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Research Paper

INVESTIGATION OF MACHINING PARAMETERS ON SS304 MATERIAL

Krishnamoorthy W[1]*, Saravanan G[1] and Senthil Kumar T[1]

Corresponding Author: **Krishnamoorthy W ✉ Krishnabemech@gmail.com*

The objective of our project is to investigate the effect of process parameters in turning of SS304-Austenitic stainless steels in a CNC lathe by using coated carbide tool. The parameters namely the spindle speed, feed rate and depth of cut are varied to experiment their effect on surface roughness and material removal rate (MRR). The experiments are conducted using L9 mixed level and one factor at a time approach. The SS304 (9 Sample) are used for CNC turning operations. The investigates reveals that the surface roughness and material removal rate is directly influenced by the Spindle speed, feed rate and depth of cut. It is observed that the surface roughness decrease and decreases with related to feed rate, spindle speed and depth of cut. While MRR increase and increases with related to feed rate, spindle speed and vice versa for all depth of cut and also monitor the machining time, percentage of load for SS304-Austenitic stainless steel machining in CNC lathe.

Keywords: Surface roughness, Economic cutting speed, Excessive tool wear

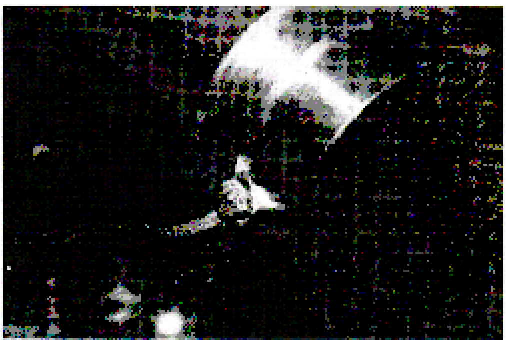
INTRODUCTION

In metal cutting and manufacturing industries, surface finish of a product is very crucial in determining the quality. Good surface finish not only assures quality, but also reduces manufacturing cost. Surface finish is important in terms of tolerances, it reduces assembly time and avoids the need for secondary operation, thus reduces operation time and leads to overall cost reduction. Besides, good-quality turned surface is significant in improving fatigue strength, corrosion resistance, and creep life. Due to the increasing demand of higher precision components for its functional aspect, surface roughness of a machined part play an important role in the modern manufacturing process. Surface roughness also affects several functional attributes of parts, such as contact causing surface friction, wearing, light reflection, heat transmission, ability of distributing and holding a lubricant, load bearing capacity, coating or resisting fatigue. Therefore, the desired surface finish is usually specified and the appropriate process are selected to reach the required quality (David E Goldberg, 1989). Surface roughness plays an important role in affecting friction, wear

[1] Department of Mechanical Engineering, BIT Campus, Anna University.

and lubrication of contacting bodies (Deb K, 1996). Surface roughness is one of the parameters that greatly influence the friction under certain running conditions (Pai B *et al*., 2001). Surface roughness of the contacting surfaces influences the frictional properties of those surface during the forming processes (Baji D and Belai A, 2006). It is clear now that surface roughness geometry strongly influences the manner in which the contacting surface roughness is influenced by various machining conditions such as spindle speed, feed rate and depth of cut (Baji D and Majce I, 2006).

There is no way to eliminate the heat generated at the cutting edge. The use of cutting fluids has an effect on the head generated by friction. However, the majority of the heat is produced by the deformation of the metal itself as it is removed. Heat can be removed by simply pouring the coolant over the tool as it cuts. This project majorly centers on this problem. This also leads to reduced tool life under various operating conditions, which leads to the replacement of tool long before the predicted theoretical tool life. The life of the cutting tool is determined by material removal rate and percentage of load.



