ScienceDirect

Materials Today: Proceedings

Available online 30 March 2023

In Press, Corrected Proof What’s this?

Effects of Molybdenum disulfide nano-particles’ concentration on waste cooking oil nanofluid in reduction feed force in CNC wet machining of SAE 1144 steel

T. Gopalakrishnan [a], R. Saravanan [b], Avinash Malladi [c], R. Manikandan [b], P. Jagadeeswaran [d], G. Anbuchezhiyan [b], M. Ganesh [e]

Show more

Share Cite

https://doi.org/10.1016/j.matpr.2023.03.442
Get rights and content

Highlights

- Nano fluids can also be utilized as a lubricant in the machining of precision shafts.
- MoS_2 Nanofluid with waste coconut oil as liquid lubricant.
- The average Feed force needed for machining was lowered by 54.08375 N.
- Nanofluid on waste cooking oil in which the concentration of MoS_2 Nano-particles was changed.

Abstract

Used Cooking oil, which is typically discarded as garbage in vegetarian eateries, is put to good use in this study as a precursor to a unique nano fluid. Nano fluids can also be utilized as a lubricant in the machining of precision shafts. This study looked into how a fluid containing nanoparticles of molybdenum disulfide in used cooking oil can reduce feed forces. In this study, two groups of samples were used: group I consisted of items that had undergone green machining (turning) on a heavy-duty lathe, serving as a control group. The intervention group's sample was processed using a wet machining technique that relied on waste cooking oil supplemented with 0.3% Molybdenum disulfide Nano-particles, representing a clean technology approach. There were supposed to be 12 people in each group based on the G-Power 80% estimate, but in the end 16 people per group were considered for the tests. Material processing of SAE 1144 shaft by molybdenum disulfide enriched waste cooking oil based wet machining significantly reduced the Feed force compared to green machining and Molybdenum disulfide Nano-particles enriched waste cooking oil based wet machining method under a variety of input conditions with similar results. ($p<0.05$) A value of $p=0.009$ is considered statistically significant. Experimental results show that the feed force can be greatly reduced from 134.139375 N to 80.055625 N when using the suggested molybdenum disulfide enriched waste cooking oil-based wet machining technology to produce SAE 1144 shafts.

