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A Review of Recent Application of Machining Techniques, based on the Phenomena of CNC Machining Operations

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Abstract

This review paper focus on the application of various machining techniques based on the phenomena of CNC operations, the study of different machining operations cannot be over emphasized due to its importance in the area of manufacturing and production companies. Therefore, this paper has study various application of this CNC machining techniques such as minimum quantity lubricant, cryogenic cooling, flood cooling, dry, high pressure coolant, compressed air / vapour /gas as coolant, solid lubricant/cooling and vegetable oil and their effect during machining for sustainable development and the study concluded that researcher still need to carry out more research on a single unique technique that can operate with multi-delivery lubrication method.

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Keywords: Cryogenic Cooling; Dry Machining; Machining; MQL; Vegetable Oil

1. Introduction

The globalization process has given the opportunity for most countries around the world to produce goods. This globalization process has brought about serious competition among manufacturing companies, leading to differences of quality of products being produced. Therefore, most company carry out research on different ways or techniques that they can adopt to produce good quality and sustainable product at a reduced cost. The most recent manufacturing techniques used in CNC machining operations are shown in Fig. 1.

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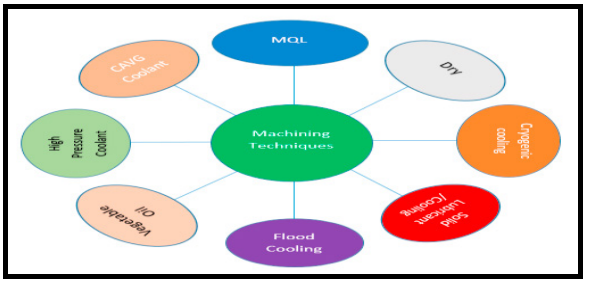

Fig. 1: Types of machining techniques.

2. Machining with Minimum Quantity Lubrication Technique (MQL)

Minimum Quantity Lubricant (MQL) is a system in which little quantity of cutting liquid is utilized in machining [1] The common flow rate of cutting fluid in MQL application between 50 and 500 ml/h; this is calculated to be 10,000 times lesser than the ordinary flood cooling. The work of Kumar *et al.,* [2], considered fast turning of Inconel-718 with various cutting tools by utilizing the MQL procedure; the study made an assessment between dry, wet and MQL strategies concerning tool life and surface roughness. A minimum surface roughness and cutting tool wear was attained under the MQL environment and observed to be superior to wet and the dry machining for various coated tool devices in the work of [3].

Recent studies have found out that MQL limit the utilization of coolant and lubrication, with positive effect on the environment when compere to traditional flood lubricant, MQL procedure utilizes just a couple of millilitres of cutting lubricant every hour for the machining procedure. The cutting fluid in MQL system is either connected from outside as a vaporizer (utilizing compacted air), or sprayed at a high pressure on the cutting region with the assistance of a spout. In Tawakoli *et al*., [4], it was observed that under specific conditions, MQL procedure can accomplish better performance in terms of grinding operation, power consumption, surface finishing and leftover stress, with less lubricant than surge cooling process. Reduction in heat generated was also observed with MQL technique when compared with dry machining.

It has been observed that the kind of lubricant being utilized is environmentally unsustainable, this further encourages the adoption of MQL technique towards reduction of ecological risks. Sharma et al., [5] mineral oil was supplanted as base oil in the turning procedure of high carbon chromium AISI D2 steel by utilizing Tungsten carbide embed (CNMG12408). The outcomes were then contrasted under dry and MQL conditions. They found out that cutting temperatures reduced by just about half using MQL method. The execution of coconut oil on machining of AISI 304 material with a carbide device was carried out in the work of Xavior and Adithan [6]. The authors observed that coconut oil lessened wear rate of the apparatus, as well as improving the surface finish, when compared to mineral oils. These discoveries were upheld by findings in Phuoc *et al.* [7], examination on the execution of nanoboric corrosive suspensions in SAE-40 and coconut oil during the turning of AISI 1040 steel utilizing established carbide device.

