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Case Study on Effect of Cutting Fluids in Turning Operation

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Abstract: **The development of lubricants like, cutting fluids was traditionally based on mineral oil as a base Fluid. This fact is related to the technical properties and the reasonable price of mineral oils. Cutting fluids are used widely to reduce the negative effects of the heat and friction on both tool and workpiece. The cutting fluids generally produces three positive effects in the process such as heat removal, lubrication on the chip–tool interface and chip removal. Issues of using fluids in machining related to environment, health, and manufacturing cost that need to be solved and options to reduce their use has to be accomplished. Hence there arises the need for an ecologically benign metal working fluid in machining operations. A comparative study of Dry Machining and Wet Machining where rice bran oil and coolant oil (Shell Tellus-40) is used as the cutting fluid serves as the scope of this study. The results obtained with conventional flood cooling method are compared with that of Dry cutting. The experiment is carried out in a CNC lathe for turning operation on plain carbon steels EN8 and EN9 for surface roughness and tool life by varying parameter like Cutting speed and Feed keeping depth of cut constant.**

Keywords: **cutting fluids, CNC lathe, technical properties and the reasonable price of mineral oils.**

1. INTRODUCTION

Cutting fluids are used to reduce the effects of the heat and friction on both tool and workpiece. The cutting fluids generally produce positive effects in the machining processes such as heat elimination, lubrication on the chip–tool interface and chip removal. The heat generated at the tool-chip interface during a machining process is critical for work piece quality. The cutting fluids which are widely used to carry away the heat generated at the tool-workpiece interface in machining do not possess a pathogenic clinical history and are relatively free from inherent hazards. Hence there arises a need to develop an eco-friendly and user friendly cutting fluid over conventional cutting fluids. Rice bran oil has been used as one of the cutting fluids in this work because of its thermal and oxidative stability which is higher than that of other vegetable based cutting fluids used in machining industries.

1.1 properties of rice brawn oil:

Rice bran oil is being used as one of the cutting fluids in this work because of its good thermal conductivity and oxidative stability. It has been found that Rice bran oil improves the tool life with a better surface finish for machining at low and medium cutting speed. Use of cutting fluids in machining processes can reduce the cutting temperature and provides lubrication to tool and workpiece. These add to longer tool life and improved surface quality.. Hence there arises the need for an ecologically benign metal working fluid in machining operations. Rice bran oil has been tested for use as a feedstock for biodiesel to be used as a diesel engine fuel. In this manner, it can be applied to power generators and transport using diesel engines. The oil must meet the Weihenstephan standard for pure vegetable oil used as a fuel, otherwise moderate to severe damage from carbonisation and clogging will occur in an unmodified engine.

2. LITERATURE REVIEW

D. P. Adler et.al examined the Role of Cutting Fluids in Machining and Environmental or Health Concerns to reduce or eliminate the concerns associated with cutting fluid usage [1]. Cutting fluids have seen extensive use and have been commonly viewed as a required addition to high productivity and high quality machining operations. Cutting fluids related cost and health issues associated with exposure to cutting fluid mist and a growing desire to achieve environmental sustainability in manufacturing have caused industry and academia to re-examine the role of these fluids and quantify their benefits.

In sustainable machining concept, the introduction of coolant techniques such as semi-dry machining so called minimum quantity lubrication (MQL)[2] and cryogenic coolant have shown promising performances in terms of cutting tool life. Nowadays, MQL is widely used in machining performances. The increasing requirements in machining operations for higher performance and higher efficiency respecting also environmental phenomena are influencing the use of different coolants and flushing conditions [3]. In machining difficult-to-cut materials, in particular high-temperature materials, conventional wet cooling is unsuitable due to the insufficient cooling effect and the energy and cost intensive equipment required.

