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Improvement in Abrasive Wear Resistance by Oxy Acetylene Flame Spraying Method

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***Abstract:** Hard facing is a low cost method of depositing wear resistant surfaces on metal components to extend the service life. The present work undertaken to study the abrasion wear behaviour of thermal sprayed cobalt and nickel based coatings deposited by Oxy acetylene flame spraying method under the carburising flame. Wear behaviour was evaluated using dry sand abrasion wear testing machine. It was observed that the micro hardness value and abrasive wear resistance of Co based coated sample are more than the NI based coated sample. Wear behaviour of these coatings is governed by the material parameters such as microstructure, the hardness of coating and test parameters. Abrasive wear resistance of Co based coated sample in comparison to base metal was increased about 8-9 times and 3 times for Ni based coated sample. Heat treatment of the both powder coatings improved abrasive wear resistance but Co based coating shows better improvement than Ni based coatings.SEM study shows the cracks formation in the case of Ni based coated sample.*
***Keywords:** Oxy acetylene flame spraying, Abrasive wear, Co based coating, Ni based alloy coating, Heat treatment, Microstructural characterization, MicrYohardness, Surface roughness, Porosity, EDS, SEM.*

I. INTRODUCTION

Surface properties can be engineered by thermal spraying for increasing wear resistance and service life of tribological components. Wear resistant coatings can be applied by conventional weld surfacing and thermal spraying techniques as per scale of work. Thermal spraying involves the development of suitable wear resistant material coating which is meeting the service requirements [1–4]. Cobalt base alloys are commonly used for increasing life of component subjected to abrasive wear conditions such as Gate valves used in the offshore oil industry for controlling the fluid flow [5, 6].The predominant wear processes on gate valves are erosion, and two- and three-body abrasion caused by the presence of sand in the hydrocarbon fluid. Sand is often entrained in the fluid owing to the geology in which the reservoirs are located. The concentration of sand is usually in the range 10–100 ppm by weight and is 60–700 µm in size, and when it impinges on the valve interior considerable damage can result. This damage can compromise the hard-faced sealing surfaces and thus containment of hydrocarbon fluids [7]. Flame spraying, similar to plasma spraying, is a very versatile process since it is possible to produce coatings of various chemical compositions, structures, and thicknesses. The alloys used for hard-facing are based on Fe, Ni and Co. Ni-based alloys are corrosion resistant, except for environments containing sulphur compounds. NiCrFeSiB alloys are relatively resistant to abrasive wear. Ni being the major element, it provides ductility and enhances resistance to corrosion. Chromium produces high resistance to wear and corrosion. Boron enhances wear resistance, along with silicon reduces the melting point of the alloy, and acts as a flux [8]. Stellite 6 (Co-Cr base alloy) powder and Deloro 50 (Ni-Cr based alloy) powder which is easily deposited using low cost flame spraying method, therefore, is of greater commercial importance for abrasive wear application. In the present, attempts have been to improve the abrasive wear resistance by using oxy-acetylene flame spraying method on low carbon steel.

II. EXPERIMENTAL PROCEDURE

A. Materials

The chemical composition of steel substrate and commercial powders used in this investigation is shown in Table. 1. Thermal spraying was carried out on the steel plate of size 90 × 50 × 12 mm3. The procedure used to develop the coating is shown in Table 2. Commercial powders Co-Cr based alloy and Ni –Cr based alloy were used for deposition on the low carbon steel substrate. The temperature of powder in the hopper was approx 30 °C .while during the flame spraying it was in the range of 2000–2200 °C. Heat treatment of these coatings was carried out using a muffle furnace by soaking specimens at 800 °C for 2 h followed by still air room temperature cooling [7].

Table1: Chemical Composition Of Base Metal And Coating Powder

Element concentration in percentage by weight											
Element	C	S	P	Si	Mn	Ni	Cr	W	Co	Fe	B
Substrate	0.179	0.018	0.007	0.231	0.654	-	0.029	0.006	-	Bal	-
Deloro 50	0.45	-	-	4	-	Bal	10.5	-	-	4	2.3
Stellite 6	-	-	-	-	-	1.8	28.5	1.2	Bal	-	-

Table2: Thermal Spray Parameter

Sr.No	Prametres	Quantity
1	Cleaning of substrate using acetone	-
2	Grit blasted at the substrate under pressure	3 kg/m^3
3	The pressure of the oxygen	3Kpa
4	The pressure of acetylene	1.2Kpa
5	Torch angle with respect to plate	60°
6	Distance of torch tip from the substrate	20 mm
7	Torch speed	0.10 m/min
8	Preheat temperatures	300°C
9	Post-spray heat treatment temperatures	800°C