MQL has two major supply techniques such as the internal and external application as shown in Fig. 2. These techniques have been applied in several machining operations, for turning, milling, drilling, shaping and boring [8].

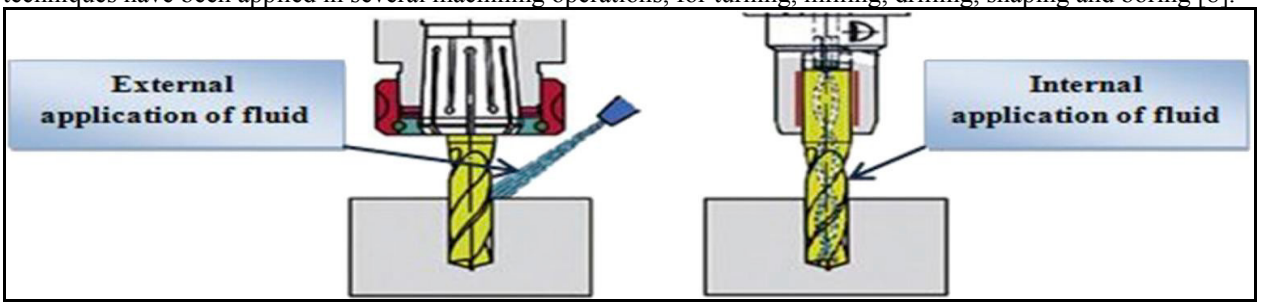

Fig. 2: MQL External and Internal delivering techniques [9].

3. Machining with Solid Lubrication

Several scientists have emphasized the challenges of water and soil contamination by the utilization of mineral based cutting liquids [10]. To reduce the utilization of metal working liquids, strong oil and cooling becomes a

suitable arrangement that is ecologically acceptable. Under this circumstance, direct processing of AISI 1045 steel to look at the adequacy of strong oils (Koolkut-40) when mixed with MoS_2 and graphite for sustainable machining. According to Reddy *et al.,* [11], Necessitated a planned set-up to inject the strong oil particles (normal size 2 microns) to the cutting zone It is also imperative that strong ointment should solidly hold fast to the slicing instrument to improve working life. The work concluded that the angle of inclination of MoS_2 is better because of the nearness of free electrons. The particular vitality utilization while machining with molybdenum based ointment is likewise observed to be low. At the point when compelled with wet machining the normal diminishment in particular vitality for graphite and MoS_2 is observed to be 20% and 28% separately [12]. It was further found that the surface complete in wet condition is substandard when compare with strong ointment condition. The general execution of strong lubricant is observed to be superior to anything that of dissolvable oil. Among the MoS_2 and graphite, the execution of molybdenum disulphide yielded better outcomes [13].

4. Machining with Cryogenic Cooling System

In machining, a lot of heat is generated at the cut. The rise in temperature because of the heat generated can cause rapid wear of the cutting tool; in other to resolve these negative impacts of heat and temperature, Liquid Nitrogen (LN) is connected to the cutting region [5,14]. The utilization of LN rapidly decreases the heat generated and further controls the lubricant pad between the interface of the cutting tool and the chips [15]. According Lawal *et al.,* [16] cryogenic cooling fills the accompanying needs of evacuation of the heat, and in this manner brings down the cutting zone temperature, protects the microstructure of materials, and lessens the coefficient of contact. The work of Machai and Biermann [17], investigated machining of Tie10Ve2Fee3Al with uncoated carbide embeds under wet and fluid CO_2 condition. The authors make used of various machining parameters with a cooling system under cryogenic condition, the tool life was enhanced in the cryogenic condition when compared with emulsion cooling. At machining speed of 150 m/min, the cutting tool wear increases under emulsion cooling. Fatima and Mativenga [18], discovered that under ideal machining environment, about 45% of chip tool interaction area is surrounded on the roughness. This circumstance diminished the device chip contact length, as well as obstructing the movement of the cutting tool. Sadik *et al.* [19], also discovered that decrease in coefficient of erosion and increment in shear edge happened because of surface organizing, which helped in diminishing the cutting force. The application of liquid nitrogen has been proven to be feasible in metal to metal machining in the manufacturing industry.

