ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 1, Issue 12, March 2015

Dry Sliding Wear Behavior of Cr_3C_2-NiCr Coating on Austenitic Stainless Steel

D.Sudhakar[a], D.Jeyasimman[a], M.Duraiselvam[b]
[a]Department of Mechanical Engineering, Periyar Maniammai University, Thanjavur - 613403, Tamil Nadu, India.
[b]Department of Production Engineering, National Institute of Technology, Tiruchirappalli – 620015, Tamil Nadu, India.
*Corresponding author. Tel.: +91 94860 20248;
E-mail address: jeyasimman76@gmail.com (Dr. D. Jeyasimman)

ABSTRACT
Thermal spray technology encompasses a group of coating processes that provide functional surfaces to protect or improve the performance of a substrate or component. Among the various thermal spray coatings, detonation gun (D-gun) coating is often considered to be premier coating method which is used basically for enhancing the service life of the components by several folds in almost all the industrial sectors, where the components are subjected to wear, abrasion, erosion and corrosion. Also this method covers coating of almost all engineering components using metals, alloys, ceramics, cermets and composites. The aim of the project is to perform D-gun coating on austenitic stainless steel (AISI 304) using Cr_3C_2-NiCr coating systems. Generally, austenitic stainless steel of 304 type used in high temperature applications due to its less sensitive to heat because of low carbon content. In addition coating of Cr_3C_2-NiCr on this steel substrate improves wear, corrosion and high temperature oxidation; hence it can be used as valves, evaporators, pressure vessels, fuel tanks materials etc.

Key Words: ***Pin on disc method; SS304; Wear; Corrosion; Coating***

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 1, Issue 12, March 2015

1.0 Introduction

Wear is defined as surface damage or removal of material from one or both of the two solid surfaces in a sliding, rolling or impact motion relative to one another [1]. It is a serious problem in many engineering applications such as bearing, moving parts, engine parts etc. Wear is the erosion of material from a solid surface by the action of another solid. The study of the processes of wear is part of the discipline of tribology. Wear is the progressive damage, involving material loss, which occurs on the surface of a component as a result of its motion relative to the adjacent working parts; it is the almost inevitable companion of friction. Most tribological pairs are supplied with lubricant as much to avoid the excessive wear and damage which would be present if the two surfaces were allowed to rub together dry as it is to reduce their frictional resistance to motion, merge with the tertiary stage, thus drastically reducing the working life. Surface engineering processes are used to minimize wear and extend working life of material. Thermal spray coating methods was shown in Fig. 1.