Monith Biswojyothi et.al [4] investigated the grinding of Titanium alloy Ti-6Al-4V with minimum quantity lubrication conditions. In order to maintain a good surface integrity and to improve the grindability of Ti-6Al-4V experiments were conducted by varying different MQL parameters. The studies conducted allowed development of the technological systems of environmentally friendly dry machining with compensation of physical effects of cutting fluids, which is desired to be used to replace traditional machining technologies with use of cutting fluids [5]. The use of vegetable oils [6] may allow this mixture, to make possible the development of a new generation of cutting fluids where high performance in machining could be combined with good environment compatibility. Interest in vegetable oil-based cutting fluids is growing. Compared to mineral oil, vegetable oil can overall enhance the cutting performance, extend the tool life and improve the surface finishing according to some recent analysis from industry.

3. MATERIAL SPECIFICATION & MACHINE DETAILS

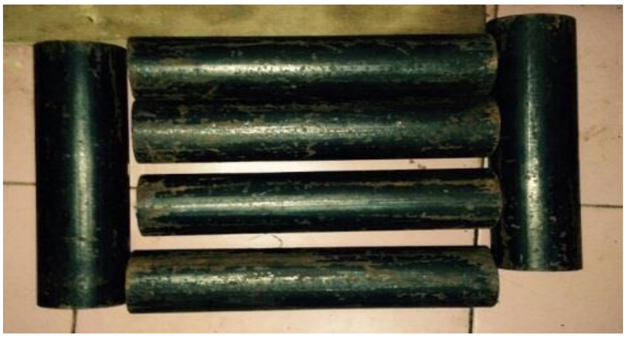
The materials that are chosen this work are EN8 (AISI 1040) and EN9 (AISI 1055) plain carbon steels. The mechanical properties are shown in the table below.

Table no. 4.1 specimen properties

MECHANICAL PROPERTIES	EN 8 (AISI 1040)	EN 9 (AISI 1055)
Hardness	201-255 BHN	170-255 BHN
Yield Stress	495N/mm²	310-355 N/mm^2
Max stress	700-850 N/mm²	600-700 N/mm^2

Chemical composition:

EN 8 (AISI 1040)	C 0.36-0.44%, Si 0.10-0.40%, Mn 0.60-1%, S .050 Max, P .050 Max
EN 9 (AISI 1055)	C 0.50-0.60%, Si 0.05-0.35%, Mn 0.50-0.80%, S .060 Max, P .060 Max



Workpiece material EN8 & EN9

EN9 is a medium carbon steel usually supplied in the black condition untreated annealed. EN9 can be surface hardened to produce a high surface hardness with good wear resistance for a carbon steel. EN9 is general engineering applications including blades, bushes, crankshafts, screws, and wood working drills. In the normalised condition EN9 can be very well used for gears, sprockets and cams.

EN8 is a popular grade of through-hardening medium carbon steel, which is machinable in any condition.EN8 is suitable for the manufacture of parts such as axles, shafts, gears, bolts etc. It can be further surface-hardened typically to 50-55 HRC by induction processes, producing components with highly enhanced wear resistance. For such applications the use of Both the material size is taken at 60mm dia and 200mm length.

CNC Machine-HMT STALLION 100MS

4. EXPERIMENT DESCRIPTION

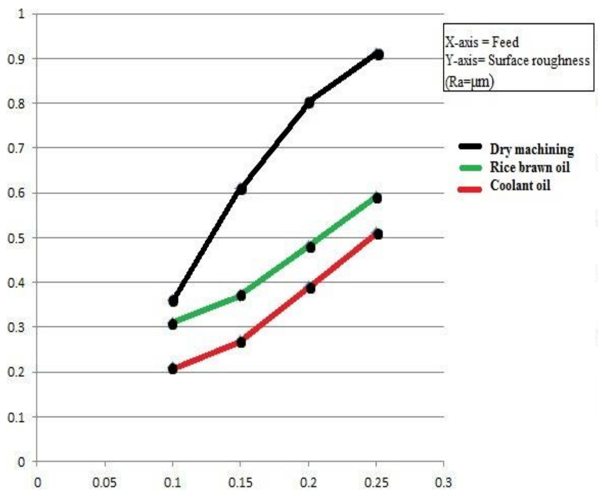
The machining was conducted on CNC lathe HMT stallion 100MS, the maximum chuck dia is 200 mm and the speed range is from 100 to 3000 rpm. The tool material is selected to be coated carbide tool insert. The coated carbide tool has an ISO designation of CNMG 120408 with a wiper geometry on its nose radius of 0.8 mm. It was mounted on the tool holder giving -5° side and back rake angle, 5° side and end cutting edge angle and 0° relief angle. The life of carbide tool insert is 15 min considering heavy machining. The workpiece material selected is EN8 (AISI 1040) and EN9 (AISI 1055). Both the specimens are cut to 200mm length and diameter taken is 60mm. The measured responses were tool life and surface roughness. The criterion of tool life was set at maximum flank wear on visual inspection or when the tool is broken (catastrophic failure). The carbide tool life is estimated to be 15 min under optimum or low machining conditions.