Lu et al., [20] work on the cryogenic machining were LN_2 and implanted energy was applied, and stated that at 0.640kWh/kg for liquid nitrogen having density of 0.807kg/L, and the system used 656 liters of LN_2 and consumed 340.4KWh of energy, when the implanted energy is included in the LN_2, then the total energy for the flood coolant is 948.8kWh and 732.9kWh for the cryogenic cutting. The result shows that the cryogenic method reduces energy consumption than the flood coolant.

5. Application of Compressed Air/Vapour/Gas as Coolant in Machining Operations (CAVG)

Maintainability in metal cutting could likewise be accomplished by totally annihilating or diminishing the utilization of machining liquid. MQL strategy is one such arrangement in which little measure of machining liquid is utilized during machining. The word related ailment caused by fog development and wastage of cutting liquid are significant downsides related with least amount oil machining [21]. Air cooling is a degree of proficiently supplant the customary/traditional cooling and MQL in machining. Air cooling is an exceptional instance of air cooling, in which dry packed air effectively cuts liquid. It is thought to be a moderately least expensive cooling technique in light of the fact that compacted air is advantageously accessible in each shop floor and production lines. Numerous scientists have utilized oxygen, CO_2, argon, water vapours, air and nitrogen for the cooling [22-23]. Cakır *et al*. [24] work on machining investigation of AISI1040 steel with CO_2, nitrogen oxide as cooling airs. The highest surface unpleasantness was accomplished with the use of CO_2 when compared to the application of the nitrogen oxide.

6. Machining with High Pressure Coolant System

Cooling with the assistance of high-weight stream machining rises as a potential system for expanded machining proficiency [25]. This technique is useful in enhancing device life, compelling chip development conduct, bringing down temperature in cutting zone and better surface morphology. In a related research carried out by Dahlman and Escursell [26], the authors specified that the utilization of ultra-high pressure coolant impressively enhanced chip control and developed edge is surprisingly lessened while turning of incredibly delicate decarburized steel with the assistance of thermally touchy tooling. Surface unpleasantness esteem is decreased by 80%, and apparatus wear is

altogether diminished by utilizing ultra-*high* performance concrete (UHPC) with the utilization of instruments which are inclined to high temperature breaking. Despite the developed edge that was observed because of bond of the work material, the impact of UHPC decreased built-up edge (BUE). Since there are no particular instruments utilized as a part of the examination, a further nitty-gritty investigation will be required with devices particularly adjusted for UHPC. The strategy has been exhibited as a successful technique to eliminate the developed imperfections. High weight fly cooling is a positive philosophy that provides an exceedingly pressurized or compacted liquid to the apparatus/work piece interface [27]. The system moved headway in the conventional assembly process using the mechanical and humid qualities of a profound packed water (or any liquid) stream entered into the twisting zone. It has been broadly connected in metal cutting tasks and most considered elements are the device wear and instrument life, surface complete, and chip arrangement components. In high weight stream cooling, the pressurized liquid can infiltrate into the cutting tool and work piece and in addition the pressurized liquid enhanced the chip interface area brings about lessened cutting tool wear.