CNC LATHE

It has long been recognized that conditions during cutting, such as feed rate, cutting speed and depth of cut, should be selected to optimize the economics of machining operations, as assessed by productivity, total manufacturing cost per component or some other suitable criterion. Since long researchers showed that an optimum or economic cutting speed exists, this could maximize material removal rate. Manufacturing industries have long depended on the skill and experience of shop-floor machine-tool operators for optimal selection of cutting conditions and cutting tools. Considerable efforts are still in progress on the use of handbook based conservative cutting conditions and cutting tool selection at the process planning level. The most adverse effect of such a not-very scientific practice is decreased productivity due to sub-optimal use of machining capability. The need for selecting and implementing optimal machining conditions and the most suitable cutting tool has been felt over the last few decades. Despite early works on establishing optimum cutting speeds in CNC machining, progress has been slow since all the process parameters need to be optimized.

Furthermore, for realistic solutions, the many constraints met in practice, such as low machine tool power, torque, force limits and component surface roughness must be overcome. The non-availability of the required technological performance equation represents a major obstacle to implementation of optimized cutting conditions in practice. This follows since extensive testing is required to establish empirical

performance equations for each tool coating work material combination for a given machining operations, which can be quite expensive when a wide spectrum of machining operations is considered.

CNC codes

Preparatory Functions (G-codes)

This is denoted by 'G'. These are present function associated with the movement of machine axes and the associated geometry, it prepares the machine control unit .

Miscellaneous Function (M-codes)

Miscellaneous functions perform a variety of auxillary commands, such as stopping the program, starting or stopping the stopping the spindle or feed, tool changes, coolant flowetc, which control the machine tool. This is denoted by 'M'. These functions actually operate some controls on the machine tool and thus affect the running of the machine.

SURFACE ROUGHNESS AND MRR DETAILS

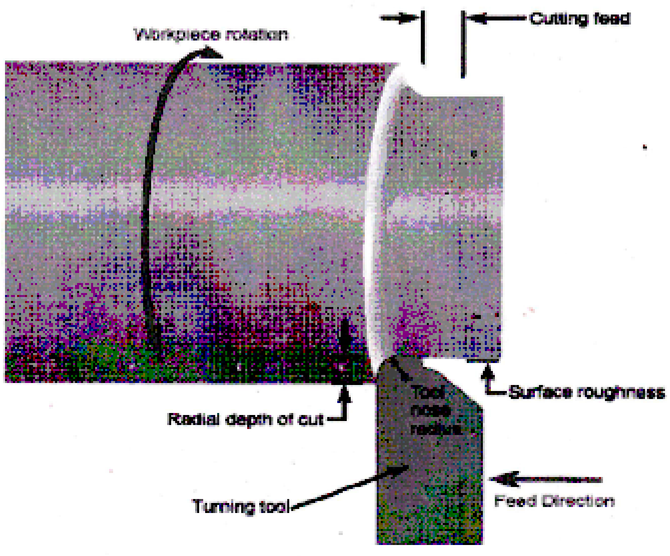
To turn stainless steel 304 material in CNC Fanuc control lathe machine, for that we are using TNMGI60404 cutting tool in the inserted type toll holder. The CNC turning operation program has given. The spindle speeds, feed rates safe and depths of cut were selected form the standard tablets given for the safe operation of the materials to avoid excessive tool wear and tool failure. The surface roughness of all the sample pieces were measured using a surface roughness tester, it is capable of evaluating surface texture with a variety of parameters according to various national and international standards. The measurement results are displayed digitally/ graphically on the touch panel, and output to the built-in printer. The stylus of the detector unit traces the minute irregularities of the work piece surface. Surface roughness is determined from the vertical stylus displacement produced during the detector traversing over the surface

G-CODES	FUNCTION
G00	Rapied positioning
G01	Linear interpolation
G02	Circular interpolation cw
G03	Circular interpolation ccw
G04	Dwell
G20	Input in inch
G21	Input in mm
G28	Reference point return
G32	Thread cutting
G50	Spindle speed clamping
G70	Finishing cycle
G71	Multiple turning cycle
G72	Multiple facing cycle
G74	Peak drilling cycle
G75	Grooving cycle
G76	Thread cutting cycle
G98	Feed per unit (mm/minute)
G99	Feed per revolution (mm/revolution)

