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Paper

On

A comparative study of surface roughness in Multi tool turning with single tool turning through factorial design of experiments

By

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ABSTRACT

The present paper shot to focus primary on embryonic a few criterion on the basis of which a range of control parameters can be selected in order to attain the desired level of the surface finish on the material for development of techniques using factorial design of experiments for acquiring appropriate surface finish by multi tool machining. Throughout real machining process there are different factors which unfavorably impinge on the finish and therefore, the proper methological concern of these factors appear to be most crucial for achieve the appropriate and preferred level of surface finish. The present paper will attempt to a comparative study of surface roughness in Multi tool turning with single tool turning through factorial design of experiments on AISI-1018.

Keywords: Surface unevenness, multi tool turning, factorial design (FD)

1. INTRODUCTION

Different kinds of manufacturing processes used to transform the obtainable suitable raw material to complete goods. Prelude shaping gives an chance to afford the appropriate and preferred form and is treat as the first step of a manufacturing method. Casting, molding, forging, welding etc can grant the form to the material. Further, different machining processes bring the dimension of the part under manufacturing to a correct size. In many application mainly when the part is made of some brittle material the scratches set up on the surface becomes the source of stress concentration and this may lead to instigation of crack- propagation and finally to the failure of the part while in action. Therefore it is important to achieve good surface finish of such parts because this improve its strength as well as the life mostly if the loading condition is dynamic and repeated in nature.

2. LITERATURE REVIEW

A number of studies have been made to investigate the surface finish. It has been seen that Lin, W.S. (1) have studied the study of high speed fine turning of austenitic stainless steel . Sze-Wei, Gan and Han-Seok, Lim and Rahman,M Frank Watt(2) have discussed a fine tool servo system for global position error compensation for a miniature ultra-precision lathe. Vikram Kumar, CH R. and Ramamoorthy, B (3) have dealt with Performance of coated tools during hard turning under minimum fluid application. Further Sharma, D.K. and Dixit, U.S.(4) have compared the dry and air-cooled turning of grey cast iron with mixed oxide ceramic tool. Go¨kkaya, Hasan and Nalbant, Muammer(5) have studied The effects of cutting tool geometry and processing parameters on the surface roughness of AISI 1030 steel. However, Isik,Yahya(6) have investigated the machinability of tool steels in turning operations. Dhar, N.R_and Ahmed, M.T.and Islam, S.(7), did an experimental investigation on effect of minimum quantity lubrication in machining AISI 1040 steel and Chang, Chih-Wei and Kuo, Chun-Pao (8) have attempted to evaluate surface roughness in laser-assisted machining of aluminum oxide ceramics with Taguchi method.

It is to be noted that all the above investigators have reported their results for single tool surface finish operation only. And they have concentrated on only some parameters and nobody has attempted any comprehensive accounting of result, inorder consider all the possible parameters and on various types of the materials. There are many experiments which being performed for investigating the surface roughness by using single tool on lathe machine. In the proposed work an attempt has been made to compare the effect of cutting parameters on surface roughness in multi tool turning and single tool turning on AISI-1018.

3. FACTORIAL DESIGN OF EXPERIMENT

Factorial Design of the experiment is the method to recognize the significant factors in a process, make out and fix the problem in a practice, and also identify the possibility of estimating interactions. This is done using a full factorial DOE. A two level factorial DOE has been used. This means two levels of each factor will be studied at once. If there are K factors that we need to evaluate in a process we need to run the experiment 2^k times. Each factor will have two levels, a "high" and "low" level.

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4. EXPERIMENTATION

If two tools, both side of the bed on the lathe carriage and mounted in such a way that both tool moving in one direction then this is term as Duplex attachment or Duplex turning. Duplex turning provide two tool cutting operation moving in one direction. Experiments are conducted in accordance with the statistical technique of experimental design

4.1. EXPERIMENTAL SETUP

Fig 1: Attachment for Duplex turning on Lathe machine

5. CUTTING PARAMETERS AND TOOL: Feed, Depth of cut, Cutting speed, HSS tool

6. ANALYSIS OF EXPERIMENTAL DATA (9)

S.NO.	Single tool machining				Duplex Machining			
	F	D	S	R1	F	D	S	R2
1	0.071	0.8	180	4.3	0.071	0.4+0.4	180	2.7
2	0.14	0.8	180	6.3	0.14	0.4+0.4	180	3.8
3	0.071	1.4	180	5.9	0.071	0.7+0.7	180	4.3
4	0.14	1.4	180	6.0	0.14	0.7+0.7	180	4.0
5	.071	0.8	280	4.1	0.071	0.4+0.4	280	2.2
6	0.14	0.8	280	5.4	0.14	0.4+0.4	280	3.5
7	0.071	1.4	280	5.6	0.071	0.7+0.7	280	3.7
8	0.14	1.4	280	5.8	0.14	0.7+0.7	280	3.3

