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Vegetable Oil Based Nano Cutting Fluids and its Applications In Reduction Of Tool Wear - A Review

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Abstract-Cutting fluids are mainly employed to increase the machining accuracy and productivity by effectively reducing the heat developed during machining period. Nano cutting fluid applications in metal cutting industries were increased over the past decade. The dispersion of Nano particles to the conventional cutting fluids produces higher performance Nano metal working fluids. Vegetable oils are the predominant alternatives to the conventional mineral oil based cutting fluids by dispersing the different types of Nano particles the physical and thermo chemical properties of vegetable oils were increased. It is found that the use of vegetable oil based Nano cutting fluids reduces the tool wear and increase the tool life. Many researchers have found the various properties, performance of Nano cutting fluids and concluded that this is the perfect alternative solution for the cutting fluid needs and tool life aspects in industries. A detailed review of the vegetable oil based Nano cutting fluids and its preparation and the benefits obtained were discussed in this paper.
Key words: Vegetable oil, Nano cutting fluids, Tool wear, Metal cutting fluids.

I. INTRODUCTION

Metal cutting is the process of converting raw work part into finished components using hard cutting tools attached to machines. Over the period of operations the tool edges and faces getting wear and reduced in its actual size, It largely affects the final dimensions of the work piece and tool life. The tool wear mainly occurred due to the heat generated during the interaction between the tool and work piece for reducing this heat we can increase the tool life by the way we can improve the dimensional accuracy of components manufactured. Increased tool life may provide more cost savings on purchasing of new tool and wastage of components. Nano cutting fluids are the combination of Nano particles and a fluid in a single dispersed phase.

In addition to the important purpose of reducing friction and wear, lubricating oils are also needed to carry out removal of heat, corrosion prevention, transfer of power, providing a liquid seal at moving contacts and removal of wear particles [1]. The experimental analysis of Nanoparticle mixed cutting fluid applies to the machining operations have been studied from various research articles shows better results in tool wear reduction. Vegetable oil based Nano fluids improves the machining productivity and quality of the product by reducing heat and vibrations, Resulting to an efficient machining operation in terms of increased tool life and improved surface finish. Xinwei Wang et al [2] Examines the Effective thermal conductivity of mixtures of fluids and Nano particles and the results shows that the thermal conductivities of Nano fluids are higher than those of the base fluids. S. Khandekar et al [3] conducted tests on the properties improvement of cutting fluids along with Nano particles inclusion and results produced drastically higher physical property changes to the base fluids and also it leads to better outputs in machining operations.

The development of effective Nano cutting fluid technology reduces the usage of hazardous and environmentally polluting cutting fluids in industries. The recent technological advancements created a better platform for production of a new kind of bio-degradable Nano fluids also its entry into the machining industries. This vegetable oil based nano cutting fluids produces a better surface finish and tool life in many experimental studies, the effectiveness in performance and its harmless characteristics leads to resulting an in increase the emergence variety of nano cutting fluids for metal cutting operations.

II. VEGETABLE OIL BASED NANO CUTTING FLUIDS AND TOOL WEAR

Sunday Albert Lawal [4] Attention is focused on recent research work on the application of vegetable oil-based cutting fluids in

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machining non-ferrous metals. The efficiency of various vegetable oil-based cutting fluids based on some process parameters such as thrust force, temperature developed at the tool chip interface and flank wear during machining of some non-ferrous metals using different tool materials were highlighted. The results obtained and established vegetable oil-based cutting fluids as a good metal cutting fluid. The experimental results show that the performance of vegetable based metalworking fluid over the nonferrous metals is higher when compared to the mineral oil based cutting fluids. It is Examined that Titanium alloys-drilling with MQL palm oil, MQL synthetic oil, water soluble with flood conditions. MQL palm oil shows reduced thrust force of 19% lower tool wear compared to MQLSE and then machining of Aluminum and copper in Turning using Groundnut, coconut, palm, butter, oils the Groundnut and palm oil were effective in reducing cutting force, and then Brass and Aluminum in Turning using Palm oil as cutting fluid indicates that Effective reduction of cutting force when compared to mineral oil.

