REVIEW AND ANALYSIS ON MILLING MACHINING OF TITANIUM ALLOYS WITH EDIBLE OIL MIXED WITH NANO PARTICLES USING MQL TECHNIQUE

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Abstract

As a review, this work examines the milling machining of titanium alloys with the MQL process while using edible oil as a lubricant. This paper, which used the machining and MQL techniques, reviewed a number of works. Where MQL method denotes lubrication in the smallest possible quantity.As a result of its promising properties such as high strength-to-weight, high yield strength, and excellent wear resistance, titanium alloys are the leading contenders in numerous applications.Lubrication Requires a Minimal Amount Nano fluid (MQL-Nano fluid) is a viable, long-term alternative to conventional flood cooling for hard-to-cut materials like titanium. It also provides excellent cooling and lubrication.

Keywords: Titanium Alloys, Edible oils, Nano particles, MQL Technique, Lubricating Oil

1. INTRODUCTION

Machining oils are made from vegetable and petroleum products. It is used in low parameters of machining. Soluble oils are typically droplets of oil in the atmosphere. Synthetic and semi-synthetic oils are primarily derived from chemicals. They are used for machining operations with high machining speed and feed rate. The biggest drawback of machining fluids is their adverse impact on humans and the environment. The disposal of machining fluid is also a major challenge, as most of the machining fluid cause's environmental damage. Machining fluid also accounts for around 20 % of the total cost of production, so the optimum use of machining oil is the first priority to maximize profits in any manufacturing sector.

As a result of their excellent mechanical, physical, and chemical properties such as high yield strength, high strength-to-weight ratio, and high toughness, titanium alloys are widely employed in a wide range of industrial domains such as aerospace, defence, energy, and automotive production.High temperatures do not affect the hardness or strength of these materials, making them ideal for use in high-temperature environments such as those found in aerospace, nuclear, power generation, and automobiles.With their high stresses and elevated cutting temperatures, titanium alloys are notoriously difficult to process. This is mostly because titanium has a low thermal conductivity, which reduces tool life and increases the risk of premature failure. The heat created while machining titanium alloys is mainly dissipated through the cutting tool and cooling media other than the workpiece or chip because of their low thermal conductivity.

Excessive heat generation during cutting processes has been studied, optimised, and improved in many ways to increase machinability, particularly for difficult-to-cut materials.Molybdenum disulphide Nano-particles (nMoS2) emulsified in coconut results in lower surface roughness and wear of tool relative to sesame oil. Some researchers have found that the lubrication capability of LEUCHSOL RGX and JC-6800EP significantly improved surface morphology and reduced residual stress, further enhancing product life and service efficiency.

Recent developments in lubrication and cooling approaches, such as minimum quantity lubrication (MQL), cryogenic cooling, compressed air cooling, dry machining, and Nano-cutting fluid lubrication, have been described in various literature articles. They include: (NCFL). As a result, the most practical cutting approach for machining difficult-to-cut materials must be thoroughly investigated from a sustainability perspective. Cutting fluid application uses a potential new technology called as minimum quantity lubricant (MQL) (MQL).

MQL is a lubrication/cooling technique in which a precise amount of cutting fluid is injected into the cutting zone under the influence of compressed air. The MQL approach with vegetable oil is the most environmentally friendly lubricating method mentioned above. The use of vegetable oil instead of commercial cutting fluids not only provides the best lubrication, but it also offers an environmentally friendly alternative to commercial cutting fluids (e.g. mineral Oil).Air compressor, flow control system, container for CLs (coolant lubricants), tuning and spray nozzles make up the MQL system. Using particular cutting fluids, such as Nano-fluids, to develop the wettability elements of the MQL method is a key role in improving the cooling and lubricating functions.

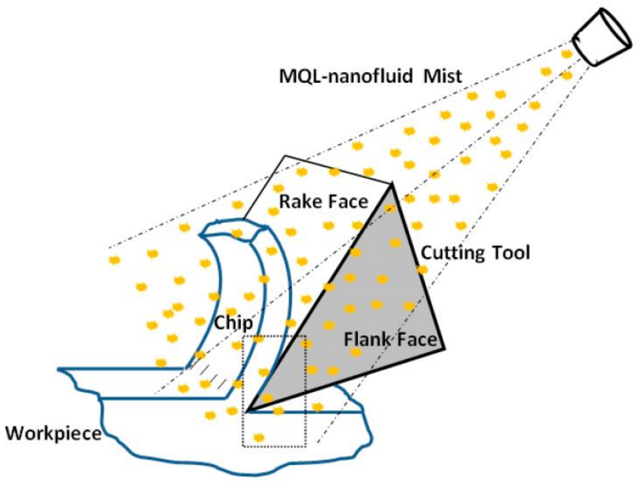

Fig 1. 3D drawing with the actual MQL-Nano fluid nozzle orientation during machining Process