Table1: Comparison between Single tool and Duplex machining roughness

6.1. EFFECT ESTIMATION (9)

FACTORS	Single tool machining		Duplex Machining	
	EFFECT	SUM OF SQUARE	EFFECT	SUM OF SQUARE
F	0.9	3.25	0.475	0.9025
D	0.825	2.25	0.725	2.1025
S	-0.375	0.5625	-0.575	1.3225
FD	-0.725	2.1025	-0.8	2.56
FS	-0.125	0.0625	-0.025	0.00025
DS	-0.175	0.1225	-0.075	0.0225
FDS	0.225	0.2025	-0.075	0.0225
PURE ERROR	4.182		1.22	
TOTAL	12.72		8.1775	

Table 2: Comparison between effect of single tool and duplex machining

6.2. ANOVA TABLE OF SURFACE ROUGHNESS (9)

S. NO.	Single tool machining				Duplex machining			
FACTOR	SUM OF SQUARE	DF	MEAN SQUARE	F0	SUM OF SQUARE	DF	MEAN SQUARE	F0
F	3.25	1	3.24	6.198**	0.9025	1	0.9025	05.918**
D	2.25	1	2.25	4.30**	2.1025	1	2.1025	13.786**
S	0.5625	1	0.5625	1.04*	1.3225	1	1.3225	08.672**
FD	2.1025	1	2.1025	4.02**	2.56	1	2.56	16.78**
FS	0.0625	1	0.0625	0.119*	0.00025	1	0.00025	00.0163*
DS	0.1225	1	0.1225	0.234*	0.0225	1	0.0225	00.1475*
FDS	0.2025	1	0.2025	.39*	0.0225	1	0.0225	00.1475*
PURE ERROR	**4.182**	**8**	**0.52275**		**1.22**	**8**	**0.1525**	
TOTAL	**12.72**	**15**			**8.1775**	**15**		

Table3: Fo-Test Comparison between single tool and duplex machining

From F -Table F (0.10, 1, 8 is 3.46.)

** Show significant effect

* Show non significant effect

6.3. REGRESSION MODELING

Surface Roughness	Single tool machining	Duplex machining
R	$[5.43+0.45X_1+0.41X_2-0.362\ X1X2]$	$[3.46+0.235X_1+0.3625X_2-0.2875X_3-.4125X_1X_{2}]$

Table 4: Regression Equations for single and duplex machining

6.4. ADEQUACY OF THE MODEL FOR SINGLE TOOL TURNING

Adequacy of the Model	Single tool machining	Duplex machining
$R^2 = SS_{model}/SS_{total}$	**0.67**	**0.85**

Table 5: Comparison between Adequacy of single tool and duplex machining

7. ANALYSIS OF CUTTING PARAMETERS AND SURFACE ROUGHNESS

S.N	FL	FH	SL	SH	DL	DH	F	D	S	R1	R2	X1	X2	X3	R	r
1	0.071	0.14	180	280	0.8	1.4	0.071	0.8	180	4.3	3	-1	-1	-1	2.737	4.208
2	0.071	0.14	180	280	0.8	1.4	0.14	0.8	180	6.3	4	1	-1	-1	4.032	5.832
3	0.071	0.14	180	280	0.8	1.4	0.071	1.4	180	5.9	4	-1	1	-1	4.287	5.752
4	0.071	0.14	180	280	0.8	1.4	0.14	1.4	180	6	4	1	1	-1	3.932	5.928
5	0.071	0.14	180	280	0.8	1.4	0.071	0.8	280	4.1	2	-1	-1	1	2.163	4.208
6	0.071	0.14	180	280	0.8	1.4	0.14	0.8	280	5.4	4	1	-1	1	3.458	5.832
7	0.071	0.14	180	280	0.8	1.4	0.071	1.4	280	5.6	4	-1	1	1	3.713	5.752
8	0.071	0.14	180	280	0.8	1.4	0.14	1.4	280	5.8	3	1	1	1	3.358	5.928

Table6:Analysis of cutting parameters

FL=Feed rate lower level(mm/rev)

FH= Feed rate higher level(mm/rev))

SL=Speed lower level(rpm)

SH= Speed higher level(rpm)

DL=Depth of cut lower level(mm)

DH= Depth of cut higher level(mm)

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F=Feed rate (mm/rev)

S=Speed (rpm)

D=Depth of cut (mm)

R1=Roughness value for single tool (µm)

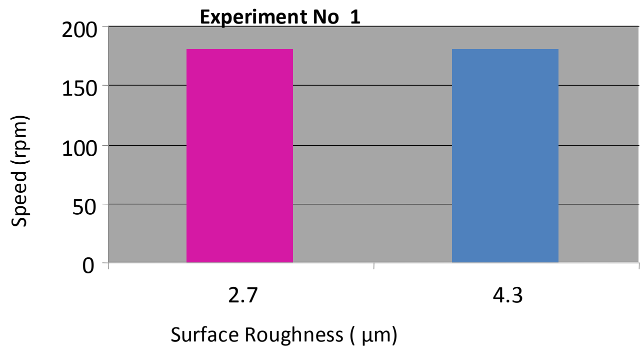
R2= Roughness value for multi-tool (µm)

R=Calculated value of roughness(µm) for multi tool turning

r= Calculated value of roughness (µm) for single tool turning.

