A Review on Performance Analysis of Nano Fluids in Machine Vibration by Using FFT Analyzer

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Abstract

Vibration is the main issue which damage to the machine and machine accuracy. Nano fluid lubricants is the solution which not only decreasing production time, energy, cost, friction and vibration but also increase surface finish, minimizes cutting force, tool wear and heat generation at cutting zone. In this paper brief review has been done on the basis of roll of nanofluid to reduce vibration during machining. For that different type of nanofluid, vibration measurement technique during experimentation and impact of nanofluid on cutting parameters such as cutting force, tool wear, surface roughness and temperature at tool chip interface has been clarified.

Keywords

Nanoparticals; Nanofluid; Machining Parameter; Vibration; Tool Wear; Temperature.

I. Introduction

The industry has shown interest in the higher productivity with minimum breakdown and maintenance. Machine components, bearings and gears runs at maximum load and high speed condition. These conditions give pressure on the running system. Hence a lubricant is necessary to minimize the temperature, vibration and pressure. This lubricant performs as blood for all machining process. The usage of lubricant extends the working efficiency, machine life and also helps in sound and vibration reduction.

The additives inside the lubricant minimize the wear and also friction among the contacting faces. [5]. Chlorine, Sulphur and Phosphorous having compounds were place in use to respond chemically with the metallic surfaces, forming simply sheared films of sulphides, phosphides or chlorines and thereby avoiding severe wear. But phosphorus and chlorine containing compound have environmental effects thus is limited as lubricant [8]. So, many researchers aim at finding new lubricant additives.

Mechanical vibrations are induced by cyclic differences in machine components and due to the dynamic collaborations between tool and work piece. Tool vibration lessens performance of metal cut operations results in reduced surface quality, life of the tool and builds unpleasant noise [20].

Nanotechnology is the developing technology. Many researchers were characterized and synthesized the nano particles in latest years because of their superb physical properties [19]. In tribology, to resist exciting pressure conditions the nano particles added in the lubricant (base fluid). All tribo-mechanical properties rest on the appearances of nano particles like shape, size and concentration [22]. The present nano particles in fluid produce ball bearing effect, performances as a protecting film and better load carrying capacity [24].

II. Nanoparticles

Nanoparticles are the ultra-fine metallic or non-metallic particles. Metallic nanoparticles are made from several metals (aluminium, copper, silver, nickel etc.) and non-metallic metal are made from non-metals (metal oxides, various allotropes of carbon etc.) [1].

Various Nanoparticles are CuO, MoS2, Copper Nano particle, Diamond , Al_2O_3 and Diamond, Al_2O_3 , Zinc Oxide, CNT , Nano-Diamond, SiO_2, MWCNT [4, 30]. Nano meter range is main part of nano technology and also growing parts in materials science engineering [3]. Number of nano particles present in the base fluid lead to enhance convective heat transfer coefficient and viscosity [3-4]. Nano particles containing liquid reduce rms vibrations of roller via raising the liquid viscosity while improving the extreme load it can carry [17].

In the machining during the lubrication the nano particles are able to show three types of appliances. First the nano particles perform as nano-bearings, at this state adhere of nano particle on the wear surface area is low and scarcely noticeable. In second case, nanoparticles can react with surfaces creating antifriction compounds. Finally, nano particles can form layer on the wear surfaces by tribosinterization [8].

A. Hernandez Battezet al [8] presented results by adding of copper oxide nanoparticles in to the polyalphaolefin PAO6 to reduce friction with respect to base fluid for a tribological contact steel–NiCrBSi coating. The improvement of tribological properties is greater at high load. Hence, fewer nano particles percent is necessary to distinct the asperities of both surfaces.

Prakash et al [17] investigated the vibration characteristics of ball bearing got with CuO (nanoparticles) added lubricant. CuO were formed by chemical technique and categorised by XRD and TEM for the study of the crystallanity and ultrastructure. The produced CuO were of the size range 5-8 nm. The nano fluid prepapred by adding nanoparticle 0.2%, 0.5%, and 1% of CuO in the lubricant and then it used for the further analysis.

