iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 9 **Issue:** VII **Month of publication:** July 2021

DOI: https://doi.org/10.22214/ijraset.2021.36767

Experimental Investigation of Nano Fluid in Machining Process to Enhance the Performance

Gaurav Tandekar[1], Pranay Helunde[2], Sagar Kute[3], Sandeep Tadaiya[4], Vineer Dhoaliya[5], Mrudul Bhandarkar[6]
[1, 2, 3, 4, 5, 6] *Department of Mechanical Engineering, J D College of Engineering & Management, Nagpur, Maharashtra, India*

Abstract: The surface roughness is paying a very dominant role in manufacturing industries. It is one of the parameters that cannot be avoided in machining process. Investigation was done on turning titanium alloy grade 2 with uncoated carbide insert in a CNC lathe. During machining on titanium, the high cutting temperature found, because of that friction in tool causes, for that purpose we are carry more cutting fluid, cutting tool & actual machining parameter. The present work shows the concentration of multi-walled carbon nanotube (MWCNT) & Graphene nano-particles are in used. The Nano fluid is prepared by using various ratios of nano-particles (MWCNT & Graphene), rice bran oil and blended oil as a base fluid. sodium dodecyl benzene sulfonate (SDBS) Surfactant added in cutting-fluid to provide better lubricant properties. The statistical planning of the experiment is done by using Taguchi method. The process parameters considered in the study are cutting speed, feed rate, depth of cut and surface roughness is considered as a response parameter.

Keywords*: *Nano particle, base fluid, surfactant, MQL, Taguchi method, surface roughness.

I. INTRODUCTION

Machining is a process in which a cutting tool is used to remove small chips of material from the workplace. It is required for desired shape & size of the product. The main forces on machining as per customer requirements the product should be at low cost & good quality. Almost all industries output products are depending on surface quality, cutting force, tool wear, power consumption etc. While machining, a large amount of heat generated at the tip of tool in such condition cutting fluid playing very important role as a coolant to reduced that kind of problems during machining. Titanium and its alloy have the prime choice for many fields of applications. This grade possesses high strength to weight ratio, ductility, corrosion resistance. We take this material as a challenging because it is hard to machine. So, to achieve the success om titanium we need to take proper selection of method, machining parameter, cutting tool & most important cutting fluid. In the work dry machining, conventional machining, pure MQL (only base fluid), and nano fluid are cared out by using cutting fluid on (titanium alloy grade -2). We compare that on which parameter the good surfaces finish obtained. While dry machining it is observed that the high temperature occurs in this process required cutting tool to withstand elevated temperature. In conventional cooling method causing problem for the manufacturers, as substance present in them caused serious health effects on the worker and secondary environment, for the environmental safety pure MQL (only base fluid) is prepared as a cutting fluid on turning operation. Then finally it comes to used nanofluid (MWCNT & graphene) with uncoated carbide insert for a good cutting fluid, high thermal conductivity and lower contact angle or higher weldability. These properties help in reducing the operating temperature, cutting force, improvement in the life of tool and surface finish. Preparation shown that dispersion at nano particles in base fluid after the thermo physical behaviour of their fluids. As per study MNCNT and graphene was selected for preparing nano fluid as both have high thermal conductivity than any other nano -particles. It has been found that rice bran oil and coconut oil as a base fluid comes into picture.

II. LITERATURE REVIEW

Kumar Sharma (2019) the thermal conductivity of all studied nanofluids increases with an increase of temperature as well as particle volume fraction. An enhancement of 11.13% and 9.85% in thermal conductivity were recorded for 1.25 vol. % Al-MWCNT and 1.25 vol. % alumina based nanofluids, respectively over base fluid. The effective viscosity of all the nanofluids is found to increase with an increase in the particle volume fraction and decrease with an increase in the temperature. The amount of wear of pin material decreases with increase in the concentration of Al2O3 mixed nanofluid as well as Al-MWCNT hybrid mixed nanofluid over base fluid. 1.25 vol. % Al-MWCNT hybrid nanofluid yields minimum amount of wear.

