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A Review Paper on Thermal Spray Coating Machine Process & Advantages, Limitations, Applications

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Abstract: ***Thermal spray techniques are surface modification treatment in which melted and semi-melted material spray on workpiece material. Thermal spray techniques process are classified in different process: Detonation Gun spray, flame spray process, HVOF, plasma spray, wire arc spray, cold spray process. In this research paper briefly defined basic principle, advantages, limitations, process and focused on plasma process. Plasma spray techniques to deposit coatings consist of atomization and deposition of molten or semi-molten droplets of the coating material on substrates. Now a days plasma spray coating process(atmospheric plasma and vacuum plasma) is the most common used spray technique for depositing a wide range of nanocomposite powder coatings. Plasma sprayed coatings are used as erosion or abrasion, corrosion resistant coatings in a wide variety of applications in industry. Extensive research shows that the deposition parameters like energy input, powder feed rate, standoff distance in the plasma and powder properties affect the porosity, splat size, phase thickness, hardness etc of plasma sprayed coatings. These in turn, have an influence on the erosion wear resistance of the coatings. Quantitative studies of the combined erosive effect of repeated impacts are very useful in predicting component lifetimes, in comparing the performance of materials and also in understanding the underlying damage mechanisms involved.***
Keywords: Spray Coating, Thermal Spray, Plasma Spray, Porosity, Thickness

I. INTRODUCTION

A coating is a thin layer of material which is applied to cover a substrate. Coatings are applied for a different types of reasons. One of the most common reasons is to improve the surface properties of a workpiece.

By using different coating processes, coating materials and the process parameters, the coating properties may be different. In the industrial applications the process properties include thickness, porosity, adhesion deposition rate, hardness, surface roughness are surface finish Treatment of Surface is an established provider of advanced materials processing and coating technologies for a wide range of applications in different types of sectors the automotive, Aerospace, Oil & Gas, Semiconductor, missile, power, electronic, biomedical, textile, petroleum, petrochemical, chemical, steel, power, cement, machine tools, construction industries. Surface treatments process typically are removing material, adding material or chemically altering the surface.

A. Different Types of Surface Treatments Process are Available

1) Anodizing
2) Electroplating
3) Cladding
4) Diffusion coating
5) Polymer film
6) Lubricants
7) Thermal spray coating
8) Induction hardening

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B. Thermal Spraying

It is the generic category of material processing technique & that can be apply consumables in the form of a finely divided molten or semi molten droplets to produce a coating onto the workpiece kept in front of the impinging jet. The melting of the consumables may be accomplished in a number of ways, and the consumable can be introduced into the heat source in wire or powder form. Thermal spray consumables can be metallic, non-metallic, refactory, ceramic or polymeric workpiece material. There are two basic ways of generating heat required for melting the consumable:

1) Combustion of flue gas
2) High energy electric arc

C. Various Advantages of Thermal Spraying Technology are Listed as

Thick coating can be applied high deposition rates on workpiece material
Thermal spray coating can be applied both manually and automatically
Choice of wide range of coating material: metals, alloys, ceramics, cermets

D. Different Thermal Spray Coating Process

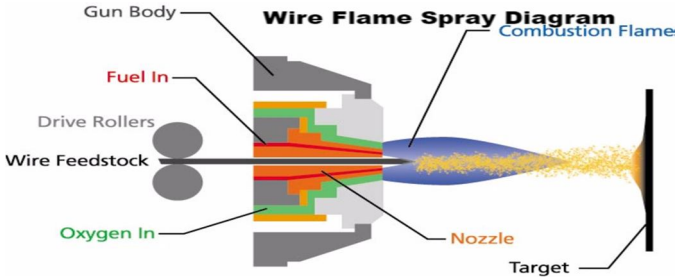

Figure 1.1

E. Flame Spraying with Wire

The arrangement is shown in figure 1.1, and the set-up consists of a spraying gun, power control panel, a wire feeding arrangement, oxygen and acetylene gas cylinders and an air compressor. A proportionate mixture of oxygen and acetylene is taken inside a chamber located. The set up cost for flame spraying is quite low compared to other thermal spray coating processes. Thick metallic layer can be deposited easily and hence it is quite useful for rebuilding purpose. But it is applicable only on metallic materials. Other material are not used for coating.

