Recent Studies In The Application Of Internal Cooling System In Conventional Machining Process

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Abstract: In general, most of the manufacturing industries use lathe machine, because of its applications in various fields of automotive, defense, missile technology and aerospace. The workpiece material used in these fields are owing high hardness and good physical properties. In this machining process extreme heat is generated, which interrupts the chip flow. In turn it effects the surface finish of the machined surfaces and also decreases the tool life. Tool temperature cause damages like wear resistance and reduction of mechanical resistance therefore efficient cooling strategies are used to minimize the cutting zone temperatures. Now-a-days demands increasing on machining new cooling techniques, among them closed internal cooling system can be an alternative to green environment. Application of Nano particle blended in cutting fluids reduces the cutting zone temperatures, increases tool life, material removal rate and surface finish. However, the existing literature shows that under same application thermophysical properties are improved from other fluids. In this paper, a concise study of operating and machining conditions of lathe machine under internal cooling system is made and observations from the literature survey are discussed.

Index Terms: Internal cooling, Heat dissipation, Cutting temperature, Lathe machining, Nanofluids.

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1 INTRODUCTION

IN industries like automotive, aerospace and gas turbines the machining of superalloys has become an inevitable manufacturing process [1]. Among a number of cooling applications, like High pressure coolant, Cryogenic cooling, compressed air cooling, closed internal method. Now-a-days demands increasing on machining new cooling techniques, among them closed internal method is the method to obtain green environment it removes heat by introducing internal micro structures with in the tool [2]. Due to excellent weldability, corrosion and oxidation resistance, superalloys are becoming popular [4]. Machining titanium is done by using diamond coated internal cooling tool [21]. In wet machining cutting fluids are of different types of oils like soluble, straight, synthetic and semi synthetic [11]. Coolants has both advantages and disadvantages. The limitations of a conventional coolant system are viz., dripping tools, strong smell, slippery floors, air pollution and dirt. Other criteria to the lubricant alongside technical performance, environmental, economic, safety and health, such as: toxicity, human compatibility, anti-aging emulsify ability, bacteria resistance, recyclability, wash ability, compatibility with materials, smell [14]. A new method is introduced by mixing Nano particles in cutting fluids because of its wide range of applications. Recent studies indicate that nanofluids transfer higher heat and less friction. [3]. Nano fluids are classified into two types metallic (Cu, Al, Zn, Ni, Si, Fe, Ti, Au and Ag), and non-metallic (Al_2O_3, CuO, SiC, ZnO, TiO_2). Oxidizing is prevented by adding corrosion inhibitors [1]. Concentration of Nano particles, size, type of Nano particles and type of base fluid are crucial in influencing the cutting fluid properties, with increasing the concentration of Nano particles in cutting base fluids developed tribological properties [8]. Various researchers on the application of Nano-cutting fluids and their preparation [11]. Carbon nanotubes and vegetable oil are used to improved machining performance and achieved green environment [4]. By using metal oxide-based ZnO Nano fluid as a coolant reduces the cutting temperature compared with normal conventional cooling [19]. Tool temperature is the main consideration by the authors. In metal cutting internal cooling tool is mainly focused on removal of heat from the chip, workpiece and tool [21]. Effective lubricating action and an efficient cooling are achieved with high pressure jet cooling method by this method temperatures are decreased [10]. Cutting temperature strongly effect the tool wear [13]. Arduino UNO R3 controller board, bridging of amplifier, software and analog K-type thermocouple sensor are used to calculate temperatures of cutting zones [12]. In a precision lathe thermal error is identified for dynamic modelling [5]. Temperature of the cutting zones were decreased using heat pipe cooling system with minimal fluid application at cutting zones, high velocity jet is flushed with a minimum cutting fluid and compared with thermal models [16][18][20][22]. Dry machining is compared with cryogenic machining high machining stability is achieved due to the reduction of specific cutting force components [17]. Surface defects are analyzed using dry and wet machining, wet machining achieved good surface finish [23]. Acoustic emission monitors the lathe’s tool tip condition in order to increase the tool service life [15]. Tool system prototype was built and analyzed thermal characterizes during the process, in machining trials no external coolant was used [24]. Internal cooling method is employed, experiments were carried out and analyzed with finite element simulation with parameters like speed, feed, depth of cut [18]. Using ANSYS CFX software, different boundary conditions are taken and stimulated the analyze internal energy, temperature and pressure of the cooling fluid [7].

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2 SUMMARY OF OPERATING CONDITIONS FROM THE EXISTING LITERATURE

Author J S.no	Work piece material	Cutting tool	Cooling fluid	Environment
Yahya Isik [1]	Waspaloy AMS5708	CVD-coated carbide CNMG 190604	Pure water	Dry and wet
Tao Wu [2]	-	-	Purified water	Dry and Wet
Yu Su [3]	annealed carbon steel bar of AISI 1045	-	nanofluid MQL with vegetable-based oil and ester oil as base fluids	Dry and Wet
Talwinder Singh [4]	Inconel 625	-	MWCNT in soybean oil	Dry and Wet
Angelo Sancheza [7]	austenitic steel	copper	Refrigerant type R22	Dry and Wet
Mehul Gosaia [12]	tempered EN 36 Hardened steel	CNMG4325 Grade TN2000 tool insert with K20 shim	-	Dry
Anton [14]	C45E	-	-	Dry
A. Noorul Haq [17]	-	copper, steel and brass	-	dry
Pusavec [18]	AISI 1045	CNMG 1204	-	dry
Syed hameed [19]	Mild steel	-	ZnO nanoparticles+SAE -30	Dry and Wet
Ghosh[27]	AISI 4140 (23 HRC	SNMG 120408+ nano coated .(multi layered)	soluble oil, water-based Al2O3 and MWCNT- nanofluid	Dry and Wet