Sahu N.K (2017) evaluation of machining performance of nanofluid having dispersion of MWCNTs in distilled water for turning of Ti–6Al–4V alloys has been carried out. Preparation of nanofluid was done with 0.2% (volume) of MWCNT in distilled water with SDS as surfactant. Later on, machining was done with three different cooling strategies such as machining without coolant (dry), machining with conventional cutting fluid and with MWCNT-based nanofluid.

Okokpujie (2018) The experimental analysis was carried out to study the surface roughness of the machined surface of the AA8112 alloy during the end milling operations employing the MQL techniques. However, the valuation process of the five machining parameters, which include spindle speed, feed rate, length of cut, depth of cut and helix angle, was analysed under the three-lubrication machining environment.

Sharma, A. K (2018) A hybrid nano cutting fluid with improved thermal and tribological properties was developed from blending MWCNT with alumina-based nanofluids in fixed volumetric proportions (10:90). The performance of the alumina-MWCNT hybrid nano lubricants as cutting fluids in turning operation under MQL technique in terms of tool flank wear and nodal temperature was compared to the alumina-based monotype lubricants.

No´ra Justh "SEM–EDX was used to determine how effective the oxidation and the washing steps were (Table 2). The detailed EDX data and the results show that the addition of MWCNTs has improved the antiwear, friction coefficient and load carrying capacity of the base lubricant."

III.PREPARATION OF NANOFLUID

A. Minimum Quantity Lubrication (MQL)

The concept of MQL is fundamentally different than that of flood coolant and this can be a large stumbling block to machinists who are new to MQL. The use of flood coolant is incredibly basic. As long as relatively clean coolant 'floods' the interface of the cutting tool and workpiece, the heat generated by machining operations is kept at bay. This process works (another reason it is widely accepted!), but has some significant consequences. One of the main downsides to the use of coolant, is that it adds extra equipment into the equation. Equipment to recirculate, filter, test, and treat coolant to keep it viable is required. Contamination from bacteria, tramp oil, and swarf are major concerns as the disposal of spent coolant. Spent coolant is typically classified as toxic waste and its disposal is regulated. Users of flood coolant must factor the cost of its disposal into their machining costs. Another consequence of coolant is that it's messy. Despite containment methods, coolant invariably winds up covering more than just the cutting tool and work. Machines, floors, and finished parts are often left wet from coolant, causing potential slip hazards and often requiring part cleaning before secondary operations can take place. Repeated exposure to many coolants can have real consequences for the humans involved as well. Some coolants have been shown to cause dermatitis and to be carcinogenic with long-term exposure to coolant vapor. Studies have shown that the cumulative cost of coolants/mwfs can equal as high as 15% of the total cost to produce a part.

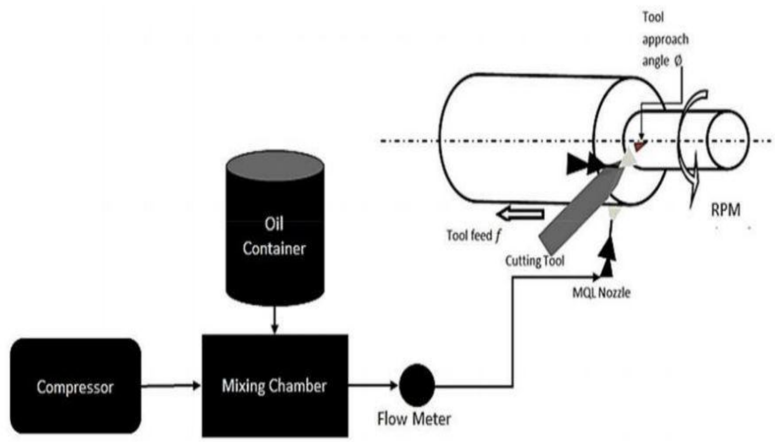


Fig. 1. MQL System

The cost and negative effects of flood coolant set the stage beautifully for MQL. When presented with an alternative which saves money, eliminates the mess, disposal, and negative aspects of coolant, you'd think that machinists everywhere would be scrambling to implement this new technology wouldn't you? In fact, MQL technology has gained much wider acceptance in European machining due to stricter environmental regulation. In the U.S., MQL still faces an uphill battle to win the 'hearts and minds' of machinists. This website attempts to promote MQL knowledge and awareness in the industry and will hopefully become a forum for the discussion of this emergent technology.