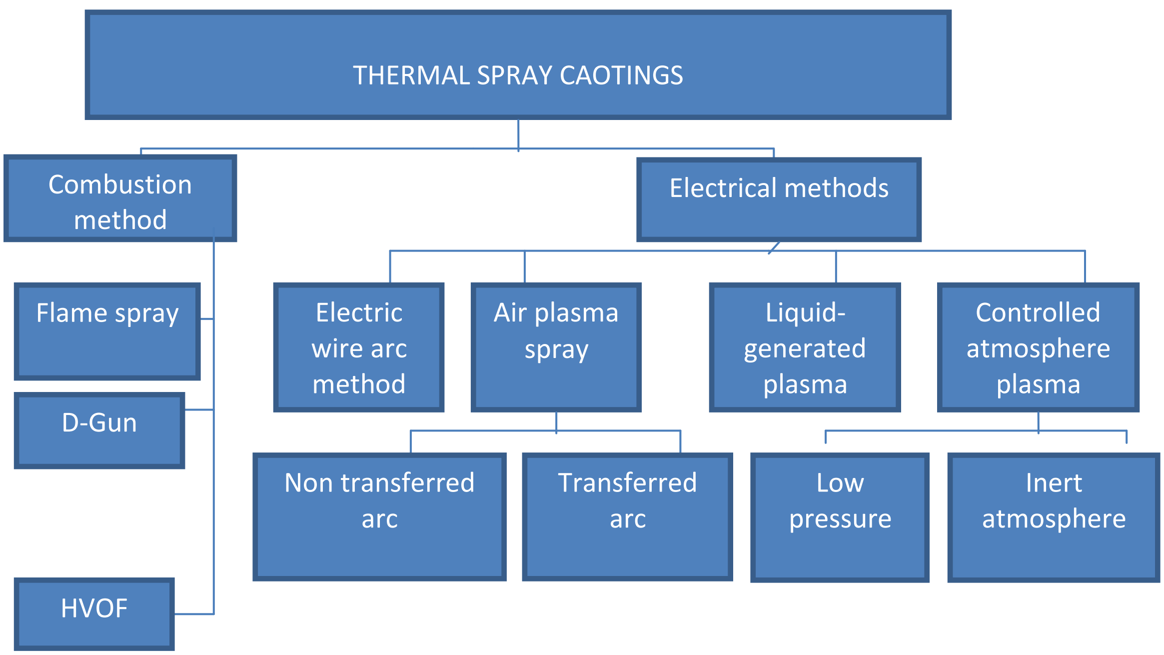

Fig. 1 Thermal spray coating methods

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 1, Issue 12, March 2015

1.1 Detonation-Gun Spraying (D-Gun)

The D-gun™, shown schematically in Fig. 2 includes a long, water-cooled barrel with an ID of about 25mm A mixture of oxygen and acetylene is fed into the barrel, together with a charge of powder The gas is ignited, explodes and its detonation wave accelerates the powder. In order to avoid 'backfiring', explosion of the fuel gas supply, an inert gas, such as nitrogen, issued between the portions of exploding mixture. Nitrogen also purges the barrel.

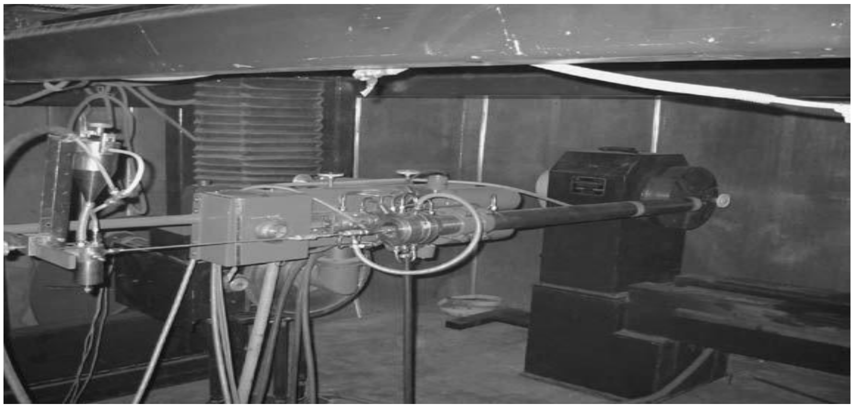

Fig.2. D-Gun method for thermal spray coating.

1.2 Experimental setup and procedure

Pin-on-disc testing is a commonly used technique for investigating dry sliding wear. As the name implies, such apparatus consists essentially of a "pin" in contact with a rotating disc. Either the pin or the disc can be the test piece of interest. The contact surface of the pin may be flat, spherical, or, indeed, of any convenient geometry, including that of actual wears components. In a typical pin-on-disc experiment, the coefficient of friction is continuously monitored as wear occurs, and the material removed is determined by weighing and/or measuring the profile of the resulting wear track.

To study the dry sliding wear behavior of the Cr coated AISI 304 Austenitic stainless steel and uncoated AISI 304 Austenitic stainless steel, wear test were carried out using DUCOM TR-20M-106 Pin-on-disc wear testing machine (Fig. 3) was used. The test was performed as per ASTM: G99. The equipment consisted of a rotating spindle to which the disk is fixed by securing M8 counter sunk bolt. A pivoted lever arm with balancing weight and provision for fixing the pin along with the holder were to be brought into position (to the desired track diameter). The pin was secured by tightening the allen head grub screw in the holder [2].

The lever arm was rested on the disk after ascertaining the disk track diameter. Desired loads were added to the location at the lever arm one by one. The duration of the test was set. The LVDT probe was positioned on the weights to measure displacement and the load cell to sense the tangential force. An induction coil was inbuilt in the equipment to raise the temperature to desired level to carry out the experiment. The wear and friction force was simultaneously recorded by using the software WINDUCOM.