3 SUMMARY OF MACHINING CONDITIONS FROM THE EXISTING LITERATURE

Author J S.no	Temperatures of tool (℃)	Process Parameters:	RESULTS
Yahya Isik [1]	456-641	Cutting speed 45, 65, 95m/min Feed rate 0.10mm/rotational speed Depth of cut 0.50mm	Temperatures (tool ,chip interface) comparison Tool wear Surface roughness
Tao Wu [2]	200-450	Cutting speed 320 r/min Feed rate 0.16 mm/r Depth of cut 1 mm	Temperatures comparison Tool wear
Yu Su [3]	380-550	Cutting speed/(m/min) 55, 96 Feed rate/(mm/rev) 0.1 Depth of cut/(mm) 1.0	Temperatures comparison Wettability Thermal conductivity
Talwinder Singh [4]	-	Cutting speed: (m/min.) 16.48 25 37.5 50 58.52 Feed rate: (mm/rev.) 0.05 0.07 0.1 0.13 0.15 Depth of cut:(mm) 0.13	Tool wear Surface roughness
Angelo Sancheza [7]	45-50	Cutting speed: (m/min.) 100,130,170 Feed rate: (mm/rev.) 0.1 Depth of cut:(mm) 1.0	Temperatures Heat transfer coefficient Heat flux
Mehul Gosaia [12]	135	Cutting Speed (rpm) 450 710 1120 Depth of Cut (mm) 0.40 0.80 1.20 Feed Rate (mm/rev) 0.180 0.355 0.560	Temperature
Anton [14]	140-160	Time	Temperatures (deactivated and activated internal cooling) Tool wear.
A. Noorul Haq [17]	600-750	Heat pipe parameters Length (mm) Diameter (mm) Vacuum (mmHg) Material	Flank wear Crater wear Thermal analysis
Pusavec [18]	-	Depth of Cut (mm) 1 Feed Rate (mm/rev) 0.1,0.7	Cutting forces Friction coefficient
Syed hameed [19]	34-30	Cutting Speed (m/min) 630,400,280 Depth of Cut (mm) 0.4 Feed Rate (mm/rev) 0.4	Temperatures Surface roughness Zeta potential analysis
Ghosh[27]	-	Cutting velocity: 80,115, 160, 225, 315 m/min Feed rate: 0.05, 0.1 mm/rev; Depth of Cut: 0.6 mm	Cutting forces cutting velocity

4 OBSERVATIONS MADE FROM LITERATURE SURVEY

The major findings from the literature survey are as following: Internal coolant is sufficient to reduce the cutting temperature and avoid critical cutting temperature. So that the flank wear, crater wear decreases abruptly. As the both temperature and wear decreases, the tool life increases significantly. In comparison with depth of cut and feed rate and cutting speed, depth of cut has very significant effect and cutting speed and feed rate has moderate effect. The steady state is achieved in a short span when the internal cooling system is used and there is a decrease in the temperature rates in the cutting zone. The increase in the cutting speed leads to the increase in the tool tip temperature. The reason behind this is due to plastic deformation of the material and also an increase in the friction. Further increase in temperature, because of more plastic deformation so that the mechanical energy is converted into the heat energy. The internal cooling can be provided by different geometric patterns such as providing tiny grooves beneath the tool holder, providing the chamber under the shim of the tool holder, and by designing different profiles by utilizing the maximum area of cross section. Even introducing the heat pipe below the tool insert is one of the sustainable methods for the temperature reduction. The surface quality can be improved by considering higher cutting speed. The softening of the material, take place at high temperature results in lower surface roughness. The optimum condition for obtaining maximum surface finish with least rise in temperature at tool tip is high cutting speed with low depth of cut in medium feed rate. The phase change fluid such as R22 can be used in the internal cooling method for better results. In addition to that cutting fluids such as deionized water, compound emulsions etc. also be used. There are several optimization techniques one among them are the age-old one-factor-at a-time method to advanced response surface methodology (RSM). However, Taguchi method is very convenient as it can give better combinations with a smaller number of repetitions. The various possibilities for getting higher cooling rates in the design of an internal cooling system are: the inlet and outlet diameters of the hole has the most significant impact on the tool cooling efficiency among velocity of the cutting fluid, insert thickness, shim thickness etc., Usually tool-chip interface temperature is measured by the standard thermocouple method. The limitation of this method is every time the calibration should be done for the change of tool and work piece materials. So, for the effective measurement inverse heat conduction method is used. Most commonly used device for the temperature measurement is K-type (Chromel- Alumel) thermocouple.

5 CONCLUSION

The comparisons of wet and dry machining were done. In temperature analysis clearly shows that temperature decreases by using green internal cooling system. A brief discussion of machining and operating condition of lathe machine from the literature survey.

6 FUTURE SCOPE

Design of the tool holder and coolant there is a lot of scope for improvement. The tool holder design can be modified such as providing chamber under the shim, providing tiny grooves under tool bit or adopting different geometrical patterns such as spiral, helical shape etc., under the tool bit. The other method is usage of heat pipe for internal cooling method. As coolants nanofluids, brine solution, refrigerants can be opted for better results.

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