B. Nano Particles used

1) *Multi-walled carbon nanotube (MWCNT):* MWCNTs consist of multiple carbon nanotubes nested within one another. The number of nanotubes that are within a MWCNT can vary - from as little as 3, to over 20. At the same time the diameter of both the internal nanotube and the external most nanotube can vary - from 2nm for the innermost tube, to over 50nm for the outer wall. Just like single-walled nanotubes, they exhibit exceptional electrical, thermal, and mechanical properties. However, due to the increased number of walls, there is a higher likelihood of defects being present compared to single-walled nanotubes - resulting in reduced performances. The outer walls of MWCNTs can be modified with functional groups such as hydroxides, carboxylic acids, or amides to produce additional functionality (e.g., improved dispersibility, or the ability to attach binding sites for use in biomedical applications).
2) *Graphene:* Graphene is one of the most emerging material having unique physical and chemical properties. Recent study shows that graphene-based composites with different nanoparticle show extensive application potential in various areas of energy, environmental and biomedical science. In this review we focus on recent advances on the synthesis approach for graphene-nanoparticle composites, summarize their properties and discuss their advantages toward different applications. In particular we have summarized the advantages of graphene-nanoparticle composites in catalysis, photocatalysis, fuel cell catalysis, electrochemical sensing, surface enhanced Raman based detection, water purification adsorbent and other applications.

C. Base fluid used

1) *Rice Bran Oil:* Vegetable oil is selected among all available conventional cutting oils because of several reasons. The foremost one is they are eco-friendly. Secondly vegetable oils are nearly perfect Newtonian fluids. After a lot of analysis and research, rice bran oil is found as most suitable base oil among a set of vegetable oils. Thermal conductivity of rice bran oil is highest among those vegetable oils such as avocado, canola, grape seed, olive, peanut, macadamia nut, rice bran, safflower, sesame, soybean, sunflower and walnut. From the literature review, it has been observed that mostly nanoparticles were intermixed with water, paraffin, alcohol but not vegetable oil with MQL especially for hard turning of an alloy steel.
2) *Coconut Oil:* Coconut oil is being used as one of the cutting fluids in this work because of its higher thermal conductivity and oxidative stability. It has been found that coconut oil improves the tool life with a better surface finish for machining at low and medium cutting speed.

D. Surfactant used

Surfactants are compounds known as surface active agents which comprise of hydrophilic and oleophilic groups that can help reduce the surface tension of a liquid and reduce the interfacial tension of the two-phase system—that is between two liquids, gas and liquid, or liquid and solid. Surfactants may act as dispersants, detergents, wetting agents, or foaming agents.

1) *Sodium Dodecyl Benzene Sulfonate (SDBS):* Sodium dodecylbenzene sulfonate (SDBS) is one of the most popularly used surfactants for the dispersion of nanoparticles into base fluids. SDBS is a member of alkylbenzene sulfonates which are categorized as an anionic surfactant, comprising a hydrophilic sulfonate head-group and a hydrophobic alkylbenzene tail-group.92 SDBS has a chemical formula of $C_{18}H_{29}SO_3Na$ or $CH_3(CH_2)_{11}C_6H_4SO_4Na$ and a molecular weight of 348.477 g/mol. SDBS is the most important surfactant owing to its excellent performance and relatively low cost.93 It has a colour of white to light yellow flakes.

E. Cutting fluid

1) According to research, we have adopted to take rice bran oil [3] and blended oil (50% of rice bran oil + 50% of coconut oil) [4] as a base fluid.
2) Then we added MWCNT (2%,5%) and Graphene (2%,5%) nanoparticles with base fluid to form a nanofluid. Also, we adopt sodium dodecyl benzene sulfonate (SDBS) as a surfactant. Volume concentration for SDBS is 5% and 10% respectively.

IV. METHODOLOGY

A. Workpiece Material

Grade 2 titanium is called the workhorse of the commercially pure titanium industry, thanks to its varied usability and wide availability. It shares many of the same qualities as Grade 1 titanium, but it is slightly stronger. Both are equally corrosion resistant. Titanium Grade 2 may be considered in any application where formability and corrosion resistance are important, and strength requirements are moderate.