S. Khandekar et al [3] presents the Nano-cutting fluids are the mixtures of conventional cutting fluid and nano particles. The addition of the nanoparticles can alter wettability characteristics, lubricating, and cooling properties of nano-cutting fluids. In the present work, nano-cutting fluid is made by adding 1% Al_2O_3 nano particles in conventional cutting fluid. The wettability property of this nano-cutting fluid on a carbide tool tip is measured using the macroscopic contact angle method. Comparative study of tool wear, cutting force, work piece surface roughness, and chip thickness among dry machining, machining with conventional cutting fluid as well as nano-cutting fluid has been undertaken. This study clearly reveals that the cutting force, work piece surface roughness, tool wear, and chip thickness are reduced by the using nano-cutting fluid compared to dry machining and machining with conventional cutting fluid. Adding nano particles to the conventional cutting fluid greatly enhances its wettability, thermal properties, lubricating characteristics. There is a reduction of 50% and 30% in cutting force and There is 54.5% and 28.5% reduction in the Ra value of the machined surface when compared to dry machining.

A. Hernández Battezet al [5] presented results from the addition of copper oxide nanoparticles to the polyalphaolefin PAO6 reduces friction with respect to base oil for a tribological contact steel–NiCrBSi coating. The improvement of tribological properties is higher at high load. Hence, less nano particles concentration is necessary to separate the asperities of both surfaces.

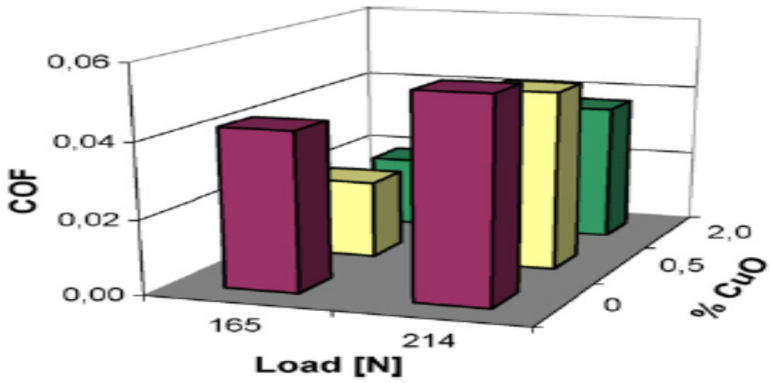

Fig. 1. Mean friction co-efficient of Nano fluids and base oil

During the process of lubrication the nano particles are able to exhibit three kinds of mechanisms. First the nano particles act as nano-bearings, in this condition the deposition level of nano particles in the wear surface area is low and hardly detectable. Secondly, nanoparticles can react with surfaces forming antifriction compounds. Finally, nano particles can deposit on the wear surfaces by tribosinterization.

Krishna Mohana Rao. G, et al [6] focuses on the application of Eco friendly nano fluids in machining. One of the most critical factors which determine the quality of work part is the heat generated at cutting zone during the machining process. Conventional cutting fluids are vastly applied to dissipate the heat generated during machining. In spite of its wider use, conventional metal working fluids cause the health of workers. Many researchers have initiated the search for safe and user friendly alternatives to conventional lubricating fluids. experiments are carried out by several researches to assess the performance of vegetable oil based nano cutting fluids in metal working.

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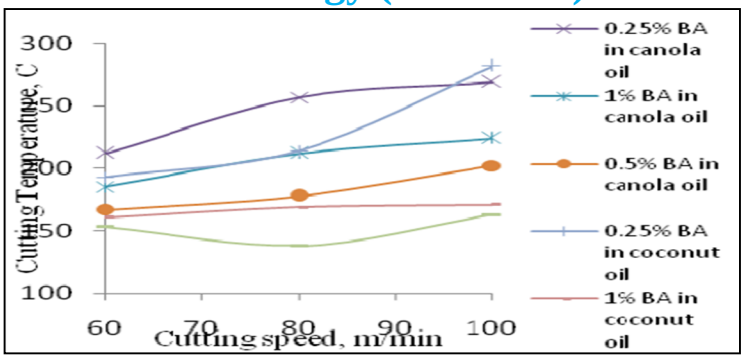