III. Nanofluids

Nanofluids is a mixture of metallic or non-mettalic nano size particles and base fluids [1]. Nanofluids have certain superior features those create them very significant for a number of engineering applications. Some superior qualities of Nano fluids are [1, 3-4].

- Increase thermal conductivity more than exception and much greater than theoretical prophecy.
- Fast heat transfer capacity.
- Better stability as comparative to other colloids.
- Minimization of erosion and clogging in micro channels.
- Reduction in pumping power
- Reduce friction coefficient.
- Better lubrication

There are basically two techniques used to make Nano fluids. First is one step method and second is two-step method [1, 3]. In first step nanoparticles are made as dry powders. Physical Vapour Deposition (PVD) and Liquid Chemical Method are several technique use to prepare nano powder [1].

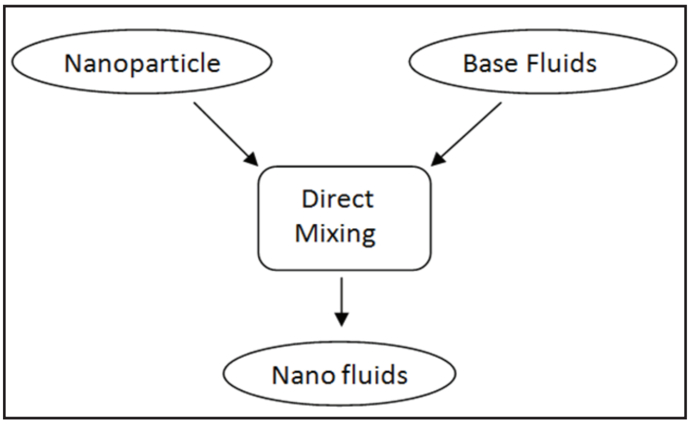

Fig. 1: Basic Block Diagram of Preparation of Nanofluid

In second step method Nano fluid is prepared by adding nono particles in to the base oil. Commonly, Nano particles having high surface area because of high surface area, they have affinity to aggregate, for that to enrich the stability of nanoparticles some significant processes are used. Which are surfactants, Surface modification techniques, pH control of nanofluids, Ultrasonic agitation [1, 7] and some Stability evaluation methods are Sedimentation method, Spectral analysis method, 3ωMethod, Centrifugation method, Electron microscopy and light scattering methods [1].

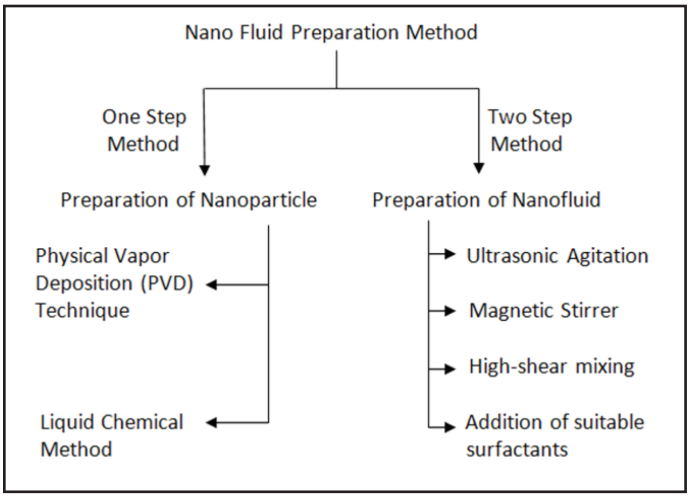

Fig. 2: Classification of Nano Fluid Preparation Method

Thermal conductivity of conventional oil is enrich by insertion of fine solid particles are done. Milli-micro meter-sized particles, has been well identified for above 100 years. But, big mass particles cause several problems like wise erosion, agglomeration and clogging in the flow path etc. [5].

K.P. Sodavadia et al [6] investigated the use of solid lubricants as nano boric acid add in to coconut oil. In turning process stainless steel machined by carbide tool. particle size 50 nm boric acid were added in to coconut oil. Then the deviation in normal tool flank wear, heating of cutting tool with cutting speed, surface roughness and feed rate are defined with nano solid lubricant additions in coconut oil [18].

