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EFFECTS OF HYBRID NANO CUTTING FLUID AND PROCESS PARAMETERS ON MATERIAL REMOVAL RATE AND SURFACE FINISH IN TURNING OF SS304 ALLOY

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ABSTRACT: In the present competitive world, the manufacturing industry requires a good knowledge about proper utilization of resources. Accuracy and surface finish of components mainly depends on the machining process. In any metal cutting operation, the cutting fluid plays vital role by cooling and lubricating the cutting tool-work piece interface. This work presents the effect of minimum quantity lubrication (MQL) using hybridization of two different Nano fluids (Alumina and molybdenum) in turning of stainless steel 304.The hybrid Nano fluid was prepared by mixing alumina based Nano fluid with molybdenum disulphide (MOS2) Nano particles in a fixed volumetric proportion of 90:10.The turning performance of SS304 as compared to completely dry and wet machining in terms of material removal rate and surface roughness. An attempt was made by using Vegetable cutting fluids mixed with 2% of Nano aluminium oxide particles constant in all trails and Molybdenum disulphide will taken in different Wt. % (0,1,3) during turning of stainless steel 304 with varying process parameters: speed, feed and depth of cut. The machining performance of hybrid Nano-cutting fluid is compared with that of alumina-based Nano fluid in terms of material removal and surface finish. The use of this hybrid Nano-cutting fluid reduction of cutting speed, feed force and surface roughness compared to alumina oxide mixed Nano fluid. The process parameters are optimized using Taguchi Design of Experiments. The best parameters are predicted and % contribution of process parameters is analysed by using ANOVA analysis. Based on the results, it can be concluded that MRR is influenced predominantly by depth of cut and wt. % of Nano cutting fluid and surface finish is influenced by weight% of Nano cutting fluid and cutting speed.

1.INTRODUCTION:

A lathe is a machine tool which turns cylindrical material, touches a cutting tool to it, and removes the material from the work piece to get the required shape and size. The lathe is one of the machine tools mostly used in material removal process. A material is firmly fixed to the chuck of a lathe and switched on and the chuck is rotated. And since the table which fixed the byte can be moved in the vertical direction and the right-and-left direction by operating some handles. It touches a byte's tip into the material by the operation, and makes a mechanical part.

TYPES OF LATHES

1. **Engine Lathe:** the foremost common sort of shaping machine, motor driven and comes in giant sort of sizes and shapes.
2. **Bench Lathe:** A bench prime model typically of low power won't to create preciseness machine tiny work items.
3. **Lathe**: A shaper that has the power to follow a templet to repeat a form or contour.
4. **Automatic Lathe:** The lathe in which the work piece is automatically fed and removed without use of an operator. Cutting operations are mechanically controlled by a sequencer of some type.
5. **Turret Lathe:** The lathes which have multiple tools mounted on torrent either attached to the tailstock or the cross-slide, which allows for quick changes in tooling and cutting operations.
6. **Computer Controlled Lathe:** extremely automatic lathes, wherever cutting, loading, tool ever-changing, and half unloading are mechanically controlled by pc secret writing.

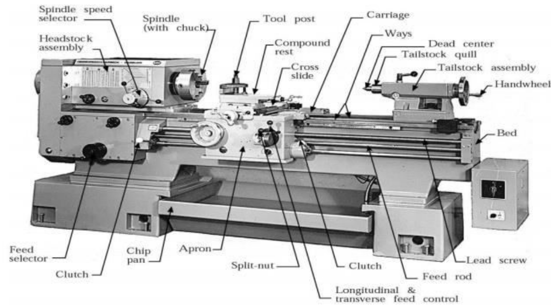

Fig 1: Lathe Machine

2.LITERATURE REVIEW:

VenkataRao.R&Kalyankar.V.D(1)is adopted multi-pass turning operations is to produce products with low cost and high quality, with a lower number of cuts. Parameter optimization plays an important role in achieving this goal. Process parameter optimization in a multi-pass turning operation usually involves the optimal selection of cutting speed, feed rate, depth of cut and number of passes. In this work, the parameter optimization of a multi-pass turning operation is carried out using a recently developed advanced optimization algorithm, named, the teaching–learning-based optimization.

