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Effect of Different Cutting Tools in Turning Operation – A Comparative Study to Ensure Green Performance

Suvayu Sarkar, Ankur Das
Brainware Group of Institutions,IndiaStudent of the Department of Mechanical Engineering
Brainware Group of Institutions, India
Assistant Professor of the Department of Mechanical Engineering
Corresponding Author: Suvayu Sarkar

ABSTRACT
Machining depends on various input parameters such as selection of various cutting tool, variation of speed, depth, feed, selection of cutting fluid etc. Ecological and Environmental aspects are being considered while doing this project. The purpose of this project is focussed on study of speed, surface roughness, cutting forces and power consumption on a centre lathe using single point cutting tool. The tools selected are Carbide and Ceramic. Various cutting fluid are also used such as vegetable oil, palm oil, soya oil etc. The aim of this project is to do a case study varying the various parameters and find the most eco friendly and least power consumed procedure which will benefit the Environment. Further, the selection of cutting tool will be done by the different Multi criteria decision making (MCDM) techniques which enhance the green performance of machine.

Keywords: Ecological, Environmental ,Carbide, Ceramic, MCDM

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I. INTRODUCTION

Machining is the process of removing unwanted material from work piece in the formation of chips. To perform the operation a relative motion is required between the tool and work piece. A cutting tool exerts a compressive force on the work piece which stresses the work material beyond its yield point and therefore material deforms plastically and shears off. Plastic flow takes place in a localized region called shear plane. The sheared material begins to flow along cutting tool face in form of chips. The flowing chips cause tool wear. The heat produced during shearing action raises temperature of work material, cutting tool and chips. Temperature rise in the cutting tool softens it and causes loss of keenness in the cutting edge leading to failure.

There are various machining operations, each of which is capable of generating a certain part geometry and surface texture. In turning a cutting tool with a single cutting edge is used to remove material from a rotating work piece to generate cylindrical shape. Drilling is used to create a round hole and is accomplished by a tool that has two or four helical cutting edge. In boring a tool with single bent pointed tip is advanced into roughly made hole in a spinning work piece to slightly enlarge the hole and improve its accuracy. In milling a rotating tool with multiple cutting edges is moved slowly relative to the material to generate a plane or straight surface. There are also other conventional machining processes like shaping, planning, broaching, sawing, grinding etc.

The Machining process is a complex process since it includes lot of input variables like right selection of tool, use of lubricant, use of coolant etc. It is very much necessary to achieve some factors in metal cutting such as optimizing tool life in order to minimize production cost, maximizing production rate to reduce production cost .Optimum speed must be selected. If cutting speed is reduced in order to enhance tool life the material removal rate is reduced and production cost is increased. Besides such process causes ill effects in environment thus the concept of green machining or green manufacturing emerges.

A significant shift in manufacturing techniques is being noticed in developed economics all over the world. Smarter and leaner production techniques have been displaced inefficient means of production. On a more noticeable level hybrid vehicles are beginning to populate our roads. The term 'Green Manufacturing' has established itself in the vocabulary of engineers and the manufacturing professionals.

Green Manufacturing is generally defined as 'elimination of waste by re-defining the existing production process or system'. This manufacturing concept is not just restricted to addressing the social and environmental impact of a pollution-centric process. Green manufacturing addresses process redundancy, ergonomics and cost implications due to faulty methods of producing goods. Faster and cheaper are no longer the only two criteria in manufacturing a product or evaluating an existing process line. Several other factors such as materials used in manufacturing, generation of waste, effluents and their treatment (or possible elimination), life of the product and finally, the treatment of the product after it useful life are all useful considerations. Green manufacturing can lead to lower raw material costs (recycling wastes, rather than purchasing virgin materials), production efficiency gains, reduced environmental and occupational safety expenses and improve corporate image

In general, Green manufacturing involves production processes which use inputs with relatively low environmental impacts, which are highly efficient and which generate little or no waste or pollution. Green manufacturing encompasses source reduction (also known as waste or pollution minimization or prevention), recycling and green product design. Source reduction is broadly defined to include any actions reducing the waste initially generated. Recycling includes reusing wastes as ingredients in a process or as an effective substitute for a commercial product, or returning the waste to the original process which generated it as a substitute for raw material feedstock. Green product design involves creating product whose design, composition and usage minimizes their environmental impacts throughout their lifecycles.

II. LITERATURE SURVEY

Saleem et al. (2013) proposed that the use of Biodegradable oil can be an alternative source of lubricant .This paper reports the experimental results of using Mustard oil (vegetable oil) with MQL as an alternative cutting fluid while performing Turning operations on a Centre lathe machine using single point cutting tool of H.S.S. Results on tool life and tool wear were compared against other conventional coolants such as (10%Boric acid +SAE-40 Base oil) and (10% MoS_2 +SAE-40 Base oil). Machine trial were performed on a solid cylindrical work piece of mild steel at constant rotation of 250 rpm and with a single point cutting tool of high speed steel(H.S.S). [1]

Junyan et al. (2010) proposed that the important implementation of stricter Environmental Protection Agency regulations associated with the use of ample amount of coolants and lubricants has led to this study on a new green machining technology with application of water vapor as coolants and lubricants in cutting Ni-based super alloys and titanium alloy Ti-6Al-4V with uncoated carbide inserts (ISO Type K10). The purpose of this paper is to show that machining technology with application of water vapour could be an economical and environmentally compatible lubrication technique for machining difficult-cut-materials. [2]

Park et al. proposed that Minimum quantity lubrication (MQL) has been used as an alternative solution for flood cooling as well as dry machining. However, the benefit of MQL is only realized in mild machining conditions as the heat generation during more aggressive machining conditions cannot be effectively eliminated by the small amount of oil mist being applied during MQL process. To extend the applicability of MQL to more aggressive machining conditions, we have developed a potential additive to MQL lubricant. [3]

Siniawski& Bowman et al. (2011) proposed that a practical review of metal working fluids and their implications to the machining practice. Despite their widespread use and applications, there are several scientific and economic factors that call for an investigation of current practices and development of new approaches.