F. Flame Spraying with Powder

The arrangement is shown in Figure 1.2. This arrangement consist spray gun, Air- compressor, powder feed stock etc. The process is carried out with a gun in which facility for fuel gas oxygen & acetylene are injection and powder storage are combined with gun. The consumable-powders are kept inside the hopper integrated with the gun and can be released to the flame by the action of a trigger. Oxygen & acetylene are created flame and flame contact with powder and powder convert in molted or semi-molted form. A large number of alloys (even cermet's) are available in powder form. But ceramic materials can not be used for deposited in this method. The deposition rate is very slow compare to other process.

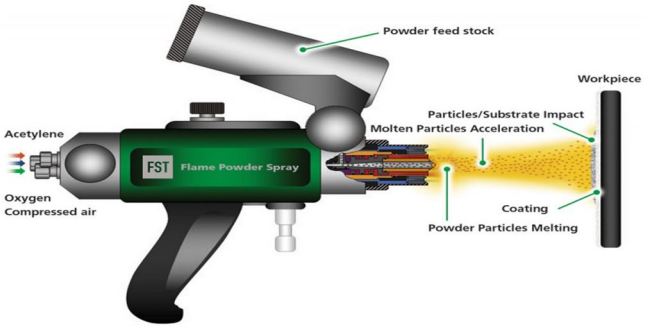

Figure 1.2

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G. Detonation Gun Coating

The basic process set up is shown in Figure 1.3.The consumable powder is fed into the gun under a very small gas pressure. Valves are opened to allow oxygen and acetylene to enter the combustion chamber of the gun. Both gases are mixed properly in the combustion chamber. The mixture is then detonated by the sparks from spark plugs and an explosion occurs immediately. After explosion powder contact with flame and convert in molted form. Using this technique metals, alloys and ceramics can be melted. other material not used in This process for coating.

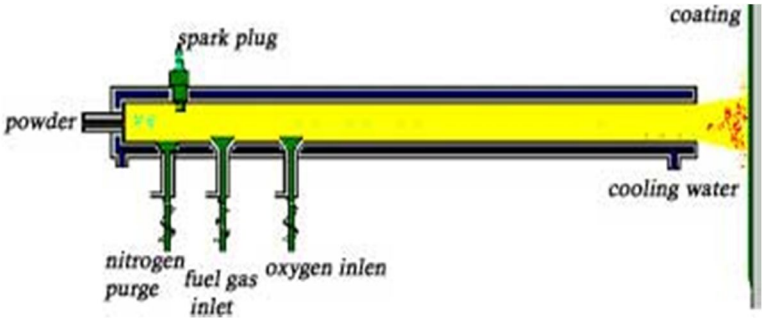

Figure 1.3

H. High Velocity oxy-fuel Spraying (HVOF)

The simple arrangement is shown in Figure 1.4. From one end of the Oxygen and fuel gas (propylene or hydrogen) mixture is introduced in the combustion chamber and center of the gun provide ignition plug and create flame contact with oxygen & fuel gases. From one end of the gun, powder is fed in the center of the flame by a carrier gas. The particles melt and are immediately deposited to the workpiece by the gas, escaping at a very high velocity and high temperature through the nozzle of the gun.