Introduction

Companies are under increasing pressure to create high-quality items at competitive prices in response to intensifying competition on a global scale [1], therefore they must carefully select the machining parameters that will result in the desired properties being present in the machined components. When the improper parameters are employed, the surface quality of the machined parts can suffer, which has repercussions for both price and quality. For cutting tools, this could mean rapid wear, cracking, and deformation [2], [3]. Thanks to improvements in technology and the availability of new cutting fluids, even previously difficult-to-machine materials can now be machined. The additives in these cutting fluids are chosen for the machining conditions and the material being worked on [4]. While cutting fluids can make machining more efficient, they also have the potential to do harm to the environment (during both disposal and recycling) and to workers' health (skin irritation). To lessen the negative impacts of cutting fluids, engineers devised minimum quantity lubrication systems [5] that use only a tiny amount of coolant in conjunction with air to limit the amount of fluid needed during the machining process. When compared to a solution-type cutting fluid, MQL showed greater effectiveness in minimising nose and flank wear when cutting carbon steel, as reported by Obikawa et al. [6]. Dniz et al. [7] evaluated MQL and other cooling procedures' effects on the machinability of AISI 52100 steel using a variety of cutting tool materials. They found that conventional coolant machining led to more tool wear and smoother surfaces than dry or MQL machining. While many past research compared the MQL method to the dry, standard coolant and compressed air, this study recommends MQL turning for improved surface roughness and less tool wear. In another set of experiments, Dhar et al. [8] compared the MQL method to the dry and normal coolant in order to determine how turning AISI 1040 steel affected cutting temperature, chip shape, and dimensional accuracy. Results from experiments show that MQL can significantly reduce cutting temperature and dimensional error rates across a wide range of cutting speeds and input rates. Cutting temperature at the tool-chip interface can be reduced by MQL to near zero degrees Celsius, which is a significant improvement over alternative cooling approaches [9], [10], [11], [12]. This occurs because pressurised air aids the lubricant in penetrating the surface to a greater depth. Chip breakability and separation were enhanced [13] due to MQL's ability to efficiently lubricate the cutting zone and blast cut chips away from the cutting zone utilising pressurised air. To increase the efficiency of MQL cooling systems and to enhance the tribological properties, the use of nanofluids that incorporate nano lubricants and nanoparticles is growing in popularity. Comparing the results with dry and pure MQL, Yildirim et al. [14]. found that adding hBN nanoparticles, which have a low coefficient of friction and great lubricating characteristics, produced significantly better results. by a factor of 0.5 and 1.0 for volume. They claim that nano-MQL has the highest machining output outcomes. In addition, MQL with hBN additions of 0.5% showed a 43% improvement in tool wear, while MQL with hBN additions of 1% showed a 30% improvement in cutting temperature, both in comparison to the dry condition. A different investigation found that adding hBN nanoparticles improved both the milling process and the final product [15]. Tribometer research by Nguyen et al. [16] further supports the idea that hBN particles are great at reducing wear on the flanks and in the centre of a surface. Prior studies similarly discovered that introducing hBN nanoparticles into the coolant improved the quality of the machined components [17], [18]. Several nanosolid lubricants, including silicon carbide, Al2O3, carbon, carbon derivatives, and graphene, improved the overall machining process [19]. When evaluating the effectiveness of two different nano-MQL methods, [20] found that CNT (carbon nanotubes)-based NFMQL was superior than alumina-based NFMQL with regard to chip morphology and tool wear (nanofluid minimum quantity lubrication). Cryogenic chilling (CC), cryogenic treatment, and cooling and lubricating with nano-MQL (Al2O3 nanoparticle addition) were used to evaluate the machinability of nickel alloy [21]. (CT). Their research showed that CC machining was more effective in reducing cutting edge wear, whereas nano-MQL machining reduced cutting forces by 16%.

For the most part, lathes are used for turning. While the workpiece is spinning, a cutting tool removes material from its outer diameter. The primary objective of turning is to reduce the diameter of the workpiece to the required size [22]. There are two sorts of turning procedures: rough and finish. In order to mill a part to a specific thickness, a rough turning method is used, which prioritises speed over precision and roughness over smoothness. Produced to exact specifications, with a smooth, well-finished surface [23].

Accurate output can be achieved by carefully adjusting cutting settings, which in turn lessens the need for costly equipment and shortens production cycles. The cutting tool's speed and motion are specified using a number of parameters that can be adjusted for different tasks. slicing to fit the shape and composition of the object being worked [24].

To calculate the spindle's RPM by dividing the cutting speed by the workpiece's circumference in inches (R.P.M). A number of factors, such as the area of the cut or the diameter of the slit, affect the actual cutting speed. The b) Feed-Cutting Method It is the distance the cutting tool travels with each revolution of the tool. It is measured in metres per turn. Machine operation modes include feeding the tool into the machine and inserting the tool into the machine.

The rate of the cutting instrument is defined as the rate at which it slices through the material. It is the combination of the cutting speed (also measured in millimetres per second) and the spindle speed. Long-term use of cooling and lubrication (C/L) chemicals has proven effective in enhancing machining [25]. Increased tool life, decreased tool wear, improved heat dissipation, less cutting force, and improved surface smoothness are all claimed benefits of improved tribological behaviour at the joints (tool work chip). These advantages are influenced by the chemical composition of the substance utilised. Mechanical characteristics of the work, including the tool, and the C/L agents Additionally, machining range or cutting practise on the workpiece [26].

The selection of C/L agents is highly context dependent. Ecological and technological considerations have played a role in decision making in recent years. Indicative of air, soil, and water pollution is the disposal of traditional cutting fluids. the filtration of cutting fluid, the cleaning of tools, and the concerns for employees' skin. When the machine temperature is increased, a lot of focus is placed on the surface. Lubrication prevents corrosion and wear on moving parts by decreasing friction and heat generated by the rubbing of moving parts against one another [27], [28]. It also acts as a barrier against moisture, dust, and other pollutants.