ShrikantBorade .al.(1). Investigated on surface roughness and temperature of EN 353 steel using Turning process. The Taguchi design of experiment methodology has been used for planning and designing the experiments. Depth of cut and then followed by feed and at last speed have been found to be most significant factors for surface roughness at 92% significance level , with percentage contribution of 46% and 33%. The optimal parameter

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combination obtained from single variable optimization are speed 800 rpm , feed 0.07mm/rev , depth of cut 0.05mm.This experiment shows that surface roughness and temperature reduced significantly by machining EN 353 steel using nano fluid (3 vol % of Aluminium oxide) as compared to Vegetable oil.

3.EXPERIMENTATION:

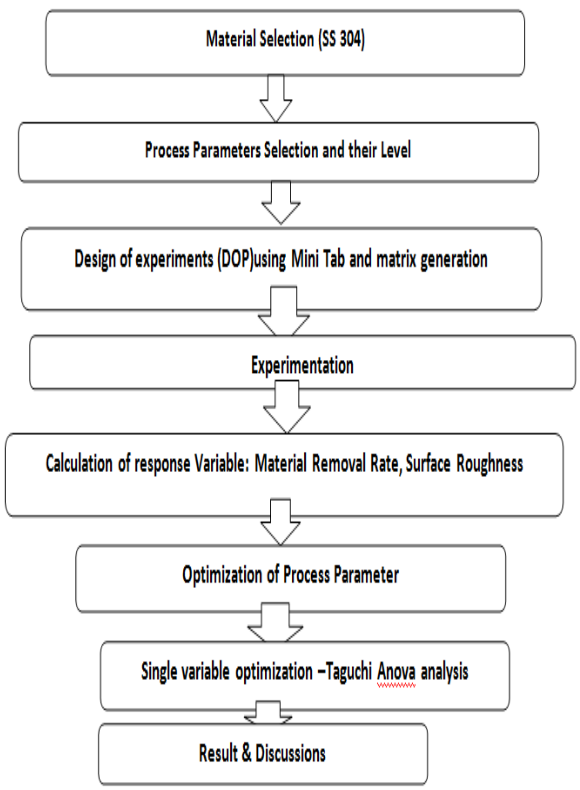

Fig. 2 Plan of work

SELECTION OF WORK MATERIAL

STAINLESS STEEL 304alloy :SS 304 is chosen to study and this material can findvarious applications .Because of its as-welded and good corrosion resistance. Due to this this was used in most of the industrial applications, for manufacturing of interior parts of automobiles .In view of the present research objectives, experimental investigation and analysis were carried out in different parametric combinations, for deriving effective parametric combination.

Table 1 Chemical composition of SS 304

Elemen	C	Mn	P	S	Si	Cr	Ni	N2	Iron
%	0.08	2.00	0.045	0.03	0.75	18.0-20.0	10.00	0.1	Bal

The work piece dimensions are length 50mm and diameter is 16mm.

Table No: 2 Mechanical and Thermal properties of Material

Mechanical Properties	
Density(g/cc)	8
Poison's ratio	0.29
Elastic Modulus (Gpa)	193-200
Ultimate Tensile Strength (Mpa)	1260-1390
Yield Point (Mpa)	1041-1160
Elongation at break (%)	70
Hardness (HRC) BRINELL	123
Thermal Properties	
Melting Point(^{0}C)	1400-1455
Thermal Conductivity(W/m.K)	16.2
Specific Heat(J/Kg.K)	435

PREPARATION OF TiB_2 NANO CUTTING FLUID: For preparation of Aluminium oxide (Al2O3) and molybdenum disulphide (MOS_2) hybrid Nano cutting fluid the Magnetic stirring method is used. In this process, the Al2O3 and MOS_2 nano particles are mixed with vegetable oil (base fluid) to make hybridNano fluid. Nano Al2O3 and MOS_2 particles are selected due to their superior tribological and antitoxic properties.