There are numerous methods that diverge from traditional “wet” machining, which move towards an environmentally friendly and cost effective machining process.[4]

Kolawole&Odusote et al. (2013) proposed that vegetable oils are being investigated to serve as a possible replacement for non-biodegradable mineral oils, which are currently being used as base oil in cutting fluids during machining processes. In this present study, the performances of palm oil and groundnut oil were compared with that of mineral oil-based cutting fluid during machining operation of mild steel. Temperature of the work pieces as well as their chip formation rates using these vegetable oils as cutting fluids under different cutting speed (rev/min), feed rate (mm/rev) and depth of cut (mm) were compared with that of mineral oil and dry machining. [5]

Khan &Dhar et al. (2006) proposed that Metal cutting fluid changes the performance of machining operations because of their lubrication, cooling and chip flushing functions, but the use of cutting fluid has become more problematic in terms of both employee health and environmental pollution. The minimization of cutting fluid also leads to economical benefits by way of saving lubricant costs and work piece/tool/machine cleaning cycle time.[6]

Adam et al. (2011) purposed a project research is focused on the study of surface roughness and chip formation during milling operation of Mild Steel using vegetable based oil as a lubricant. Experimental set up designed by using milling machine. Taguchi Method of Orthogonal

Array with factorial design of experiments used to analysis the response. Surface roughness and chip formation predicting models was developed by using experimental data and analysis of the present lubricant and vegetables based oil. In the development of predictive models, cutting parameters of cutting velocity, feed rate, and depth of cut were considered as model variables. [7]

Lawal et al. (2012) suggested about the advantage of cutting fluids and the its performances with respect to the cutting force surface finish of work piece, tool ware and temperature at the cutting zone . In this paper,the applicability of vegetable oil – based cutting fluid and as a result investigation is being made reduction of use in mineal oil based cutting fluid [8]

III. OBJECTIVE

The use of vegetable oils for lubrication purposes have been practiced for many years. They are easily obtained from nature. Vegetable oil has excellent lubricant ability and superior than mineral oil. Vegetable oils are eco friendly because they are excellent lubricant, biodegradable, viscosity.

Taking into consideration of above the project work a plan has been made to investigate and identify the effect of some input parameters on the quality of surface and cutting force while using vegetable oil as cutting fluid. The input parameters taken in consideration are speed, feed, depth of cut. The output parameters calculated are cutting force, surface roughness, Metal removal rate and power consumed.

IV. EXPERIMENTATION

4.1. Tool and workpiece

Machine	Centre Lathe
Operation	Turning
Job material	Mild Steel round bar (300mmX75mm)
Tool material	1)HSS 2)Tungsten carbide
Tool holder	Tool post with 3-D force measuring dynamometer

4.2. Selection of Cutting parameters

Three cutting parameters namely spindle speed, feed and depth of cut have been selected by prior experimentation within the range of available values of cutting parameters in the cutting tools.

Spindle speed (rpm)	455, 215, 95
Feed (mm/min)	0.1, 0.5, 0.25
Depth of cut (mm)	1, .4, .2

4.3. Cutting fluids

1) Sunflower oil
2) Mustard oil
3) Soya bean oil
4) Conventional cutting fluid

4.4. Other tools

1) Force dynamometer
2) Surface roughness tester (range- -200µm - 150µm)

4.5 Arrangement of the experiment

1) Work piece preparation
2) Bucket with pipe line for coolant flow (Ø5mm, PVC made)
3) Stand for coolant store
4) 4 Empty bottles to collect used coolant
5) Steel pipe (1/2 inch) to be used as nozzle
6) Tray to collect cutting fluid (plastic)
7) Setup of talysurf and force dynamomter
8) Plastic funnel, brush etc.

4.6 Experimental procedure

1) Lathe is prepared for the experiment
2) Job is hold at chuck
3) The HSS cutting tool is installed
4) Cooling arrangement is prepared and installed in the machine to pour the cutting fluid on machining zone through a connected pipe under effect of gravity. (All coolants are used one by one)
5) The cutting force and surface roughness are measured in different cutting condition.
6) Similar procedure is followed while using tungsten carbide tool.
7) Finally MRR, Cutting force, Power are calculated and optimized cutting condition are analyzed by AHP.

V. RESULTS AND DISCUSSION

Five cutting conditions were considered while performing the experiment:-
1) 3 vegetable oils
2) Conventional cutting fluid
3) Dry cut

The Forces were measured by a lathe dynamometer (Px,Py,Pz) and also the surface roughness using a talysurf for given speed feed and depth of cut. Data were collected in form of table and graphs are plotted.Two cutting tools were used (a) HSS cutting tool (b) Carbide tool.

HSS Turning Tool

5.1 No Coolant:

Result:

All the values of using speed, feed rate, depth of cut, surface roughness, cutting force is given in the following table.

Table – 5.1 Observation Table

Sl. No.	Speed RPM	FeedRate (mm/s)	Depth ofCut (mm)	CuttingV elocity (mm/s)	Cutting Forces			Surface Roughness(Ra) µm	MRR (mm^3/s)	Power consumption (Watt)
					Px (N)	Py (N)	Pz (N)			
1	455	0.066	0.05	1762.95	4	1	2	0.385	1.501	3525.9
2	455	0.083	0.25	1762.95	8	6	4	0.180	9.441	7051.8
3	455	0.125	0.5	1762.95	4	5	7	0.170	28.23	12340.65
4	455	0.066	0.05	1762.95	5	8	7	0.202	1.501	12340.65
5	215	0.066	0.25	833.04	2	6	4	0.045	3.547	3332.16
6	95	0.066	0.5	368.08	7	5	7	1.959	3.135	2576.5
7	455	0.066	0.25	1762.95	4	7	6	0.007	0.742	10577.7
8	215	0.083	0.25	833.04	3	8	6	0.443	4.461	4998.24
9	95	0.125	0.25	368.08	5	7	6	0.009	2.968	2208.48
Mean value								0.486	6.16	6550.23

Surface roughness:
The variation of surface roughness (Ra) with material removal rate is shown in fig

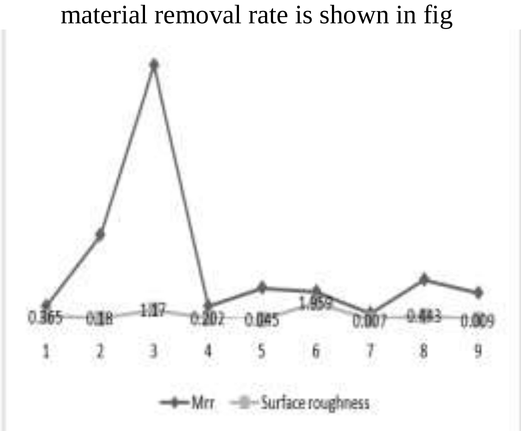


Fig.-6.1: Material removal rate vs surface roughness

The values of different material removal rates against surface roughness are presented by the plot. Firstly, the values of surface roughness increase with increasing of MRR value.

