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MINIMUM QUANTITY LUBRICATION USED IN VEGETABLE OILS TO REDUCE FRICTION AND SAFETY FOR WORKERS HEALTH

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Abstract

The purpose of the research is to investigate the performance of different type's natural vegetable oils through the use of minimum quantity lubrication. In this research we are use a material of AISI 4130 steel to surface grinding. The AISI 4130 steel has low carbon content because it is used for welding. The minimum quantity lubrication technique used in vegetable oils in terms of cutting forces, surface temperature is evaluated. We use three different vegetable oils at different pressure and different flow rate. The research can reduce the production cost and increase the value of the product. We use three vegetable oils soya bean, sunflower, and groundnuts are used at different flow rate 80, 120, 160 and used different pressure of the fluid 4 bar, 5 bar, 6 bar. We measure the surface temperature and grinding forces of the work piece. The flow rate increase from 80 to 160 ml/hr. and pressure increase from 4 to 6 bar there is reduction in grinding forces and grinding temperature due to more quantity of oil make a lubricating film over the surface of the work piece and heat is transferred to the surroundings.

Keywords. Surface Grinder, Thermocouple, Dynamometer, L_9 Array, Taguchi Method

I. INTRODUCTION

Grinding Process

As compared to turning and milling, the grinding can provide a better surface finishing. The working tool in this case is rotating wheel, which on bringing the close contact with the surface of the work piece produce the required surface finish. Abrasive grains when bounded together with a binder perform the cutting action by the wheel and remove the tiny chips from the surface of the work material (Singal and Singal 2010). With the passage of time, the abrasive grains suffer from the wear and it results in the fracturing of the grains and the weakening of the bonds. In this way, the dull pieces are broken away and the sharp new grains are revealed (Rajput 2007). The efficiently grinding mainly requires:

Lubrication is the process of applying metal working fluids in order to reduce the friction and wear. As we already discussed that the surface of tools and work pieces are subjected to high stresses at very high working speed, the temperature of the tool and the work piece along with their interface becomes so large that melting occurs. Poor surface quality is formed. To overcome these problems, lubrication is necessary(Vasu and Kumar 2011).The fluids perform the various functions of cooling and lubricating the tool-work piece interface. Also it carries chips produced during grinding operation along with it. Water-soluble chemical fluids, water-soluble oils, synthetic oils, and petroleum-based oils are most commonly used.The use of fluids in a grinding process is necessary to cool and lubricate the wheel and work piece as well as to remove the chips produced in the grinding process. Some lubricants are very harmful for the environment such as petrochemical and synthetic based cutting fluids as they result in toxic environment which is harmful for the operator. One of the advantages is the cooling effect which reduces the temperature in the cutting zone. One another advantage is of lubrication which decreases cutting forces and due to this the coefficient of friction between the tool and chip becomes lower as compared to dry machining (Dudzinski, Devillez et al. 2004). Traditionally, the Cutting fluids are used for the metal cutting work as it reduces the heat from cutting zone and also performs the required flushing action. Heat transfer from the tool work piece interface depends upon the temperature of the cutting fluid used. The cooler the cutting fluid, more effective is the transfer of heat.There are numerous advantages of the cutting fluids but inspite of them, there are also certain problems assisted with them (de Jesus Oliveira, Guermandi et al. 2012). There high costs increases the overall production cost. Cutting fluids are also dangerous for the workers as these cause various skin diseases due to the chemicals contained in them. Proper disposal of the cutting fluids is also required as great environmental hazards are posed by them. Various modifications are done to the cutting fluids to overcome or reduce various problems of foaming, bacteria and fungi. Most widely used base oil is paraffin oil.

Minimum Quantity Lubrication

Minimum Quantity Lubrication sometimes also termed as nearly dry grinding or semi dry grinding uses a minute quantity of lubrication. The quantity of the fluid used varies from 60 ml/hr. to 500 ml/hr. and this much quantity cannot be recovered from the parts(Silva, Bianchi et al. 2005).As a very little amount of lubrication is used, post cleaning of parts is not required as remaining film of lubricant vaporize by the high temperature of the cutting zone. In this process, the mixture of lubricant and compressed air in the form of aerosol or spray is sprayed directly by the nozzle to the tool-work interface at high pressure. This high pressure results into the penetrating of the oil to the cutting zone to reduce the cutting temperature and friction(Sadeghi, Hadad et al. 2010)With respect to cutting forces, surface finish, cutting temperature and tool wear, minimum quantity lubrication gives the beneficial results as compared to results obtained with the dry machining and flood machining. Minimum quantity lubrication gives the best performance of machining operations because of their lubrication, cooling and chip flushing characteristics by the high pressure varying between 5 bar to 8 bar(Vasu and Kumar 2011).

