iJRASET
International Journal For Research in Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 9 **Issue:** XII **Month of publication:** December 2021

DOI: https://doi.org/10.22214/ijraset.2021.39738

www.ijraset.com

Call: 08813907089 | E-mail ID: ijraset@gmail.com

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 9 Issue XII Dec 2021- Available at www.ijraset.com

"An Investigation of wear behavior of TiO_2 nanoparticles mixed with Hybrid powder coating on MS material"

Akshay Shinde[1], M. S. Harne[2]
[1]*PG Student,* [2]*Asst. Professor, Mechanical Engineering Department, Government College of Engineering, Aurangabad*

Abstract: ***To improve the wear resistance of the hybrid powder coating, TiO_2 nanoparticles was hot mixed to form a homogenous mixture with the powder in the range varying wt. dry sliding wear test conducted to determine the wear resistance. The experiments were design according to Taguchi L9 array to find the optimum nanoparticles content required to minimize the wear rate of the coating. ANOVA was used to determine the effect of the parameters on wear rate. It showed that reinforcement has the maximum contribution on the wear rate of the coating as compared to load and frequency. From the graph of means optimum parametric values was obtained at 2 % wt of reinforcement, 2 N load and 2 Hz frequency. The wear rate decrease with the increase in reinforcement.***

Keywords: Taguchi Method, Tribometer, Hybrid powder, TiO_2, Wear Rate.

I. INTRODUCTION

Powder coating includes depositing a finely ground pitch (powder) on a substrate and heating the coat in the oven. During the curing process, the powder melts and makes a uniform, consistent coating. Powder coatings give incredible erosion, effect, and scratch resistance, and gloss. Manufacturers utilize powder coating measures in a wide range of uses as they cheap in labor, materials, and energy are adaptableand present cost, and in light of the fact that powder coats are durable.

Initially the coating was applied by flame spraying on the metallic surface to protect from weathering and scratch. And after the evolving of the process, most powder-coating applications required dipping a hot part into a powder bed which is fluidized. But this method caused in uneven thickness of film. Electrostatic spray equipment provided a wayto coat cold substrate which helped in forming of uniform, thinner coating resulting in saving of raw material.

Powder-coating methods are used in most production related field for forming protective finishes. Powder can be formed to provide protective surface, and endurance characteristics, and to obtain higher hardness, chemical resistance, and gloss persisting surface. With the help of automation the powder coating can be applied on hot and cold substrate where the environment is of corrosive and have high pressure. Automobile industries uses powder coating, for example, to shield under-hood parts from high temperature environment and pressure. The surface finish provided by powder coating is also good and improves the quality of the wheel, mirror frame, oil filter, and coil spring. Automakers are using powder coatings not only as primers for topcoats, but for the topcoats, with improved durability. Some appliance manufacturers change the energy consuming procedure of applying a porcelain surface on washing machine tops with specially framed scratch-resistant powder coatings. Appliance parts, such as range dryer drums, housings, and microwave oven inside and frame, are now powder coated

II. EXPERIMENTATION

A. Methodology of Experiment

There are several optimization techniques to develop product, process or operation. Various techniques can be applied to optimize curing process. Sometimes different techniques are required integrate to get statistically significant results, which can lead to better conclusions and recommendations. Some extensively used methods in developing a process or a product are Build Test Fix (BTF), Design of Experiment (DOE) and One Variable at a Time (OVAT); BTF is very primitive and unorganized approach. It is iterative method of developing a process focused on improvement from last experiment. DOE is highly efficient method of investigating the effect of parameters as it varies multiple parameters at once. As more parameters are investigated, more number of new combinations is required. DOE cannot control individual parameters and more relies on statistical data. In one variable at a time (OVAT) approach, variation is done with one variable at a time and other parameters are kept constant until the effect of one parameter is studied. It is highly precise method to study effect of each parameter at different levels. Reinforcement, load and frequency were identified as most predominant parameters affecting on wear rate. Based on the observation, Taguchi method has been used to optimize the process parameters. OVAT analysis has been conducted to find out effective range of parameters for optimization study.

©IJRASET: All Rights are Reserved

L9 orthogonal array (OA) has been selected from available designs. Standard notation for OA is given below
OA = Ln (Xm)
Where n= number of experiments, X= number of levels and m= number of parameters under study. From available designs for 3 levels 3 parameters, OA with least number of experiments required to conduct (L9) has been selected. ANOVA has been conducted to find out contribution of each parameter in the output. Minitab 19 software has been used for analysis.

B. Experimental Machine Selection

Table 1 states the specification of the Tribometer setup used in this study. All the experiments were conducted Government College of engineering, Aurangabad, M.S, India.



Figure 1. Tribometer Setup

Table 1. Tribometer Specification.

Make Model	Ducom Ltd. Banglore, India
Upper Specifications	Pin (dia.x1)-- Φ4x15mm, Φ 6x15mm, Φ 8x15mm, Φ 10x15mm. Pin Rectangular (bxhxl)-4x6x15 Pin Square (lxbxh)- 4x4x15mm, 6x6x15mm, 8x8x15mm. Ball- Φ10mm
Lower Specifications	Rectangular Block (lxbxh)- 40x40x5, 30x30x5, 20x20x5mm
Hardness Lower Specifications	60HRC
Lower Specifications	EN31 Steel
Stroke Length Ranges	10, 20 and 30 fixed.
Temperature Ranges	Ambients 200 to 200^{o}C, Ambients 200 to 200^{o}C (For Both Lubrication). Least count.-0.21^{o}C, Sensor: PT-100
Load Ranges	5 to 100 N
Frequency (Speed) Range	1-20Hz (1200rpm) Least count: 1rpm, Sensor, Proximity Sensor
Power	230 Vx 1 Φx50Hz,8A

C. Selection of Material

a) Titanium Oxide: Titanium Oxide is better thermal and wears shock resistances. It has good mechanical properties and at high temperature. It provide corrosion resistance and it not solubles in water and diluted acid



Figure 2 TiO_2

III. RESULTS AND DISCUSSION

To get complete understanding of effects of input parameters Reinforcement, load and frequency on output Wear Rate, you usually assess signal to noise ratio or main effects plot for means. For this purpose, Minitab 18 statistical software has been used. Wear rare have been done. ANOVA has been conducted to find out effect each parameter on wear rate and linear regression model has established to predict values of wear rate.

A. Experimental Result

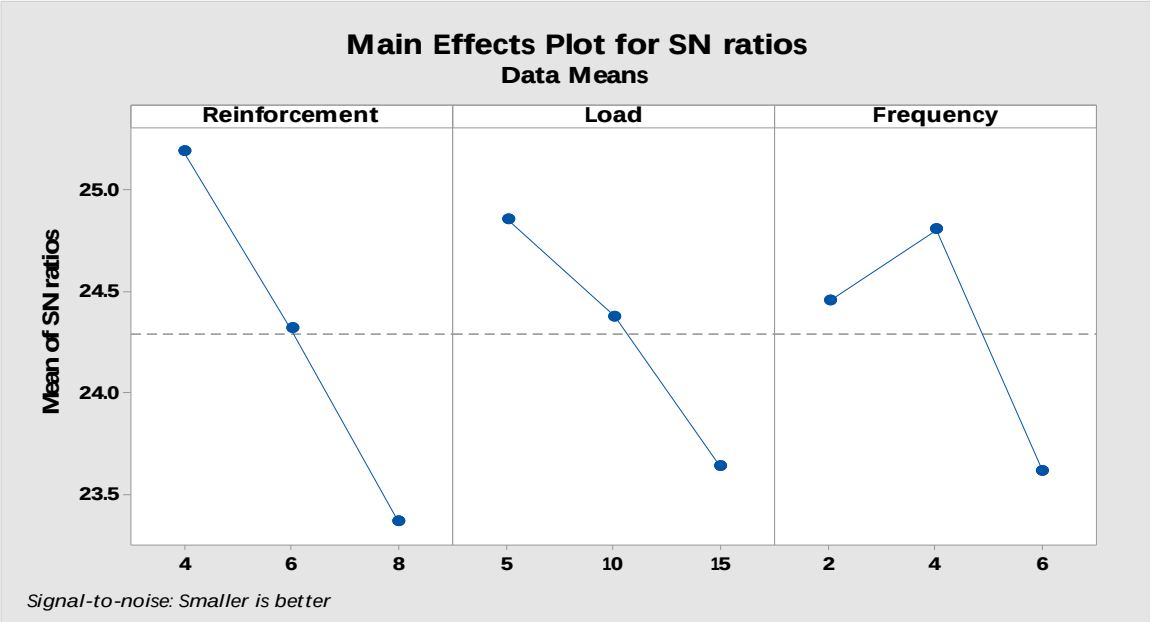
Table 3 shows L9 OA with measurement of wear rate for runs one to nine. It also shows S/N ratio for the all nine experiments.