8: GRAPHICAL ANALYSIS

8.1. (SURFACE ROUGHNESS VS SPEED)



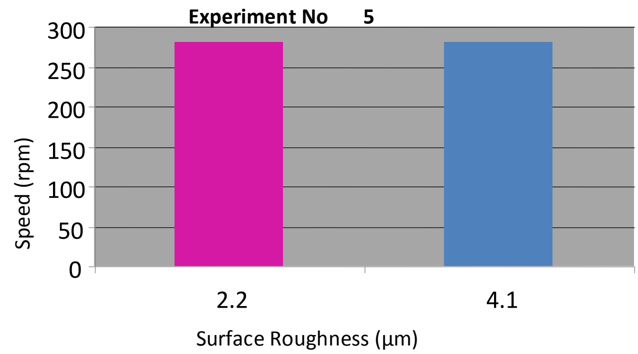
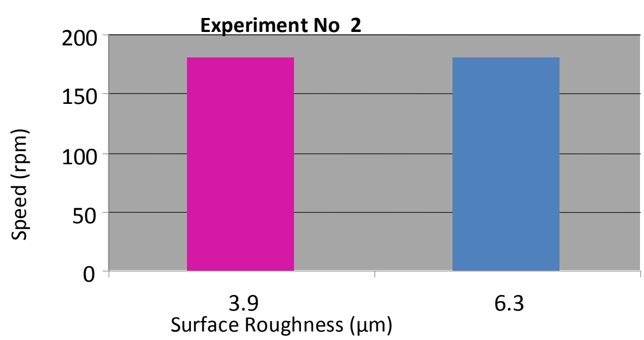


Fig: 2(Experiments 1 & 5) [F =0.071 mm/rev D =0.8 mm]

Duplex Turning **Single tool Turning**

The following observations have been made

- At Speed 180 rpm while feed 0.071mm/rev and depth of cut 0.8 mm roughness is 4.3 µm for simple turning while surface roughness is 2.9 µm for Duplex turning.
- At speed 280 rpm, feed 0.071mm/rev and depth of cut 0.8 mm, the roughness 4.1 µm for simple turning, while 2.3 µm for duplex turning.
- It is clear that when speed increases from 180 rpm to 280 rpm by keeping the Feed and depth of cut constant the surface roughness decreases for simple Turning from 4.3 to 4.1 µm and also for duplex turning 2.9 to 2.2 µm.



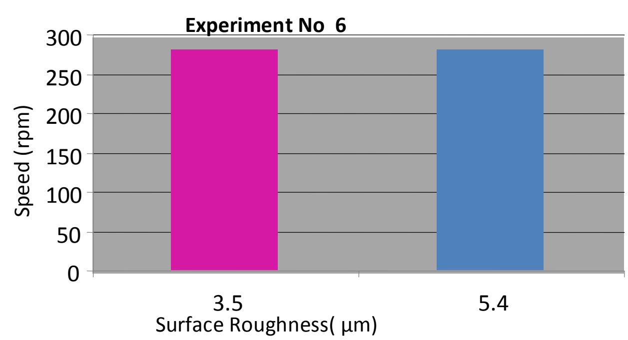


Fig:3 (Experiments 2 & 6) [F =0.14 mm/rev, D =0.8 mm]

The following observations have been made

- At Speed 180 rpm while feed **0.14 mm/rev** and depth of cut 0.8mmroughness is 6.3 µm for simple turning while surface roughness is 3.9 µm for duplex turning.
- At speed 280 rpm, feed **0.14 mm/rev** and depth of cut 0.8mm, the roughness 5.4 µm for simple turning, while 3.5µm for duplex turning.
- It is clear that when speed increases from 180rpm to 280 rpm by keeping the feed and depth of cut constant the surface roughness decreases for simple turning from 6.3 to 5.4µm and also for duplex turning 3.9 to 3.5µm