M code	Function
M00	Programming stop
M01	Optional stop
M02	Program end
M03	Spindle rotate cw
M04	Spindle rotate ccw
M05	Spindle stop
M06	Tool change
M08	Coolant
M09	Coolant off
M10	Vice open
M11	Vice close
M30	Program end
M98	Sub program call
M99	Sub program exit

irregularities. The Arithmetic Mean Deviation of the profile, surface roughness average (Ra) of the each sample piece is noted down as a surface roughness measure. 9samples of the surface roughness profile S210surface roughness tester value and material removal rate to calculate values given the table.

S.No	Name of the Parameter	Symbol	Range
1	Spindle Speed	N	300-500 rpm
2	Feed rate	F	1-2 mm/rev
3	Depth of Cut	Dcut	1-2 mm



Surface roughness

Surface roughness is determined from the SJ220surface roughness tester. The Arithmetic Mena Deviation of the profile, surface roughness average (Ra) of the each sample piece is noted down as a surface roughness measure. 9 samples of the surface roughness value given table.

Turning of Metal Removal Rate. The rate at which material is removed from an unfinished part, usually measured in cubic millimeter per minute.

Calculation of MRR

Material removal rate (MRR) has been calculated from the difference of weight of work piece before and after experiment by using the following formula to calculate the N9 samples value are table

MRR = (Wi – Wf)/ PsT mm^3/ min

where

Wi is the initial weight of workpiece in gms

Wf is the final weight of workpiece in gms

T is the machining time in minutes

Ps is the density of SS 304-austenitic stainless steel.

Machining Time

The time during which a piece of equipment (machine, lathe, unit, or apparatus), without direct participation of an operator, produces a change in the dimensions, shape, or state of a work piece. The machining time depends on the characteristics of the manufacturing process; on the qualitive features of the raw material, semi finished product, or stock; on the type of equipment and tool; and on the mechanization and automation of labor.

Machining time T_{mp}=L fN per pass (cut) in sec.

L = length

F = feed

N = rpm

Process parameters

Cutting speed (V)

The cutting speed(in a lathe for turning operation) is the peripheral speed of the Workpiece past the cutting tool.

V=πDN I 1000 mm/min

where,

V=Cutting/peripheral speed,mm/min

D=Diameter of the job, mm and

N= Job or spindle speed, rpm

Feed (f)

It is defined as the distance that a tool advances in to the work during one revolutionof the headstock spindle.

f = L/NxTm

where,

L=Length of cut, mm

N= Job or spindle speed, rpm

T=Machining time/cutting time, min Depth of cut(d)

The depth of cut is the perpendicular distance measured from the machined surface to the uncut surface of the workpiece.

d = Di – Df/ 2 mm

where,

Di =Initial/original diameter of the workpiece, mm, and

Df=Final diameter of the workpiece, mm

EXPERIMENT WORK

Material and Surface Preparation

It is well recognized that you can make a poor coating perform with excellent pre-treatment, but you cannot make an excellent coating perform with poor pre-treatment. Surface pre-treatment by chemical or mechanical means is also important in painting, and the methods used are designed to ensure good adhesion of the paint to the alloy surface. Main specifications concerning surface preparation. Most metal surface treatment and plating operations have three basic steps:

1. Surface cleaning or preparation, which involves the use of solvents, alkaline cleaners, acid cleaners, abrasive materials, and/or water.
2. Surface modification, which involves some change in surface properties, such as application of a metal layer or hardening.
3. Rinsing or other work piece finishing operations to produce the final product.

Nickel and Chromium coated carbide tools

Nickel

Nickel coating is recommended for use in phenolic resin bond and polyimide bonding systems to improve the mechanical retention characteristics of the diamond. It also improves grinding wheel life and surface finish.