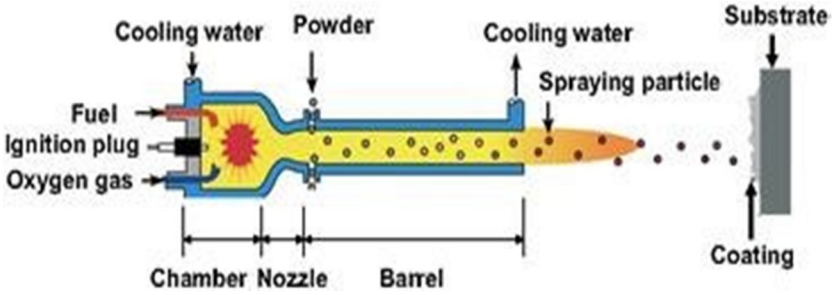

Figure 1.4

I. Electric arc Spraying

The arrangement is shown in Figure 1.5. An electric arc is created between the two electrodes cathode & anode. This arc produced by using high compressed air and power supply. The heat produced melts the wire and these molten tips are dislodged and directed to a target by a compressed air jet. The wires are fed by the independent wire feed mechanisms. This mechanism control by control panel. Electric power is supplied by a rugged welding power supply.

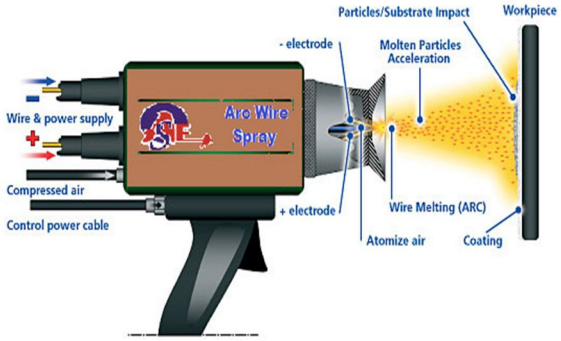

Figure 1.5.

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J. Plasma Spraying

Plasma spraying process is the most versatile & newly developed thermal spraying process. The general arrangement is shown in Figure 1.6. An arc is created between tungsten tipped copper cathode and an annular copper anode. Both are cooled by surrounding of water. Plasma generating gas is forced to pass through the available space between two electrodes. While passing through the arc, the gas undergoes ionization in the high temperature environment resulting plasma. The ionization is achieved by collisions of electrons of the arc with the neutral molecules of the gas.

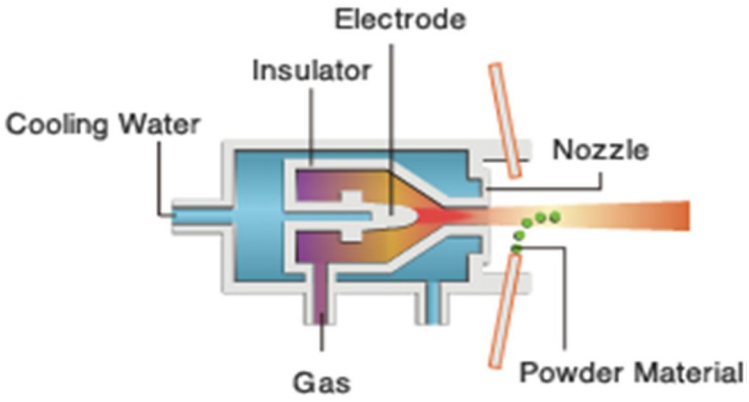

Figure 1.6.

K. Wear Resistance Coating

Wear resistance coating can be divided into the following categories:

1) Carbides: WC, Sic, Tic, Zrc, Cr2c3 etc
2) Oxides
3) Metallic
4) Diamond coating

All above material use as a coating material in this plasma process on any type of workpiece. All material are special advantage so use material as your requirement.

L. Advantages of Plasma Process

1) Plasma coating find wide range of applications industrial sector
2) Plasma coating more flexibility than the other traditional coating process
3) It is increase the life of component by 20% to 30% than the other traditional coating process
4) Plasma coating process have low running cost
5) It give good adhesion strength as well as good hardening strength

M. Limitations of Plasma Process

The is requires high initial setup cost
Process is only suitable for the batch production

N. Applications of Plasma Process

1) Textiles industry
2) Paper and printing industry
3) Automotive industry and production of engines
4) Hydraulic equipment
5) Chemical industry
6) Aircraft industry

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II. LITERATURE REVIEW

Authors are Tarun Goyal, Ravinderjit Singh Walia, and T. S. Sidhu.[14] published title paper "study of Coating Thickness of Cold Spray Process Using Taguchi method" in this journal Materials and Manufacturing Processes(Tylor and Francis),Feb 2011.They have found this Results, In this paper Researches used substract type, stand off distance, type of powder feeding arrangement parameters and find thickness of substract using taguchi L18 ANOVA method. In this research authors found that different materials used and got different highest thickness like: B221(AL)alloy,B435(NI)alloy and B36(BASS) and best thickness range is 70.86<th<84.96. In this paper authors found that argon powder feed arrangement is higher thickness compare to gravity powder feed arrangement.