Fig. 3. Pin-on-disc method for wear testing

1.3 Experimental formulation

The mass losses were calculated at every interval of sliding distance for different normal loads with respect to various sliding velocities. An X-Y plotter attached to the tester continuously recorded the coefficient of friction.

The coefficient of friction is $\mu = \left(\frac{F}{P}\right)$ (1)

where F is the frictional force measured by the tester and P is the normal load on the specimen. The volume loss due to the wear test was calculated from the weight loss according to the following equation [2]:

$$Volume\ loss(mm^3) = \left(\frac{Weight\ loss(g)}{Density(g/mm^3)}\right) \times 1000 \quad (2)$$

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 1, Issue 12, March 2015

The wear tests were conducted five times for every pin and the obtained data were represented by the average value together with error bars. The wear rate was calculated from the following expression:

$$Wear\,rate\,(mm^3/m) = \left(\frac{Volume\ loss(mm^3)}{Sliding disance(m)}\right) \times 1000 \qquad (3)$$

The dimensions of the pin material is 8mm diameter and 30 mm length, pins are cut from the austenitic stainless steel 304 8mm diameter bar and finished to required size was shown in Fig. 4. Chemical composition of AISI 304 Austenitic stainless steel was shown in Table 1.

Fig.4. AISI 304 Pin Materials

Table 1 Chemical Composition of AISI 304 Austenitic stainless steel

Element	C	Cr	Fe	Mn	Ni	P	S	Si
Wt %	0.08	19	71	2	9	0.045	0.03	1

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 1, Issue 12, March 2015

1.4 Preparation of disc specimen (counter part material)

The test specimens used for dry sliding wear test are in the form of pins and disc. Steps involved in disc preparation are preparation of sample by cutting & machining, it to require dimensions and polishing.

In this step AISI 304 Austenitic stainless steel sample were cut to require 3mm thickness and machining the diameter to 90mm for weight not more than 220gms that is the maximum capacity of the electronic analytical balance and also for fixing the sample in tribotester for conducting the pin on disc wear test.

Fig.5. Uncoated AISI 304 Austenitic stainless steel

Table 2 Experimental parameters for AISI uncoated 304 Austenitic stainless steel

S.NO	Vel (m/s)	Temp (°C)	Load (N)	Sliding Distance (m	Track Dia (mm)	Speed (RPM)	Time (Min)
1	2	RT	10	1000	50	736.9	8.33
2	2	RT	20	1000	50	736.9	8.33
3	2	200	10	1000	70	545	8.33
4	2	200	20	1000	70	545	8.33

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 1, Issue 12, March 2015

Table 3 Experimental parameters for Cr_3 C_2-NiCr coated on AISI304 Austenitic stainless steel

S.NO	Vel (m/s)	Temp (°C)	Load (N)	Sliding Distance (m	Track Dia (mm)	Speed (RPM)	Time (Min)
1	2	RT	10	1000	50	736.9	8.33
2	2	RT	20	1000	50	736.9	8.33
3	2	200	10	1000	70	545	8.33
4	2	200	20	1000	70	545	8.33

2.0 Result and Discussion

Comparison between depth of wear and coefficient of friction (COF) of coated and uncoated AISI 304 stainless steel samples at 10N in RT was shown in Fig 5.

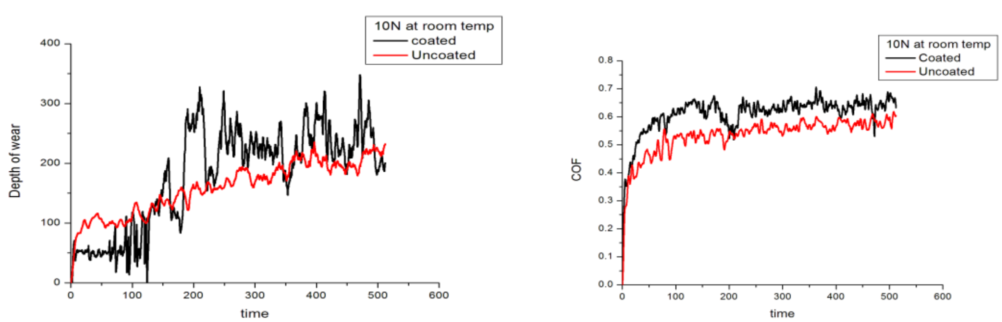

Fig. 5 Depth of wear and coefficient of friction of coated and uncoated AISI 304 stainless steel samples