Vegetable oils are hand friendly have number of advantages like as biodegradability, affordability and easiness of availability. Sesame oil, Coconut oil, sunflower oil and canola oil etc., are being used by various researchers in various machining process as cutting fluids [14].

Krishna Rao et al [9] used Eco friendly fluids with nano inclusion in during machining. Conventional cutting fluids are mostly applied to scatter the heat generated during machining. In the most application, conventional metal working fluids are the unhealthy for workers. Many researchers have started the search for safe and operator friendly replacements to conventional cutting fluids.

Table 1: Report of Several Articles About Preparation of Nanofluids

Ref.	Nanoparticles Use	Wt % added (with varying proportions)	Base fluid use	Mixing Method
[6]	Nano boric acid (50 nm)	0.25%, 0.5%, 1.0%	Coconut oil	-
[8]	CuO (30–50nm)	0.5% and 2.0%	Polyalphaolefin (PAO6)	Ultrasonic probe for 30 min.
[9]	Nano boric acid (100 nm)	0%, 0.25% 0.5%, 1% , 2%, 3%, 4%, 5%,	vegetable oil (Castor, Sunflower, Sesame, Soya bean, Canola, Coconut)	Sonicator for 1hour
[11]	Aluminium oxide (Al_2O_3), molybdenum disulfide (MoS2) and graphite 40 nm	3 %.	Vegetable oil	Ultra-sonicated in a sonicator (40 kHz, 100 W) (for 1 hour) and magnetic stirrer (30 minute)
[13]	TiO_2	0.5%, 2.5% and 4.5%	de-ionised water	Immersion method.
[14]	Nano molybdenum disulphide (nMoS2)	0.25%, 0.5%, 0.75% and 1%	Coconut oil, sesame oil, canola oil	Ultra sonicator for 60 minutes

IV. Vibration

Vibration analysis has done in five stages. Those are monitoring, determining the preliminary condition, Analysis, Detection and recommendations this is useful for maintenance of the machine tool [1]. Vibration is the main problems in machining operation. In sorts, vibration is the oscillations happened from a stable position. Machine productivity and accuracy are disturbed because of this vibration [15].

In all machine operations Chatter vibrations are almost present and big problems in achieving preferred production. Regenerative chatter is the furthermost damaging to any process as it produces unnecessary Vibration between the work piece and the tool, resulting in high-pitch noise, ruthless surface finish and quicker tool wear which decreases machine tool life [22].

Vibrations are arises during the cutting itself therefore for the response in terms of action on the assemblies and machine tools elements is firm to realize and altering the processing parameters (depth of cut, feed and speed) decreases productivity [26].

The tool vibration rises with rise in depth of cut as well as rise in flank wear. This is because of an rise in cutting force which decreases stiffness of the cutting tool [10, 28]. Cutting tool experiences many stresses because of vibration during machining operations likewise normal stress, shear stress and also thermal shocks. These stresses reason for wear of cutting edge [29].

Jijith P. K et al [29] seen that signals having long time-short time duration, wide bandwidth, time-varying bandwidth, narrow bandwidth which results as rub & buzz noise, incorrect balanced shaft produces noise as bigger in the machine speed and vibration.

AVS. Ganeshraja et al [15] says that due to the forced and self –excited vibration the machine assembly is disturbed. Due to this, vibration is responsible for surface errors in in wheel grinding and work piece. Because of this vibration the tools are broken partly or fully, accuracy of the job is disturbed. This is done due to mainly the chatter vibration.