Some examples of aerospace applications have included airframe skins in "warm" areas, ductwork, brackets, and galley equipment. Ti Grade 2 has also been widely used in marine and chemical applications such as condensers, evaporators, reaction vessels for chemical processing, tubing and tube headers in desalinization plants, and cryogenic vessels. Other uses have included items such as jigs, baskets, cathodes and starter sheet blanks for the electroplating industry, and a variety of medical applications.

B. Machining Parameter

1) *Cutting Speed:* Cutting speed may be defined as the rate at the workpiece surface, irrespective of the machining operation used. There will be an optimum cutting speed for each material and set of machining conditions, and the spindle speed (RPM) can be calculated from this speed.
2) *Feed Rate:* Feed rate is the velocity at which the cutter is fed, that is, advanced against the workpiece. It is expressed in units of distance per revolution for turning and boring (typically inches per revolution [IPR] or millimetres per revolution).
3) *Depth of Cut:* Depth of cut (t) The tertiary cutting motion that provides necessary depth of material that is required to remove by machining. It is expressed in mm. It is usually given in the third perpendicular direction (velocity, feed and depth of cut usually act in mutually perpendicular directions).

C. Response Parameter

1) *Surface Roughness:* Surface roughness is defined as the shorter frequency of real surfaces relative to the troughs. If you look at machined parts, you will notice that their surfaces embody a complex shape made of a series of peaks and troughs of varying heights, depths, and spacing. Introduction. Ra value. Surface roughness is a measure of the texture of a surface. It is quantified by the vertical deviations of a real surface from its ideal form. If these deviations are great, the surface is rough, if they are small, the surface is smooth.

D. Taguchi Design of Experiment

In order to obtain favourable value of the machining parameters we can use various methods such as trial and error approach, design of experiments, etc. But the result will not be most accurate. We can also use full factorial method for three parameters as taken in our case then the required count of sets of experiment will be 3 3 i.e., 27. This is a very large number of experimental sets for Such an expensive material like titanium grade 2 which makes the method less cost effective. Therefore, we can use Taguchi method of orthogonal array where we can select the area of our requirement from the set available are L4, L8, L9, L16, L27. For three level of design as in our case L9 and L27 are the arrays that can be used. Therefore, we selected orthogonal array L9 for 9 sets of experimentation which will be both cost effective and time saving process.

Table 1. Standard l9 orthogonal array table

Trial No.	Speed (rpm)	Feed (mm/rev)	DOC (mm)
1	1	1	1
2	1	2	2
3	1	3	3
4	2	1	2
5	2	2	3
6	2	3	1
7	3	1	3
8	3	2	1
9	3	3	2

V. CONCLUSION

A. Nanofluid MQL significantly reduces cutting force and tool-tip temperature when compared to conventional cooling, pure MQL and dry machining. This is due to excellent thermal conductivity of MWCNT which facilitates effective heat dissipation from the cutting zone and hence better cooling effect and surface finish is obtained.

B. The detailed review study of the titanium machinability makes the conclusion by suggesting that the following are the general machining recommendation for titanium alloys: (1) using sharp cutting-edge tool (2) providing well-clamped work parts for stable cutting conditions (3) applying appropriate cooling methods (Wet, MQL, Cryogenic, etc.), and (4) minimising the vibration tendencies.

C. The Taguchi method selected the optimal parameters as Speed, depth of cut, feed rate. The surface roughness obtained by this combination which is the best surface finish and when we increase SPEED and DOC while turning on lathe machine then we get poor surface roughness.

D. Increase in cutting speed and feed rate leads to increase in tool wear; whereas surface roughness has decreasing trends with cutting speed and increasing trends with feed rate. Feed rate was found to be the most significant parameter affecting surface roughness, whereas cutting speed is identified as the most significant parameter in case of tool wear.

E. The machining of the titanium is one of the major issues in the production sector, this project helps to suggest the correct machinability parameters to machine titanium and helps to study the variation of different machinability parameters while machining titanium.

F. Good surface Roughness, Low temperatures at the cutting area, reduced cutting forces are observed when replacing the coolant with the nano cooling.