Cutting force:
The variation of cutting force (Pz) with material removal rate is shown in figure

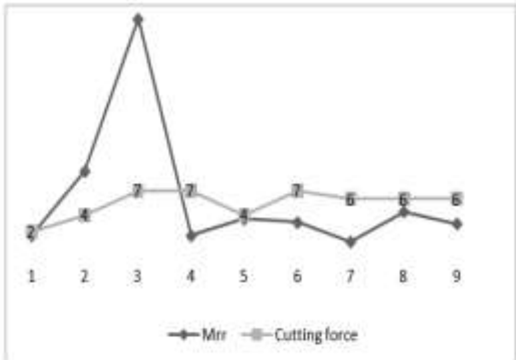


Fig.-5.2: Material removal rate vsCutting force (Pz)

The values of cutting force (Pz) against different material removal rates are presented by the plot. In this plot is shown that with higher MRR the cutting force increases and with lower MRR cutting forces Decreases.

5.2 Soya bean Oil:
Result:
All the values of using speed, feed rate, depth of cut, surface roughness, cutting force is given in the following table.

Table – 5.2 Observation Table

Sl. No.	Speed RPM	FeedRate (mm/s)	Depth ofCut (mm)	CuttingVelocity (mm/s)	Cutting Forces			Surface Roughness (Ra)	MRR (mm^3/s)	Power consumption (watt)
					Px (N)	Py (N)	Pz (N)			
1	455	0.066	0.05	1739.13	0	1	5	0.080	1.501	8695.65
2	455	0.083	0.25	1739.13	3	7	5	0.248	9.441	8695.65
3	455	0.125	0.5	1739.13	10	8	8	0.541	28.23	13913.04
4	455	0.066	0.05	1739.13	0	1	6	0.594	1.50	10434.78

									1	
5	215	0.066	0.25	821.78	2	5	7	0.261	3.547	5752.46
6	95	0.066	0.5	363.11	4	4	8	0.111	3.135	2904.88
7	455	0.066	0.25	1739.13	4	9	6	0.169	0.742	10434.78
8	215	0.083	0.25	821.78	4	10	7	0.072	4.461	5752.46
9	95	0.125	0.25	363.11	4	4	7	0.373	2.968	2541.77
Mean value								0.272	6.16	7680.60

Surface roughness:
The variation of surface roughness (Ra) with material removal rate is shown in fig

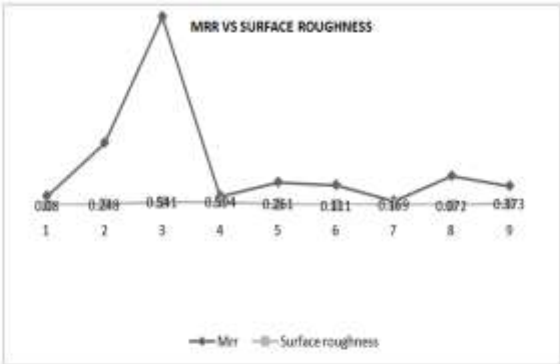


Fig.-5.3: Material removal rate vs surface roughness

The values of different material removal rates against surface roughness are presented by the plot. Firstly, the values of surface roughness increase with increasing of MRR value.

Cutting force:
The variation of cutting force (Pz) with material removal rate is shown in figure

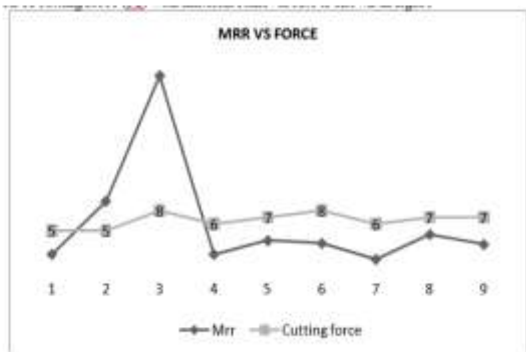


Fig.-5.4: Material removal rate vsCutting force (Pz)

The values of cutting force (Pz) against different material removal rates are presented by the plot. In this plot is shown that with higher MRR the cutting forces increases and with lower MRR cutting force Decreases.

5.3 Sunflower oil coolant:
Result:
All the values of using speed, feed rate, depth of cut, surface roughness, cutting force is given in the following table.

Table – 5.3 Observation Table

Sl. No.	Speed In RPM	Feed Rate (mm/s)	Depth of Cut (mm)	Cutting Velocity (mm/s)	Cutting Forces			Surface Roughness (Ra)	MRR (mm^3/s)	Power consumption (watt)
					Px (N)	Py (N)	Pz (N)			
1	455	0.066	0.05	1715.30	4	7	3	0.006	1.501	5145.9
2	455	0.083	0.25	1715.30	4	8	3	0.007	9.441	5145.9
3	455	0.125	0.5	1715.30	6	9	16	0.008	28.23	27444.8
4	455	0.066	0.05	1715.30	4	8	2	0.007	1.501	3430.6
5	215	0.066	0.25	810.53	4	9	2	0.007	3.547	1621.06
6	95	0.066	0.5	358.14	4	8	10	0.015	3.135	3581.4
7	455	0.066	0.25	1715.30	3	5	3	0.006	0.742	5145.9
8	215	0.083	0.25	810.53	2	4	2	0.006	4.461	1621.06
9	95	0.125	0.25	358.14	4	2	9	0.008	2.968	3223.26
Mean value								0.0077	6.16	6262.20