EXPERIMENTATION PROCEDURE: A CNC lathe (model: SPEED LX-200 SUPER ,make: MACPOWER CNC MACHINES PVT. LTD., Coimbatore, India) as shown in

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the figure is used for experimentation. The power of spindle motor is 7.5 kw and the power supply given is 230V, 50 Hz single phase supply. The Coolant used is Hybrid nano cutting fluid (Al2O3 &MOS_2)

The model is a gentle giant from Macpower comes with a torque of passionate technology. LX-200 Super , with his robust appeal is not only capable of cutting deep into the surface but surprises everyone with unimaginable smoother surface finish also.

Table:3 EXPERIMENTAL RESULTS FOR MRR AND SF:

RUNS	Type of cutting fluid	SPEED rpm	FEED Mm/rev	DEPTH OF CUT (mm)	SURFACE FINISH (R_a)	MRR Mm^3/min
01	Castor oil	1100	0.11	0.5	2.18	1208.17
02	Castor oil	1200	0.12	0.6	1.56	1202.2
03	Castor oil	1300	0.13	0.7	1.24	1390.61
04	Castor oil	1400	0.14	0.8	1.95	1090.30
05	Castor oil + Al2O3 2%	1100	0.12	0.7	1.576	112.73
06	Castor oil + Al2O3 2%	1200	0.11	0.8	1.88	1026.30
07	Castor oil + Al2O3 2%	1300	0.14	0.5	1.53	1421.20
08	Castor oil + Al2O3 2%	1400	0.13	0.6	1.475	1233.80
09	Castor oil +Al2O3 2% +1% MOS_2	1100	0.13	0.8	0.99	1649.50
10	Castor oil +Al2O3 2% +1% MOS_2	1200	0.14	0.7	1.30	1308.40
11	Castor oil +Al2O3 2% +1% MOS_2	1300	0.11	0.6	1.08	1176.50
12	Castor oil +Al2O3 2% +1% MOS_2	1400	0.12	0.5	0.84	1668.2
13	Castor oil +Al2O3 2% +3% MOS_2	1100	0.14	0.6	**0.76**	**1838.93**
14	Castor oil +Al2O3 2% +3% MOS_2	1200	0.13	0.5	0.87	1638.07
15	Castor oil +Al2O3 2% +3% MOS_2	1300	0.12	0.8	0.91	1351.40
16	Castor oil +Al2O3 2% +3% MOS_2	1400	0.11	0.7	1.14	1391.40

MICROSTRUCTURE OBSERVATIONS OF WORKPIECES USING "SCANNING ELECTRON MICROSCOPE"

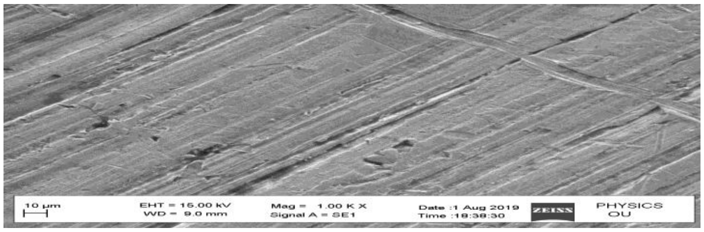

Fig 3 micro structure of the machined sample at experiment no 1,low surface finish.

4. OPTIMIZATION OF PROCESS PARAMETERS:

Table No: 4 Signal to Noise Ratios for MRR, SR

Exp. No	Wt% of Nano	Cutting Speed (rpm)	Feed (mm/rev)	Depth Of cut	MRR (mm^3/min)	S/N ratio	SR (µm)	S/N ratio
01	0%	1100	0.11	0.5	1208.17	61.6426	2.188	-6.7691
02	0%	1200	0.12	0.6	1202.2	61.59986	1.56	-3.8624
03	0%	1300	0.13	0.7	1390.61	62.8641	1.24	-1.8684
04	0%	1400	0.14	0.8	1090.30	60.7509	1.95	-5.8006
05	2%	1100	0.12	0.7	1122.73	61.055	1.57	-3.9179

