Asian Journal of Engineering and Technology Innovation 02 (02) 2014 (05-24)

Asian Journal of Engineering and Technology Innovation

ISSN : 2347-7385

RESEARCH ARTICLE

Optimization of Turning Parameters Such as Speed Rate, Feed Rate, Depth of Cut for Surface Roughness by Taguchi Method

Taquiuddin Quazi, Pratik gajanan more

Sarswati College of Engineering, Kharghar, Navi Mumbai, 410210. India.

Received on: 08-03-2014
Accepted on: 12-03-2014
Published on: 15-03-2014

Pratik gajanan more
Sarswati College of Engineering,
Kharghar, Navi Mumbai, 410210.
India.
Email: pratik.more008@gmail.com

QR Code for Mobile users

Conflict of Interest: None Declared !

ABSTRACT

This project is based upon the study which means it is derived from experiment and observation rather than theory. For the fulfilment of objective our first motive is selection of cutting tool & work tool material selection of various process and performance parameters after parameterssss selection aims to study various techniques for the optimization for that purpose literature review and industrial survey is conducted. The objective of this study was to utilize Taguchi methods to optimize surface roughness in turning mild steel, EN-8 and EN-31. The turning parameters evaluated are cutting speed of 200, 250, and 300 m/min, feed rate of 0.08, 0.12 and 0.15 mm/rev, depth of cut of 0.5 mm and tool grades of TN60, TP0500 and TT8020, each at three levels. The experiment was designed and carried out on the basis of standard L9 Taguchi orthogonal array. The results show that the Taguchi method is suitable to solve the stated problem with minimum number of trials as compared with full factorial design.

Keywords - Surface Roughness, Turning , Cutting Tool, MS, EN-8,EN-31 Taguchi Method

Cite this article as:
Taquiuddin Quazi, Pratik gajanan more
Optimization of Turning Parameters Such as Speed Rate, Feed Rate, Depth of Cut for Surface Roughness by Taguchi Method
Asian Journal of Engineering and Technology Innovation 02 (02); 2014; 05-24

1. INTRODUCTION

The surface roughness of the machined parts is one of the most significant product quality characteristics. There are various parameters used to evaluate the surface roughness. In the present research, the average surface roughness (R_a) was selected as a characteristic of surface finish in turning operations. It is the most used standard parameter of surface roughness. This characteristic refers to the deviation from the nominal surface of the third up to sixth order. The actual surface profile is the superposition of error of the form, waviness and roughness. The order of deviation is defined in international standards. The surface roughness greatly affects the functional performance of mechanical parts such as wear resistance, fatigue strength, ability of distributing and holding a lubricant, heat generation and transmission, corrosion resistance, etc. The perfect surface quality in turning would not be achieved even in the absence of irregularities and deficiencies of the cutting process, as well as environmental effects.

In a machining process, there are two sharp and often conflicting requirements. The first is high-quality surfaces and the second is high production rate. An extremely high quality surface can produce higher production costs and time consumption. Therefore, the machine tool operators would not push the machine tool and/or cutting tool to its limit, rather using less risky process factors for that reason, which neither guarantees the achievement of the desired surface quality nor attains maximum production rate or minimum production cost. Hence, it is of great importance to exactly quantify the relationship between surface roughness and cutting conditions.

Different methodologies are employed for predicting the surface roughness in turning, such as machining theory, classical experimental design and response surface methodology (Choudhury and El-Baradie,1997; Davim,2001; Arbizu and Perez,2003; Thangavel and Selladurai,2008), artificial neural networks (Özel and Karpat,2005; Lu,2008; Karayel,2009; Marinkovic and Tanikic,2011), neuro-fuzzy systems (Jiao et al.,2004; Kirby and Chen, 2007; Tanikic et al.,2010), genetic algorithm (Chen and Chen,2003; Cus and Balic,2003), and soft computing techniques (Sam antaet al.,2008). The Taguchi method is widely used for various product and process analysis and optimization because of its relative simplicity (Kopacet al.,2002; Hascalik and Cayda,2008; Tsao and Hocheng, 2008; Yusuf etal.,2010;Mustafa and Tanju,2011). A comprehensive review of optimization techniques in metal cutting processes is available (Mukherjee and Ray, 2006).

Taguchi method is a powerful tool for the design of high-quality systems. It provides a simple, efficient and systematic approach to optimize the designs for performance, quality, and cost 1–6. The methodology is valuable when the design parameters are qualitative and discrete. The methodology is valuable when the design parameters are qualitative and discrete. Taguchi parameter design can optimize the performance characteristics through the settings of the design parameters and reduce the sensitivity of the system performance to sources of variation. In recent years, the rapid growth of interest in the Taguchi method has led to numerous applications of the method in a world-wide range of industries and countries.