G. How the surfactant improves the dispersion of nanofluid, the optimum surfactant to nanomaterial ratio, and the effect of ultrasonication have been discussed. Noncovalent functionalization with the use of surfactants improves the stable dispersion of CNTs and graphene.

REFERENCES

[1] 2018 Elsevier Ltd. all rights reserved. Selection and/or Peer-review under responsibility of Materials Processing and characterization.

[2] Published by Elsevier B.V. Peer-review under responsibility of the scientific committee of the 46th SME North American Manufacturing Research Conference. Available online at www.sciencedirect.com ScienceDirect Procedia Manufacturing 00 (2018) 000–000 www.elsevier.com/locate/procedia 2351-9789

[3] Received: 20 January 2020 / Accepted: 16 April 2020 © King Fahd University of Petroleum & Minerals 2020 Arabian Journal for Science and Engineering https://doi.org/10.1007/s13369-020- 04554-y 4.

[4] Ayamannil Sajeeb and Perikinalil Krishnan Rajendrakumar Proc IMechE Part J: J Engineering Tribology 0(0) 1–8! IMechE 2018 Reprints and permissions: sagepub.co.uk/journalsPermissions.nav DOI: 10.1177/1350650118772149 journals.sagepub.com/home/pij

[5] author profiles for this publication at: https://www.researchgate.net/publication/337268 996 Article in Thermal Science · January 2019 DOI: 10.2298/TSCI190414430S

[6] Rahul Davis and Pretesh John Additional information is available at the end of the chapter http://dx.doi.org/10.5772/intechopen.69501

[7] 2351-9789 © 2018 The Authors. Published by Elsevier B.V. Peer-review under responsibility of the scientific committee of the 46th SME North American Manufacturing Research Conference. 10.1016/j.promfg.2018.07.033

[8] Please cite this article as: Munish Kumar Gupta, Pardeep Kumar Sood, Gurraj Singh, Vishal S. Sharma, Sustainable Machining of Aerospace Material - Ti (grade-2) alloy: Modelling and Optimization, Journal of Cleaner Production (2017), doi: 10.1016/j.jclepro.2017.01.133.

[9] International Journal of Engineering Research in Africa Submitted: 2015-12-15. ISSN: 1663-4144, Vol. 22, pp 94-111 Accepted:2016-01-22 doi:10.4028/www.scientific.net/JERA.22.94 Online: 2016-02-29. Trans Tech Publications, Switzerland.(2016)

[10] Arabian Journal for Science and Engineering https://doi.org/10.1007/s13369-020-04516- 4.(2020)

[11] Cite as: Phys. Fluids 31, 071301 (2019); https://doi.org/10.1063/1.5105380 Submitted: 27 April 2019 . Accepted: 28 June 2019 . Published Online: 30 July 2019

[12] The International Conference on Advances in Materials and Processing Technologies, 26-28 October 2009 Kuala Lumpur, Malaysia TAGUCHI METHOD FOR THE DETERMINATION OF OPTIMISED SINTERING PARAMETERS OF TITANIUM ALLOY FOAMS