Author are P Saravanan, V Selvarajan,SVJoshi and G Sundararajan.[15] published title paper "Experimental design and performance analysis of alumina coatings deposited by a detonation spray process" in this Journal, Journal of Physics d: Applied Physics, SEP 2000.

They have found this result by experiment. In this study authors used aluminum powder for coating and find hardness, roughness, porosity using L16 factorial design method and anova. The results of this study clearly indicate that a higher fuel ratio, a lower spray distance and a lower carrier gas flow rate which, in turn, produce coatings with a lower porosity, a higher hardness and an improved wear resistance. In this study authors got that frequency of detonation was no impact on coating but affecting on surface roughness.

Authors are Somak Datta & Dilip Kumar Pratihar & Partha Pratim Bandyopadhyay.[11] published paper title "Modeling of plasma spray coating process using statistical regression analysis" in this journal, International Journal of advance manufacturing, may(2016).They have found this type of result, In this experiment Researches main objective is find best thickness and porosity for coating substract using non-linear statistics regression analysis. In this study authors found that porosity showed significant non-linear relationships with powder flow rate and arc current and thickness is linearly vary with standoff distance and powder feed rate.

Author are H.L. de Villiers Lovelock, P.W. Richter, J.M. Benson, and P.M. Young.[13] published title paper "Parameters study of hp/hvof deposition wc-co coating" In this journal,Journal of Thermal Spray Technology. December, 1996.Researches found this result, In this paper researchers used new powder wc-17%co and wc-12%co for coating and find porosity, abrasive resistance using taguchi statistics experience method After study authors got that abrasive rate of wc-12%co coating is approximately 2/3 less than wc-17%co.Also this study authors delivered that wc-17%co coating is more constant and lower wear rate compare to wc-12%co powder coating.

Author are Manjunath Patel G C , Pradeep N B , Girisha L , Harsha H M & Arun Kumar SShettiga.[12] published title paper in this Journal, Australian Journal of Mechanical Engineering.August,2020.This researcher found this type of result, In this paper authors was used mo-ni-cr mixed powder on duplex S.S to minimize wear loss and for analysis used taguchi L9 method. In this research authors used optimal parameters Resulted in highest micro hardness 764.33 HV on the substract and this 2.78 time better than original substract.

Authors are Amir Hossein Pakseresht & Amir Hossein Javadi & Mehrdad Nejati & Kamyar Shirvanimoghaddam &Ehsan Ghasali & Reza Teimouri.[10] published research paper "Statistical analysis and multiobjective optimization of process parameters in plasma spraying of partially stabilized zirconia" In this journal, Int.J.Adv.Manuf.Technology.August 2014.They have found this type of data after experiment, In this paper authors main purpose is study tribological & mechanical performance of coating using taguchi experimental design & ANOVA. After study Researches found that hardness of coating substract is 150% more than original substract and hardness mostly affect by standoff distance and carrier gas flow rate.

Author are Z.bergant and j.grum.[18] published paper title "Quality improvement of flame sprayed, heat treated and remelted nicrbsi coatings" In this journal: Journal of thermal spray Technology. December,2008.They researcher found this result, In this paper authors study on NI-CR-B-SI coating by two-step process of flame deposition & furnace, posttreatment and improve porosity, micro-hardness, strength of substract. After study Researches found that heat treatment & remelting is performed, the highest micro-hardness is one with average value of 488microhardness was measured in the specimen coating remelting for 5min at 1080°c.