V. FFT Analyzer

FFT (Fast Fourier Transform) is use for Frequency analysis [2, 12, 29]. FFT analysis is best for stationary signal processing, but some time it provides a bad representation of signal well confined in time and so it is unsuitable for non-stationary, transient signal analysis. Typically seen that defect produce machine vibrations, so their success in correct machine condition monitoring and valuation is restricted [29]. For examining the vibrations vibration analyzer is used. The vibration analyzer probe is kept on the tool to sense vibration. For analyzing the state of tool Amplitude time spectrum is used [23, 29].
Generally, vibrations are generated due to cyclic load variations in the turning process and because of these dynamic interfaces between the work piece and the cutting tool happened. Vibration analyser signals are furthermost commonly used by various investigators because they deliver detailed vision in cutting process [22]. Accelerometer is the sensing elements device used to measure vibration response. Tool vibration decreases the good work of machine also results in reduced tool wear, tool life, surface quality and creates unfriendly noise [20].

VI. Experimentation

The machine parameters (feed, speed, depth of cut) of cutting tool with constant rotation of work piece is measured in all the turn-milling processes in experimentation. Cutting tool shank vibrations and Surface roughness in time wave spectra are noted as reactions in turning operation. New cutting tool was used for every tool speed in machining, to escape impact of tool wear [2].

AVS Ganeshraja1 et al [15] measured the grinding machine vibration by vibrometer. Vibrometer is a instruments use for determining the vibration. The vibrometer components are sensor, Rubber cap, contact pin, display screen and magnetic holder. Its very small, easy to handle and we can be used on any machines. The vibrometer depend on three modes. First is acceleration measurement mode, second is velocity measurement mode and third is displacement measurement mode.

K.P. Sodavadia, et al [6] conducted experiments to calculate the capability of nano boric acid added in coconut oil. Design of experiments was based on Taguchi's DOE. K type thermocouple is used to measure the temperature and it is attached at the bottom side of tool. Tool maker's microscope is used to calculate tool flank wear. Surface roughness is measured by Talysurf with stylus.
Performance of more than one emulsifier based nano fluid is measured in turning at constant cutting conditions. During turning cutting fluid was provide drop by drop at the tool chip interface at a flow rate of 10ml/min. and there comparative study is done by dry machining and with MQL. Cutting temperature was recorded thermocouple. Kistler Piezoelectric dynamometer used to measure Cutting forces [7].

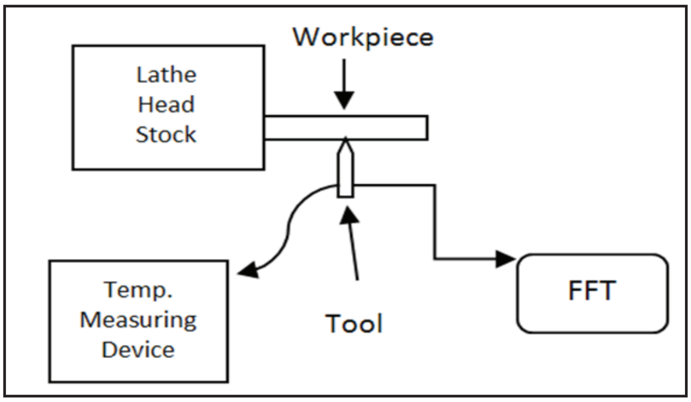

Fig. 3: Basic Block Diagram Of Experimental Setup

Vibration analysis on turbo-generator was performed at speed 3000 rpm, at load 169 mw, frequency 49.83 Hz and above. E-pro Online Vibration Monitoring System is used to measured shaft vibration and portable FFT Analyzer is used to measure by using bearing housing. It was observed that vibration in axial direction has increased at the Generator back bearing housing [21].
Experiments was done on lathe machine with the help of two cutting tool bit inserts having 0.8mm and 0.4mm nose radii for boring operation, boring is done on of AISI steel. Eight trials experiments were accompanied with two cutting factors such as first one rotational speed and second one feed rate. In each experiment (trial), a relationship among the dependent and independent variables was obtained. Tool life was predicted by studying surface roughness and rate of metal removed was estimated by Taguchi, ANOVA and Regression analysis [23].
Dr. Bashar A. Bedaiwi [31] done experimentation on a turning machine with twelve dissimilar speed. The high carbon steel (15 cm) fixed as a cantilever beam. To obtain various vibrational parameters the recorded data translated from the accelometer by USB interface to PC having special program software.