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 1, Issue 12, March 2015

Wear resistance of coated sample higher than uncoated sample because of small amount of porosity presented over here and also coefficient of friction also higher than uncoated sample the initial state of coated sample less than uncoated sample at 100 seconds [3].

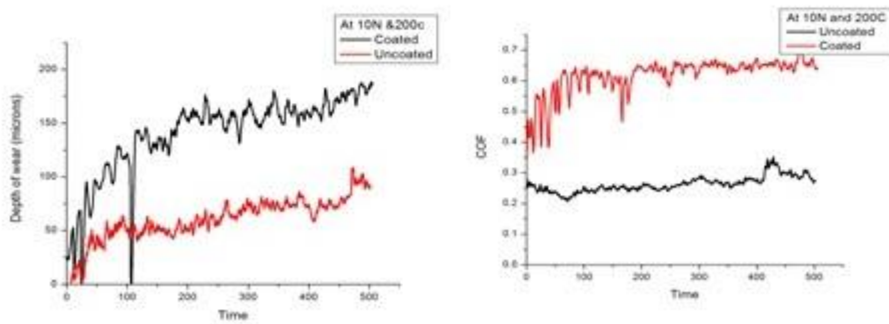

Fig. 6 Comparison between depth of wear and COF of coated and uncoated AISI 304 stainless steel samples at 10 N at 200^{0}C

For 10N with 200 º C coated samples higher than uncoated sample when compared to slightly lower than 10 N at room temperature (4). The small bent curve has occurred, there is a loose tightening of the job in the machine. The coefficient of friction is better than 10N at room temperature when compared to 10N at 200ºC (refer Fig. 6). Wear resistance variation with temperature and load was shown in Fig. 7.

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 1, Issue 12, March 2015

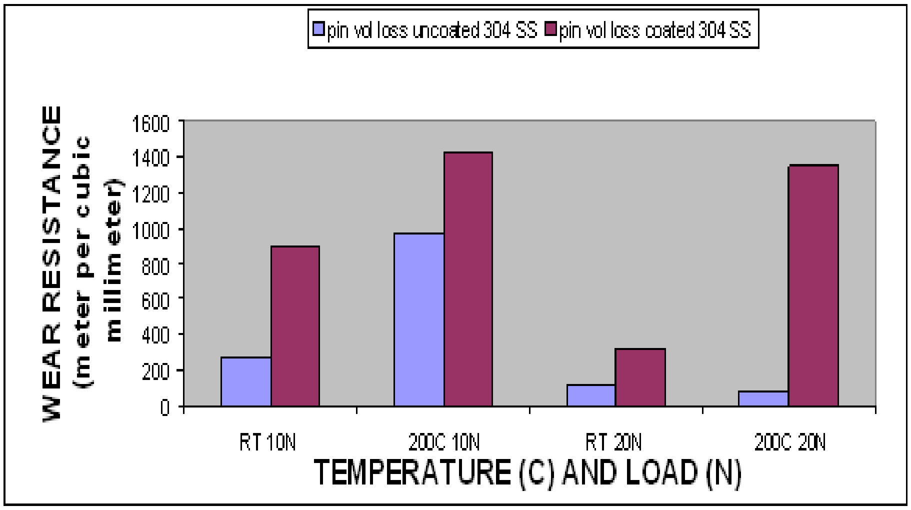

Fig.7 Wear resistance for various load and temperature.

Volume loss increase mean wear resistance of coated and uncoated decreases for both RT, 200C Volume loss decrease mean wear resistance of coated and uncoated increase for both RT, 200 Volume loss increase mean COF of coated increases and uncoated decrease for 10N at RT and 10N at 200^{0}C [5]. Volume loss decrease mean COF of coated decrease and uncoated increase for 10N at RT and 10N at 200C (refer Fig. 8). For 10N at RT uncoated and coated volume loss less than that of 20N at RT. when 10N at 200C first decrease for uncoated and then increase for coated 20N at 200^0 C [6].