Fig.2. Cutting temperature vs cutting speed

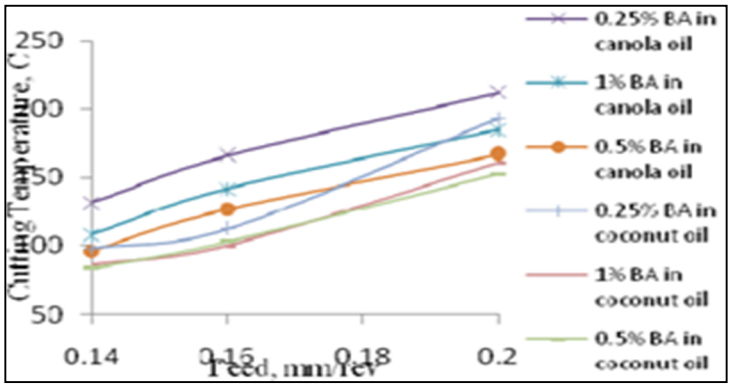

Fig.3. Cutting temperature vs Feed rate

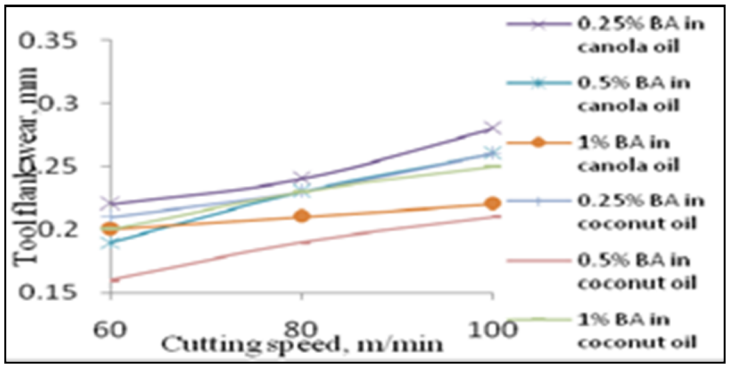

Fig.4. Tool flank wear vs Cutting speed

The changes of cutting tool temperatures, flank wear and surface finish of the machined surface with machining parameters are studied with the nano cutting fluids. It has been found that results show that the coconut oil based nano fluid has produced better performance than other mineral oil based metal cutting fluids.

Ahmed. A, et al [9] work presents and discusses the reduction of power and lubrication oil consumption in milling operation with new SiO_2 nano lubrication system. For the stringent government policies related to pollution and power, the manufacturing industries were facing a problem in developing alternative solutions. In machining, the key solution for this problem is by increasing the effectiveness of lubrication systems as this reduces the power required to overcome the friction component in machining operations for less consumption and pollution. Introducing Nano fluids reduces consumption power as the action of nano particles in the tool chip interface the cutting forces decreases enormously. By using nanolubrication in machining operations reduces the consumption of the lubrication oil significantly. For obtaining the efficient results, proper parameters and setup methods has to be

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selected. In this research, SiO2 nano particles are dispersed with mineral oil having 0.2% weight concentration. A proper ultra sonification method is used to mix the Nanoparticles thoroughly. The results show a reduction in the coefficient of friction in the tool/chip interface. Hence, the cutting force and working, the power required during machining process is reduced as (40.22-42.13%) with the application of the nanolubrication oil compared to the conventional lubrication oil.

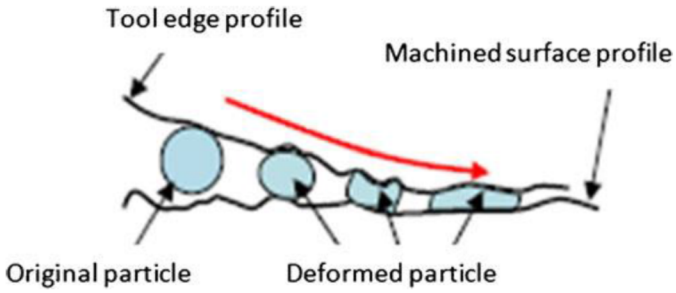

Fig.5. Nano Particle Lubrication Mechanism

K.P. Sodavadia et al [10] work examined the performance of coconut oil based Nano cutting fluids in machining. Coconut oil has higher thermal and oxidative stability than other vegetable based cutting fluids used in metal working industries. In this study nano boric acid with 50nm size is selected and suspended with coconut oil for investigating the performance of turning operation over AISI 304 austenitic stainless steel with carbide tool. The Nano Boric acid of 50 nm particles size is suspended in coconut oil with varying proportions of 0.25%, 0.5%, 1.0% by weight. The experiments were conducted with prepared Nano cutting fluid and conventional cutting oils and the performance characteristics are compared.