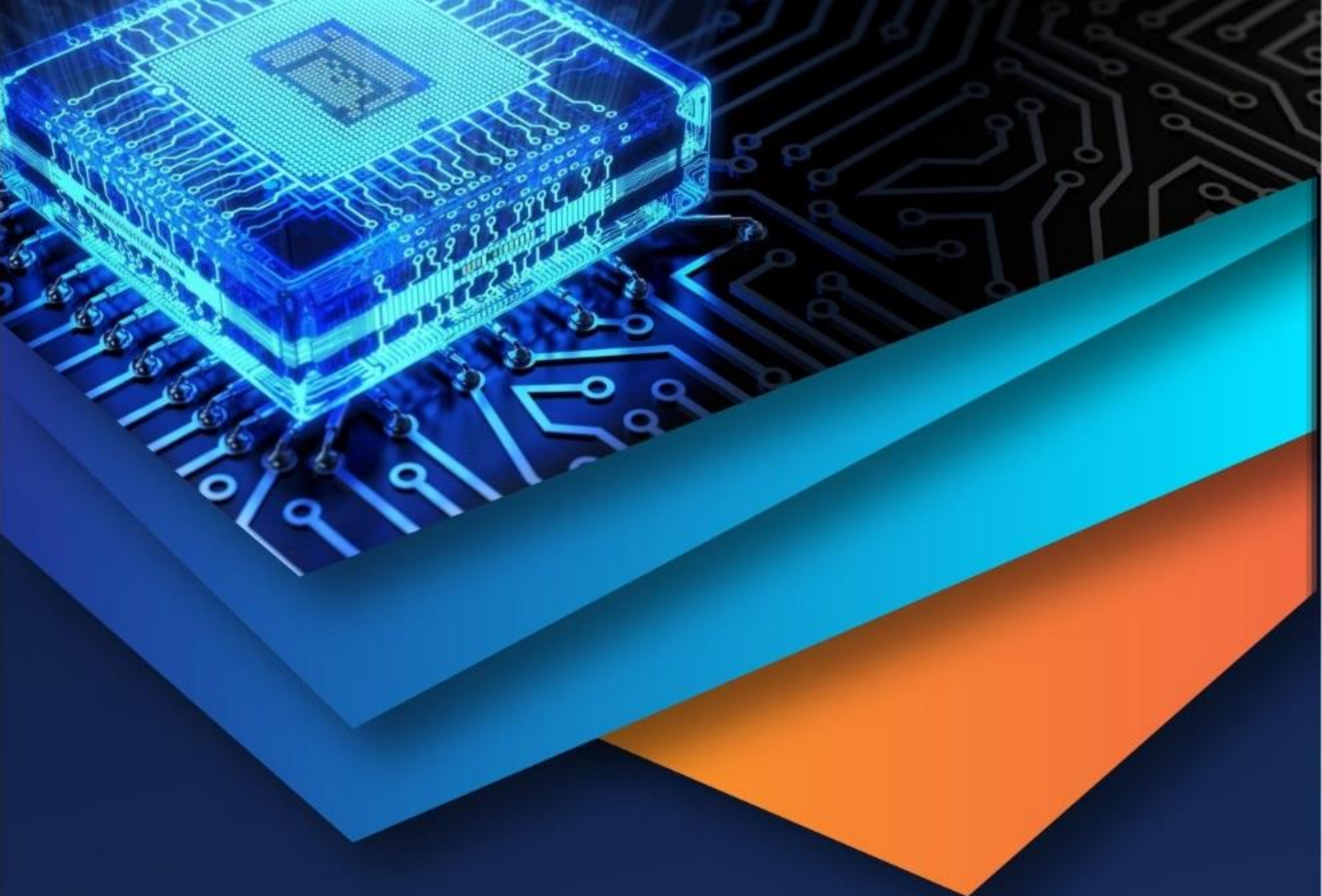
[13] Received: 18 June 2020 / Accepted: 12 January 2021 / Published online: 27 January 2021 © The Author(s) 2021 SN Applied Sciences (2021) 3:226 | https://doi.org/10.1007/s42452-021-04197-0

[14] H.M.Somashekara et al. / International Journal of Engineering Science and Technology (IJEST) OPTIMIZING SURFACE ROUGHNESS IN TURNING OPERATION USING TAGUCHI TECHNIQUE AND ANOVA ISSN : 0975-5462 Vol. 4 No.05 May 2012 1967

[15] international Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE) Vol 2, Issue 4, April 2017 See discussions, stats, and author profiles for this publication at: https://www.researchgate.net/publication/318392 922

[16] International Journal of Scientific & Engineering Research Volume 10, Issue 5, May-2019 ISSN 2229- 5518 Optimization of surface roughness in turning titanium alloy (grade2)

[17] © 2017 IJSRSET | Volume 3 | Issue 2 | Print ISSN: 2395-1990 | Online ISSN: 2394-4099 Themed Section: Engineering and Technology IJSRSET173287 | Received: 15 March 2017 | Accepted: 23 March 2017 | March-April-2017 [(3)2: 270-275] See discussions, stats, and author profiles for this publication at: https://www.researchgate.net/publication/315741 271



10.22214/IJRASET

INDEX COPERNICUS 45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY