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Tool wear effects on green and WCO/MoS_2 nanofluid clean machining

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Abstract

The philosophy of conventional machining is use of hard tool to machine soft or less hard materials. Though the hard tool is used for machining, the high friction at interface causes the wear or damage of tool. The tool wear or damage effects on the machined surfaces and degrades the quality gradually. Hence tool wear is considered as an important measure of performance in the machinability investigation. This investigation compares the tool wear on conventional green machining and proposed wet machining of SAE1144 steel. Four different Grade Nanofluids prepared with four different concentration of Molybdenum disulfide Nano-particles (0.10 wt%, 0.15 wt%, 0.20 wt%, 0.25 wt%). Other process independent parameters are also varied at four levels like Cutting Velocity (40, 90, 140 and 190 m/min), Tool Feed (0.05, 0.10, 0.15 and 0.20 mm/rev) and Nose Radius (0.30, 0.60, 0.90 and 1.20 mm). Taguchi L16 experimental Design used for conducting experiments. The experimental results are statistically validated and found significant and acceptable. The proposed novel nanofluid based wet machining reduced the average tool wear of 38% than conventional green machining.

Introduction

Today's competitive world rivalry encouraged companies to make high-quality and affordable goods, which mandated that businesses select the proper machining parameters to produce the necessary attributes in the machined parts [1]. If the proper parameters are not chosen, quick wear, breakage, and deformations may happen in the cutting tools, degrading the surface quality of the machined parts, which will then have a negative impact on the cost and quality [2]. Different cutting fluids are currently being employed in the machining of difficult-to-cut materials in parallel with technical advancements [3].Depending on the material being machined and the manufacturing conditions, these cutting fluids may contain additives [4]. Cutting fluids can enhance the machining process, but their disposal and recycling practises and potential health risks should be considered (skin irritation). Minimum quantity lubrication systems, which use small volumes of coolants combined with air to reduce the amount of fluid used during the machining process, were developed to minimize the detrimental impacts of cutting fluids [5]. According to [6], MQL was superior to a solution-type cutting fluid at reducing nose and flank wear while milling carbon steel. Using several kinds of cutting tool materials, [7] assessed the impact of MQL and other cooling techniques on the machinability of AISI 52100 steel. In comparison to dry and MQL machining settings, their research showed that typical coolant machining enhanced tool wear and lowered surface roughness. This study suggests MQL turning for better surface roughness and less tool wear, in contrast to many earlier studies that contrasted the MQL approach to the dry, conventional coolant and compressed air. In a different experiment, [8] compared the MQL technique to the dry and normal coolant, evaluating the impacts of turning AISI 1040 steel on cutting temperature, chip form, and dimensional accuracy. According to the experimental results, MQL can drastically lower the cutting temperature and dimensional error rates at a range of cutting speeds and feed rates. Due to the improved lubricant penetration with the help of pressured air, MQL leaves a nearly dry machined surface and can lower the cutting temperature at the tool-chip interface more than other types of cooling approaches [9]. Due to the efficient lubrication and the capability of the pressured air to blow cut chips outside of the cutting zone, MQL also increased chip breakability and separation [10]. The usage of nanofluids by including nano lubricants and nanoparticles is becoming more popular in order to boost the effectiveness of MQL cooling systems and improve the tribological qualities. By incorporating hBN nanoparticles with a low coefficient of friction and excellent lubricating capabilities, [11] compared the results achieved with dry and pure MQL. at0.5 and 1 vol%, respectively. They claimed that nano-MQL produced the best machining output results. Additionally, MQL with 0.5% hBN added demonstrated a 43% improvement in tool wear, while MQL with 1% hBN added demonstrated a 30% improvement in cutting temperature over the dry condition. In a different study, the authors claimed that nanoparticles with hBN added improve both the milling process and the machining results [12]. [13] conducted some tribometer experiments also shown that hBN particles are successful in minimising flank and central wear. Similar to this, earlier research found that hBN nanoparticles added to the coolant enhanced the quality of the machined parts [14]. The entire machining process was improved by the addition of several nanosolid lubricants (silicon carbide, Al_2O_3, carbon, carbon derivatives, graphene, etc.) [15]. Using two distinct nano-MQL techniques, [16] examined the chip morphology and tool wear and discovered that CNT (carbon nanotubes)-based NFMQL outperformed alumina-based NFMQL (nanofluid minimum quantity lubrication). Using cryogenic cooling (CC), cryogenic treatment, and chilling and lubrication with nano-MQL (alumina nanoparticle addition), [17] investigated the machinability of nickel alloy (CT). According to their findings, machining using CC was more effective in reducing cutting edge wear while employing nano-MQL lowered cutting forces by 16%. The most frequent machining operation on a lathe is turning.

A cutting tool removes material from the outside diameter of a spinning workpiece during the turning process. Turning's primary goal is to reduce the workpiece's diameter to the appropriate size. Turning operations come in two flavours: rough and finish [18]. By removing the most material in the quickest amount of time, rough turning operations strive to process a piece to within a set thickness while disregarding precision and surface polish. Finish turning results in a workpiece with final exact dimensions and a smooth surface finish. By producing a precise output with the proper cutting parameters, cycle times and equipment costs can be decreased. Several parameters that can be changed for various operations are used to specify the cutting tool's speed and motion. Depending on the size of the tool and the material of the workpiece [19], [20].

a) Cutting Speed

The spindle speed is calculated by dividing the cutting speed by the circumference of the work piece in revolutions per minute (R.P.M). The cut's diameter and surface area are two variables that affect speed.

b) Cutting Feed

This parameter measures the length travelled by the cutting tool during each individual revolution. It is expressed as m per revolution. Depending on the mode of operation, the tool is either fed into the workpiece or the workpiece is machining.

c) Feed Rate

It is described as the rate at which a cutting tool cuts through a substance. It is the result of the spindle speed and cutting speed, both expressed in mm per minute [21].

For a very long time, machining processes have used cooling and lubrication (C/L) agents to enhance machining. results. For instance, improved tribological behaviour at the junctions (tool work chip) is reported to result in longer tool life, less tool wear, better heat dissipation, less cutting force, and greater surface smoothness. These benefits depend on the chemical make-up of the substance being used [22]. The tool work's mechanical properties and C/L agents. A variety of variables affect the choice of C/L agents. In recent years, eco-technical factors have dictated these decisions. the contamination of water, land, and air brought on, for instance, by the discharge of conventional cutting fluids. Throughout the process, there were concerns about the workers' skin as well as the division of cutting fluid from material. Increased machine temperature places a lot of emphasis on the surface. Lubrication serves as a barrier against moisture, filth, and dust while also decreasing wear and heat between contacting surfaces that are moving relative to one another, avoiding corrosion, and reducing between contacting surfaces that are moving relative to one another [23].

One of the widely used steel for shaft manufacturing is SAE 1144 steel. [24] discussed service load test on cyclic loading circumstances on SAE 1144 steel shaft. [25] Also investigated to estimate fatigue endurance at room temperature. [26] investigated the lubrication and wear properties of SAE 1144 steel. From these it is understood that importance of machining SAE 104 steel shaft initiate clean technology of utilization of used food containers in to useful aluminium with nanoparticle reinforcement [27] utilized Nano fluid Al2O3 and CuO Nano fluids to reduce Feed energy that is reduce the Feed zone temperature in surface grinding on EN 31 steel shaft [28] utilized low concentration of Nano particles in the heat transfer fluid to increase the heat transfer in double tube heat exchanger and there by the new design will more compact in the same capacity. Excellent tribological properties of Molybdenum disulfide (MoS_2) in reduction of friction as well as wear, attracts its application in production of dry lubricant. In this research utilize it in wet lubrication application for machining the motor shafts. They usually dissolved in lubricating oils is important property in preparation of used (waste) cooking oil based coolant for machining the shafts in the heavy duty lathe. MoS_2 also employed in nano- composite coating. Ultra-fine thin coating provided to reduce friction with help of MoS_2Nanoparticles. In this research the MoS_2Nanofluid prepared with waste (used) cooking oil for liquid lubricant to improve the machinability in SAE 1144 steel shaft manufacturing.

Section snippets

Materials and methods

This investigation is carried out at the research facility of high precision heavy duty (5HP) lathe at Saveetha School Engineering, Saveetha Institute of Medical and Technical Sciences (SIMATS), Saveetha University, Chennai. The facility offers high degree of accuracy in machining and which can operate 8 different speeds in the range of 32 to 1200 rpm as well as 18 variety automated feed (0.05 to 2.5 mm/rev) conditions. As no human sample is involved in this research there is no ethical

Results and discussion

The observations of Tool wear at clean and green machining environment presented comparatively in the Table 2. The observations are validated statistically using independent samples test. Table 3 Shows the independent samples test (T-Test) output of group statistics. Conventional green machining gave average tool wear of 0.9525 µm but proposed machining 0.337225 µm Fig. 1 shows the average reduction of tool wear at 95% confidential level with ± 1SD.

In can be understood from the Table 4 the

Conclusion

The Machining of SAE1144 steel with conventional green machining practices in improved with clean machining approach. That is use of biodegradable high performance nanofluid as cutting fluid. The Waste Cooing Oil with MoS_2 combinations was tested at four different concentrations. The proposed novel nanofluid based wet machining reduced the average tool wear of 38% than conventional green machining. The observations statistically tested and fund acceptable. Within the limitation of this study

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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References (28)

L. Tharanikumar *et al.*
Enhancing the microstructure and mechanical properties of Si3N4–BN strengthened Al–Zn–Mg alloy hybrid nano composites using vacuum assisted stir casting method
J. Mater. Res. Technol. (2022)

G. Anbuchezhiyan *et al.*
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Mater. Today: Proc. (2022)

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Comparative investigation of impact strength and water absorption characteristics of novel grass powder blended GFRP and jute fibre blended GFRP with plain GFRP
Mater. Today:. Proc. (2022)

G. Anbuchezhiyan *et al.*
Experimental analysis on Feed force reduction performance by nano fluid of nano-alumina particles enriched waste coconut oil in wet machining of SAE 1045 steel shaft
Mater. Today:. Proc. (2022)

G. Anbuchezhiyan *et al.*

Experimentally investigating cutting force reduction performance by nano-alumina particles enriched waste coconut oil Nano fluid in electric motor shaft manufacturing
Mater. Today:. Proc. (2022)

R. Saravanan *et al.*
Experimental investigation on tool wear reduction by nano-alumina particles enriched waste coconut oil nano-fluid for machining SAE 1045 shaft
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G. Anbuchezhiyan *et al.*
Experimentally exploring nano-fluid of alumina nano-particles enriched waste coconut oil effects in cutting zone temperature reduction in motor shaft manufacturing process
Mater. Today:. Proc. (2022)

J.J. Jayakanth *et al.*
An investigation on wear properties of SiC/WC strengthened aluminium alloy hybrid composites
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