Electro less nickel coatings are uniform, hard, relatively brittle, lubricous, easily solder able and highly corrosion resistant. They can be precipitation hardened to very high levels through the use of low temperature treatments, producing wear resistance equal to that of commercial hard chrome coatings. This combination makes the coating well suited for many severe applications and often allows it to de used in place of more expensive or less readily available alloys.

Chromium

Chromium is used as a protective coating, providing resistance to wear, abrasion, And corrosion. It has hardness in the range 900 to HV, low –friction characteristics, and high reflectivity. It is used as a thin coating, usually in the range 0.2 to 1um thick, As the final layer in a multiple plate copper –nickel – chromium electroplating or as a thick coating up to 300 um to provide wear resistance. When used as constituent of a multiple-plate coating, chromium provides hardness, reflectivity, and tarnish resistance.

Properties of SS304

Composition

Typical compositional ranges for grade 304 stainless steels are given in table

Mechanical Properties

Typical mechanical properties for grade 304 stainless steels are given in table

Physical Properties

Typical physical properties for grade 304 stainless steels are given in table

Table: Composition Ranges for 304 Grade Stainless Steel

Grade	C	Mn	Si	P	S	Cr	Ni	N	Fe
304	Min.Max.	-0.08	-2.0	-0.75	-0.030	18.020.0	8.010.5	-0.10	Balance

Table: Mechanical Properties of 304 Grade Stainless Steel

Grade	Tensile Strength (MPa) Min	Yield Strength 0.2% Proof (MPa) min	Elongation (%in 50mm) min	Hardness	
				Rockwell B (HR B)max	Brinell(HB)max
304	515	205	40	92	201

Table: Physical Properties of 304 Grade Stainless Steel

Property	Value
Density	8.00 g/cm^3
Melting Point	1450^{o}C
Modulus of Elasticity	193GPa
Electrical Resistivity	0.072x10^{-6}U.m
Thermal Conductivity	16.2 W/m.K
Thermal Expansion	17.2x10^{-6} / K

Selection Of Material

Stainless Steel

Stainless steels resistance to corrosion and staining, low maintenance, relatively low cost, and familiar luster make it an ideal base material for a host of commercial applications. There are over 150 grades of stainless steel, of which fifteen are most common. The alloy is milled into coils, sheets, plates, bars, wire, and tubing to be used in cookware, cutlery, hardware, surgical instruments, major appliances, industrial equipment, and as an automotive and aerospace structural alloy and construction material in large buildings. Storage tanks and tankers used to transport orange juice and other food are often made of stainless steel, due to its corrosion resistance and antibacterial properties. This also influences its use in commercial kitchens and food processing plants, as it can be steam-cleaned, sterilized, and does not need painting or application of other surface finishes.

Stainless steel is used for jewellery and watches. The most common stainless steel alloy used for this is 316L. It can be re-finished by any jeweler and will not oxidize or turn black.

MACHINABILITY OF STAINLESS STEEL

Machinability is the term used to denote the machining performance of a material by a cutting tool. The ease with which a given material may be worked with a cutting tool is machinability.

Machinability Depends On

(a) Chemical composition of job material

(b) Structure

(c) Mechanical properties

(d) Physical properties

(e) Cutting conditions

The Criteria For Judging Machinability May Be:

(a) Tool life

(b) Cutting force

(c) Surface finish

(d) Chip characteristic (Chip color, types, thickness & reduction coefficient)

(e) Cutting temperature

DESIGN OF EXPERIMENTS

Turning is one of the most basic machining processes. That is, the part is rotated while a single point cutting tool is moved parallel to the axis of rotation. Turning can be done on the external surface of the part as well as internally (boring). The starting material is generally a work piece generated by other processes such as casting, forging, extrusion, or drawing.

Facing is part of the turning process. It involves moving the cutting tool at right angles to the axis of rotation of the rotating work piece. This can be performed by the operation of the cross-slide, if one is fitted, as distinct from the longitudinal feed (turning). It is frequently the first operation performed in the production of the work piece, and often the last-hence the phrase "ending up".