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 1, Issue 12, March 2015

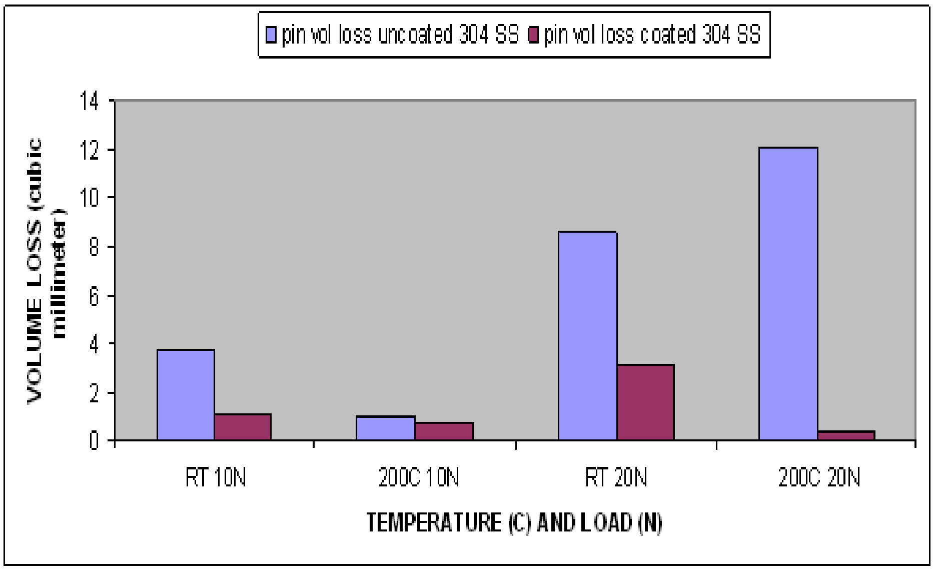

Fig. 8 Variation in volume loss for various temperatures and loads

3.0 Conclusion

1. Cr_3C_2- NiCr coated specimen exhibited higher coefficient of friction at room temperature as compared to that of uncoated stainless steel specimen.

2. Wear resistance of Cr_3C_2- NiCr coated pin is very high, as the mass loss of disc material is more but there is heavy loss of the uncoated pin

3. At constant loads and room temperature (i.e., 10N and 20N) Cr_3C_2- NiCr coated pin having good wear resistance than at 200ºC for same loads, this is due to at thermal expansion at high temperature.

4. Less volume loss on Cr_3C_2- NiCr coated sample compare with uncoated AISI304 austenitic stainless steel in all experiments.

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 1, Issue 12, March 2015

References

1. Bhushan, B., Introduction to tribology, John Wiley & Sons, 2002.
2. ASTM standard test method for wear testing with a Pin-on-Disc apparatus. ASTM G 99-95.Philadelphia.PA:1995
3. Tahar Sahraoui, Nour-Eddine Fenineche, Ghislain Mont Avon, Christian Coddet (2003) Structure and wear behavior of HVOF sprayed Cr_3C_2- NiCr and WC-Co coating. Materials & design (24) 309-313.
4. J.F.Li, C.X.Ding, J.Q.Haung, P.Y.Zhang (1997) Wear mechanism of plasma sprayed Cr_3C_2- NiCr against TiO_2 coating. Wear (211) 177-184.
5. Bin Yin.Guang li .Hudi Zhou, Jianminchen, Fengyuan Yan (2010) Sliding wear behavior of HVOF sprayed Cr_3C_2- NiCr/CeO_2 composite coating at elevated temperature up to 800°C. Tribol. Let (37) 463-475.
6. Gang-chang Ji, Chang- Jiu Li, Yu-Yue Wang, Wen-Ya Li (2006) Microstrctural characterization and abrasive wear performance of HVOF sprayed Cr_3C_2- NiCr coating. Surface Coating & Technology (200) 6749-6757.