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07	2%	1300	0.14	0.5	1421.20	63.0531	1.53	-3.6938
08	2%	1400	0.13	0.6	1233.80	61.8249	1.47	-3.3465
09	0%+2%+1%	1100	0.13	0.8	1649.50	64.3470	0.99	-0.0873
10	0%+2%+1%	1200	0.14	0.7	1308.40	62.3348	1.33	-2.2787
11	0%+2%+1%	1300	0.11	0.6	1176.50	61.4118	1.08	-0.6684
12	0%+2%+1%	1400	0.12	0.5	1668.2	64.2866	0.84	-1.5141
13	0%+2%+3%	1100	0.14	0.6	1838.93	65.219	0.76	-1.2096
14	0%+2%+3%	1200	0.13	0.5	1638.07	64.2866	0.87	-2.3837
15	0%+2%+3%	1300	0.12	0.8	1351.40	62.615	0.91	0.8191
16	0%+2%+3%	1400	0.11	0.7	1391.40	62.8690	1.14	-1.1381

Table No: 5 Response Table for Mean and S/N ratio (Larger is better criteria)

Process parameters	Level	S/N ratio				Mean			
		Wt% of nano	S	F	D	Wt% of nano	S	F	D
Average Value	L1	61.71	63.07	61.54	63.36	1223	1456	1201	1484
	L2	61.53	62.11	62.42	62.53	1201	1294	1336	1363
	L3	63.13	62.49	63.33	61.38	40.46	1335	1478	1303
	L4	**63.77**	**62.47**	**62.86**	**61.38**	1554	1346	1415	1279
	Delta	2.24	0.96	1.79	1.37	354	161	277	205
	Rank	1	4	2	3	1	4	2	3

From above table it is found that the S/N ratios and Means are in the following order: Wt% of NAN0 ranks 1st and Feed ranks 2nd. These parameters most influenced on material removal rate as compared to other process parameters

Table No: 6 Response Table for Mean and S/N ratio (Smaller is better criteria)

Process parameters	Level	S/N ratio				Mean			
		Wt% of nano	S	F	D	Wt% of nano	S	F	D
Average Value	L1	**-4.5752**	-2.0540	**-4.051**	-1.9347	1.7325	1.3750	1.6375	1.3550
	L2	-4.1103	-2.6533	-1.3617	1.37344	1.6125	1.1400	1.220	1.2175
	L3	-0.3859	-1.3529	-0.9795	42.1820	1.743	1.060	1.1900	1.3875
	L4	-0.3570	**-2.6543**	-2.3970	**-2.5943**	1.678	0.9875	1.4175	1.4325
	Delta	4.9322	1.3014	2.9968	1.4386	0.7450	0.2275	0.4975	0.2150
	Rank	1	4	2	3	1	3	2	4

PREDICTION OF OPTIMAL VALUES

Prediction of Optimal Value for Material Removal Rate

The optimum value of Material Removal Rate (MRR) is predicted at the selected Levels of significant parameters. The predicted optimal mean of theresponse

Characteristics (MRR) can be computed as

$$Y_{predicted} = Y_{exp} + (Y_n - Y_{exp}) + (Y_s - Y_{exp}) + (Y_f - Y_{exp}) + (Y_d - Y_{exp}) \text{ (or)}$$

$$Y_{predicted} = Y_n + Y_s + Y_f - 3 * Y_{exp}$$

Where, $Y_{predicted}$= Predicted MRR

Y_{Exp}= Total average response of the experiments in the array = ΣY

i.e. $\Sigma Y = 21717.63/16 = 1359.22\ mm^3/min$

Where T = sum of all experiments MRR mean values

N = number of experiments=16

$\bar{Y}_N$= average MRR at fourth level wt% of nano, Castor oil +Al2O3 2% +3% MOS_2

