Вплив мінімальної кількості змащення (МКЗ) водними розчинами лікарських рослин на процес різання при точенні сталі 40Х13 (AISI 420)

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Мастильно-охолоджуючі рідини (МОР) відіграють важливу роль у процесах обробки металів різанням. За рахунок змащуючого і охолоджуючого ефектів зменшується знос різального інструменту, поліпшується якість і точність обробки деталей. Витрати на утримання та догляд за МОР істотно збільшують вартість механообробки. Крім того, МОР можуть негативно впливати на здоров'я робітників і є джерелом забруднення навколишнього середовища. Тому одним із шляхів підвищення ефективності процесу різання є зменшення або навіть виключення застосування МОР при механічній обробці. Одним з таких методів є різання з мінімізованою кількістю мастила (МКМ). При такому різанні в зону обробки подається невелика кількість МОР – зазвичай від 50 до 500 мл/год, що у багато разів менше у порівнянні з традиційним поливом, де витрати становлять більше 5 літрів на хвилину.

Були проведені експерименти при точінні заготовок із сталі 40Х13 (AISI 420) діаметром 90 мм і довжиною 600 мм при наступних режимах обробки: швидкість різання 2,1-2,3м/с; подача S=0,3мм/об; глибина різання t = 0,5 мм при різанні всуху, поливом і МКС. У якості МОР застосовувалася 5%-емульсія ЕТ-2у і водні розчини лікарських рослин. В експериментах вивчалася роль МКМ на такі характеристики процесу різання як температура різання, знос інструменту, шорсткість обробленої поверхні і стружкоутворення.

Результати експериментальних досліджень показують, що при різанні в умовах МКМ температура різання, знос різального інструменту, шорсткість обробленої поверхні є кращою у порівнянні з поливом і різанням всуху.

Водні розчини лікарських рослин впливають на всі показники процесу різання. Ступінь впливу залежить від природи рослини і його концентрації у водному розчині.

Effect of minimum quantity lubrication (MQL) by aqueous solutions of drug plants on cutting process in turning 40X13 (AISI 420) steel

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Metalworking fluids (MWF) are undesirable factors in metal cutting. For both economic and ecological reasons, as well as because of increasing legislation, efforts are being made to reduce the use of MWF. On account of this, the introduction dry machining and minimum quantity lubrication (MQL) techniques in machining process is increasing. This paper deals with experimental investigation on the role of MQL by aqueous solution of drug plunts on cutting temperature, tool wear, surface roughness and chip formation in turning 40X13 (AISI 420) steel at industrial speed-feed combinations by uncoated carbide insert. The encouraging results include signification reduction in tool wear rate, cutting temperature, surface roughness by MQL mainly through favorable change in the chip-tool and work-tool interaction.

Keywords – Minimum quantity lubrication (MQL), tool wear, surface roughness, chip formation, metalworking fluids (MWF) application, environmentally clean cutting process, concepts of cooling and lubrication..

I. Introduction

Metalworking fluids (MWF) play a significant role in machining process. The combined lubrication and cooling effects reduce tool wear and enhance surface quality and dimensional accuracy of the workpiece. The cost of the purchase, care and dispocal MWF are two times higher and have to be taken into account when examining economics in machining [1,2]. Furthemore, MWF may have unhealthy effects on workers as well as on the environment. Because of them some alternatives has been sought to minimize or even avoid the use of MWF in machining operations. Some of these alternatives are dry machining and machining with minimum quantity lubrication (MQL). MQL refers to the use of cutting fluids of only a minute amount – typically of flow rate of 50 to 500 ml/hour – which is about three to four orders of magnitude lower than the amount commonly used in flood cooling condition, where, for example, up to 5 liters of fluid can be dispensed per minute.

II. Experimental investigation

Experiments were carried out by plain turning a 90mm diametr and 600 mm long rod of 40X13 (AISI420) steel at cutting conditions: cutting speed, V=2,1-2,3m/s; feed, S=0,3 mm/rev; cutting depth, t=0,5 mm under dry cutting, wet (flood cooling) by 5% emulsion ET-2U and MQL by aqueous solution of drug plunts to study the role of MQL on the machinability characteristics of that work material mainly aspect of cutting temperature, tool wear, chip formation and surface roughness.