VII. Machining Performance

A. Cutting Force

Nanofluid in turning, grinding, drilling and milling operation cause reduction in cutting forces with increase in percentage of nanoparticles in base fluid up to a precise level, cutting forces reduce and forces will rise to some amount [4]. Main cutting force (Fz) variation were recorded online. The dynoware software is use in the computer it records 4-Component (Fx, Fy, Fz, Mz). From the time of contact of tool and work piece the forces were documented [7]. Use of nano cutting fluid under MQL displays decrease in all cutting forces i.e Fx, Fy and Fz as related to dry, wet and conventional cutting fluid this happen because of nanoparticles rolling action and vegetable oil lubricant, this reduced friction between tool and work piece [26].
Toll wear gradually increase during machining and it simulate the cutting forces to rise. Hence cutting force is mostly considered the greatest important indicators of tool wear machining operation [20, 25].

B. Surface Roughness

Surface roughness stands amount of the texture of a surface. It is external irregularities which outcome during machining operations. Surface roughness is largely utilizing the index of machined surface quality which finally shows the tool condition [20].

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The surface finish is the necessity in machining process for turned number of work pieces. So, optimized cutting parameters selection is very main for monitoring the surface quality which is required [24, 32].
Lowest surface roughness is obtain in turning by using nano fluid as a cutting fluid compare to all other lubricant. The occurrence of nanoparticles in cutting oil improves dissipation of heat and significantly increases the wetting and lubricating properties this leads to smooth cutting and causes holding of tool cutting edge sharpness and hardness [16].
Y. Shokoohi et al [4] observed that because of more heat drawing out from cutting zone that cause reduction in workpiece temperature and micro crack pressure so enhancement in surface finished.
Surface roughness tester is use to examined the quality of surface finish. It is observed that at 0.25% nanoparticle inclusion surface roughness has improved with speed and feed. By dropping cutting temperature, cutting force and tool wear good surface quality of the work piece is obtained [14].

C. Machining Temperature

In metal cutting operation, heat development is common phenomenon and it is inescapable. The high temperature in cutting zone damages the cutting tool. Cutting tool temperature is directly proportional to the tool ware [20].The cooling capability of nanofluids is obtainable through deviation in cutting temperatures with respect to feed, speed. Cutting temperatures increased together with increase in feed and speed [14].

Nanofluids have greater thermal conductivity and show extensive effect on workpiece and tool temperature. Additionally, nanofluids with decrease in friction between workpiece and tool responsible to lower heat generation[1]. Increase heat transfer coefficient and thermal conductivity improves the heat degeneracy ability of nanofluids, so dropping cutting temperatures at tool chip interface [14].

D. Tool Wear

Tool wear is an essential parameter which directly effects performance of machine tool and the product quality [4]. Several cutting tool damage can be happened during machining process there are numerous different mechanisms of tool wear [21]. Tool wear is found to rise with rise in feed, speed and cutting time and it is seen that to be most effective in decrease tool wear when equated to other cases at identical machining conditions[14, 34, 35] After some interval of time cutting was disturbed and Extreme flank wear was get by using the metallurgical microscope [7]. Mostly cutting tools flank wear is considered as the tool life criterion from the time when it defines the diametric precision of machining process, its reliability and reality [19, 33]. Tool wears is the regular failure of cutting tools in any machining because of continues operation. If the the cutting process is kept continue, the quantity of tool wears increases which openly affect tool life. Continues cutting process by using wear tool, can raise the friction at the cutting zone and also raises power consumption [20, 27].

R Padmini et al [14] found tool wear is to rise with increase in feed, speed and machining time and by using three nanofluids, observed that CC+nMoS2 nanofluid is effective in minimization of tool wear when equated to other cases at same cutting operation [14].

VIII. Discussions and Conclusions

Experimental investigations to examine the performance of different nanofluid are carried out. Basic properties of the nanofluids increased with nanoparticle inclusions. Consistent increase in basic properties with varying nanoparticle inclusions does not mean that the same behavior should be exhibited by nanofluids during machining. It is observed that nanofluid performed better than other lubricating conditions. In fact all the nanofluids exhibited better machining performance compared to dry, conventional cutting fluid (CCF) and pure oil assisted turning.