i.e $\Sigma N_{L4}/4 = (1838.93+1638.07+1351.40+1391.40)/4 = 1554.95\ mm^3/min$

$\bar{Y}_S$= average MRR at fourth level of speed, 1400

i.e $\Sigma S_{L2}/4 = (1838.93+1668.2+1233.8+1090.3)/4 = 1457.85mm^3/min$

$\bar{Y}_F$= average MRR at fourth level of feed, 0.14mm/rev

i.e $\Sigma F/4 = (1838.93+1308.4+1421.20+1090.30)/4 = 1414.7\ mm^3/min$

$\bar{Y}_D = D_{L4}$ is the average MRR at fourth level of depth of cut, 0.8mm i.e $\Sigma D_{L4}/4 = (1838.93+1649.5+1026.30+1090.3)/4 = 1401.25mm^3/min$

Therefore the predicted optimal values of MRR are

$Y_{predicted} = Y N + Y S + Y F - 3^* Y exp$

$=1554.93+1457.8+1414.7+1401.25-3^*1357=1815.11$

Confirmation Test for Material Removal Rate

The final step in verifying the improvement in Material Removal Rate was done by conducting experiments using optimal conditions. The confirmation experiment was conducted at the optimum setting of process parameters namely Wt % of nano at level 4(Castor oil +Al2O3 2% +3% MOS_2) Speed level 1 (1100rpm), feed level 4(0.14mm/rev) and depth of cut level 3(0.6mm) and the Material Removal Rate observed to be 1838.93mm^3/min, which was around the confidence interval of the predicted optimal Material Removal Rate 1815.11mm^3/min.

Predicted values For Surface Roughness

$_{exp}$ = Total average response of the experiments in the array = ΣY

i.e. $\Sigma Y = 26.424/16 = 1.2937\mu m$

Where T= sum of all experiments SR mean values

N= number of experiments=16

$_N$ = average SR at second level of wt % of i.e. $\Sigma N/4 = (0.87+0.76+0.91+1.41)/4 = 1.58625\mu m$ $_S$ = average SR at first level of speed, 1100rpm

i.e $\Sigma S/4 = (1.532+1.39+1.22+1.382)/4 = 1.381\mu m$

$_F$= average SR at fourth level of feed, 0.14mm/rev

i.e $\Sigma F/4 = (1.814+1.63+1.22+1.35)/4 = 1.5035\mu m$

$_D$ = average SR at second level of depth of cut,0.6mm

i.e $\Sigma D/4 = (1.576+1.845+1.22+1.758)/4 = 1.59975\mu m$

Therefore the predicted optimal values of Surface Roughness are

$$Y_{predicted} = Y N + Y S + Y F - 3^* Y exp$$

$$= 1.58625+1.381+1.5035+1.59975-3 \times 1.6515$$

$$= 0.81\mu m$$

Confirmation Test for Surface Roughness:The final step in verifying the improvement in Surface Roughness was done by conducting experiments using optimal conditions. The confirmation experiment was conducted at the optimum setting of process parameters namely Wt % of nano at level 4(Castor oil +Al2O3 2% +3% MOS_2), Speed level 1(1100rem), Feed level 4(0.14mm/rev) and Depth of cut 2(0.6mm) and the SR observed to be 0.76µm , which was around the confidence interval of the predicted optimal Surface Roughness 0.81µm .