B. Microhardness Measurements

The microhardness of the hardfacing deposits was measured by a micro-hardness tester which allowed measuring the hardness of coated surface by using a Vickers intender with a load capacity of 2kg. In order to analyze the above mentioned properties of the weld hardfacing deposits, microhardness testing was conducted in longitudinal and transverse direction on the coated surface. The hardness of substrate, as sprayed surface and heat treated coated surface were summarized. For the assessment of microhardness, the measurements were taken as five readings in longitudinal and transverse direction on coated surface of each sample. A load of 1000g and a dwell time of 20 seconds were used for testing and the results thus obtained have been discussed later. Hardness test was done at welding metallurgy lab, mechanical department, SLIET, Longowal.

C. Wear Testing

The wear test for all samples was done on Dry sand abrasion wear test. For calculating the wear rate, the samples were weighed before and after the wearing of the specimen and the difference between the initial and final weight were calculated. The weighing was done on a machine with a least count of 0.001gm. The test was performed on Dry sand abrasion wear testing machine at Autofarma laboratory, mechanical department, SLIET, Longowal which was shown in Fig 1. Parameters for wear test been selected as per ASTM G65. Parameters considered during the test have been given in Table 3.

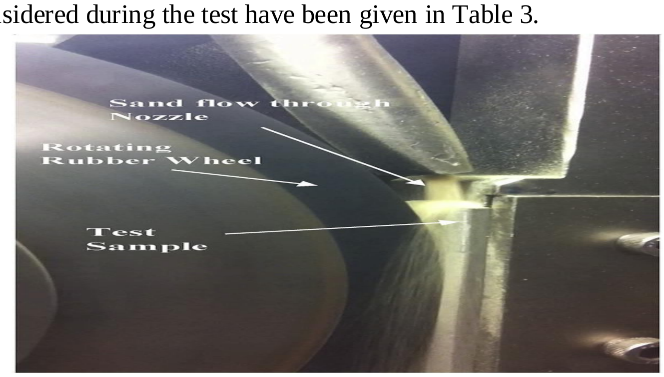


Fig 1: wear test is in process [9]

Table3: Parameter Selected For Wear Test

Applied load	54.54N
Speed	200 rpm
Erodent material	silica
Sand grit size (µm)	60-150
Test time	5 minutes
Sand flow rate	300 g/min

The test was carried out for the desired time along with above mentioned parameters. After each test, only the mass loss of the specimen was considered as the wear. The wear rate of each sample was calculated from the wear loss. Hence wear loss, wear rate, and wear resistance have been calculated as
Weight loss = Initial weight – final weight (gm)

D. Electro Dispersive Spectroscopy (Eds) Studies of the Coatings

Electro Dispersive X-Ray Spectroscopy (EDS or EDX) is an analytical technique used for elemental analysis or chemical characterization of a sample. The EDS technique detect X-ray emitted from the sample during the bombardment by an electron beam to categorize the elemental composition of the analyzed volume, Qualitative analysis, Quantitative analysis, line scan, area scan, span analysis, elemental mapping are possible with EDS detector. The SEM/EDS is the ultimate tool for deposits and wear debris analysis, particle sizing & characterization, failure analysis, contaminant analysis, metallurgical studies.

E. Scanning Electron Microscopic (Sem) Analysis of Coated Sample

SEM uses a focused beam of high energy electrons to generate a variety of signals at the surface of solid specimens. The signal that derive from electron sample interaction reveals information about the sample including external morphology (texture), chemical composition, crystalline structure & orientation of materials making up the samples..

III. RESULTS AND DISCUSSION

A. Microhardness Measurement

The average value of microhardness of Co based coated sample was found about 850 VHN and for Ni-based coated sample was about 420 VHN. These values were further increased by doing heat treatment on the coated surface. The microhardness value increased to 900 VHN in the case of Co coated sample and 550VHN in case of Ni-Coated sample. The increase in average microhardness value after heat treatment on coating may be sue to homogenization in chemical composition which increases the wear resistance of the coated sample.

B. Wear Loss Analysis

The wear loss analysis was obtained by weight loss technique which was discussed in experimentation section. The weight loss value of substrate and coated sample and post heat treated coated sample as given in Table 4.