The DOE is sometimes too complex, time consuming and not easy to use. More trials have to be carried out when the number of process factors increases. The TM uses special, highly fractionated factorial designs and other types of fractional designs obtained from orthogonal (balanced) arrays to study the entire experimental region of interest for the experimenter, with the minimum number of trials as compared with the classical DoE, especially with a full factorial design. Fewer trials imply that time and cost is reduced. For example, for experiment with 4 factors at 3 levels, a full factorial design would require 3^4=81 trials. Using Taguchi's experimental design, the standard OA denoted by the symbol L9 (3^4) requires only 9 trial.

The signal-to-noise (S/N) ratio, the analysis of variance (ANOVA) are employed to find the optimal levels and to analyze the effect of the turning parameters on surface roughness to perform the machining operation. Minitab is used to find out SN ratio and mean. It is also useful for response table for means and signal to noise ratio, main effect plot for mean and SN ratio.

OBJECTIVES OF RESEARCH WORK

The main objective is selection of cutting tool & work tool material, selection of various process and performance parameters. Then next objective is to develop a Taguchi method for investigating the effects of cutting parameters on surface roughness required in turning mild steel, low carbon steel and high carbon steel. To study the process and machining parameters for the performance characteristics of turning operation on CNC using different grades of Tool and with varying properties & surface roughness testing of work piece material to be carried out after machining. This study helps to compare the results in terms of effectiveness of the performance of different grades of Tools by varying process parameters.

MATERIAL & MACHINING CONDITION :

1) **TOOL1-TN60**

1	Material	Cermet
2	Insert Style	VBMT
3	Insert Size	221
4	Manufacturer's Grade	TN60
5	Shape	Diamond
6	Rake	Positive

Product Specifications Table

Cermet

Cermet inserts come in a wide variety of grades and designs in order to satisfy demanding operations. Designed to provide long tool life and excellent surface finishes, cermets combine toughness with superior wear resistance.

2) **TOOL2- TP0500**

Productivity: Specifically developed for application demanding excellent tool life under high heat conditions. It can also be used in situations where the time in cut is long or the work materials are relatively hard.

TP0500 was developed specifically for applications requiring a very high degree of heat and wear resistance, especially where the cutting conditions are to be fine-tuned to achieve maximum productivity .Ability to machine harder parts.

TP0500 means:

T	P	05	00
1	2	3	4

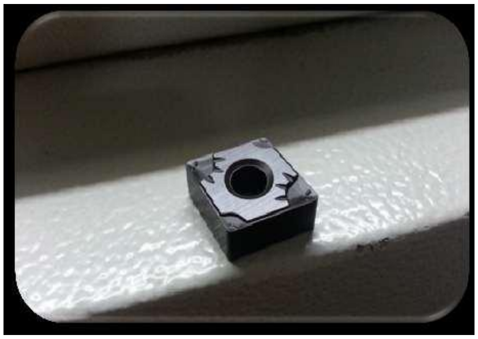
1	Type of operation
T=Turning	
M=Milling	
D=Drilling	

2	Type of material
P=Steel	
M=Stainless steel	
K=Cast iron	
H=Hard steel	
S=Superalloy & Titanium Alloy	
N=Non-ferrous	

3	Application area
05=Hard	
10=	
15=	
20=	
25=General purpose	
30=	
35=	
40=	
45=	
50=Tough	

4	Version

3) TOOL3-TT8020



PVD Coated Cermet

PVD coated cermets have features of both cermets and coated carbides. They provide good surface finishes and efficient machining. The secret of its beauty is a sophisticated manufacturing process called PVD, short for Physical Vapour Deposition. PVD basically consists in covering the entire surface of your TOOL with a thin layer of titanium, an extremely dense and exceptionally hard metal.

Advantages

l.Wide range of machining from middle roughing to finishing.
2. Better than conventional cermets when using coolant.
3. Long tool life and stable machining due to the combination of special coating layers and tough substrates.

Work piece Material :

I. MILD STEEL

Mild Steel is one of **the most common of all metals** and one of the least expensive steels used. It is to be found in almost every product created from metal.

It is weld able, very durable (although it rusts), it is relatively hard and is easily annealed.

Having less than 2 % carbon it will magnetize well and being relatively inexpensive, can be used in most projects requiring a lot of steel. However when it comes to load bearing, **its structural strength** is not usually sufficient to be used in structural beams and girders.

Most everyday items made of steel have some milder steel content. Anything from cookware, motorcycle frames through to motor car chassis, use this metal in their construction.

II. EN 8

EN8 Steel

BS970: 1955 EN8, BS970/PD970: 1970 onwards 080M40.

Related European grades: C40, C45, Ck40, Ck45, Cm40, Cm45,
Werkst off no. 1.0511, 1.1186, 1.1189.
US Grades: SAE (AISI) 1039, 1040, 1042, 1043, 1045.

EN8 is usually supplied untreated but can be supplied to order in the normalized or finally heat treated (quenched and tempered to "Q" or "R" properties for limiting ruling sections up to 63mm), which is adequate for a wide range of applications. Please refer to our selection guide for comparisons.

EN8 is a very popular grade of through-hardening medium carbon steel, which is readily machinable in any condition. (Refer to our machinability guide). EN8 is suitable for the manufacture of parts such as general-purpose axles and shafts, gears, bolts and studs. It can be further surface-hardened typically to 50-55 HRC by induction processes, producing components with enhanced wear resistance. For such applications the use of **EN8D** (080A42) is advisable. It is also available in a free-machining version, **EN8M** (212A42).