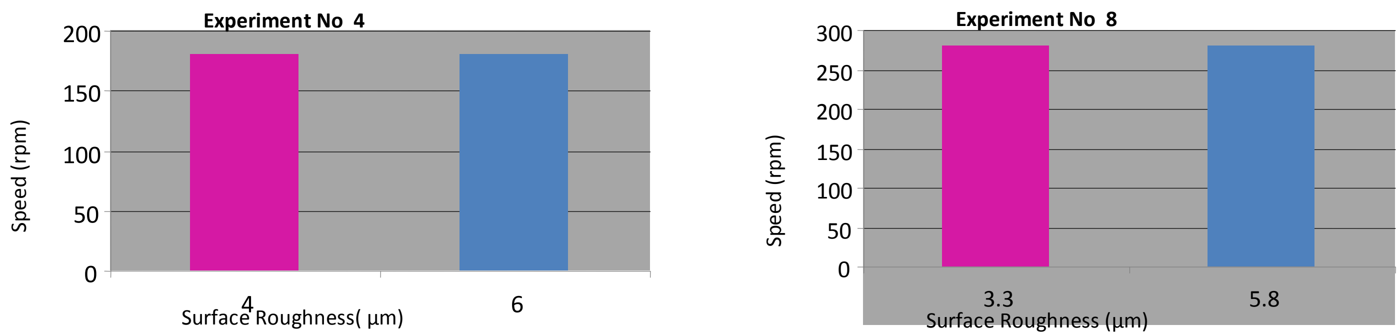


Fig: 4(Experiments 4 & 8) [F =0.14 mm/rev, D =1.4 mm]

The following observations have been made

- At Speed 180 rpm while feed **0.14 mm/rev** and depth of cut 1.4 mm roughness is 6.0 µm for simple turning while surface roughness is 4.0 µm for duplex turning.
- At speed 280 rpm, feed **0.14 mm/rev** and depth of cut 1.4 mm, the roughness 5.8 µm for simple turning, while 3.3 µm for duplex turning.
- It is clear that when speed increases from 180 rpm to 280 rpm by keeping the feed and depth of cut constant the surface roughness decreases for simple turning from 6.0 to 4.0 µm and also for duplex turning 4.0 to 3.3 µm.

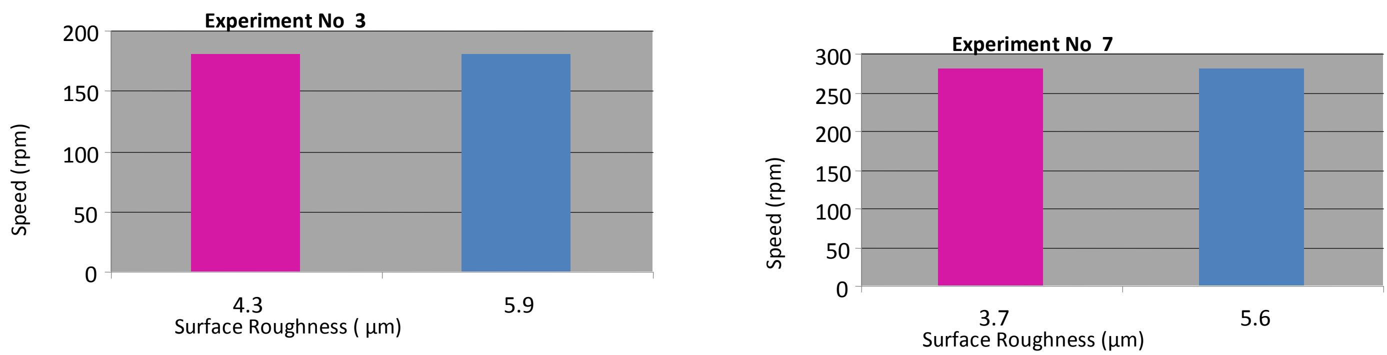


Fig: 5 (Experiments 3 & 7) [F =0.071 mm/rev, D =1.4 mm]

The following observations have been made

- At Speed 180 rpm while feed **0.071 mm/rev** and depth of cut 1.4 mm roughness is µm for simple turning while surface roughness is 4.3 µm for duplex turning.
- At speed 280 rpm, feed **0.071 mm/rev** and depth of cut 1.4 mm, the roughness 5.6 µm for simple turning, while 3.7 µm for duplex turning.
- It is clear that when speed increases from 180 rpm to 280 rpm by keeping the feed and depth of cut constant the surface roughness decreases for simple turning from 5.9 to 5.6 µm and also for duplex turning 4.3 to 3.7µm.

