptly rising wear as speed increases. A steady state phase with a roughly linear wear speed relationship follows this.

In Figure 9, Typical features of the worn surfaces of Inconel 625- Cr_3C_2-NiCr coatings.

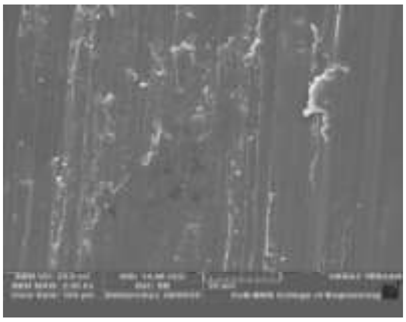

Fig 9 *worn-out surfaces for the Inconel 625- Cr_3C_2-NiCr coatings for the speed of 200 rpm and load of 20N*

Experiments have shown that for many trials, the material loss through wear is proportional to the sliding distance (and so far sliding at constant velocity to the time). [Figure 10].

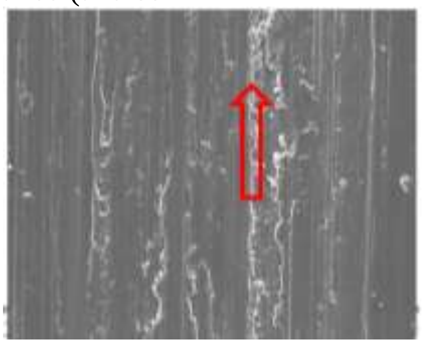

Fig 10 *worn-out surfaces for the Inconel 625- Cr_3C_2-NiCr coatings for the speed of 300 rpm and load of 20N*

Low sliding speeds enhance the development of oxide coatings. Due to the weak and swift shearing of the adhesion between the oxide layers at the asperity sites, these surfaces' oxide films shield them from serious harm [16]. In the lack of sufficient oxide layers, increasing sliding velocity causes severe wear, which manifests as huge metallic fragments ripped away by the strong adhesive junctions. Between subsequent contacts, the oxide films do not have a chance to properly develop. As the rate of wear rises, the effect is an increase in wear. [Figure 11].

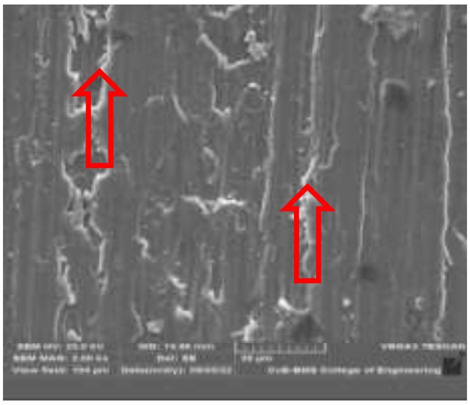

Fig 11 *worn-out surfaces for the Inconel 625- Cr_3C_2-NiCr coatings for the speed of 400 rpm and load of 20N*

It is obvious that wear has somewhat increased with an increase in wear test speed. At 400 rpm, there was severe delamination of the coated surfaces [Figure 12]. One likely explanation for this is because there is a significant rise in wear as speed is increased from 100 rpm to 300 rpm, followed by a gradual and somewhat linear increase in wear as load increases. In other words, the early speed phase is a transitory period marked by a significant rise in wear as speed increases, and it is followed by a steady state period in which the wear speed relationship is roughly linear.

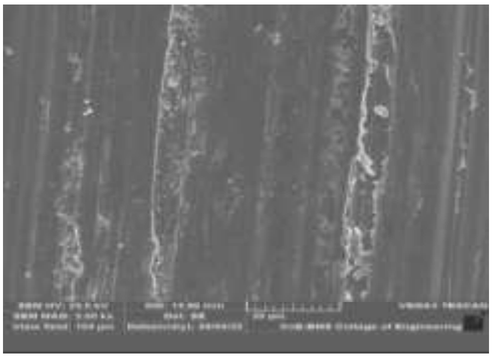

Fig 12 *worn-out surfaces for the Inconel 718- Cr_3C_2-NiCr coatings for the speed of 200 rpm and load of 20N*

Comparing the two reveals that there are no discernible changes in wear behaviour at lower loads and sliding speeds, but at higher loads and sliding speeds, there are variances between the two directions of coatings. On the other hand, at low sliding speeds, the worn surface is found to have more severe damage that is normal to the direction of applied pressure [17]. It can be because abrasion of the wear surface parallel to the pressure direction requires more friction forces [Figure 13].

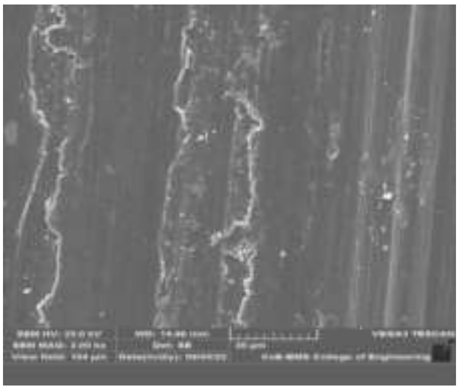

Fig 13 *worn-out surfaces for the Inconel 718- Cr_3C_2-NiCr coatings for the speed of 300 rpm and load of 20N*

Additionally, grooves are seen in these distinct grooves on the coated substance. This is a result of the substrate's subpar mechanical characteristics. It can be inferred from the wear surface that grooves play a significant role in wear behaviour, progressing wear by their expansion. The wear surface fracture at the groove's end and along the groove speeds up the expansion of the groove. The wear surface shows that the predominant wear mechanism and intermediate sliding speeds are adherent abrasive wear. [Figure 14].

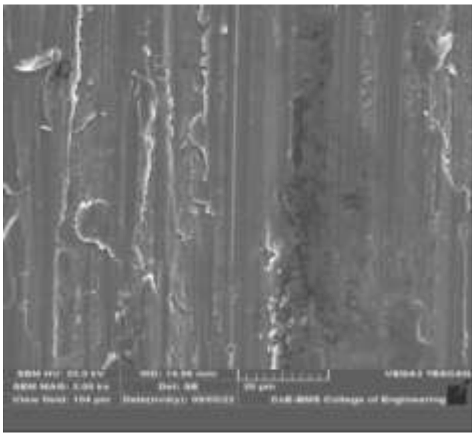

Fig 14 *worn-out surfaces for the Inconel 718- Cr_3C_2-NiCr coatings for the speed of 400 rpm and load of 20N*

Only minor surface degradation was observed at modest sliding speed (200rpm) and load (20N). Fracture, matrix, and reinforcement appear to advance the removal of the coating material, which may be the result of the high friction force being delivered to the worn surface. Considerably deteriorating the wear resistance of matrix alloy is delamination brought on by excessive substrate surface fracture. As the surface materials are stripped away, the shear strain rises and the cracks become closer to the surface. The surface layers are removed as a result of delamination. The aforementioned data led to the conclusion that delaminating wear is the primary wear mechanism at high loads.

4. CONCLUSION

By conducting wear test on pin on disc test machine, concluded that the Inconel 625 specimen achieve the minimum wear rate (0.0027) at maximum load of 400N compared to remaining two 600 and 718 Inconel specimen. And by studying surface morphology of coated specimen we observed that strong adhesive junctions or bond for Inconel 625 as compare to other two Inconel specimen 600 and 625.

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