Experiments were conducted for turning operation under varying speed and feed, depth is taken as constant. The cutting fluids that are used are rice bran oil and coolant oil (Shell Tellus grade-40). The experiment commences with dry machining (no coolant assistance) upon the workpiece specimen followed by the wet machining (coolant assisted) on CNC lathe. Set of experiments are done by varying the speed, feed and depth is kept constant for dry machining and wet machining with rice bran oil and coolant oil. Both the coolants were introduced to the tool chip interface via hand pumps having adequate flow rate. The experimental results are obtained and are later optimized for surface roughness and tool life using simulated annealing technique. The essential properties of Rice bran oil are good thermal conductivity and oxidation stability followed by good lubricating properties moreover it is degradable. The viscosity of rice bran oil is 41cp.

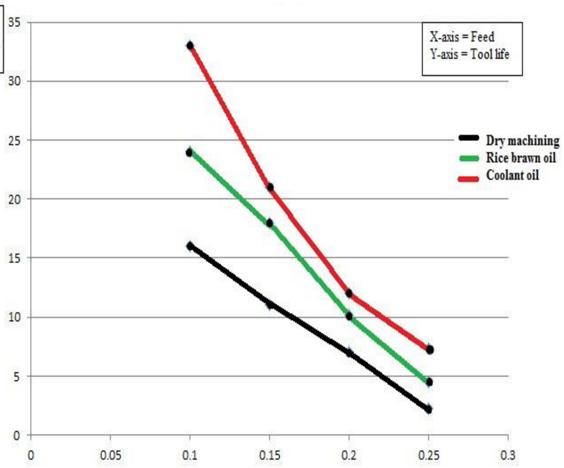
5. RESULTS

Experimental result of EN8

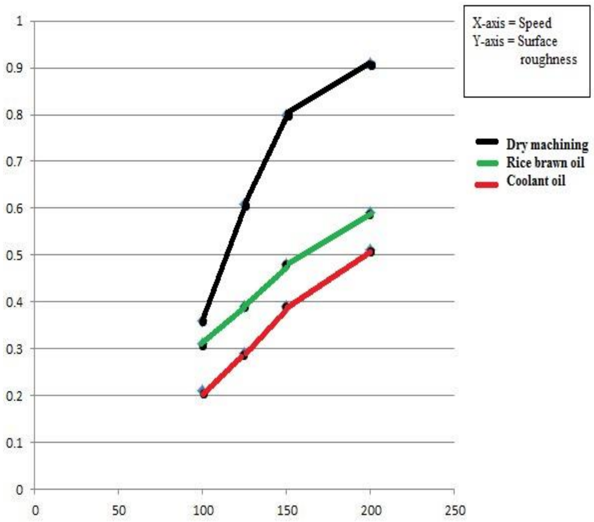
Machining Process	Speed rpm	Feed mm/rev	Tool life Min (Approx.)	Surface roughness(μm)
Dry	100	0.10	16	0.36
Dry	125	0.15	11	0.61
Dry	150	0.20	7	0.84
Dry	200	0.25	2.3	0.91
Wet r.o	100	0.10	24	0.31
wet r.o	125	0.15	18	0.37
wet r.o	150	0.20	10.2	0.48
wet r.o	200	0.25	4.5	0.59
wet c.o	100	0.10	33	0.21
wet c.o	125	0.15	21	0.27
wet c.o	150	0.20	12	0.39
wet c.o	200	0.25	7.3	0.51