8.2. SURFACE ROUGHNESS VS DEPTH OF CUT

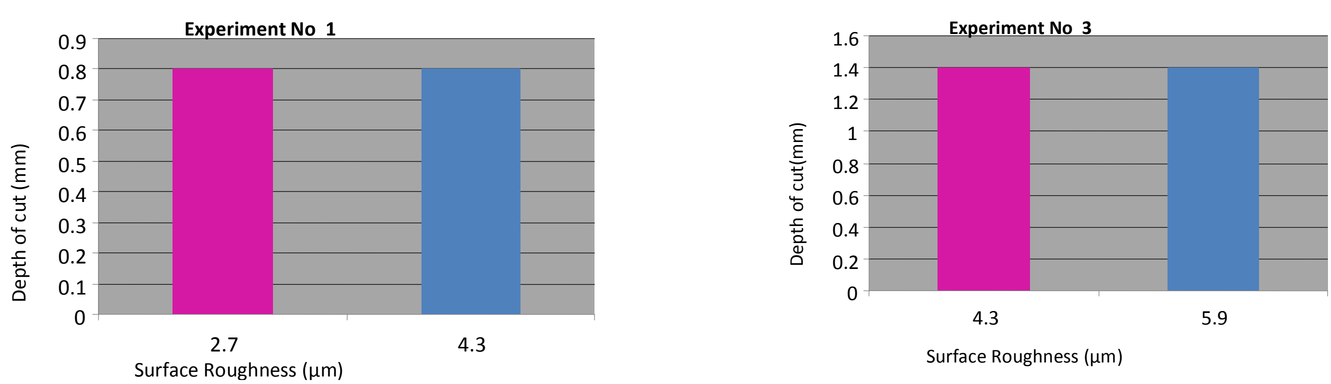


Fig: 6(Experiments 1 & 3) [F =0.071 mm/rev S=180 rpm]

The following observations have been made

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- At depth of cut 0.8 mm while feed **0.071 mm/rev** and Speed 180 rpm roughness is 4.3µm for simple turning while surface roughness is 2.7 µm for duplex turning.
- At depth of cut 1.4 mm while feed **0.071 mm/rev** and Speed 180 rpm roughness is 5.9 µm for simple turning while surface roughness is 4.3 µm for duplex turning.
- It is clear that when depth of cut increases from 0.8 mm to 1.4 mm by keeping the feed and speed constant the surface roughness increases for simple turning from 4.3 to 5.9 µm and also for duplex turning 2.7 to 4.3 µm.

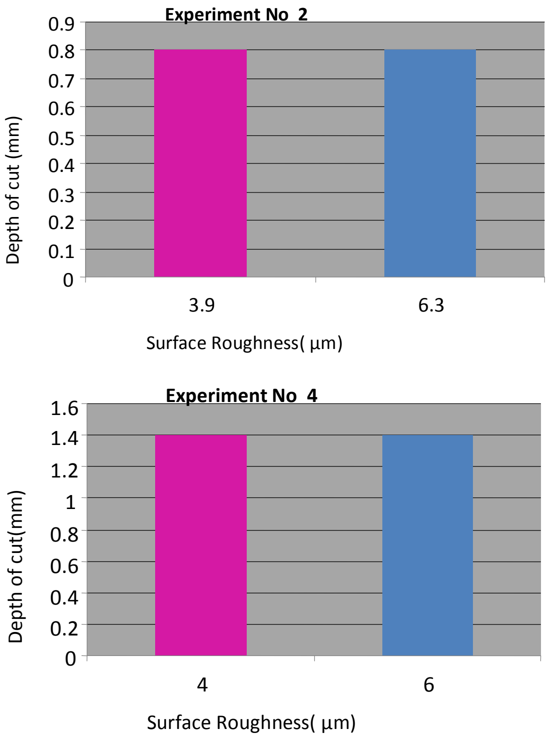


Fig:7(Experiments 2 & 4)[F = 0.14 mm/rev , S = 180 rpm]

The following observations have been made

- At depth of cut 0.8 mm while feed **0.14 mm/rev** and Speed 180 rpm roughness 6.3 µm for simple turning while surface roughness is 3.9 µm for duplex turning.
- At depth of cut 1.4 mm while feed **0.14 mm/rev** and Speed 180 rpm roughness is 6.0 µm for simple turning while surface roughness is 4.0 µm for duplex turning.
- It is clear that when depth of cut increases from 0.8 mm to 1.4 mm by keeping the feed and speed constant the surface roughness varies for simple turning from 6.3 to 6.0 µm and also for duplex turning 3.9 to 4.0µm.

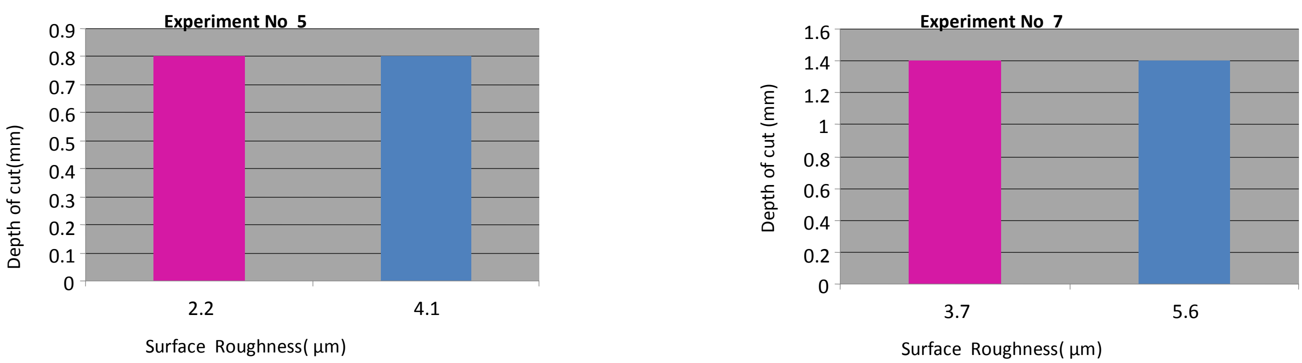
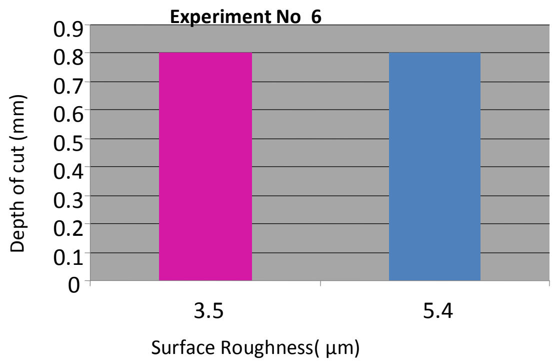