Table 4: Weight Loss Data For As Sprayed And Heat Treated Samples

Type of specimen	Weight before wear test(gm)	Weight after wear test (gm)	Weight loss (gm)
Ni-C	187.607	187.785	0.822
Ni-C-HT	182.736	182.150	0.586
Co-C	177.871	177.369	0.502
Co-C-HT	176.365	176.166	0.199
Substrate	182.499	180.712	1.78

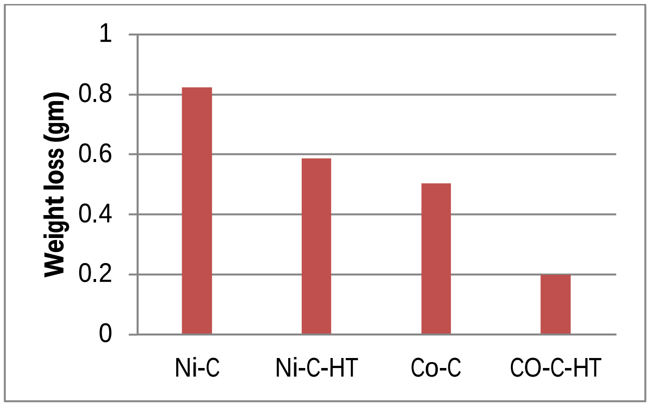


Fig 2: Comparison of weight loss

The weight loss value of Ni-based coated sample was about 0.822 gm which is further decreases by doing heat treatment on the sample and value decrease to 0.586 gm and the value of weight loss for Co coated sample was 0.502 gm further decreases by doing heat treatment on the coated sample is 0.199 gm as given in Table 4. From the Fig 2, it was found the least weight loss happens in the case of Co-C-HT (Co based coating by carburising flame under heat treatment).

The value of weight loss was decreased by doing heat treatment on the coated surface in both cases. Which probably happen due to homogenisation in the chemical composition of coating elements which increases the microhardness value that will increase the wear resistance property of the coated surface.

From the Table 4 it was also found that the weight loss of Co coated sample was less as compared to Ni coated sample. The reason behind this will further discuss in the SEM and EDS analysis.

C. Electro Dispersive Spectroscopy (Eds) Studies Of The Coatings

Electro dispersive spectroscopy of deloro 50 (Ni alloy) coatings, in heat treated conditions, is given in Fig.3 and Table 5. The EDS analysis at selected points indicates the dominance of Ni and Cr in composition with the coating, which is not approaching the composition of sprayed powder. Due to which formation of $CaCo_3$ and SiO_2 both are undesirable as shown in Table 5. EDS of satellite 6 (Co alloy) coatings in heat treated conditions are given in Fig.4. The EDS analysis, at selected points, it is clear from the chemical composition of different element shown in Table 6 which indicates the dominance of Co along with Cr in the composition of the coating, which is nearly approaching the composition of sprayed powder for the both spectrums which shows the proper coating by using the satellite 6 (Co alloy). So from the above analysis we may say that the value of microhardness and wear resistance property were better in case of Co coated sample as compare to Ni based coated sample.