Surface roughness:
The variation of surface roughness (Ra) with material removal rate is shown in fig

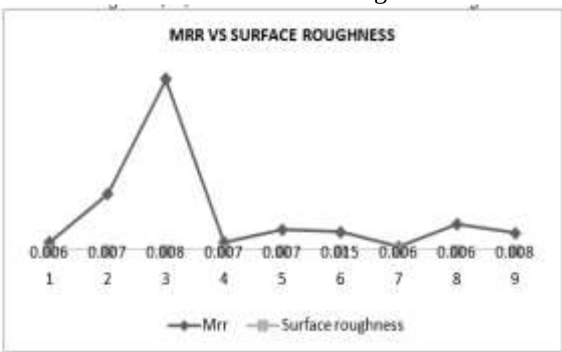


Fig.-5.5: Material removal rate vs surface roughness

The values of different material removal rates against surface roughness are presented by the plot. Firstly, the values of surface roughness increase with increasing of MRR value.

Cutting force:
The variation of cutting force (Pz) with material removal rate is shown in figure

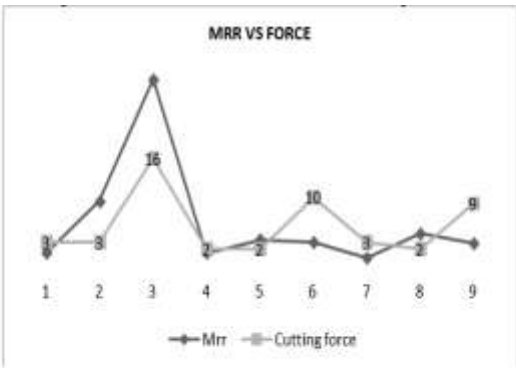


Fig.-5.6: Material removal rate vsCutting force (Pz)

The values of cutting force (Pz) against different material removal rates are presented by the plot. In this plot is shown that with higher MRR the cutting forces increases and with lower MRR cutting force Decreases.

5.4 Mustard oil coolant:

Result:

All the values of using speed, feed rate, depth of cut, surface roughness, cutting force is given in the following table.

Table – 5.4 Observation Table

Sl. No.	Speed In RPM	Feed Rate (mm/s)	Depth of Cut (mm)	Cutting Velocity (mm/s)	Cutting Forces			Surface Roughness (Ra)	MRR (mm^3/s)	Power consumption (watt)
					Px (N)	Py (N)	Pz (N)			
1	455	0.066	0.05	1691.48	4	0	3	0.006	1.501	5074.44
2	455	0.083	0.25	1691.48	5	5	4	0.006	9.441	6765.92
3	455	0.125	0.5	1691.48	11	9	3	0.007	28.23	5074.44
4	455	0.066	0.05	1691.48	0	2	15	0.007	1.501	25372.2
5	215	0.066	0.25	799.27	6	7	15	0.007	3.547	11989.05
6	95	0.066	0.5	353.16	8	12	3	0.007	3.135	1059.48
7	455	0.066	0.25	1691.48	8	15	3	0.008	0.742	5074.44
8	215	0.083	0.25	799.27	8	14	4	0.007	4.461	3197.08
9	95	0.125	0.25	353.16	11	18	3	0.007	2.968	1059.48
Mean value								0.0068	6.16	7185.17

Surface roughness:
The variation of surface roughness (Ra) with material removal rate is shown in fig

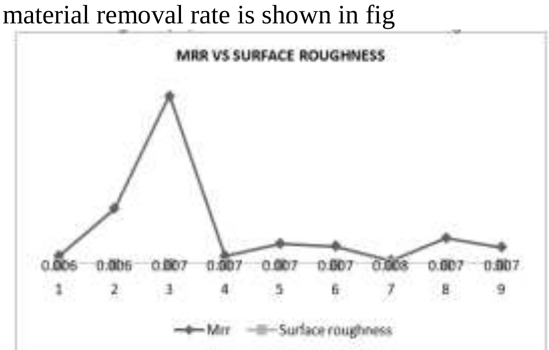


Fig.-5.7: Material removal rate vs Surface roughness

The values of different material removal rates against surface roughness are presented by the plot. Firstly, the values of surface roughness increase with increasing of MRR value.

Cutting force:
The variation of cutting force (Pz) with material removal rate is shown in figure

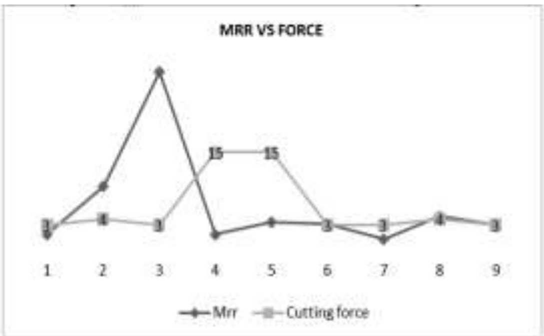


Fig.-5.8: Material removal rate vsCutting force (Pz)

The values of cutting force (Pz) against different material removal rates are presented by the plot. In this plot is shown that with higher MRR the cutting forces increases and with lower MRR cutting force Decreases.

5.5 Conventional coolant:
Result:

All the values of using speed, feed rate, depth of cut, surface roughness, cutting force is given in the following table.