Ezugwu *et al.,* [28] used this technique to examined machining of metal combinations that are difficult to cut such as Inconel 718, Tie6Ale4V amalgams and AISI 1045 steel utilizing different instrument materials including cubic boron nitride and TiAlN covered carbide. Expanded coolant supply weight result in upgraded cooling and oil conditions at the cutting interface; in this way lessened cutting powers are created and the force of cutting liquid stream, yield enhanced chip partition and division. The created surface unpleasantness was well beneath the dismissal criteria. During this examination the coolant supplies at a weight of 15 MPa reduces the built up edge, and cutting tool life was enhanced, while accelerated wear occurs because of water stream impingement due to the disintegration at higher coolant supply weight of around 20.3 MPa which result to no change in cutting tool life. The impact of high weight liquid application to the rake confront was examined by Diniz and Micaroni [29]. The findings demonstrated that the application to the rake confront brought about extensive grip holding between the instrument and chip, thereby bringing about the breaking of hardware particles and expansive cavity wear. The work did not sufficiently characterize the customary cooling conditions, and flank wear was also not evaluated. Instrument material system was connected in harsh turning of Inconel 718 for defining the procedure factors limits [30].

7. Vegetable Oil as Lubricants

The utilization of vegetable oil as cutting liquid has shown incredible oil properties in research [31]. Lawal *et al*., [16] work on the study of vegetable oil based machining working fluid in cutting of ferrous metals; the authors discovered that a pure vegetable oil is more superior when compared with the base oil. A completely defined vegetable oil ointment compared with mineral oil partners, will show a lower coefficient of grinding, proportional scraping load limit, together with inferior warm and oxidative security [27]. Lawal *et al*., [32] study flank wear optimization on coated carbide cutting tool during turning of AISI 4340 by applying different machining fluids. The result shows that palm kernel oil performance was better than other machining lubricant. Khan *et al.*, [33] also work on the effect of MQL using vegetable oil as one of the lubrication system on tool wear and surface roughness. The result shows that vegetable oil cutting environment reduces the tool wear rate and surface roughness. as shown in Fig. 3a and 3b.

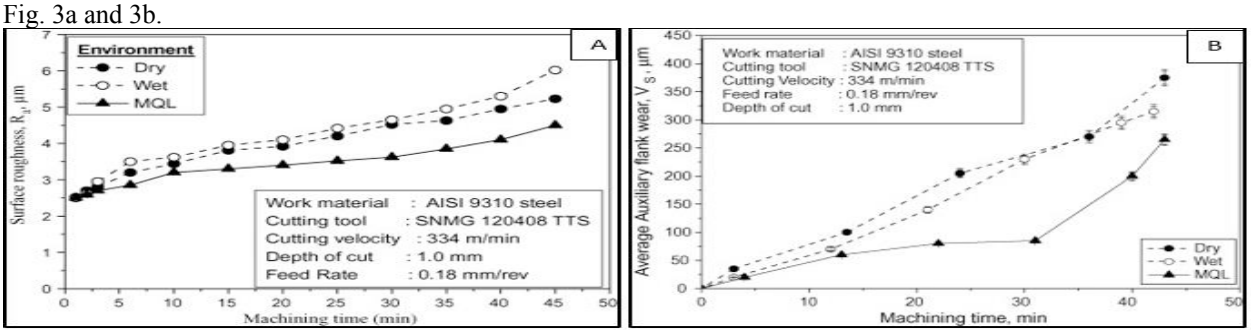

Figure 3a and 3b: Machining time variations vs. surface roughness and auxiliary flank wear at constant feed rate 0.18 mm/rev and cutting speed of 334 m/min respectively [33].

8. Dry Machining

The term dry machining has to do with machining process without the use of cutting liquids [34]. The contact diminishment in this innovation can be accomplished by the utilization of a coating layer on device substrate

materials. The covering layer must have a low grating coefficient; this depends on the decision of coating materials and in addition coating originality [35-36]. Okokpujie *et al*., [1] carried out dry machining of Al6061 in an end milling operation, with four independent variables such as cutting speed, axial depth of cut, feed rate and radial depth of cut was investigated; After machining, the surface roughness was measure and analysed with ANOVA. The result shows that feed rate and cutting speed had great influence on the surface roughness. [37-39], carried out experimental analysis on HSS cut tool on dry machining of aluminium alloy and discovered that the depth of cut is very influential. If this depth of cut is not properly studied, it will course vibration that will lead to failure of the cutting tool; this result is in line with observations made by [40] in their study of tool wear prediction.