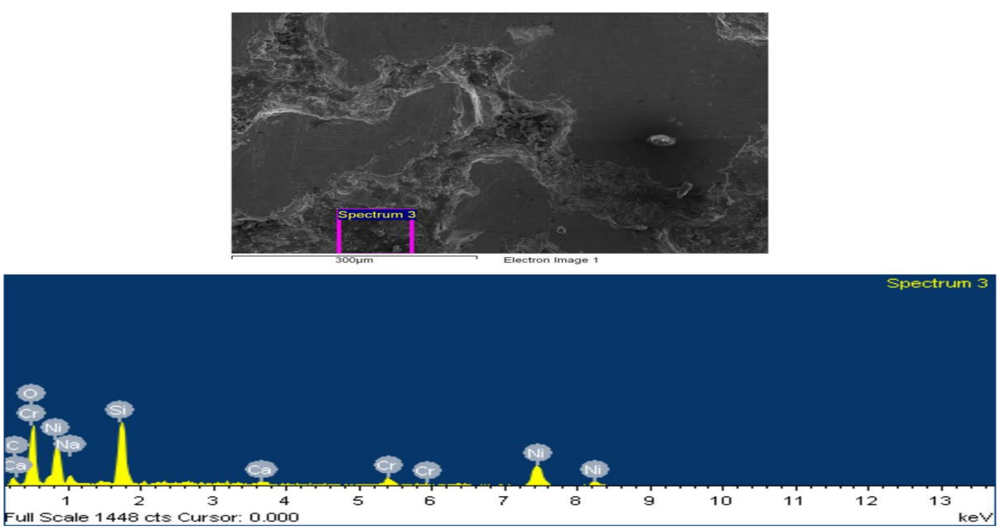


Fig 3: EDS of Ni based coated sample

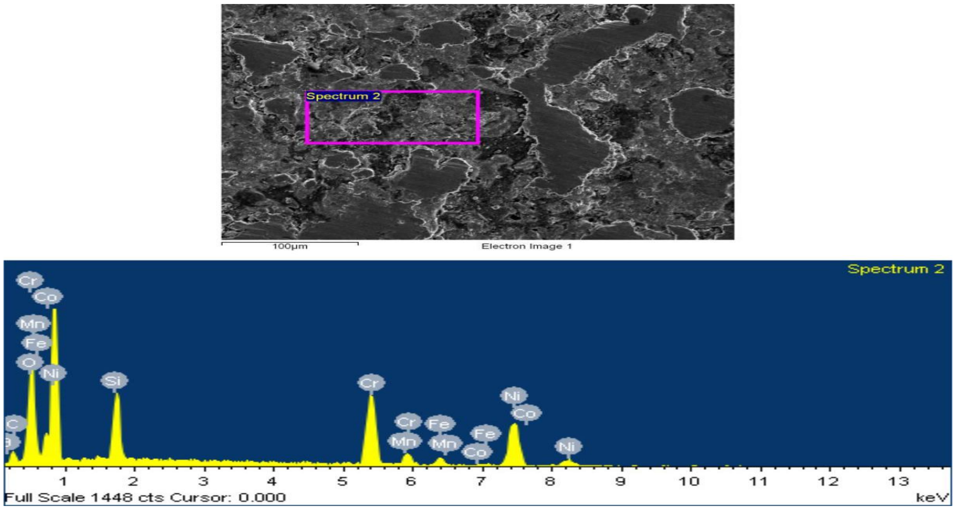


Fig 4: EDS of satellite 6 (Co alloy) coated sample

D. Scanning Electron Microscopic (Sem) Analysis of Coated Sample

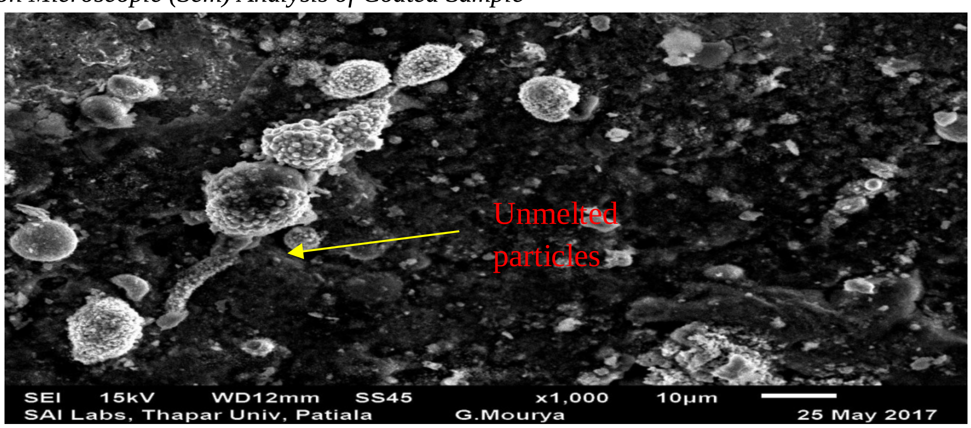


Fig 5: Scanning electron micrograph of Co based coated and heat treated sample

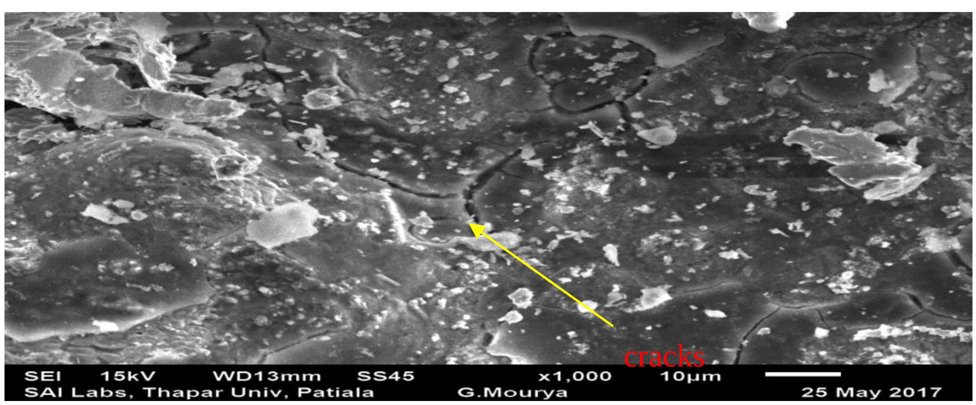


Fig6: Scanning electron micrograph of Ni based alloy coated and heat treated sample