References

[1] Mukherjee, S., Paria, S.,“Preparation and Stability of Nanofluids-A Review,” 9(2), pp. 63–69, 2013.
[2] Vikram, K. A., Ratnam, C., Narayana, K. S.,“Vibration diagnosis and prognostics of Turn-milling operations using HSS and carbide end mill cutters,” 23, pp. 217–224, 2016.
[3] Kumar, D., Amirtham, V. A.,“A review on preparation, characterization, properties and applications of nano fluids", Renewable and Sustainable Energy Reviews,” 60, pp. 21–40, 2016.
[4] Shokoohi, Y., Shekarian, E.,“Application of Nanofluids in Machining Processes - A Review,” 2(1), pp. 59–63, 2016.
[5] Raja, M., Vijayan, R., Dineshkumar, P., Venkatesan, M.,“Review on nano fl uids characterization, heat transfer characteristics and applications. Renewable and Sustainable Energy Reviews,” 64, pp. 163–173, 2016.
[6] Sodavadia, K. P., Makwana, A. H.,“Experimental Investigation on the Performance of Coconut oil Based Nano Fluid as Lubricants during Turning of AISI 304 Austenitic Stainless Steel,” 4(1), pp. 55–60, 2014.
[7] Amrita, M., Shariq, S. A.,“Experimental investigation on application of emulsifier oil based nano cutting fluids in metal cutting process,” Procedia Engineering, 97, pp. 115–124, 2014.
[8] Battez, A. H., Viesca, J. L., González, R., Blanco, D., et al.,“Friction reduction properties of a CuO nanolubricant used as lubricant for a NiCrBSi coating,” 268, pp. 325–328, 2010.
[9] Krishna Mohana Rao. G, Padmini. R, Vamsi Krishna. S., “Performance evaluation of eco-friendly nanofluids in Machining”, Recent Advances in Robotics, Aeronautical and Mechanical Engineering, pp. 221–229.
[10] Chelladurai, H., Jain, V. K., Vyas, N. S.,“Development of a cutting tool condition monitoring system for high speed turning operation by vibration and strain analysis,” pp. 471–485, 2008.
[11] Gupta, M. K., Sood, P. K., Sharma, V. S.,“Optimization of machining parameters and cutting fluids during nano-fluid based minimum quantity lubrication turning of titanium alloy by using evolutionary techniques,” Journal of Cleaner Production, 2016.
[12] Patil, N. A., Raut, L. P.,“Vibration Analysis of Ci Engine Using Fft Analyzer,” International Journal of Research in Engineering and Technology, 05, pp. 293–298, 2016.
[13] Najiha, M. S., Rahman, M. M., Kadirgama, K., “Performance of water-based TiO_2 nanofluid during the minimum quantity lubrication machining of aluminium alloy,” AA6061-T6. Journal of Cleaner Production. Elsevier Ltd., 2016.
[14] Padmini, R., Krishna, P. V., Mohana, G. K.,“Effectiveness of vegetable oil based nanofluids as potential cutting fluids in turning AISI 1040 steel,” Tribiology International, 2015.

[15] Ganeshraja AVS., Dheenathayalan T.,"Analysis And Control of Vibration in Grinding Machines," International Journal of Research in Engineering and Technology, pp. 134-136, 2014.

[16] Kumar, A., Kumar, A., Kumar, R., Rai, A.,"Tribological Investigation of TiO_2 Nanoparticle based Cutting Fluid in Machining under Minimum Quantity Lubrication (MQL)," Materials Today: Proceedings 3, pp. 2155–2162, 2016.

[17] Prakash, E., Siva Kumar K., Muthu Kumar K., "Experimental studies on vibration characteristics on ball bearing operated with copper oxide nano particle mixed lubricant," 5(5), 2013, pp. 4127–4130, 2016.

[18] Settu, S., Murugabalaji, V., Manikandan, S.,"Vegetable Oil Based Nano Cutting Fluids and its Applications In Reduction Of Tool Wear - A Review," International Journal for Research in Applied Science & Engineering Technology (IJRASET), 3(Xi), pp. 451–457, 2015.