Table 3 L9 orthogonal array with response characteristic.

Experiments	Input Factors			Output Responses	
Trial No.	Reinforcement (%)	Load (N)	Frequency (Hz)	Wear rate (mm^3/ Nm)	S/N Ratio
1	4	5	2	0.052	25.6799
2	4	10	4	0.047	26.5580
3	4	15	6	0.068	23.3498
4	6	5	4	0.057	24.8825
5	6	10	6	0.067	23.4785
6	6	15	2	0.059	24.5830
7	8	5	6	0.063	24.0132
8	8	10	2	0.070	23.0980
9	8	15	4	0.071	22.9748

The S-N ratio values are calculate with help of Minitab 18 software. It can be seen that variation in S/N ratio is minimum for all experiment.

B. Main Effects of Wear Rate



Graph 1 Main Effects Plot for S/N Ratio

From main effects plot for S/N ratio, parametric effect on response characteristic i.e The optimal input parameters were Reinforcement 2% (level 1), Load 5 N (level 2) and Frequency 2 Hz (level 2). The graph shows the effect of the control factors on Bronze material

C. ANOVA Result

To decide two assessments of populace difference, one dependent on between tests fluctuation and other dependent on inside example change. At that point the said twoevaluations of populace fluctuation are contrasted and F-Test. Compare the determined estimation of F with the table estimation of F for level of opportunity at certain degree of importance. On the off chance that the determined estimation of F is equivalent to or more prominent than the table an incentive at pre decide level of criticalness the invalid theory is dismissed in any case acknowledged. For this ANOVA table is readied. In this ANOVA table, the amount of squares (SS) because of autonomous variable and amount of squares because of blunder is independently given. Level of opportunity is the quantity of way one can choose the segments for a set up under limitations. On account of investigation there is loss of one degree in amount of squares because of relapse. Mean amount of squares are acquired by partitioning the amount of squares by dof, each for relapse and mistake. The mean amount of squares identified with mistake is called difference

Table 4 ANOVA Result.

Source	DF	Adj SS	Adj MS	F-Value	P-Value	% Contribution
Reinforcement	2	0.000230	0.000115	1.81	0.018	40.47
Load	2	0.000113	0.000056	0.89	0.008	20.03
Frequency	2	0.000198	0.000099	0.75	0007	35.10
Error	2	0.000024	0.000012			
Total	8	0.000564				

It shows table 4 that the Reinforcement (40.47%), the Load (20.03%) and the Frequency (35.10%) have major influence on the Wear Rate. Contribution of Frequency (40.47%) is highest among all three parameters hence it is most dominating parameter while Reinforcement is least affecting parameter.

©IJRASET: All Rights are Reserved | SJ Impact Factor 7.538 | ISRA Journal Impact Factor 7.894 |

D. Development of Regression Model for Wear Rate

Regression model has been developed using Minitab software. Substituting the experimental values of the parameters in regression equation, values for Wear rate have been predicted for all levels of study parameters. Graphical representation also shows that a predicted and experimental value of Wear rate correlates with each other.

Regression Equation –

Wear Rate = 0.0287 + 0.00308 Reinforcement + 0.000867 Load + 0.00142 Frequency

Table number 5 gives comparison between experimentally measured and predicted wear rate by developed mathematical equation

Table 5 Experimental and Predicted Values of Wear rate

Sr. No.	Experimental value	Predicted value	Error %
1	0.052	0.048	Error %
2	0.047	0.055	4.56
3	0.068	0.063	2.59
4	0.057	0.056	3.58
5	0.067	0.065	2.58
6	0.059	0.057	3.05
7	0.063	0.065	7.28
8	0.070	0.069	6.27
9	0.071	0.068	3.89

Difference between wear rate values calculated using regression equation and experimental values for each experience found less than 10%. Hence, we can say that the regression equation developed is valid.