Fig:8(Experiments 5 & 7) [F = 0.071 mm/rev, S = 280rpm]

The following observations have been made

- At depth of cut 0.8 mm while feed **0.071 mm/rev** and Speed 280 rpm roughness is 4.1µm for simple turning while surface roughness is 2.2µm for duplex turning.
- At depth of cut 1.4 mm while feed **0.071 mm/rev** and Speed 280 rpm roughness is 5.6µm for simple turning while surface roughness is 3.7 µm for duplex turning.It is clear that when depth of cut increases from 0.8 mm to 1.4 mm by keeping the feed and speed constant the surface roughness varies for simple turning from 4.1 to 5.6 µm and also for duplex turning 2.2 to 3.7 µm.



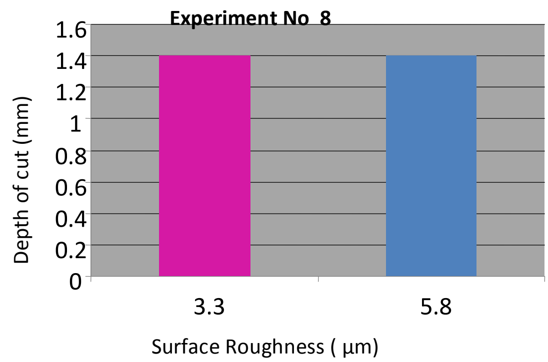
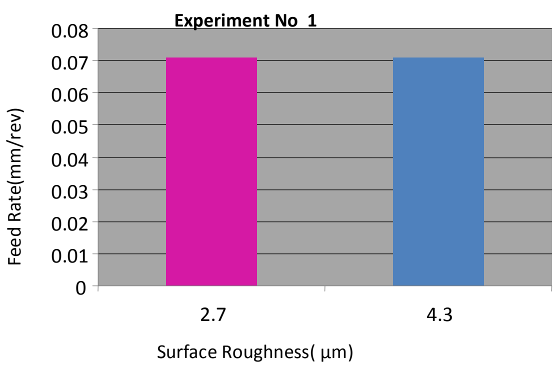


Fig: 9(Experiments 6 & 8) [F = 0.14 mm/rev, S = 280rpm]

The following observations have been made

- At depth of cut 0.8 mm while feed **0.14 mm/rev** and Speed 280 rpm roughness is 5.4 µm for simple turning while surface roughness is 3.5 µm for duplex turning.
- At depth of cut 1.4mm while feed **0.14 mm/rev** and Speed 280 rpm roughness is 5.8 µm for simple turning while surface roughness is 3.3 µm for duplex turning.
- It is clear that when depth of cut increases from 0.8 mm to 1.4 mm by keeping the feed and speed constant the surface roughness varies for simple turning from 5.4 to 5.8 µm and also for duplex turning 3.5 to 3.3 µm.

8.3: SURFACE ROUGHNESS VS FEED



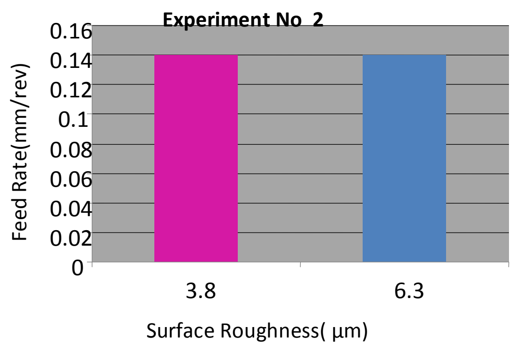


Fig.10 (Experiments 1& 2) [D = 0.8 mm, S = 180 rpm]