The simple bur reliable tool-work thermocouple technique has been employed to measure the average cutting temperature during turning under dry, wet and MQL conditions. The wear of tool were measured using microscope model IMTSL 150-50, B fitted with micrometer of least count 1μm. The surface rougness of of the machines surface after each cut was measured by profilograf-profilometr PP-202.

The aqueous solutions of the following drug plants were used as a cutting fluid: chamomile, sweat-weed and eucalyptus. These plants were selected as components based on the grounds indicated below.

Firstly, these plants are widely used to treat respiratory system by inhalation method. Secondly, for a long period of use of these plants in medicine, no any application contraindication was found. The concentration of a component in the solution was 2.5-3gr per 100ml of water. In researches as solutions of one plant, so their mixtures were used.

III. Experimental results and discussion

The machining temperature at the cutting zone is an important index of machinability and needs to be controlled as far as possible. MQL is expected to provide some favorable effects mainly through reduction in cutting temperature. It was observed that MQL by aqueous solution of drug plunts enabled reduction of rhe average cutting temperature by about 7%-15% as comparision dry cutting.

The cutting tools in conventional machining, particularly in continuous chip formation processes like turning, generally fail by gradual wear by abrasion, adhesion, diffusion, chemical erosion, galvanicaction, etc. depending upon the tool-work materials and machining condition. Tool wear initially starts with a relatively faster rate due to what is called break-in wear caused by attrition and microchipping at the sharp cutting edges.

The results of investigations shows that the examined plants have an influence on the wear of cutting tools. However this influence rate is variable, and depends on the used drug plants and its concentration. Thus, when cutting is dry, the tool wear was 0.63 mm and when using of 5% emulsion – 0.29 mm.

The lowest wear of three tested plants was obtained by using chamomile (0.3 mm). The usage of sweat-weed reduces wear of tool in 1,6 times in comparison with dry cutting (0.4 mm). If you use eucalyptus, the wear of tool increased in 1.2 times in comparison with dry cutting and it equaled 0.75 mm.

Researches were also conducted with different combinations of herbs and their concentration according to the plan of the experiment. Depending on the applied components and their concentration, the level of wear varied from 0.2 to 0.52 mm. The lowest level was achieved in the presence of all three components in equal concentrations.

As MQL reduced tool wear on auxiliary cutting edge, surface roughness also grew very slowly under MQL by aqueous solution of drug plants conditions. It appears that surface roughness grows quite fast under dry machining due to more intensive temperature and stresses at the tool-tips, MQL appeared to be effective in reducing surface roughness. However, it is evident that MQL improves surface finish depending upon the work-tool materials and mainly through controlling the deterioration of the auxiliary cutting edge by abrasion, chipping and built-up edge formation.

Measuring of the chip shrinkage shows that drug plants influence well to this factor. So when dry cutting, the shrinkage index was 2.2-2.4. Using 5% emulsion – 1.8-2.0. When using aqueous solutions of chamomile, sweat-weed and eucalyptus, as well as their combinations, the chip shrinkage index was 1.7-1.9.

Researches have shown that aqueous solutions of drug plants can have a significant effect on the chip. Thus, when dry cutting and with the usage of emulsion the drain chip is observed. The usage of eucalyptus can obtain refraction of chip, as well as reduction of the chip curvature radius.

Conclusion

Based on the results of the present experimental investigation the following conclusions can be drawn:

i. The cutting performance of MQL machining is better than that of dry and conventional machining with flood MQF supply because MQL provides the benefits mainly by reducing the cutting temperature, which improves the chip-tool interaction and maintains sharpness of the cutting edges.

ii. MQL jet provided reduced tool wear, improved tool life and better surface finish as compared to dry and wet machining od steel.

iii. Drug plants may affect the cutting process. The degree of influence depends on the type of plant and its concentration in aqueous solution.

iv. The obtained results emphasize the important role of active substances in changing technological parameters of the cutting process, in particular from the wear of cutting tool, the coefficient of the chip shrinkage and chip formation.

v. It is obvious that active molecules contained in the plants do not decay at high temperatures, and interacting with each other, form effective lubricating layers.

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