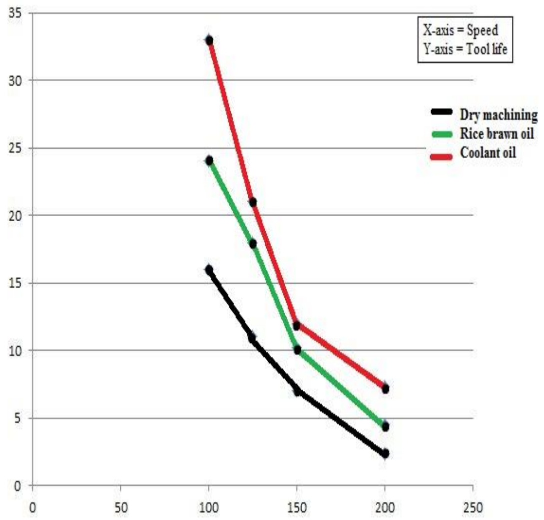
Feed (mm/rev) Vs Surface roughness (µm) of EN8



Graph of Feed (mm/rev) Vs Tool life (min) of EN8



Speed (rpm) Vs Surface roughness (µm) of EN8

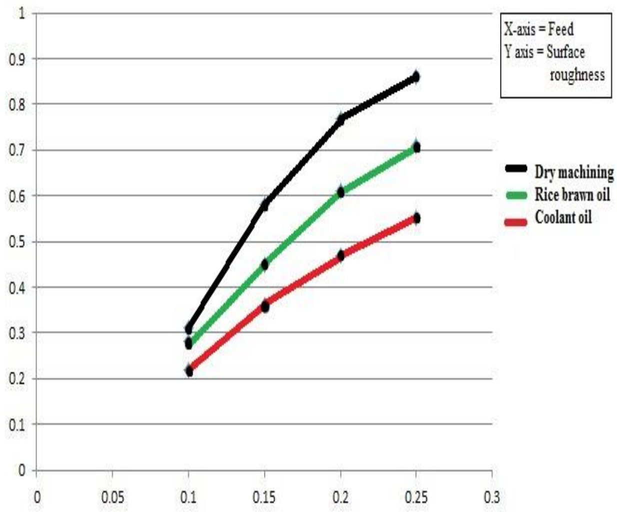


Graph of Speed (rpm) Vs Tool life (min) of EN8

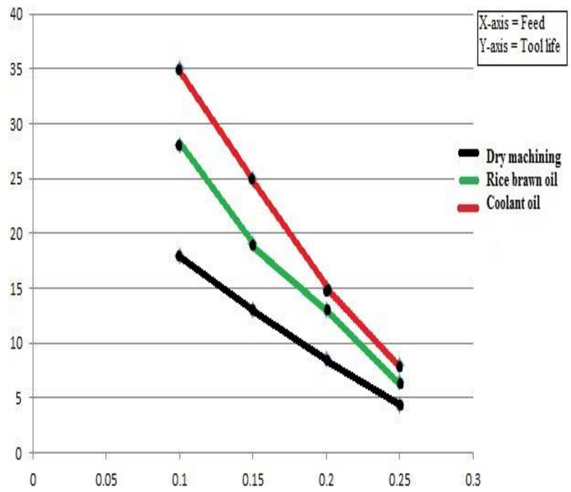
R.o and c.o represents rice bran oil and coolant oil respectively. The surface roughness was measured using surface roughness tester. Graphs are plotted for Feed Vs Surface roughness, Feed Vs Tool life, Speed Vs Tool life and Speed Vs Surface roughness respectively.