Table – 5.5 Observation Table

Sl. No.	Speed in RPM	Feed Rate (mm/s)	Depth of Cut (mm)	Cutting Velocity (mm/s)	Cutting Forces PxPyPz			Surface Roughness (Ra)	MRR (mm^3/s)	Power consumption (watt)
1	455	0.066	0.05	1667.66	4	2	3	0.007	1.501	5002.98
2	455	0.083	0.25	1667.66	6	9	2	0.014	9.441	3335.33
3	455	0.125	0.5	1667.66	7	7	5	0.006	28.23	8338.3
4	455	0.066	0.05	1667.66	4	2	5	0.007	1.501	8338.3
5	215	0.066	0.25	788.01	5	6	5	0.007	3.547	3940.05
6	95	0.066	0.5	348.19	9	12	4	0.007	3.135	1392.76
7	455	0.066	0.25	1667.66	5	3	3	0.007	0.742	5002.98
8	215	0.083	0.25	788.01	6	9	4	0.007	4.461	3152.04
9	95	0.125	0.25	348.19	7	11	4	0.008	2.968	1392.76
Mean value								0.0077	6.16	4432.83

Surface roughness:
The variation of surface roughness (Ra) with material removal rate is shown in fig

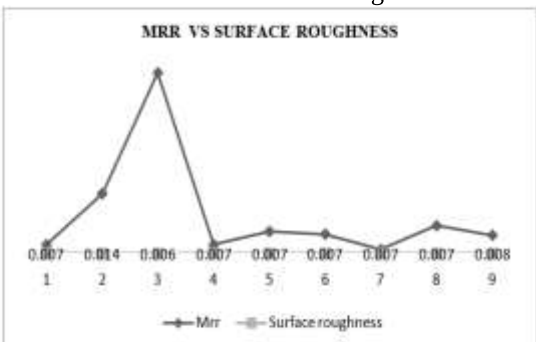


Fig.-5.9: Material removal rate vs surface roughness

The values of different material removal rates against surface roughness are presented by the plot. Firstly, the values of surface roughness increase with increasing of MRR value.

Cutting force:
The variation of cutting force (Pz) with material removal rate is shown in figure

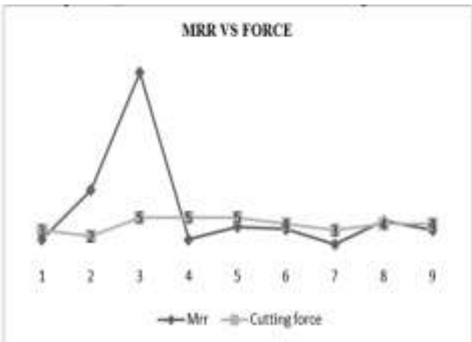


Fig.-5.10: Material removal rate vsCutting force (Pz)

The values of cutting force (Pz) against different material removal rates are presented by the plot. In this plot is shown that with higher MRR the cutting forces increases and with lower MRR cutting force Decreases.

Carbide Tip Tool
5.6 No Coolant:
Result:

All the values of using speed, feed rate, depth of cut, surface roughness, cutting force is given in the following table.

Table – 5.6 Observation Table

Sl. No.	Speed In RPM	Feed rate (mm/s)	Depth of cut (mm)	Cutting Velocity (mm/s)	Cutting Forces			Surface Roughness (Ra)	MRR (mm^3/s)	Power consumption (watt)
					Px (N)	Py (N)	Pz (N)			
1	455	0.066	0.05	1643.83	0	2	7	0.005	1.501	6575.32
2	455	0.083	0.25	1643.83	1	3	5	0.006	9.441	8219.15
3	455	0.125	0.5	1643.83	0	8	6	0.006	28.23	9862.98
4	455	0.066	0.05	1643.83	0	1	8	0.007	1.501	9862.98
5	215	0.066	0.25	776.75	5	7	4	0.006	3.547	3107
6	95	0.066	0.5	343.21	4	5	6	0.007	3.135	2059.26
7	455	0.066	0.25	1643.83	2	8	4	0.015	0.742	6575.32
8	215	0.083	0.25	776.75	6	9	5	0.009	4.461	3883.75
9	95	0.125	0.25	343.21	7	8	5	0.007	2.968	1716.05
Mean value								0.00755	6.16	5762.42

Surface Roughness:
The variation of surface roughness (Ra) with metal removal rate is shown in figure

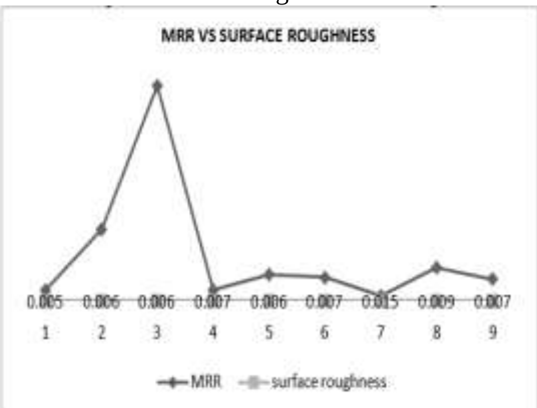


Fig.-5.11: Material removal rate vs Surface roughness

The values of different material removal rate against surface roughness are presented by the plot.

Cutting Force:
The variation of cutting force (Pz) with MRR is shown in figure

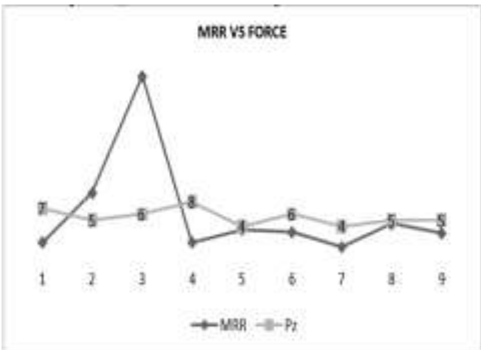


Fig.-5.12: Material removal rate vsCutting force (Pz)

The values of cutting force (Pz) against different material removal rates are presented by the plot. In this plot is shown that with higher MRR the cutting forces increases and with lower MRR cutting force Decreases.

5.7 Soyabean Oil:
Result:
All the values of using speed, feed rate, depth of cut, surface roughness, cutting force is given in the following table.