E. Confirmation Experiment Result

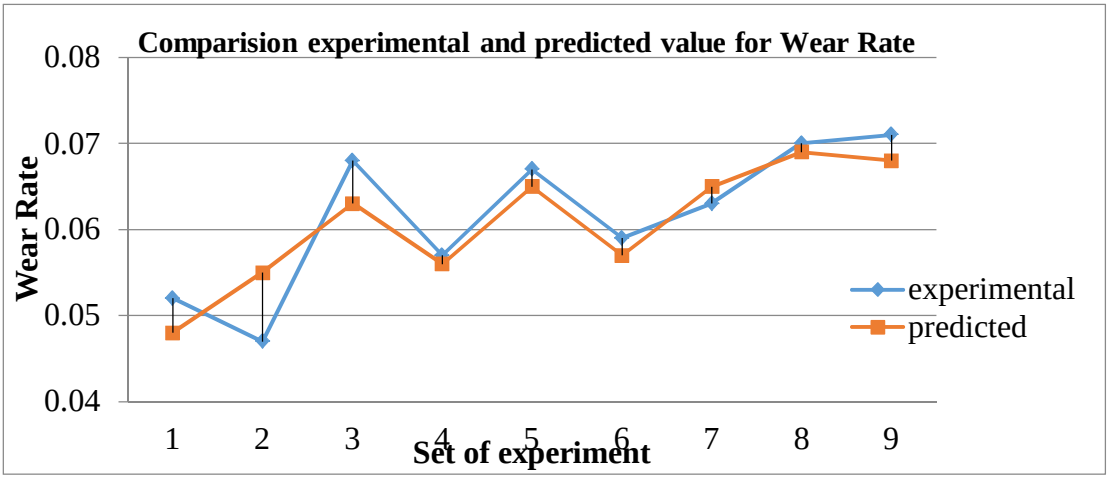
Table 5 shows the difference between value of Wear rate of confirmation experiment and value predicted from regression model developed.

Graph 2 Confirmation Experiment Result

Parameter	Predicted value	Experimental value	Error %
Wear Rate (mm^3/Nm)	0.051	0.046	9.80

Confirmation experiment is conducted by keeping parameters at optimum levels suggested by Taguchi method and the wear rate value obtained has been compared with value predicted by the regression model keeping the parameters at same levels. It can be seen that the difference between experimental result and the predicted result is 9.80%. This indicates that the experimental value correlates to the estimated value.

Table 4.9 Confirmation experiment result for Wear Rate



Confirmation experiment is conducted by keeping parameters at optimum levels suggested by Taguchi method and the Wear Rate value obtained has been compared with value predicted by the regression model keeping the parameters at same levels. It can be seen that the difference between experimental result and the predicted result is 9.80 %. This indicates that the experimental value correlates to the estimated value

IV. CONCLUSIONS

In this study influence of operating parameters such as Reinforcement, Load, and Frequency and their optimization and ANOVA tool were used to find the significant quantity of nanoparticles which can be added to the Hybrid powder coating to improve its wear resistance. Following conclusions are drawn.

1) From experimentation the optimum value was found to be 2 % weight reinforcement, 5N load and 2Hz frequency. But the most important result was that 2% weight of reinforcement shows better wear resistance than the Hybrid powder and 10% weight reinforcement powder. And ANOVA analysis for wear resistance shows the percentage contribution and for reinforcement it was 40.47 %.

2) ANOVA results indicate that frequency plays prominent role in determining the Wear Rate. The contribution of Reinforcement, Load and Frequency to the quality characteristics Wear Rate is 40.47%, 20.02% and 35.10% respectively.

3) There was a best improvement in the wear rate of 2 % weight of TiO_2coating compared to the others coatings. The boron carbide reduces the contacts area between the coating and the sliding pin which helps to delay the onset of wear during reciprocating abrasion test and also decreases of wear rate.

4) The addition of nanoparticles above 2 % hinders the electrostatic charging process of the powder. Due to which it affects the mechanical properties of coating

5) Hot mixing of the powder with TiO_2 helped in homogenous mixing of nanoparticles. Mixing of nanoparticles does not affect the adhesiveness of the coating

6) Value of Wear Rate is lower obtained in confirmation experiment. Hence, good quality of Hybrid coating with TiO2 can be achieved using suggested level of parameters by Taguchi method.