[19] Viktor P. Astakhov,"The assessment of cutting tool wear", International Journal of Machine Tools & Manufacture, 44, 2004, pp. 637–647, 2015.

[20] Ambhore, N., Kamble, D., Chinchanikar, S., Wayal, V.,"Tool condition monitoring system: A review," Materials Today: Proceedings, 2(4–5), pp. 3419, 2015.

[21] Mankar, R. D., Gupta, M. M.,"Vibration based condition monitoring by using Fast Fourier Transform " A case on a turbine shaft", International Journal of Engineering Research and Applications (IJERA), pp. 11–15, 2014.

[22] Siddhpura, M., Paurobally, R.,"International Journal of Machine Tools & Manufacture A review of chatter vibration research in turning," International Journal of Machine Tools and Manufacture, 61, pp. 27–47, 2012.

[23] Rao, K. V., Murthy, B. S. N., Rao, N. M.,"Cutting tool condition monitoring by analyzing surface roughness, work piece vibration and volume of metal removed for AISI 1040 steel in boring," MEASUREMENT, 46(10), pp. 4075–4084, 2013.

[24] Abouelatta, O. B., Ma, J.,"Surface roughness prediction based on cutting parameters and tool vibrations in turning operations," Journal of Material Processing Technology, 118, pp. 269-277, 2001.

[25] Bansal, P., Upadhyay, L.,"Effect of Turning Parameters on Tool Wear , Surface Roughness and Metal Removal Rate of Alumina Reinforced Aluminum Composite," Procedia Technology 23, pp. 304–310, 2016.

[26] Isak Karabegovic, et al.,"Influence Of Self-Excited Vibrations on the Surface Roughness of Workpieces obtained by Longitudinal Turning," International Journal of Engineering, pp. 163–166, 2014.

[27] Gowd, G. H., Goud, M. V., Theja, K. D., Reddy, M. G.,"Optimal Selection of Machining Parameters in CNC Turning Process Of EN-31 Using Intelligent Hybrid Decision Making Tools," Procedia Engineering, 97, pp. 125–133, 2014.

[28] Kolhe, B. P., Rahane, S. P., Galhe, D. S.," Prediction and control of Lathe Machine tool vibration – A Review," IJARIIE, (3), pp. 153–159, 2015.

[29] Jijith P. K, Lalu P. P.,"Tool Condition Monitoring Using Vibration Analysis," International Journal of Mechanical Engineering (IJME), 3(5), pp. 1–8, 2014.

[30] Tyagi, D. K., Jain, A. K.,"Experimental Study on Vibration Characteristics of Roller Bearing Using Mixed Nanofluids: A Review," 3(4), pp. 855–860, 2014.

[31] Dr. Bashar, Bedaiwi, A., et al.,"Experimental and Numerical study of Turning Cutting tools Random vibration towards mitigation", Journal of Engineering and Development, 17(3), pp. 86-94, 2013.

[32] Abuthakker, S. S., Mohanram, P. V, Mohankumar, G.,"The Effect of Spindle Vibration on Surface Roughness of Workspiece in Dry Turning Using Ann," International Journal of Lean Thinking, 2, 2011.

[33] Prasad, B. S., Babu, M. P.,"Correlation between vibration amplitude and tool wear in turning: Numerical and experimental analysis," Engineering Science and Technology, an International Journal, 2016.

[34] Izelu, C. O., Eze, S. C., Oreko, B. U., Edward, B. A.,"Effect of Depth of Cut, Cutting Speed and Work-piece Overhang on Induced Vibration and Surface Roughness in the Turning of 41Cr4 Alloy Steel," International Journal of Emerging Technology and Advanced Engineering, 4(1), pp. 1–5, 2014.

[35] Khaisar, M., Devaputra, G.,"Prediction of Tool Wear During Turning of EN9 Work Material Against Coated Carbide Insert Using Vibration Signal Processing," International Journal of Research in Engineering and Technology, 03, pp. 564–571, 2014.

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