Table – 5.7 Observation Table

Sl. No.	Speed In RPM	Feed rate (mm/s)	Depth of cut (mm)	Cutting Velocity (mm/s)	Cutting Forces			Surface Roughness (Ra)	MRR (mm^3/s)	Power consumption (watt)
					Px (N)	Py (N)	Pz (N)			
1	455	0.066	0.05	1548.54	5	4	2	1.501	0.039	3097.08
2	455	0.083	0.25	1548.54	7	8	3	9.441	0.075	4645.62
3	455	0.125	0.5	1548.54	11	8	5	28.23	0.085	7742.7
4	455	0.066	0.05	1548.54	6	5	2	1.501	0.077	3097.08
5	215	0.066	0.25	731.72	6	7	4	3.547	0.036	2926.88
6	95	0.066	0.5	323.32	8	4	4	3.135	0.179	1293.28
7	455	0.066	0.25	1548.54	7	8	2	0.742	0.096	3097.08

8	215	0.083	0.25	731.72	7	8	3	4.461	0.045	2195.16
9	95	0.125	0.25	323.32	9	7	4	2.968	0.1	1293.28
Meanvalue								6.16	0.081	3265.35

Surface Roughness:
The variation of surface roughness (Ra) with metal removal rate is shown in figure

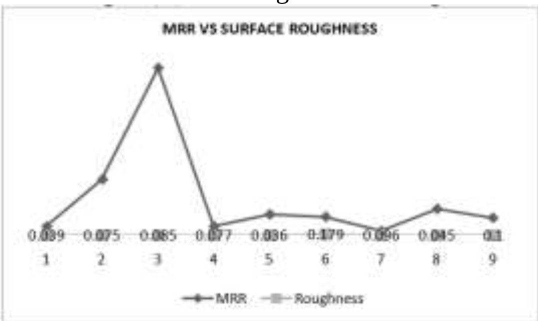


Fig.-5.13: Material removal rate vs Surface roughness

The values of different material removal rate against surface roughness are presented by the plot.

Cutting Force:
The variation of cutting force (Pz) with MRR is shown in figure

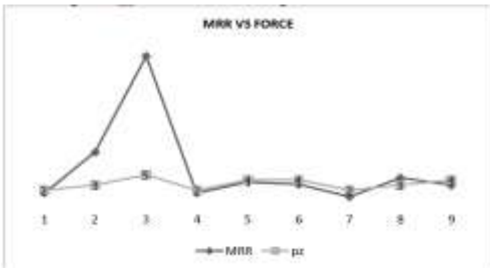


Fig.-5.14: Material removal rate vsCutting force (Pz)

The values of cutting force (Pz) against different material removal rates are presented by the plot. In this plot is shown that with higher MRR the cutting forces increases and with lower MRR cutting force Decreases.

5.8 Sunflower oil coolant:
Result:
All the values of using speed, feed rate, depth of cut, surface roughness, cutting force is given in the following table.

Table – 5.8 Observation Table

Sl. No.	Speed In RPM	Feed rate (mm/s)	Depth of cut (mm)	Cutting Velocity (mm/s)	Cutting Forces			Surface Roughness (Ra)	MRR (mm^3/s)	Power consumption (watt)
					Px (N)	Py (N)	Pz (N)			
1	455	0.066	0.05	1596.19	5	1	3	0.006	1.501	4788.57
2	455	0.083	0.25	1596.19	5	7	2	0.006	9.441	3192.38
3	455	0.125	0.5	1596.19	5	9	2	0.006	28.23	3192.38
4	455	0.066	0.05	1596.19	5	3	2	0.006	1.501	3192.38
5	215	0.066	0.25	754.24	5	8	3	0.007	3.547	2262.72
6	95	0.066	0.5	333.27	5	3	4	0.007	3.135	1333.08
7	455	0.066	0.25	1596.19	5	7	2	0.011	0.742	3192.38
8	215	0.083	0.25	754.24	5	8	3	0.011	4.461	2262.72
9	95	0.125	0.25	333.27	5	3	4	0.007	2.968	1333.08
Mean value								0.0074	6.16	2749.96

Surface Roughness:
The variation of surface roughness (Ra) with metal removal rate is shown in figure

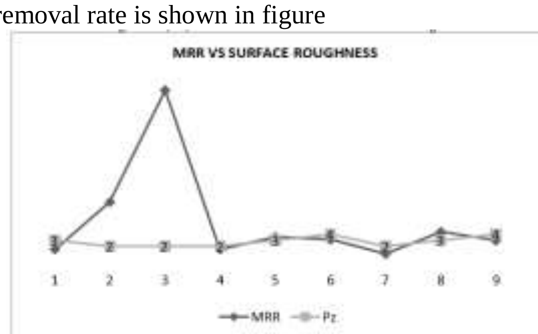


Fig.-5.15: Material removal rate vs Surface roughness

The values of different material removal rate against surface roughness are presented by the plot.

Cutting Force:
The variation of cutting force (Pz) with MRR is shown in figure

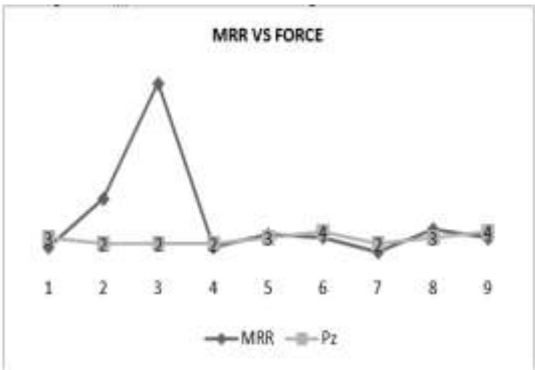


Fig.-5.16: Material removal rate vsCutting force (Pz)

The values of cutting force (Pz) against different material removal rates are presented by the plot. In this plot is shown that with higher MRR the cutting forces increases and with lower MRR cutting force Decreases.

5.9 Mustard oil coolant:

Result:

All the values of using speed, feed rate, depth of cut, surface roughness, cutting force is given in the following table.