7) Values of Wear Rate calculated using regression model correlates with experimental values with error less than 10%. Hence the model developed is valid and experimental results of Wear Rate with any combination of operating parameters can be estimated within selected levels.

REFERENCES

[1] Tuan Anh Nguyen, The Huyen Nguyen, Thien Vuong Nguyen, Hoang Thai, and Xianming Shi, “Effect of Nanoparticles on the Thermal and Mechanical Properties of Epoxy Coatings”, Journal of Nanoscience and Nanotechnology Vol. 16, 9874– 9881, 2016, doi:10.1166/jnn.2016.12162.

[2] M.H. Moradi, M. Aliofkhazraei, M. Toorani, A. Golgoon, A.S. Rouhaghdam, “SiAlON–epoxy nanocomposite coatings: Corrosion and wear behavior”, J. Appl. Polym. Sci. 133 (2016) 1–13, doi.org/10.1002/app.43855.

[3] Xianming Shi, Tuan Anh Nguyen, Zhiyong Suo, Yajun Liu, Recep Avci, “Effect of nanoparticles on the anticorrosion and mechanical properties of epoxy coating”, Surface & Coatings Technology 204 (2009) 237–245, doi:10.1016/j.surfcoat.2009.06.048.

[4] Maria Fernandez Alvareza,, Francisco Velascoa , Asuncion Bautistaa , Beatriz Galianab, “Functionalizing organic powder coatings with nanoparticles through ball milling for wear applications”, Applied Surface Science 513 (2020) 145834, doi.org/10.1016/j.apsusc.2020.145834.

[5] Rohit U. Krishnan ,a, Jithin Mohan, “Development of Bronze Metal Matrix Composite for Automobile and Marine Applications” (2019)

[6] Larisa dyachkov, eugene feldshtein, “tribotechnical properties of sintered bronze-based composites reinforced with al-based hard particulates”. (2017)

[7] O.O. Ajayi, Cinta Lorenzo-Martin, “Enhancement of bronze alloy surface properties by FSP second-phase particle incorporation (2017)

[8] Z.N. Farhat, Y. Ding, D.O. Northwood, A.T. Alpas, Effect of grain size on friction and wear of nanocrystalline aluminum, Mater. Sci. Eng. A206 (2018) 302–313.

[9] S. Palraj, M. Selvaraj, K. Maruthan, G. Rajagopal, “Corrosion and wear resistance behavior of nano-silica epoxy composite coatings”, Prog. Org. Coat. 81 (2015) 132–139, doi.org/10.1016/j.porgcoat.2015.01.005.

[10] A.Y. Grigoriev, G.V. Vaganov, V.E. Yudin, N.K. Myshkin, I.N. Kovaleva, I.V. Gofman, L.N. Mashlyakovskii, I.V. Tsarenko, “Friction and wear of powder coatings of epoxy composites with alumosilicate nanoparticles”, J. Frict. Wear 33 (2012) 101–107, doi.org/10.3103/S1068366612020043