In many cases, the shaft will be made out of SAE 1144 steel. [29] described a service load test performed on an SAE 1144 steel shaft under cyclic loading conditions. [30] Studies were also conducted to get an approximate value for fatigue endurance at room temperature. The lubrication and wear characteristics of SAE 1144 steel were studied [31]. Machining an SAE 104 steel shaft into one made of aluminium with nanoparticle reinforcement is seen as a step towards a more environmentally friendly method of recycling food-container aluminium. [32] used Al2O3 and CuO Nano fluids to lower Feed energy, therefore lowering Feed zone temperature, while surface grinding an EN 31 steel shaft. [33] used a heat transfer fluid with a modest concentration of Nano particles to improve the heat transmission in a double-tube heat exchanger, allowing for a smaller, more space-efficient design. Molybdenum disulfide (MoS2) is used in the manufacturing of dry lubricants due to its exceptional tribological qualities in lowering friction and wear . Machining the motor shafts involves the use of wet lubrication, which is explored here. Because of their solubility in oils, they are a vital component of the used (waste) Cooking oil-based coolant utilised in the high-powered lathe's shaft-machining processes. The nano- composite coating [34] also uses MoS2. Friction can be reduced by using MoS_2 Nanoparticles in an ultra-thin coating, which is provided.

Using waste cooking oil that is commonly discarded for metal cutting is a unique aspect of this investigation. When it is utilised in the flood cooling process, the coolant may be reused several times. As a result, the objective of this study is to improve the machinability of SAE 1144 steel shafts by the application of a liquid lubricant composed of MoS2 Nanofluid produced from waste (used) cooking oil. To enhance machinability for producing SAE 1144 steel shafts, this study utilised MoS_2 Nanofluid made with waste (used) Cooking oil as liquid lubricant.

Section snippets

Materials and methods

This study makes use of MOS2 nanoparticles with an average particle size of<5 nm. The samples of used frying oil collected from 'Kereala Chips', Chennai Branch, Vadaplani. The 0.10 percent concentration was chosen. 12 h of mixing used cooking oil with MOS_2 nanoparticles produced a nano fluid capable of suspending MOS_2 nanoparticles in the used cooking oil. After preparation, storage for 48 h in a static environment indicated no sedimentation. The suggested lubricant is biodegradable, and a

Results and discussion

Table 2 displays a comparison of the data collected on feed force in both dirty and environmentally friendly machining settings. Statistically, the findings are checked for accuracy by employing an independent samples test. Group statistics from an independent samples test (t-Test) are displayed in Table 3. Group 2 (intervention group) used clean machining, while Group 1 (control group) used green machining. According to Table 4, the typical Feed force experienced by machine operators when

Conclusion

This research compares the possibilities of a shift from Green Machining to Clean Machining to reduces cutting force during the machining of motor shaft the investigated clean machining possibilities. This study investigated the effect of increasing the nanoparticle concentration of molybdenum disulphide in a nanofluid created from used cooking oil on the surface finish of SAE 1144 steel produced by wet machining. Proposed machining is preferred than dry machining for making SAE1144 Steel motor

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.

Recommended articles

References (34)

Y. Peng *et al.*
Determination of polycyclic aromatic hydrocarbons in edible oil by magnetic solid phase extraction based on a mesoporous molybdenum disulfide/graphite prior to gas chromatography-mass spectrometry
Microchem. J. (2022 Dec)

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.*
Reconnoitering the influence of nanofluid of Nano-alumina particles enriched waste coconut oil in machining SAE 1045 shaft on modification surface finish
Mater. Today:. Proc. (2022)

B. Srihari *et al.*
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

Mater. Today:. Proc. (2022)

K. Karunakaran *et al.*

Experimental investigations on synthesis and characterization of tamarind seed powder reinforced Bio-composites

Mater. Today:. Proc. (2022)

D. Sreeram *et al.*

An investigation of the effects of hot rolling on the microstructure and mechanical behavior of nano-sized SiC particulates reinforced Al6063 alloy composites

Mater. Today:. Proc. (2022)

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)

View more references

Cited by (0)

View full text