Experimental result of EN9

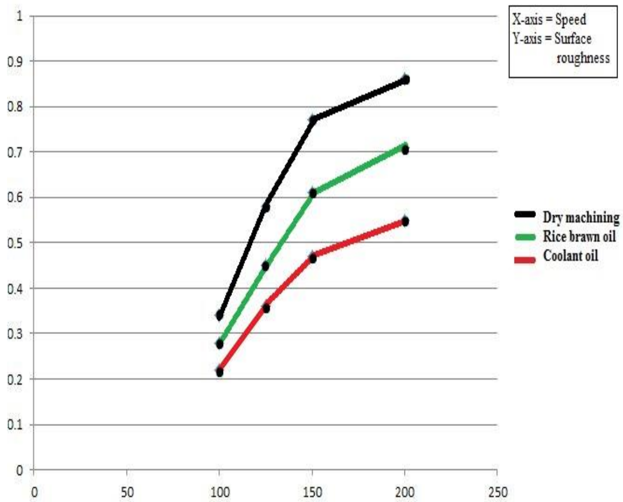
Machining Process	Speed rpm	Feed mm/rev	Tool life min	Surface roughness(µm)
Dry	100	0.10	18	0.31
Dry	125	0.15	13	0.58
Dry	150	0.20	8.6	0.77
Dry	200	0.25	4.3	0.86
Wet r.o	100	0.10	28	0.28
wet r.o	125	0.15	19	0.45
wet r.o	150	0.20	13	0.61
wet r.o	200	0.25	6.4	0.71
wet c.o	100	0.10	35	0.22
wet c.o	125	0.15	25	0.36
wet c.o	150	0.20	15	0.47
wet c.o	200	0.25	8	0.55



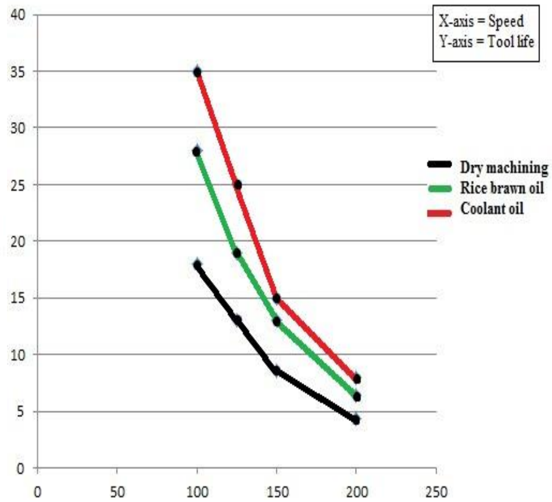
Feed (mm/rev) Vs Surface roughness (μm) of EN9



Graph of Feed (mm/rev) Vs Tool life (min) of EN9



Speed (rpm) Vs Surface roughness (μm) of EN9



Speed (rpm) Vs Tool life (min) of EN9

6. CONCLUSION

From the experiment it is evident that the cutting fluids have influence over machining parameters. The experiment was carried out on a CNC lathe for turning operation. The parameters varied were Feed and Speed, keeping depth of cut constant. Results were obtained for the set of experiments carried out for Feed Vs surface roughness, Feed Vs tool life, Speed Vs surface roughness and Speed Vs tool life. Results indicate that the cutting conditions obtained for Coolant oil (Shell Tellus) is higher than Rice bran oil. Considering the economical and environmental factors, the use of mineral oils extracted from petroleum products has to be limited as they adversely affect the environment due to its non-degradability. This study is aimed to derive an ecologically benign property through the comparison between Dry and wet machining using Rice bran Oil and Coolant oil as cutting fluids. The effects of both these fluids on machining processes are identified experimentally and are plotted to reach onto a valid conclusion.The results indicate that the best cutting conditions were obtained for Coolant oil, followed by Rice bran oil. Rice bran oil when compared to Coolant oil is available at low cost, it possesses sufficient viscosity of 41cp, good oxidation stability and thermal properties moreover it is degradable. Hence it can be concluded that, the vegetable based coolant derivatives possess good properties and stands next to the coolants derived from petroleum products. Vegetable based coolants can be well utilized as a suitable and possible alternative for mineral oil based coolants considering the environmental issues of pollution and wastage accumulation.

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