The following observations have been made

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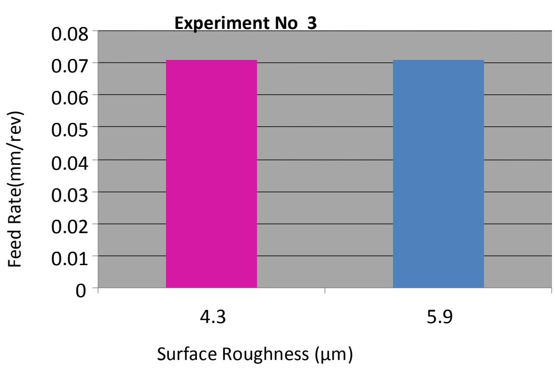
- At feed **0.071 mm/rev** while depth of cut 0.8mm and Speed 180 rpm roughness is 4.3 µm for simple turning while surface roughness is 3.7 µm for duplex turning.
- At feed **0.14 mm/rev** while an depth of cut 0.8mm Speed 180 rpm roughness is 6.3µm for simple turning while surface roughness is 3.8µm for duplex turning.
- It is clear that while feed increases from 0.071 mm/rev to 0.14 mm/rev by keeping the depth of cut and speed constant the surface roughness varies for simple turning from 4.3 to 6.3 µm and also for duplex turning 3.7 to 3.8 µm.



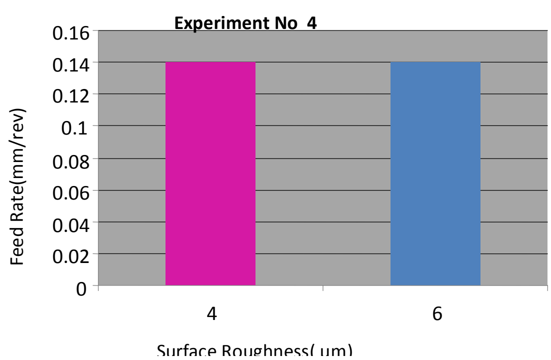


Fig: 11(Experiments 3 & 4) [D = 1.4 mm , S = 180 rpm]

The following observations have been made

- At feed **0.071 mm/rev** while depth of cut 1.4 mm and Speed 180 rpm roughness is 5.9 µm for simple turning while surface roughness is 4.3µm for duplex turning.
- At feed **0.14 mm/rev** while a depth of cut 1.4 mm Speed 180 rpm roughness is 6.0 µm for simple turning while surface roughness is 4.0µm for duplex turning.
- It is clear that while feed increases from 0.071 mm/rerv to 0.14 mm/rev by keeping the depth of cut and speed constant the surface roughness varies for simple turning from 5.9 to 6.0 µm and also for duplex turning 4.3 to 4.0 µm.

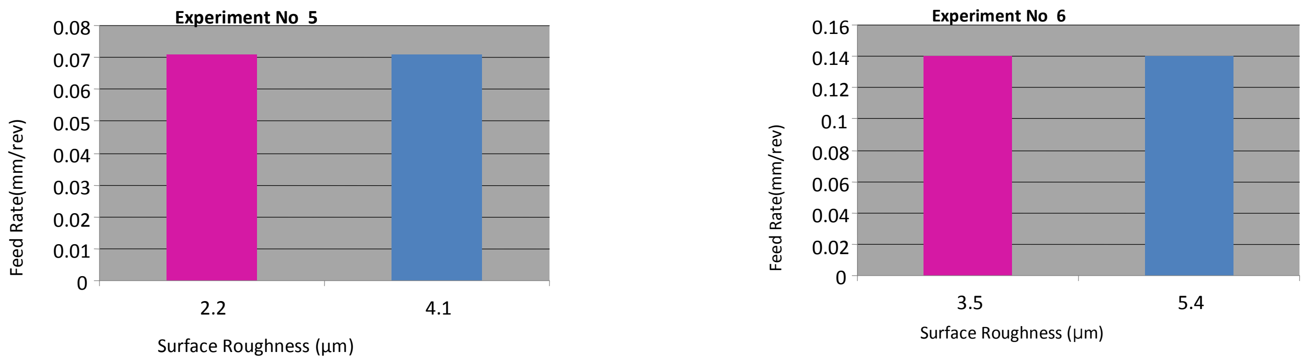


Fig: 12(Experiments 5 & 6) [D = 0.8 mm, S = 280 rpm]

The following observations have been made

- At feed **0.071 mm/rev** while depth of cut 0.8 mm and Speed 280 rpm roughness is 4.1 µm for simple turning while surface roughness is 2.2µm for duplex turning.
- At feed **0.14 mm/rev** while a depth of cut 0.8mm Speed 280 rpm roughness is 5.4 µm for simple turning while surface roughness is 3.5µm for duplex turning.
- it is clear that when feed increases from 0.071 mm/rev to 0.14mm/rev by keeping the depth of cut and speed constant the surface roughness varies for simple turning from 4.1to 5.4 µm and also for duplex turning 2.2 to 3.5µm.