The studies were performed on coated specimens for the purpose of comparison of Co based alloy and Ni based alloy samples. Scanning electron microscopy is done to check the size and the shape of the coating powder & to know about the material or surface behavior against applied load or wear of the coated surfaces of the respective samples. The SEM micrographs of the top surface of the Co alloy and Ni alloy samples are shown in Fig.5 and Fig.6. In the case of Co based coatings, the microstructure consists of interlocked particles with irregular morphology. It can be observed from the microstructures that coatings, in general, possess some porosity, inclusions and partially melted particles. The structure, by and large, seems to be dense. The surface appears to be uneven; however, in the majority of the microstructure, a proper coalescence of the particles has taken place. There is a presence of some tiny particles in the coatings.

From the above shown Fig 5 it was clearly seen there are some voids and unmelted particle present on the coated surface in case of Co based coatings. In case of Ni based coatings shown in Fig 6 it was clearly seen that there are cracks and some semimelted particles are present on the coated surface.

From the above analysis we may conclude that the better wear resistance property was found in case of Co based coatings as compare to Ni based coatings due to cracks and irregular surface was present in case of Ni based coatings.

IV. CONCLUSION

A. Microhardness of the substrate has improved to 4 times approximately in case of satellite 6 (Co alloy) coating in heat treated condition & 2 times approximately in case of deloro 50 (Ni alloy) coatings in heat treated condition respectively, i.e. microhardness varies from 180 VHN to 850 VHN in case of stellite 6 (Co alloy) coating in heat treated condition & 180 VHN to 425 VNH in case of deloro 50 (Ni alloy) coatings in heat treated condition.

B. It was found that by doing heat treatment on the coated sample the microhardness value is increased to approximately1.25 times. The wear resistance value is increased to approximately 4 times in case of satellite 6 coatings & 1.8 times in case of deloro 50 coatings.

C. Wear strength has improved to 8 times in case of Co based alloy coating in heat treated condition & 3 times approximately in case of based Ni alloy coatings in heat treated condition respectively, i.e. weight loss from 1.78 gm to 0.199 gm in case of based Co alloy sprayed coating & 1.78 gm to 0.584 gm approximately in case of Ni based alloy sprayed coatings in heat treated condition.

D. Based on present study, Co based coatings after heat treatment can be recommended for the applications where components are subjected to abrasive wear environment.

REFERENCES

[1] Ghosh, P.K., Dwivedi, D.K. and Mishra, P.S., 2001. Studies on oxidation and wear resistance of hard surfacing produced by gas thermal spray of modified nickel base eutectic alloy powder. Indian welding journal, 34(1), pp.35-41.

[2] Dwivedi, D.K., 2004. Microstructure and abrasive wear behaviour of iron base hardfacing. Materials Science and Technology, 20(10), pp.1326-1330.

[3] Sharma, T., Maria, S. and Dwivedi, D.K., 2005. Abrasive wear behaviour of Fe-30Cr-3.6 C overlays deposited on mild steel. ISIJ international, 45(9), pp.1322-1325.

[4] Yadav, A.K., Arora, N. and Dwivedi, D.K., 2006. On microstructure, hardness and wear behaviour of flame sprayed Co base alloy coating deposited on mild steel. Surface engineering, 22(5), pp.331-336..