II. LITERATURE REVIEW

Jia, Li et al. (2016) evaluated the influence of jet parameters of MQL on the lubricating property of

Ni based alloy grinding by performing grinding operation on Ni based alloy using K-P36 numerical control surface grinder. Grinding forces were measured using 3-D dynamometer to calculate specific grinding energy and coefficient of friction surface roughness was also measured. Result tell us the calculated values of air pressure, gas liquid ratio and fluid flow rate.

Kedare, Borse et al. (2014) investigated the effect of Minimum Quantity Lubrication on the surface roughness of mild steel of 15HRC on universal milling machine. During milling operation, the effect of speed, feed and depth of cut were studied upon surface finish during milling operation. The end milling was performed under the Minimum Quantity Lubrication condition (900ml/hr.). This was compared with the conventional flooded lubrication (2liter/min). Results showed that the surface finish had been considerably increased. Due to reduced cutting temperature, the cutting performance was much better

De Jesus Oliveira, Guermandi et al. (2012) investigated the experiments using grinding on AISI 4340 quenched, tempered steel and a vitrified cubic boron nitrate wheel. Various output variables were measured like surface roughness, diametrical wheel wear, metallographic images of ground surface, subsurface. It was found that MQL technique, with cleaning compressed air jet proved to be extremely efficient improving the surface finish and reducing the wear of wheel Company to other lubrication methods.

III. EXPERIMENT PROCEDURE

Selection of the Material

I had selected AISI 4130 material for my research work. It has low carbon content. AISI 4130 contains chromium and molybdenum as strengthening agents. It can be welded easily because of its low carbon content. The work piece has the dimensions 100*12*15 mm. It has the composition of different elements such as Cr, Mo, C, Mn, P, S, and Si. It is a low alloy steel which has hardness of B (90-96) and tensile strength (590Mpa-760Mpa). This material is used for the structural work such as Aircraft engine mounting and welding tubing.

Selection of the Process Parameters

The research has been carried out to evaluate the effect of the various process parameters on the operation of grinding. I have studied the effect of different types of vegetable oils, flow rates and at different pressures. I have selected the groundnut oil, sunflower oil and soyabean oil. I had compared these at different pressures and different flow rates. At the end all these were compared with the flood coolant.

Selection of the Machine

The grinding machine required to perform the necessary operation which I selected was a surface grinder. This surface grinder was placed in KAY JAY FORGING PVT. LTD. Ludhiana. It fulfilled all our requirements of varying depth of cut. Its least count was0.004 mm. It can be operated manually or automatically according to our requirement. It was having magnetic bed, with the help of which we did not need to clamp our dynamometer.

Experiment

The experiment was performed in the KAY JAY Forging pvt. Ltd Ludhiana. The experimental setup has been properly arranged. The dynamometer was held by the magnetic field of the magnetic bed. The vice to hold the work piece is clamped on the dynamometer. Thermocouple is also used to calculate the temperature readings during experiment. The required compressor was connected to the nozzles to provide the required pressure of air-oil mixture. After all this experimental setup has been arranged, the experiment was performed and the readings were calculated at the required times.

GRINDING MODE	Surface grinder
WHEEL SPEED	22 m/s
TABLE/WORK SPEED	0.66 m/s
DEPTH OF CUT	30 µm
GRINDING PASSES	20
GRINDING ENVIORNMENT	MQL, Flood cooling
VEGETABLE OIL	Soybean oil, Sunflower oil, Groundnut oil
MQL FLOW RATE	80, 120 and 160 ml/hr.
AIR PRESSURE	4, 5 and 6 Bar
FLOOD CUTTING FLUID	Water soluble servo oil
FLOOD CUTTING FLOW RATE	8000 hr.