Authors are Gustavo Bavaresco Sucharski1, Anderson Geraldo Marenda Pukasiewicz2, Rodolpho Fernando Váz3.[8] published title paper "Optimization of the deposition parameters of HVOF FeMnCrSi+Ni+B Thermally sprayed coating". In this journal, Soldagem & Inspeco.(Techanical paper) 2015.They have found this type result, In this study Researches main goal is find the best value of porosity, oxide content, microhadness using different parameters are standoff distance, gas pressure, powder feed rate using taguchi L9 orthogonal array. In this part authors used three different substract is FeMnCrSi+Ni+B and found that optimal results. Researches found carrier gas pressure best value is 1.034MPa and standoff distance best value is 200mm and powder feed rate best value is 45g.min for produces low porosity and microhadness.

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Authors are Naveena b.e. R.Keshavamurthy and B.H.Channabasappa.[9] published title paper "Studies on Parametric Optimization for Plasma Sprayed Fly Ash -Al2O3 Composite Coatings", In this journal: Applied Mechanics and Materials (Trans Tech Publication), 2015.

They have found this type result, In this study Researches used plasma sprayed fly ash-Al2O3 composite coating and find best hardness, porosity, bond strength using parameters are standoff distance, powder feed rate, current density using taguchi ANOVA method. After study authors found that best value of bond strength is 54.8N/mm2 and best value of porosity is 7% and hardness range is 437Hv-736Hv using different parameters.

Authors are Rakesh Kumar & Santosh Kumar.[1] published title paper" thermal spray coating: A study" in this journal international journal of engineering sciences & researche technology. They have found this result compare to all thermal coating process got lowest porosity(1%-5%) in HVOF & cold spray, plasma process and highest adhesive strength(>60 MPA) got in HVOF & cold spray, D-gun process by the study of already different available researche paper. From the study it is found that high hardness, uniform thickness and continuous layer of coating can obtain by HVOF.

Authors are serkan Ozel, Erdinc Viral, Murat Binici.[16] published title paper" Taguchi method for investigation of the effect of TBC coating on NiCr bond-coated diesel engine on exhaust gas emissions" in this journal International advance researches and engineering journal. They have found this type of result while carbon monoxide(CO) and hydrocarbon (HC) emission are lower in cr2o3 ,cr2o3+50% Al2o3 and cr2o3 + 85% Al2o3 ceramic coated diesel engines compared to standard diesel engine. Carbon dioxide (co2) emission is higher in ceramic coated diesel engines compared to standard diesel engine. The Taguchi analysis of CO, CO2 and HC gives best results in Cr2o3 +75% Al2o3 coated diesel engine at 2600 rpm

Authors are Lachake harshad Sanjay, Prof.bhamre V.G., Prof.B.C., Prof.Ghodake A.P.[4] published title paper A review on plasma spray coating and it's characterization in this journal International researche journal of engineering technology. They have found this researche the main aim of this research is to increase the tribological properties of the substrate material. This process will improve wear resistance and corrosion resistance property capacity of material against effect.

Authors are M.Magnani, P.H. Suegama.[17] published title paper" Influence of HVOF parameters on the corrosion and wear resistance of WC-Co coating spray on Aa7050 T7 in this journal surface & coating technology. They have found this result, comparing the different spray parameters, oxygen flux produced the sample which showed the highest corrosion resistance in aerated and unstirred 3.5% NaCl solutions. After experiment authors found highest thickness 230mm and highest harness 1094 HV in W19s coating sample.

III. DISCUSSION

In this review paper, we have firstly focusing on surface treatments process definition, types, advantages etc. After surface treatments process, we have focused on understanding of different thermal spray coating process like: detonation Gun, flame, HVOF, plasma, cold spray in briefly. We can say that plasma and HVOF more advantages compare to other process. All thermal spray process were used according to their coating quality, properties required, material of workpiece and coating material etc.

IV. CONCLUSION

Surface coating process is improve life of material & reduce the cost of maintenance. From this study we have reached that thermal spray coating process is very important & very useful process in all surface treatments process. After study of different researche higher hardness, thickness, deposition efficiency, and lower porosity can be obtained in plasma and HVOF process. Now a day plasma is more popular process for coating because it's wide range of advantages & applications and also it's simplicity and flexibility.