Table – 5.9 Observation Table

Sl. No.	Speed in RPM	Feed rate (mm/s)	Depth of cut (mm)	Cutting Velocity (mm/s)	Cutting Forces			Surface Roughness (Ra)	MRR (mm^3/s)	Power consumption (watt)
					Px (N)	Py (N)	Pz (N)			
1	455	0.066	0.05	1572.36	5	3	3	0.139	1.501	4717.08
2	455	0.083	0.25	1572.36	6	7	3	0.034	9.441	4717.08
3	455	0.125	0.5	1572.36	12	7	5	0.054	28.23	7861.8
4	455	0.066	0.05	1572.36	2	6	3	0.012	1.501	4717.08
5	215	0.066	0.25	742.98	2	8	5	0.025	3.547	3714.9
6	95	0.066	0.5	328.29	5	4	6	0.018	3.135	1969.74
7	455	0.066	0.25	1572.36	3	9	5	0.044	0.742	7861.8
8	215	0.083	0.25	742.98	5	6	3	0.062	4.461	2228.94
9	95	0.125	0.25	328.29	9	4	6	0.044	2.968	1969.74
Mean value								0.048	6.16	4417.57

Surface Roughness:

The variation of surface roughness (Ra) with metal removal rate is shown in figure

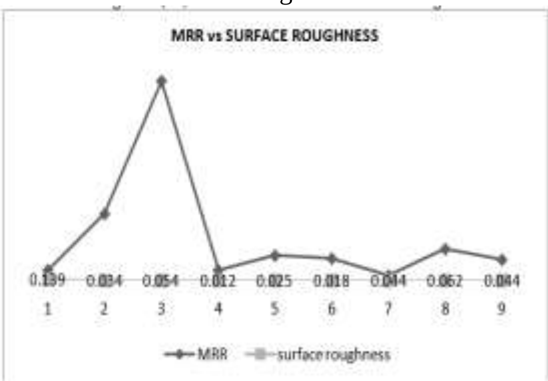


Fig.-5.17: Material removal rate vs Surface roughness

The values of different material removal rate against surface roughness are presented by the plot.

Cutting Force:

The variation of cutting force (Pz) with MRR is shown in figure

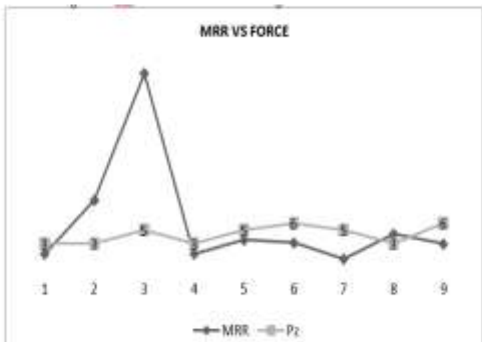


Fig.-5.18: Material removal rate vsCutting force (Pz)

The values of cutting force (Pz) against different material removal rates are presented by the plot. In this plot is shown that with higher MRR the cutting forces increases and with lower MRR cutting force Decreases.

5.10 Conventional Coolant:

Result:

All the values of using speed, feed rate, depth of cut, surface roughness, cutting force is given in the following table.

Table – 5.10 Observation Table

Sl. No.	Speed RPM	Feed rate (mm/s)	Depth of cut (mm)	Cutting Velocity (mm/s)	Cutting Forces			Surface Roughness (Ra)	MRR (mm^3/s)	Power consumption (watt)
					Px (N)	Py (N)	Pz (N)			
1	455	0.066	0.05	1620.01	4	4	3	0.007	1.501	4860.03
2	455	0.083	0.25	1620.01	2	8	2	0.007	9.441	3240.02
3	455	0.125	0.5	1620.01	4	6	3	0.009	28.23	4860.03
4	455	0.066	0.05	1620.01	4	4	3	0.007	1.501	4860.03
5	215	0.066	0.25	765.50	2	7	4	0.007	3.547	3062
6	95	0.066	0.5	338.24	5	12	7	0.007	3.135	2367.68
7	455	0.066	0.25	1620.01	6	7	2	0.008	0.742	3240.02
8	215	0.083	0.25	765.50	6	7	3	0.007	4.461	2296.68
9	95	0.125	0.25	338.24	7	10	3	0.007	2.968	1014.7
Mean value								0.0073	6.16	3311.24

Surface Roughness:
The variation of surface roughness (Ra) with metal removal rate is shown in figure

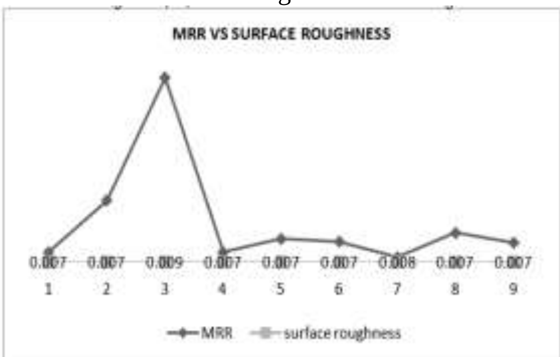


Fig.-5.19: Material removal rate vs Surface roughness

The values of different material removal rate against surface roughness are presented by the plot.

Cutting Force:
The variation of cutting force (Pz) with MRR is shown in figure

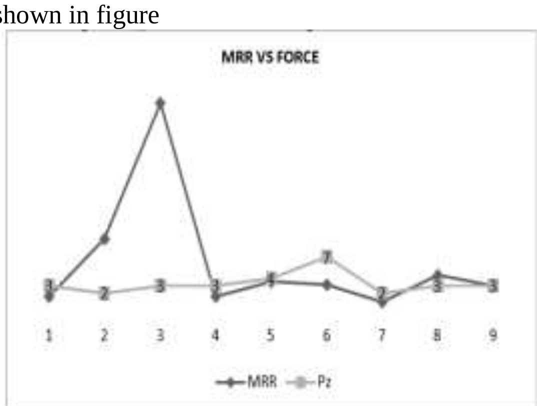


Fig.-5.20: Material removal rate vsCutting force (Pz)

The values of cutting force (Pz) against different material removal rates are presented by the plot. In this plot is shown that with higher MRR the cutting forces increases and with lower MRR cutting force Decreases.

5.11Selection of coolant by Analytic Hierarchy Process

The Analytic Hierarchy Process (AHP), introduced by Thomas Saaty (1980), is an effective tool for dealing with complex decision making, and may aid the decision maker to set priorities and make the best decision. By reducing complex decisions to a series of pairwise comparisons, and then synthesizing the results, the AHP helps to capture both subjective and objective aspects of a decision. In addition, the AHP incorporates a useful technique for checking the consistency of the decision maker's evaluations, thus reducing the bias in the decision making process.