2. CHANGES IN METAL-CUTTING FLUID TECHNOLOGY

A large majority of lubricating oils used to be derived from natural oils, such as animal and vegetable fats, vegetable oils, and marine oils, which include triglycerides of C8-C22 fatty acid mixtures. During the industrial revolution of the nineteenth century, the demand for lubricants skyrocketed, far outstripping the available supply of natural oils.When crude oil was refined for gasoline, it created a new compound called mineral oil, which had some

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lubricating qualities. This was a by-product of the increased exploitation of petroleum as a fuel source. As a result, enormous supplies of mineral oil were made available at low costs. A study indicated that mineral oils are less volatile and last longer than natural oils. They're also less expensive and are accessible in a wide range of viscosities. A wide variety of linear and branching alkanes (such as waxes and paraffins), alicyclic and olefin species, as well as aromatic species, make up these extraordinarily complex combinations of C20-C50 hydrocarbons The hetero atoms, primarily sulphur, are likewise in high concentration in these materials.

Cutting Fluids used in Machining Industry

The cutting fluid plays a crucial role in any lubrication system that depends on complexity of machining operations and formulations of cutting fluids. The cutting fluid types categorized are shown in figure 2.

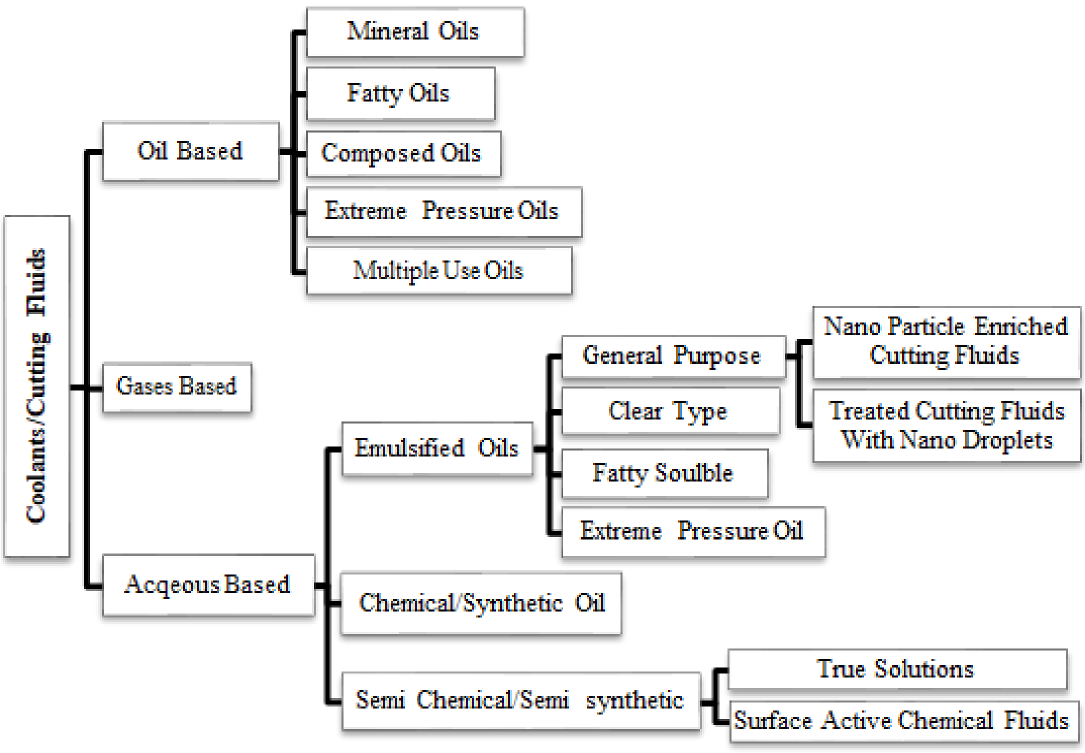

Fig 2. Nano Fluids used in Industry

3. DIFFERENT EDIBLE OILS & ITS APPLICATIONS

MQL using vegetable oil with Nano-platelet solid lubricant in milling titanium alloy was investigated by Trung Nguyen et al. [1]. Exfoliated graphite Nano-platelets (xGnP) grade C750 (or xGnP750) in Minimum Quantity Lubrication machining of Ti-6Al-4V were investigated by him as a possible use of a Nano-platelet, lamellar-type solid graphite lubricant (Ti64). The lubricity is introduced at the tool/work material contact because of the lamellar or layered crystal structure, which allows each layer to glide easily against subsequent layers.