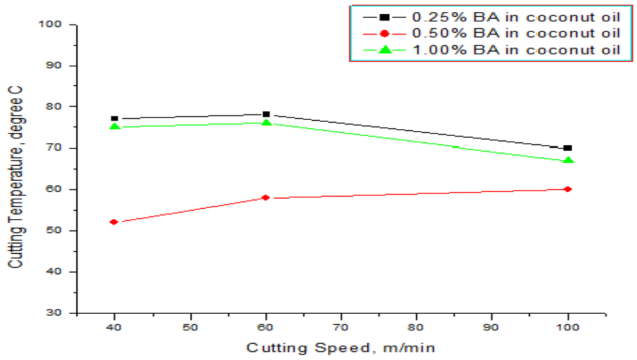

Fig.6.Cutting Speed vs Cutting Temperature

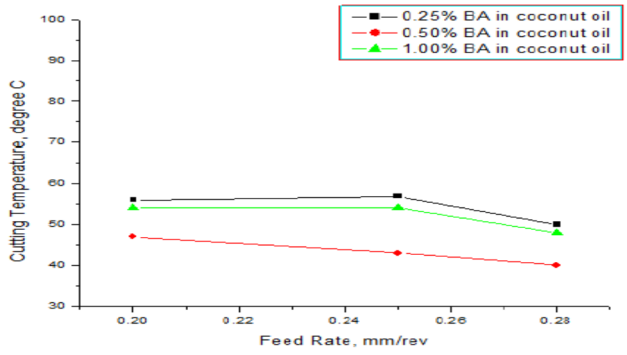

Fig.7. Feed Rate vs Cutting Temperature

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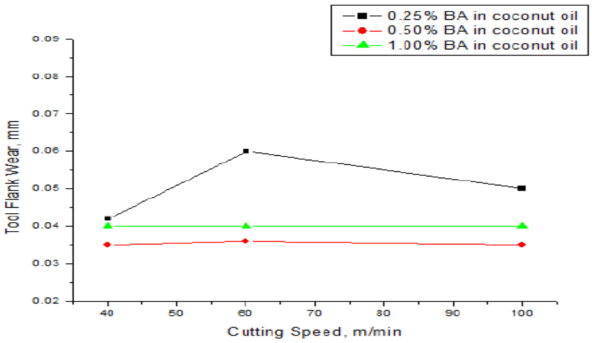

Fig.8. Cutting Speed vs Flank Wear

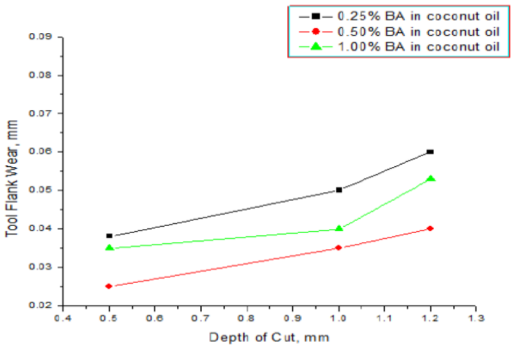

Fig.8. Depth of cut vs Flank Wear

The experimental results revealed that the thermal conductivity, heat transfer co-efficient of coconut oil increased with the increased percentage of Boric acid inclusion. This leads to reduction in cutting temperature evolved during operation, cutting tool flank wear and the surface roughness of the machined component with Nano lubricants compared to the base oil. Finally, coconut oil with 0.5% Nano Boric acid suspensions showed better performance compared to other Nano fluid combinations and conventional cutting fluids and base fluid.

Vaibhav Koushik A.V et al [10] revealed that several Articles have already provided indications on the scope of vegetable based oils effectively replacing the mineral oils as metal working oils and further research efforts are in progress confirming this hope. Some of the oils like castor oil, coconut oil, rapeseed oil and canola oils are in undergoing further evaluations for Nano cutting fluids development.

C Vamsi Krishna et al [23] Observed that cutting temperature, flank wear and surface roughness Reduced significantly with Nano Metalworking Fluids suspended in coconut oil and this was attributed to the Tribological action of boric acid and the better lubricating properties of the base Coconut oil.