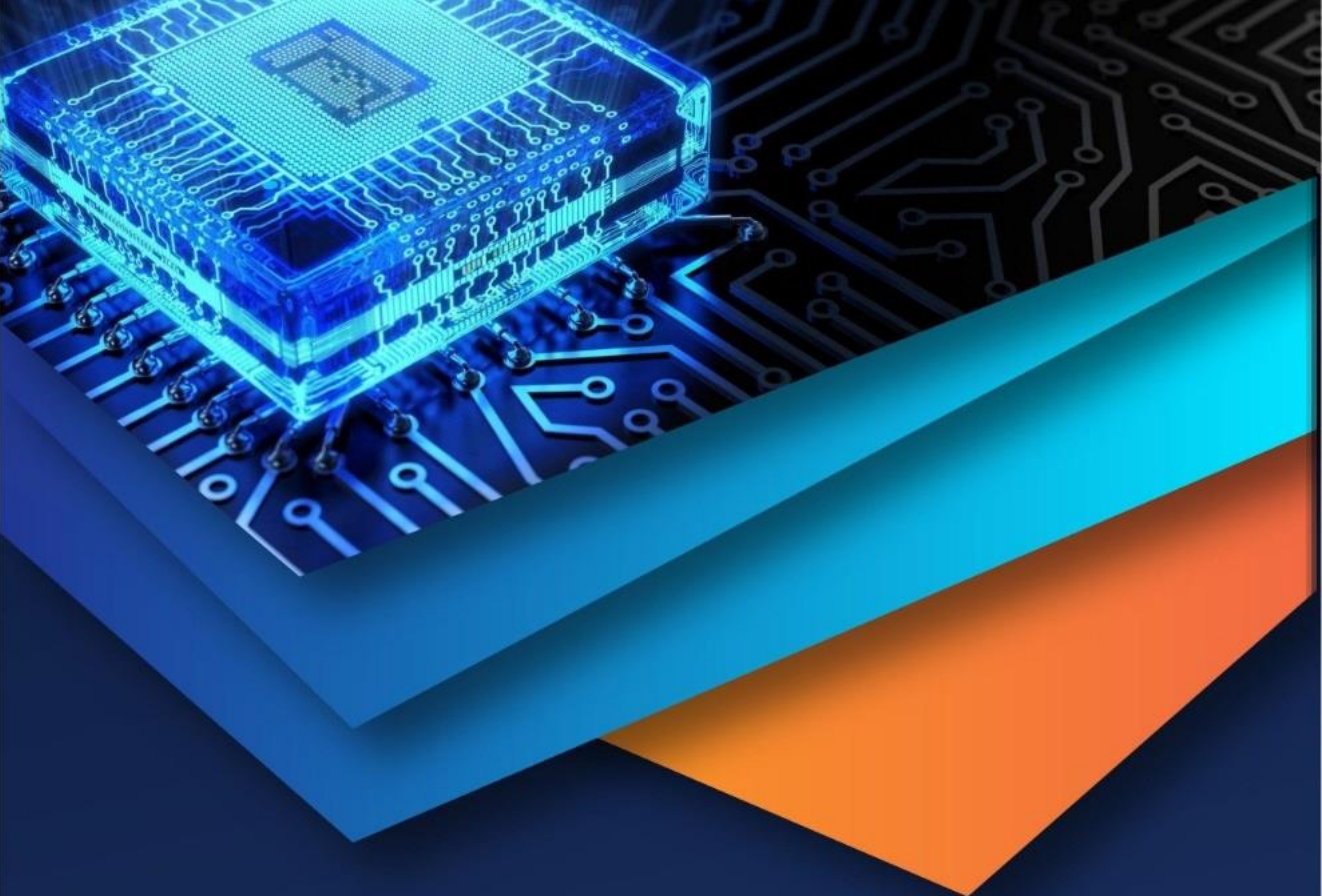
[5] Kim H.-J. and Kim, Y.J., 1999. Wear and corrosion resistance of PTA weld surfaced Ni and Co based alloy layers. Surface engineering, 15(6), pp.495-501.

[6] Wheeler, D.W. and Wood, R.J.K., 2005. Erosion of hard surface coatings for use in offshore gate valves. Wear, 258(1), pp.526-536.

[7] Harsha, S., Dwivedi, D.K. and Agrawal, A., 2007. Influence of WC addition in Co–Cr–W–Ni–C flame sprayed coatings on microstructure, microhardness and wear behaviour. Surface and Coatings Technology, 201(12), pp.5766-5775..

[8] Hejwowski, T., Szewczyk, S. and Weroński, A., 2000. An investigation of the abrasive and erosive wear of flame-sprayed coatings. Journal of Materials Processing Technology, 106(1), pp.54-57.

[9] Natarajan, S., Anand, E.E., Akhilesh, K.S., Rajagopal, A. and Nambiar, P.P., 2016. Effect of graphite addition on the microstructure, hardness and abrasive wear behavior of plasma sprayed NiCrBSi coatings. Materials Chemistry and Physics, 175, pp.100-106.



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