Parting is used to create deep grooves which will remove a completed or part-complete component from its parent stock.

Grooving is like parting, except that grooves are cut to a specific depth by a form tool instead of severing a completed/part-component from the stock. Grooving can be performed on internal and external surfaces, as well as on the face of the part (face grooving or trepanning).

Drilling is used to remove material from the inside of a work piece.

This process utilizes standard drill bits held stationary in the tail stock or tool turret of the lathe.

Screw cutting both standard and non-standard screw threads can be turned on a lathe using an appropriate cutting tool. (Usually having a $60^{o,}$ or 55^{o}nose angle) either externally, or within a bore. Generally referred to as single-point threading.

The Centre lathe (UK) or engine lathe is an universal tool, universal in that most machining operations can be performed with this machine tool. These operations include the following:

1. **Reaming** – HSS (High Speed Steel) fluted reamer, carbide tipped floating reamer
2. **Taper turning**

a) from the compound slide & using a form tool

b) from taper turning attachment

c) by the offsetting of the tailstock – this method more suited for shallow tapers

CNC PROGRAM

```
O0666;
Nl;
G0 X32 Z50 M7;
M4 S1400;
Z0.5;
G71 U1.5 R0.5;
G71 P18 Q19 U0 W0 F0.3;
N18 G0 X26 ;
G1 Z-30;
N19 X32.5;
G0 Z50 M5;
T0 M9;
G0 X0 Z-50 T0;
M30;
;
%
```

Here,

T08-Tool offset no

M4-Coolant on

G71-Turning Cycle

U-Side Depth Of Cut Relief Amount

M5-Spindle Off

M9-Coolant Off

- End Of the Block

RESULTS AND DISCUSSION

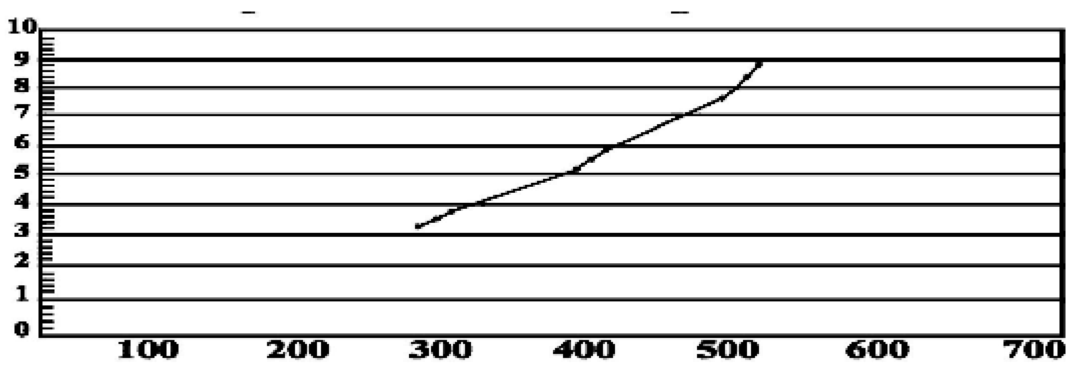
Experimental result of Machining time, Surface roughness and MRR value

Sample No	Machining time (sec)	Surface roughness (R_a) (um)	Material Removal Rate (MRR) (mm^3/min)
1	46	3.199	10760.86
2	24	3.432	20625
3	17	3.626	29117.64
4	39	5.243	12692.30
5	20	5.396	24750
6	14	5.660	35357.14
7	34	7.771	14558.82
8	16	8.361	30937.5
9	12	8.597	41250