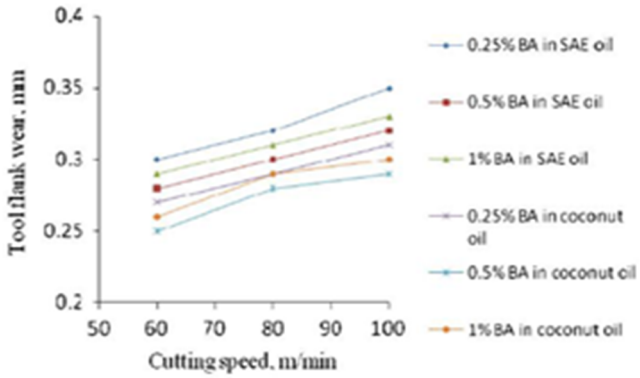

Fig.9.Tool flank wear vs Cutting Speed

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III. CONCLUSION

Many interesting characteristics of vegetable oil based Nano cutting fluids have been reported in past two decades. This paper presents the recent developments in nano cutting fluids and its potential applications in mechanical industries. The emergence of Nano metal working fluids using vegetable oil based solutions become the possible alternatives for conventional mineral oils based hazardous and environmental polluting cutting fluids and several researchers found the same from their works at various occasions. In this review paper an effort taken to show the enlightened performance of vegetable oil based Nano cutting fluids in various machining operations e.g. Turning, Milling, Facing, Drilling etc.. In terms of analyzing the tool life ,tool wear and surface roughness given by many papers. Toxic fume generation, waste disposal, Health issues of workers are the problems faced by the industries by using the mineral oil based lubricating oils in machining, by developing the Eco friendly vegetable oil based nano cutting fluids leads to complete elimination of the above mentioned problems as well as obtaining optimum performance of machining in terms of higher tool life ,surface finish ,machining accuracy.

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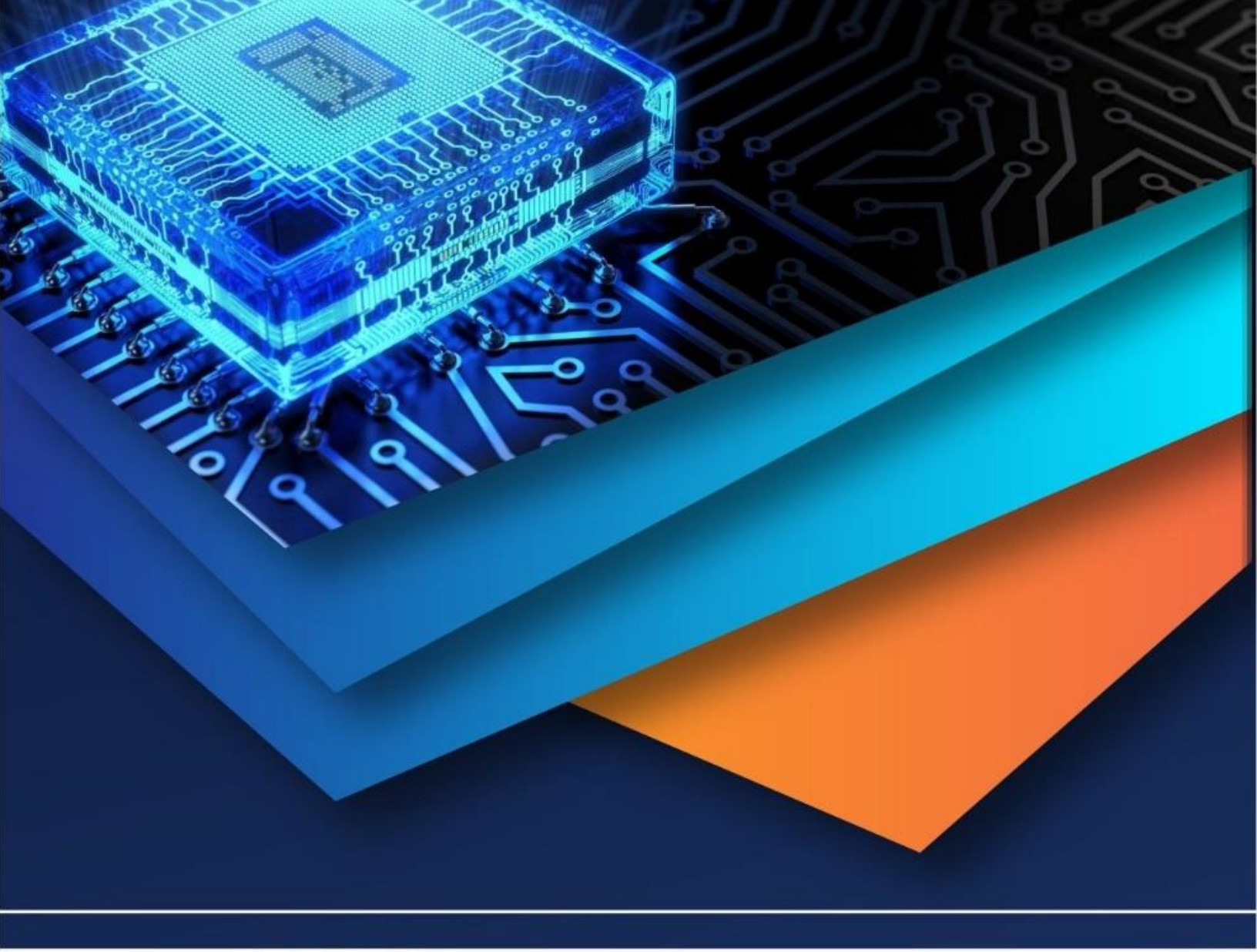

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