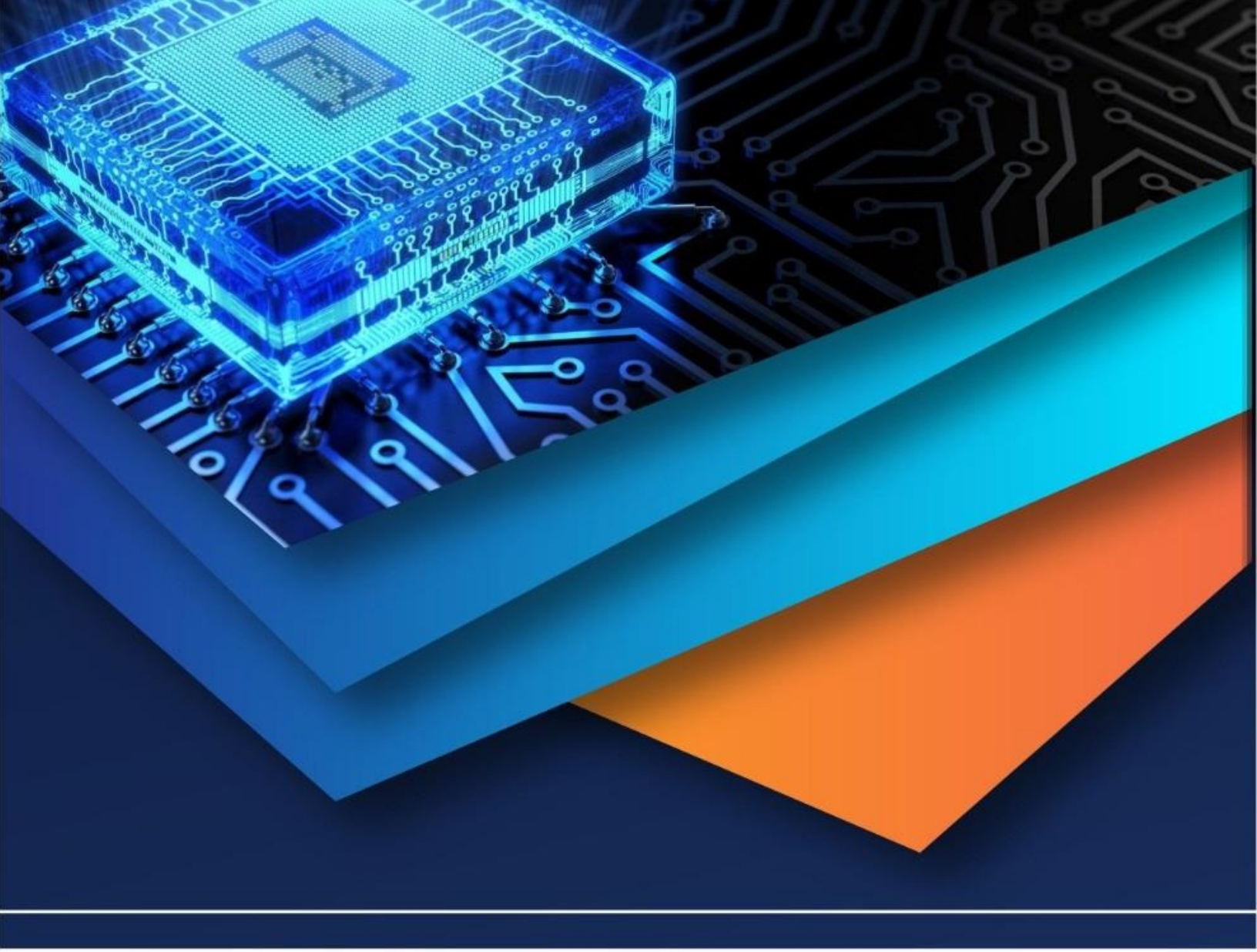
[11] Maria Fernandez Alvarez, Francisco Velasco, Asuncion Bautista, “Epoxy powder coatings hot mixed with nanoparticles to improve their abrasive wear”, Wear Volumes 448–449, 15 May 2020, 203211, doi.org/10.1016/j.wear.2020.203211

[12] To Thi Xuan Hang, Trinh Anh Truc, Truong Hoai Nam, Vu Ke Oanh, Jean- Baptiste Jorcin, Nadine Pebere. “Corrosion protection of carbon steel by an epoxy resin containing organically modified clay”, Surface and Coatings Technology Volume 201, Issues 16–17, 21 May 2007, Pages 7408-7415

[13] Yingke Kang, Xinhua Chen, Shiyong Song, Laigui Yu, Pingyu Zhang, “Friction and wear behavior of nanosilica-filled epoxy resin composite coatings”. Applied Surface Science Volume 258, Issue 17, 15 June 2012, Pages 6384-6390

[14] Jingjing Yu, Wenjie Zhao, Yinghao Wu, Deliang Wang, Ruotao Feng, “Tribological properties of epoxy composite coatings reinforced with functionalized C-BN and H-BN nanofillers”. Applied Surface Science (2010), doi.org/10.1016/j.apsusc.2017.11.204

[15] X.S. Xing, R.K.Y. Li, “Wear behavior of epoxy matrix composites filled with uniform sized sub-micron spherical silica particles”. Wear 256 (2004) 21–26, doi:10.1016/S0043-1648(03)00220-5.



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Call : 08813907089 (24*7 Support on Whatsapp)