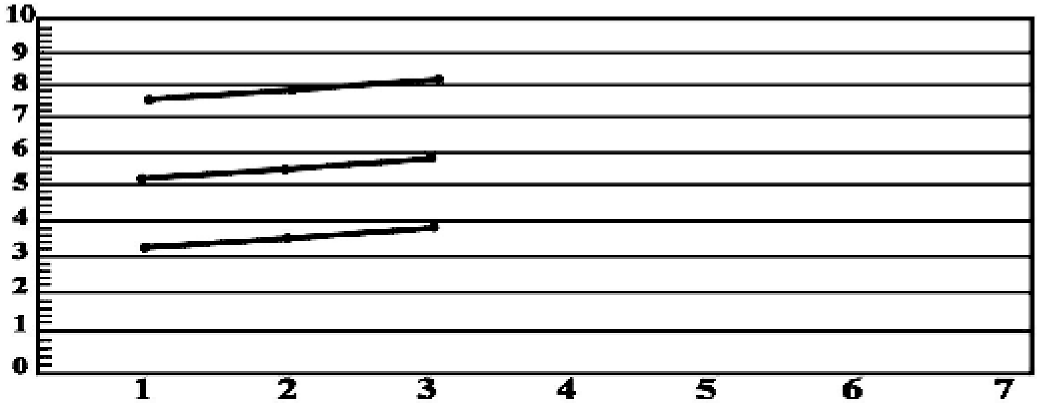
Design of Experiment (DOE)

Sample No	Speed (rpm)	Feed (mm/rev)	Depth of cut (mm)
1	300	1	1
2	300	2	2
3	300	3	3
4	400	1	1
5	400	2	2
6	400	3	3
7	500	1	1
8	500	2	2
9	500	3	3