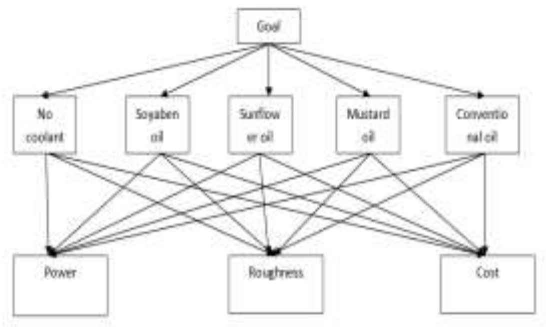
Step1. Develop the weights for the criteria by

- Developing a single pair-wise comparison matrix for the criteria;
- Multiplying the values in each row together and calculating the nth root of said product;
- Normalizing the aforementioned nth root of products to get the appropriate weights; and
- Calculating and checking the Consistency Ratio (CR).

Step2. Develop the ratings for each decision alternative for each criterion

- Developing a pair-wise comparison matrix for each criterion, with each matrix containing the pair-wise comparisons of the performance of decision alternatives on each criterion;
- Multiplying the values in each row together and calculating the nth root of said product;
- Normalizing the aforementioned nth root of product values to get the corresponding ratings; andcalculating and
- Checking the Consistency Ratio (CR).

Step3. Calculate the weighted average rating for each decision alternative. Choose the one with the highest score.
GOAL: Selection of Coolant for HSS & Carbide tool to ensure Green performance.



Description of Criteria Matrix :
Power = P1
Roughness = R1
Cost = C1
Description of Alternative matrix :

No Coolant = A
Soyaben Oil = B
Sunflower Oil = C
Mustard Oil = D
Conventional Oil = E

Observation by AHP technique:

The mathematics of the AHP and the calculation techniques are explained in the section "The AHP calculations" but its essence is to construct a matrix expressing the relative values of a set of attributes. For example, what is the relative importance to the management of this firm of the cost of equipment as opposed to its ease of operation? They are asked to choose whether cost is very much more important, rather more important, and as important, and so on down to very much lessimportant, than operability. Each of these judgments is assigned a number on a scale. One common scale (adapted from Saaty) is the one shown in **Table 1**.

Intensity of importance	Definition	Explanation
1	Equal importance	Two factors contribute equally to the objective.
3	Somewhat more important	Experience and judgment slightly favour one over the other.
5	Much more important	Experience and judgment strongly favour one over the other.
7	Very much more important	Experience and judgment very strongly favour one over the other. Its importance is demonstrated in practice.
9	Absolutely more important	The evidence favouring one over the other is of the highest possible validity.
2, 4, 6, 8	Intermediate values	When compromise is needed.

Table 1

A basic, but very reasonable, assumption is that if attribute A is absolutely more important than attribute B and is rated at 9, then B must be absolutely less important than A and is valued at 1/9.

These pair wise comparisons are carried out for all factors to be considered, usually not more than 7, and the matrix is completed. The matrix is of a very particular form which neatly supports the calculations which then ensue.

The next step is the calculation of a list of the relative weights, importance, or value, of the factors, such as cost and operability, which are relevant to the problem in question (technically, this list is called an **eigenvector**). If, perhaps, cost is very much more important than operability, then, on a simple interpretation, the cheap equipment is called for though, as we shall see, matters are not so straightforward. The final stage is to calculate a **Consistency Ratio (CR)** to measure how consistent the judgments have been relative to large samples of purely random judgments. If the **CR** is much in excess of 0.1 the judgments are untrustworthy because they are too close for comfort to randomness and the exercise is valueless or must be repeated. It is easy to make a minimum number of judgments after which the rest can be calculated to enforce a perhaps unrealistically perfect consistency.

The final results of HSS tool are given below:

Option	Dry	Soyabean oil	Sunflower oil	Mustard oil	Comvantional oil
Criterion	0.137	0.473	0.085	0.261	0.041
Power	0.106	0.080	0.093	0.08	0.06
Roughness	0.26	0.236	0.280	0.23	0.21
Cost	0.65	0.682	0.626	0.67	0.71
Result	0.139	0.472	0.084	0.253	0.040
3rd 5th		2nd	4th	1st	

Table 2

The most suitable coolant is Conventional Oil when HSS tool is used for cutting.Since, it ensures the green performance for the experiment.

The final resultsof Carbide tool are given below:

Option	Dry	Soyabean oil	Sunflower oil	Mustard oil	Conventional oil
Criterion	0.46	0.90	0.044	0.26	0.136
Power	0.106	0.080	0.093	0.080	0.060
Roughness	0.260	0.236	0.280	0.230	0.210
Cost	0.650	0.682	0.626	0.670	0.710
Result	0.467	0.08	0.04	0.25	0.133
3rd	5th		2nd	1st	4th

Table 3

The most suitable coolant is Sunflower Oil when Carbide tool is used for cutting.Since, it ensures the green performance for the experiment.

VI. CONCLUSION

In present work turning operation has been done and surface roughness, cutting force and cutting power have been measured by using conventional fluid, soya bean oil, mustard oil, sunflower oil and using dry cutting condition also.HSS and Carbide tool have been used for experimentation. Effect of spindle speed, feed rate and depth of cut on surface roughness, cutting force and the cutting power has been analyzed.

In case of HSS tool the maximum power generated was obtained while using soya bean oil while the least was generated using conventional cutting fluid. Similarly in case of Carbide tool the maximum power generated was under dry cutting condition while the minimum power was generated while using sunflower oil.

Also, while using HSS tool the maximum surface roughness measured was under dry condition while minimum while using mustard oil. In case of carbide tool the maximum surface roughness was measured using soya bean oil while the minimum using sunflower oil.

From this analysis it has been observed that the sunflower oil gives best surface finish and the power consumed is also minimum. So, sunflower oil is considered as the best coolant for the experiment which gives good quality and ensures the green machining criteria.

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