ANOVA ANALYSIS

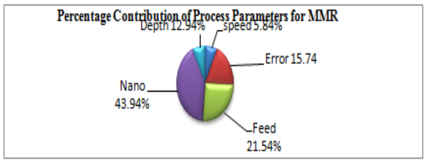

Fig: 4 Percentage Contribution of process parameters for Material Removal Rate

ANOVA for Surface Roughness

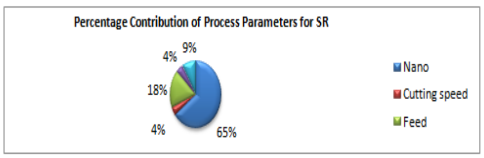

Fig: 5 Percentage Contribution of process parameters for Surface Roughness

5. RESULTS AND DISCUSSION

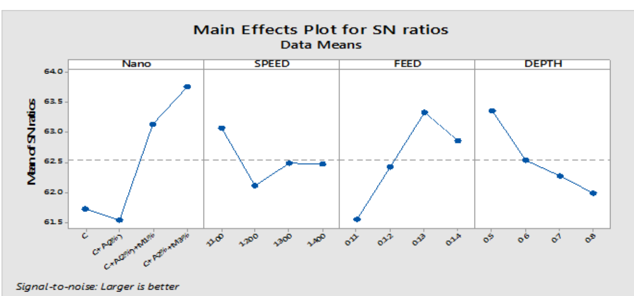

Fig. 6 Graph of Input Parameters v/s MRR

the first graph shows the effect of Wt. %

of Nano on material removal rate. From it is clearly shown that with increase in % of Nano powder, material removal rate increased. Initially when Wt. % of Nano is 0% MRR is 1208.1 mm^3/min. When the Wt. % of Nano increased to Castor oil +Al2O3 2% +3% MOS_2, material removal rate increased to 1838.93 mm^3/min.

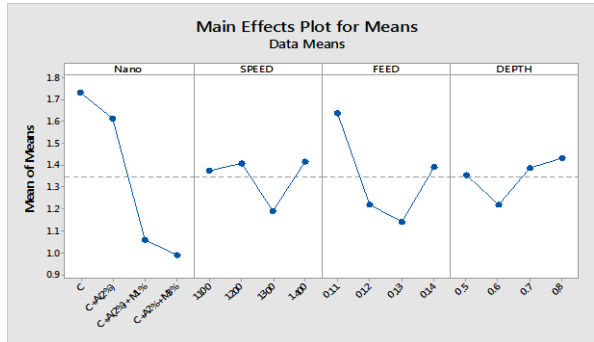

Fig. 7 Graph of Input Parameters v/s SR

It shows increase Depth of cut of has little effect on the decrease of surface roughness From Fig. 5.2, it states that if depth of cut increased from 0.5 to 0.6 mm there was a decrease in surface roughness from 0.76µm to 0.86µm. Now, if depth of cut further increased from 0.6 to 0.7 mm then surface roughness decreased from 0.76 to 0.91µm. If the depth of cut further increased from 0.7 to 0.8 mm then slight decrease in surface roughness from 0.91 to 0.76µm. It shows depth of cut has less effect on surface roughness

7. CONCLUSIONS

- Surface finish and MRR can be improved by using different process parameters.
- The surface finish (0.76µm) is better at lowspeed (1100 rpm), high feed (0.14mm/rev) and depth of cut (0.6 mm) and % wt. of Nano (Castor oil +Al2O3 2% +3% MOS_2)
- The MRR(1838.93 mm3/min) is better at depth of cut(0.6 mm),speed(1100 rpm) and high feed(0.14 mm/rev) and % wt. of Nano (Castor oil +Al2O3 2% +3% MOS_2).
- SS 304 material can be machined with carbide insert tool material.

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- It is found that at high feed and high %wt. of Nano fluid more surface finish is occur. From this feed and Nano fluid ratio are the major parameters that influence the surface finish.
- It is found that at high feed of cut more MRR is occurring. From this, feed and %wt. of Nano fluid is the major parameter that influenced the material removal rate.

From Taguchi analysis it can be concluded that:

a)The material removal rate was found to be 1838.07mm^3/min at optimal parameter levels of % of Nano powder at level 4(Castor oil +Al2O3 2% +3% MOS_2), Cutting speed at level 1(1100 rpm), Feed at level 4(0.14 mm/rev), Depth of cut at level 2(0.6mm).

b) The Surface Roughness was found to be 0.76µm at optimal parameter levels of % of Nano powder at level 4(Castor oil +Al2O3 2% +3%MOS_2), Cutting speed level 1(1100 rpm), Feed at level 4(0.14mm/rev), Depth of cut at level 2(0.6mm).

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