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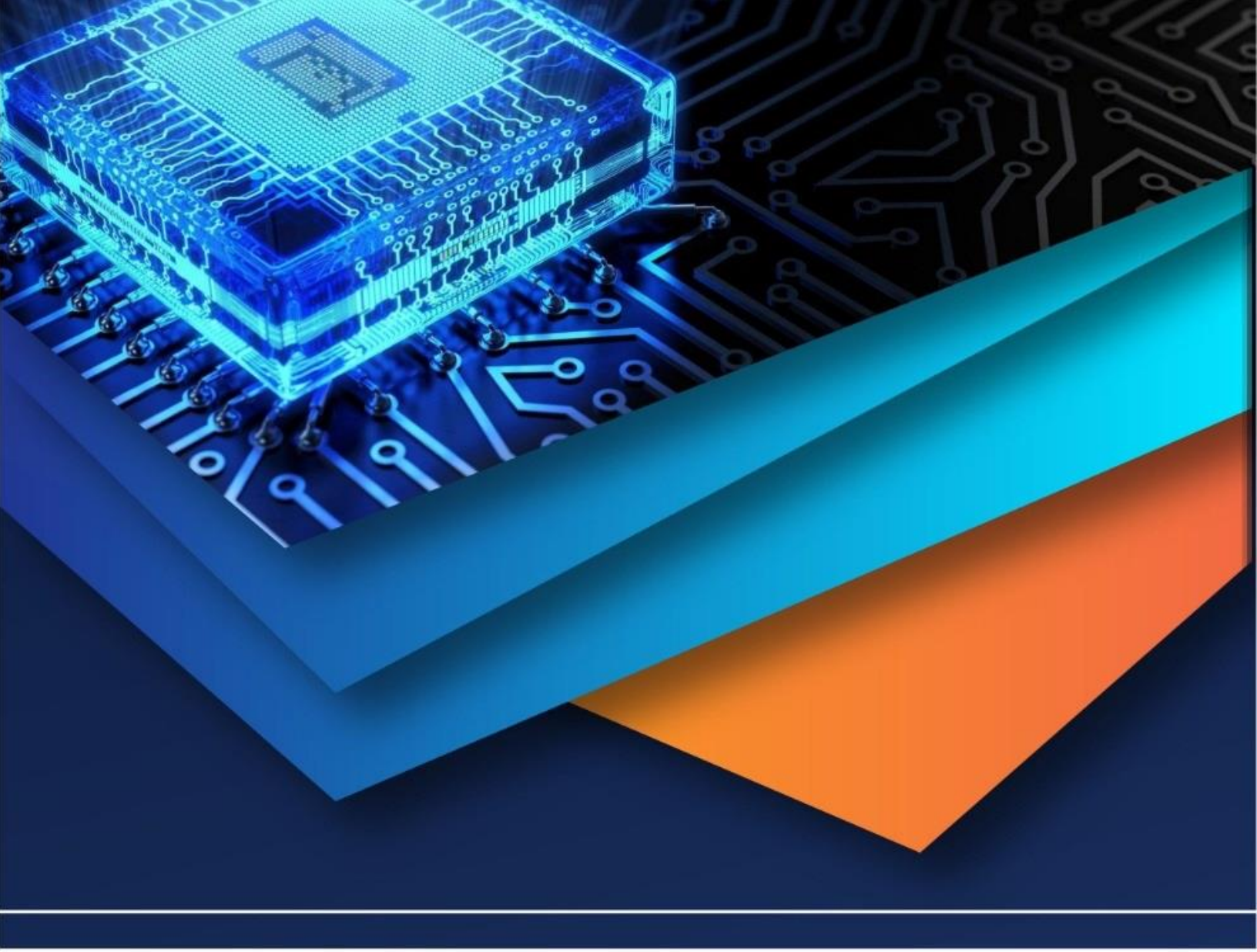

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