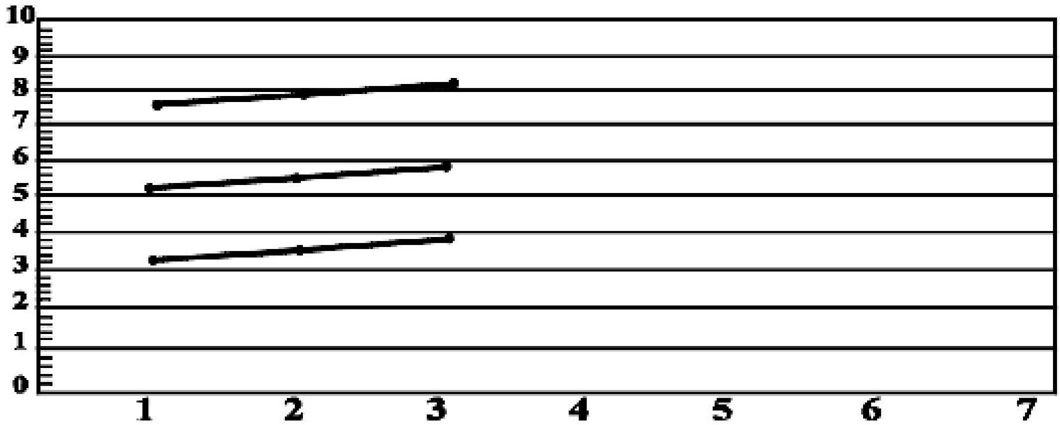
Graph: Speed Vs. Surface Roughness



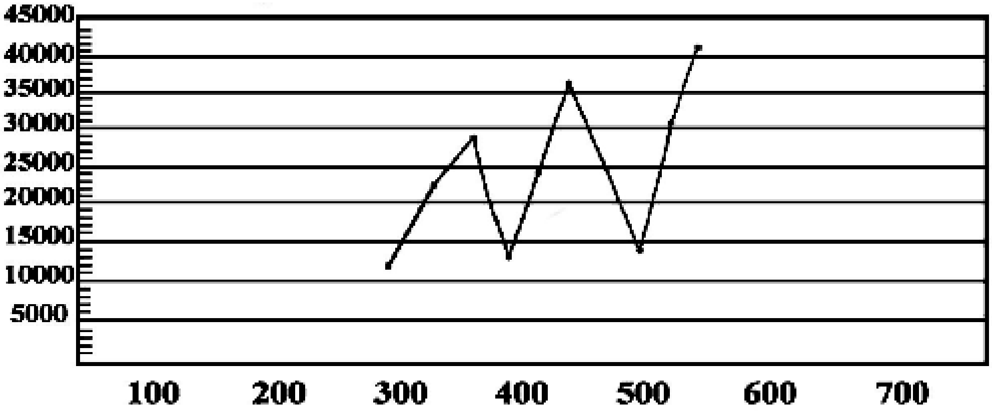
Graph: Feed Rate Vs. Surface Roughness



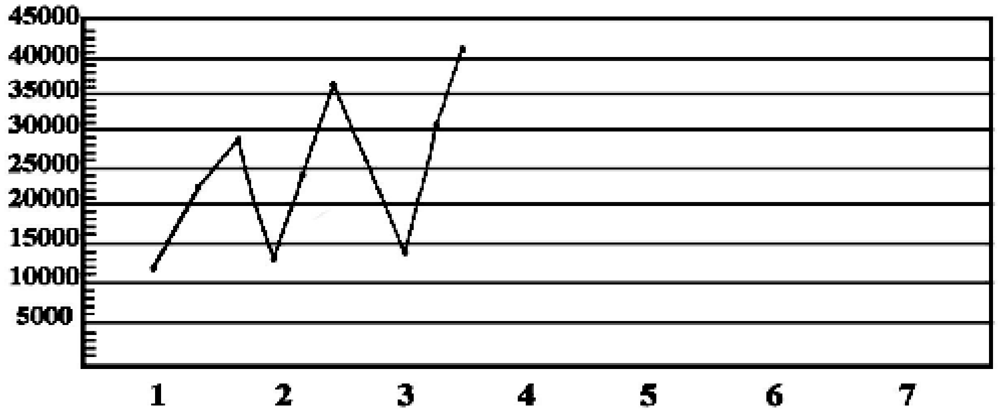
Graph: Depth of Cut Vs. Surface Roughness



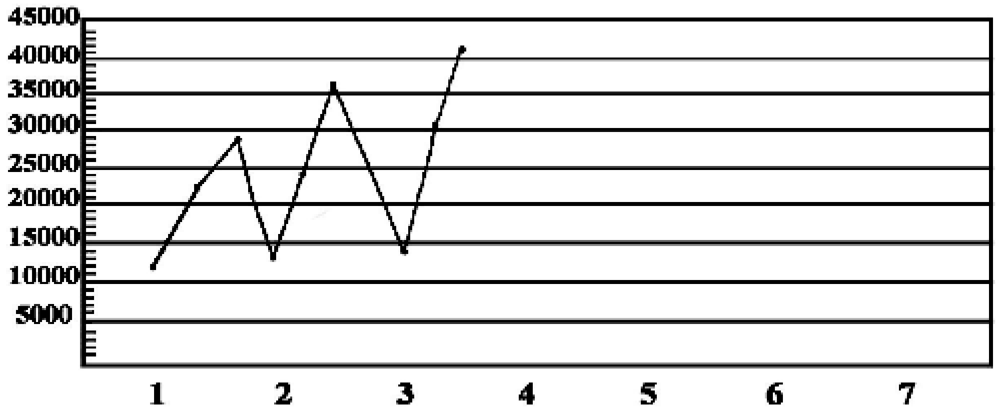
Graph: Speed Vs. Material Remove Rate



Graph: Feed Rate Vs. Material Remove Rate



Graph: Depth of Cut Vs. Material Remove Rate



CONCLUSION

From this experiment of effect of spindle speed, feed rate and depth of cut on surface roughness and material removal rate of SS304 it may be concluded that the better surface finish may be achieved by turning SS304 at low feed rate and depth of cut with low spindle speeds. The outlying points in the Graphs. Better (Low) surface finish is sample number land its value 3.199mm.

In MRR of SS304 it may be concluded that the higher value by turning SS304 at high feed rate and depth of cut with high spindle speeds. The outlying points in the Graphs. Better (Higher) MRR is sampling number 9 and its value 41250 mm^{3Z}/min

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