To prevent them from passing through the human skin and inhaling through the nose, the Nanoplatelets are micro-sized in diameter rather than Nano-thick.

Nano fluid minimum quantity lubrication was used in the experiments conducted by Jungsoo Nam et. al. [2] on titanium alloy (Ti-6Al-4V), a representative difficult-to-cut material (NFMQL). In order to compare the miniaturised machine tool system, micro-drilling experiments are carried out using compressed air (CA), pure MQL, and NFMQL. He used a vegetable-based fluid and diamond-sized nanoparticles (35 nm and 80 nm) as the active ingredients. To summarise, his findings reveal that the NFMQL can lower drilling torques and thrust forces, but this impact is more pronounced at a low feed rate (10 millimetres per minute). Nano diamond particles at low feed rates have a tiny size (35 nm) and a high weight concentration (0.4% wt. %), which reduces the edge corner radii and hole circularity errors greatly.

Khaled ali Osman et.al. [3] Wrote a review paper on the sustainability & Application of minimum quantity lubrication techniques in machining process of titanium alloy. He said that the processes level, cutting fluids (CFs) are among the most unsustainable materials and need to be addressed properly in accordance with three main and decisive aspects, also known as the triple bottom line: ecology, society, and economics. Minimum quantity lubrication (MQL) is a promising technique that minimizes the use of CFs, thus improving sustainability. This paper presents a review of the literature available on the use of the MQL technique during different machining processes involving titanium alloys (Ti-6Al-4V). He concluded by saying that the drawbacks are compiled for each eco-friendly technique: dry, MQL, and cryogenics with combinations of MQL and cryogenics, critically considering machining parameters such as cutting speed, feed rate, and output measures, namely surface roughness, tool life, and cutting temperature.

Adam Race et.al. [4] Performed the milling processes using traditional cooling method using flood or high pressure lubricant emulsions. He also stated that these emulsions are expensive in their maintenance and disposal, and present a significant environmental concern. This novel study combines evaluations of the performance of low-impact cooling strategies, such as dry milling or minimum quantity lubrication (MQL), in the manufacture of an industrially important pressure vessel carbon steel (SA516) using coated carbide inserts. Tool wear, surface roughness, residual stress and energy consumption were measured during metal cutting trials for each strategy and then compared. He also measured energy footprints for dry and MQL were also lower when compared to flood coolant machining providing cost savings and environmental advantages in manufacturing using ESM approaches.

Dinh Nguyen et.al. [5] Conducted Wear Performance Evaluation of Minimum Quantity Lubrication with Exfoliated Graphite Nano platelets in Turning Titanium Alloy. He evaluated the performances of dry, minimum quantity lubrication (MQL), and MQL with Nano fluid conditions in turning of the most common titanium (Ti) alloy, Ti-6Al-4 V, in a solution treated and aged (STA) microstructure. In particular, the Nano fluid evaluated here is vegetable (rapeseed) oil mixed with small concentrations of exfoliated graphite Nano platelets (xGnPs). A series of turning experiments was conducted with uncoated carbide

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inserts, while measuring the cutting forces with a dynamometer under the dry, MQL and MQL with Nano fluid conditions supplying oil droplets externally from our MQL device. The inserts are retrieved intermittently to measure the progress of flank and crater wear using a confocal microscopy. This preliminary experimental result shows that MQL and in particular MQL with the Nano fluid significantly improve the machinability of Ti alloys even in turning process. However, to attain the best performance, the MQL conditions such as nozzle orientation and the concentration of xGnP must be optimized.

Conclusions

Significant reductions in machining force and machining friction were achieved under a minimum amount of lubrication. Reduction in machining temperature was achieved due to the excellent thermal dissipation of the machining fluid. The formation of adhesion wear and build-up edge on the tool surface is reduced.As a result, tool life under continuous MQL condition is higher than the conventional technique. In the MQL setting, the surface roughness values are found to be lower particularly at higher machining speed by using food grade vegetable oil, aided operation of MQL.

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