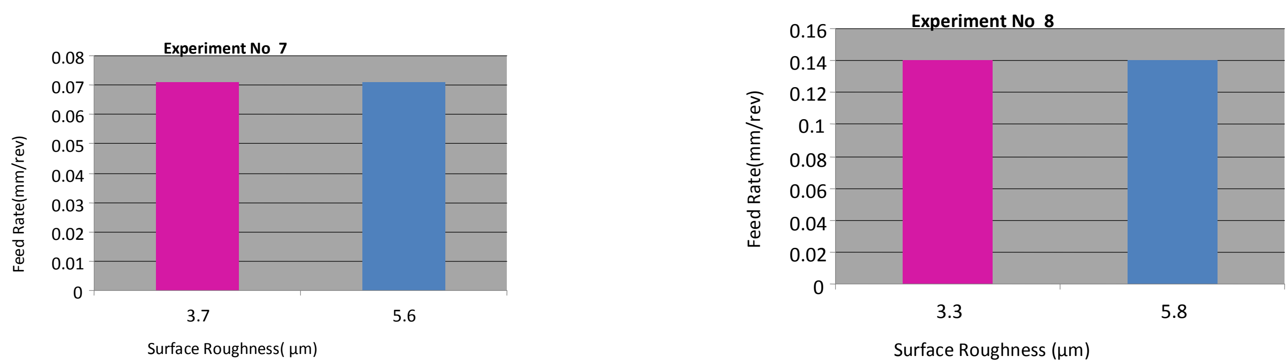


Fig: 13(Experiments 7 & 8) [D = 1.4 mm, S = 280 rpm]

The following observations have been made from

- At feed **0.071 mm/rev** while depth of cut 1.4 mm and Speed 280 rpm roughness is 5.6 µm for simple turning while surface roughness is 3.7µm for duplex turning.
- At feed **0.14 mm/rev** while an depth of cut 1.4 mm , Speed 280 rpm roughness is 5.8 µm for simple turning while surface roughness is 3.3 µm for duplex turning.
- It is clear that when feed increases from 0.071mm/rerv to 0.14mm/rev by keeping the depth of cut and speed constant the surface roughness varies for simple turning from 5.6to 5.8 µm and also for duplex turning 3.7 to 3.3µm.

9. RESULTS AND DISCUSSION

1. It has been observed in single tool turning that large feed rate produce more cutting force. it has been also observed that vibration increases when feed rate increases which leads the chatter but while we used multi-tool (Duplex) machining ,the surface finish increased as compared to single tool machining.
2. Result indicates that in multi-tool (Duplex) machining provide better stability as compared to single tool machining because of using two tools on same cross-slide.
3. It has been concluded that using of two tools or in duplex machining, surface finish improved while increasing the depth of cut.

4. The demarcation in duplex turning better surface finish achieved as compared to single tool turning for same cutting speed. By multi-tool machining we reduces the depth of cut hence reduce the cutting force so at low cutting speed the cutting forces reduced in multi-tool The fluctuation in the surface roughness with cutting speed at low cutting speeds, the cutting forces are high and tendency of work material to form a built up edge is also stronger. Due to increase in temperature and consequent decrease of frictional stress at the rake face at higher cutting speeds, cutting forces and tendency towards built-up edge formation weakens. Both these effects are beneficial for surface finish. At relatively small cutting speed the built up edge does not form on account of the cutting temperature being too low. As speed increased, condition become more and more favorable for built up edge formation. However when the cutting speed is increased further, the built up edge size start decreasing owing to increased tool temperature. Finally, at a sufficiently high speed, the built up edge disappears thus the

surface finish increases. Surface roughness fluctuates with cutting speed. Duplex machining gives better surface finishing with respect to single tool. By duplex machining we have reduces depth of cut hence reduces the cutting force so at low cutting speed the cutting forces induced in duplex machining is less than single tool hence tendency to work material to form a built up edge is also deceases and gives better surface finish with respect to a single tool. At higher cutting speed forces and tendency toward built up edge formation weakens in duplex machining with respect to single tool. Both these effects are favorable for surface finish hence duplex machining gives better surface finish with respect to machining with single tool.

5: The surface roughness increases with increasing the shear plane area. Duplex machining gives better surface finish with respect to single tool by duplex machining we have reduces the shear plane area, when shear plane area reduces then surface finish increases.

8. CONCLUSIONS REMARKS

The Following conclusions have been made from the experimental investigation-

- Surface finish obtained at low cutting feeds is better than higher cutting feeds.
- Higher depth of cut gives less surface finish with respect to at lower depth of Cut.
- There is fluctuation in surface roughness with cutting speed. Surface finish Obtained at higher cutting speed is better than lower cutting speed.
- Surface finish obtained at low shear plane area is better than higher shear Plane area.
- Multi tool machining gives better surface finish with feed with respect to single tool.
- Surface finish obtained through duplex machining is better than single tool with shear plane area.
- Multi tool machining reduces the radial vibration, which is to be produced by Single tool and increase in stability of the system or machine tool.
- Multi tool machining reduces the radial deflection of the work piece and maintains the dimensional accuracy of the work piece.
- Duplex machining also increase the tool life.

9: SCOPE FOR FUTURE WORK

- These experiments can also be performed for wet condition by using cutting fluid.
- It can also be performed changing the different tools like carbide, ceramic etc.
- It can be performed by using different other kinds of forming tools.

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