IV. METHODS

Taguchi Method

The most important part of the research is analyzing the results obtained. There are various methods to analyze the results. I have used taguchi method for the required analysis. This method improves the consistency of the production and determines the controllable or uncontrollable variables. Taguchi design tries to identify the controllable factors or variables that can minimize the effect of uncontrollable factors or variables.

L_9 ARRAY

According to the number of experiments, the orthogonal array is selected. Suppose if u have 3 numbers of variables with their 3 levels, then the number of experiment will be 9. After selecting the orthogonal array the next step is to put the controllable variable in the columns and then afterwards perform the experiment. I had selected 3 controllable variables that can be controlled or manipulated easily. These 3 variables were vegetable oils, oil flow rate, and pressure of oil. From these 3 variables and their 3 levels, I had selected L9 orthogonal array in which 9 experiments are to be performed. In this research we find the sunflower oil is the best oil as compared to soya bean and groundnuts oil. The sunflower is more viscosity. It causes they can be helped to reduce the temperature and grinding forces of the work piece. The flow rate 180ml/hr and pressure 6 bar causes reduction in grinding forces and grinding temperature due to more quantity of oil makes a lubricating film over the surface of the work piece and heat is transferred to the surroundings

V. RESULTS

I had applied Taguchi method in order to obtain the required results. I had selected the L9 array for the required comparison of the various readings. The readings were formulated in tables and these were presented over bar graphs with the help of Minitab software which is statistical analysis software. The results obtained were discussed to know the reason behind the result. All the effects of Vegetable oils, flow rates and pressure were compared with that of the flood coolant.

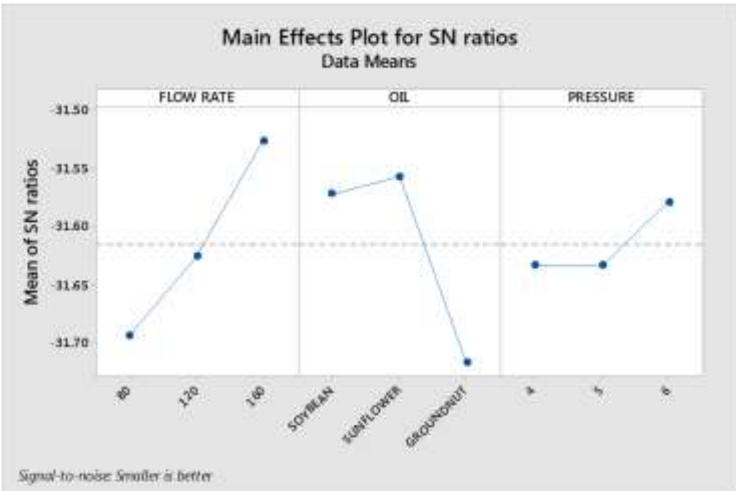

Figure: Main Effects Plot For S/N Ratio Of Temperature

The flow rate 180ml/hr and pressure 6 bar causes reduction in grinding forces and grinding temperature due to more quantity of oil makes a lubricating film over the surface of the work piece and heat is transferred to the surroundings.

VI. CONCLUSIONS

Among the three vegetable oils, sunflower generates the lowest grinding force and also exhibits the lowest grinding temperature. Soyabean oil yields the second lowest grinding force. Therefore the sunflower oil is obtained as the better oil among the three oils.

It has been observed that as the flow rate increases from 80 to 120 ml/hr. there is reduction in grinding forces and grinding temperature due to more quantity of oil makes a lubricating film over the surface of the work piece and heat is transferred to the surroundings. This provides cooling effect which leads to reduction in grinding forces and temperature.

Minimum quantity lubrication proves to be environment friendly and cost effective as cutting fluids required for machining is comparatively less than the flood cooling.

VII. FUTURE SCOPE

In our research, they were used in the minute quantities at the different value of flow rates and pressure. Vegetable oils are able to replace the highly toxic cutting fluids. This study has identified several future directions for the development of MQL using different vegetable oils which are as follows

- The research can be performed on new vegetable oils taking their lubricating properties in mind.

- The research may include the use of the nanofluids which can be proved useful in assisting the various lubrication and temperature reducing properties.

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