Furthermore, Nwoke *et al*., [41] studied the effect of vibration in turning operation of Al 4340 material, and found out that the increase in feed rate lead to increase in vibration. Okokpujie et al., [42] study the Effects of machining variables on vibration frequency of perspex material, the result shows that machining parameters are significant tools in turning operation. Okonkwo *et al*., [43] also investigated Chatter vibration frequency and compared the two boundary conditions, that is Clamped-Pinned (C-P) and Clamped-Free (C-F) machining settings. The result shows that C-P reduces vibration with about 30% when compared with C-F setting.

9. WET / FLOOD COOLING

Regular wet cooling is a customary strategy of cooling of cutting zone. Under flood cooling nozzle rate are normally runs from 10 l/min (0.01 m3/min) for single-direct cutting devices toward 225 l/min (0.225 m3/min) per shaper for numerous tooth cutters, for example, in processing. In activities, for example, boring and end processing, liquid weights in the scope of 700-14000 kPa are utilized to wash away the chips. Ogedengbe et al., [44] applied cooling system for the temperature reduction during turning of carbon steel and the coolant were able to reduce the temperature effect to 7.9^{o}c. The surface integrity of the machined work piece reduces from the maximum to the minimum surface roughness values further reducing to 0.612µm and 0.110µm as clearly seen in Figure 4a. These improvements were as a result of a diminishing of the heat generation during machining as shown in Fig. 4b.

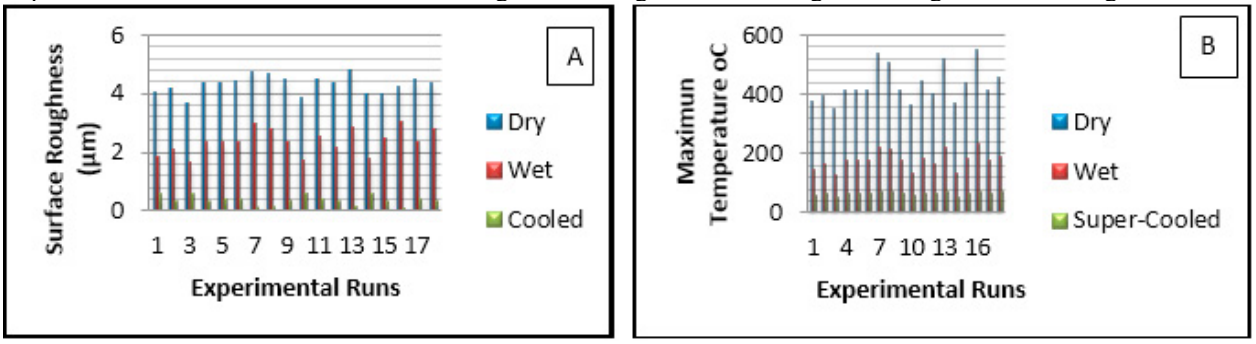

Fig. 4a and 4b: shows the surface roughness and maximum temperature attained during machining of various lubricating conditions

Even with the good aspect of reduces the heat generation during machining or turning operation, there are some negative effects of wet/flood cooling operations such as, disposal of cutting liquid, cost of cutting liquid, spreading of cutting liquid around the machine Harmful residuals, disposal of wet chips and less deceivability, if this process is not properly investigated it will lead to corrosion of the working materials after the operation [45-47]

10. Conclusions

Machining is the major art of manufacturing companies in terms of producing good quality product, this process involves the machine parameters, lubricants and the environment. Due to the ecological pollution the government regulations encourage manufacturing industry to implement machining techniques that are environmental friendly in their operations. This paper presents a comprehensive review on the different machining techniques and conclude that though MQL techniques is steel the best operating technique, but there are needs for researchers to develop a single technique that can multi-deliver lubricant (that contains high pressure, vegetable oil and MQL) with effective performance.

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