080M40 (EN8) Specification		
Chemical composition		
1	Carbon	0.36-0.44%
2	Manganese	0.10-0.40%
3	Phosphorus	0.60-1.00%
4	Molybdenum	0.050 Max
5	Silicon	0.050 Max
6	Sulphur	-
7	Chromium	-
8	Nickel	-

III) EN31 High Carbon Alloy Steel

EN31 is a high carbon Alloy steel which achieves a high degree of hardness with compressive strength and abrasion resistance.

TYPICAL ANALYSIS			
C.	Mn.	Cr.	Si.
1.00%	0.50%	1.40%	0.20%

Turning machine : Supercut 5

Surface Measuring Machine :

Wyko NT9100 Optical Profiling System

NT9100 shares many of the performance attributes with the larger systems, including: easy measurement setup, fast data acquisition, comprehensible and extensible data analysis, and angstrom-level repeatability. An X-Y stage automation option brings programmability to the NT9100, a first for a Wyko tabletop profiler. The system comes complete with the industry-leading Wyko Vision software package for advanced 2D and 3D data analysis and visualization. Vision provides over 200 built-in analyses, as well as automated measurement sequences (recipes), data logging, and pass-fail criteria for real-time process feedback and SPC.

PROCESS PARAMETERS

Two process parameters are selected for optimization: Speed rate, Feed Rate.

Tool Used: Minitab Statistical 16 (30-Days Trial Version) Software [For Taguchi Design & Analysis]

The selection of machining conditions was made according to cutting tool manufacturer's recommendations, literature reviews and parameters used in industry.Experiments were conducted with the process parameters given in **Table 8**, to obtain the machined surface. The feasible space for the cutting parameters was defined by varying the cutting speed in the range 200-300 m/min, the feed rate in the range 0.08-0.15 mm/min.

Cutting Parameter

CuttingParameters	Notation	Unit	Levels of factors		
			1	2	3
Cuttingspeed	V	m/min	200	250	300
Feed rate	F	Mm/min	0.08	0.12	0.15

Table No.8 Cutting Parameter

Performance Parameters

Surface Finish: The degree of smoothness of a part's surface after it has been manufactured. .

Surface roughness is an important measure of product quality since it greatly influences the performance of mechanical parts as well as production cost. Surface roughness has an impact on the mechanical properties like fatigue behaviour, corrosion resistance, creep life, etc. It also affects other functional attributes of parts like friction, wear, light reflection, heat transmission, lubrication, electrical conductivity, etc.

Methodology Adopted

In full factorial design, the number of experimental runs exponentially increases as the number of factors, as well as their level increases. This results in a huge experimentation cost .So, in order to compromise these two adverse factors and to search for the optimal process condition through a limited number of experimental runs Taguchi's L9 orthogonal array consisting of 9 sets of data was selected to optimize the multiple performance characteristics of the turning process.

Taguchi method

Taguchi method is a powerful tool for the design of high-quality systems. It provides a simple, efficient and systematic approach to optimize the designs for performance, quality, and cost. The methodology is valuable when the design parameters are qualitative and discrete. Taguchi parameter design can optimize the performance characteristics through the settings of the design parameters and reduce the sensitivity of the system performance to sources of variation. In recent years, the rapid growth of interest in the Taguchi method has led to numerous applications of the method in a world-wide range of industries and countries.

The DOE is sometimes too complex, time consuming and not easy to use. More trials have to be carried out when the number of process factors increases. The TM uses special, highly fractionated factorial designs and other types of fractional designs obtained from orthogonal (balanced) arrays to study the entire experimental region of interest for the experimenter, with the minimum number of trials as compared with the classical DoE, especially with a full factorial design. Fewer trials imply that time and cost is reduced. For example, for experiment with 4 factors at 3 levels, a full factorial design would require 3^4=81 trials. Using Taguchi's experimental design, the standard OA denoted by the symbol L9 (3^4) requires only 9 trial.

Experimental Work

Taguchi Design:

Taguchi designs use orthogonal arrays, which estimate the effects of factors on the response mean and variation. Orthogonal arrays allow you to investigate each effect independently from the others and may reduce the time and cost associated with the experiment when fractionated designed are used.

1) **EN-8 material with TN60 Tool**

The analysis is done by Minitab 16 software.

Taguchi Design
L9 (3**2)
Factors: 2
Runs: 9
Columns of L9 (3**4) Array

Taguchi Design analysis for Response Variable
Taguchi Analysis:
Linear Model Analysis: SN ratios versus A, B
The regression equation is
Surface roughness (R_a) = -2.6926 + 0.24766A200 - 0.0309A250 + 2.2832 B0.08 + 0.2723 B0.12
Estimated Model Coefficients for SN ratios

Term	Coef	SE Coef	T	P
Constant	-2.69264	0.3373	-7.984	0.001
A 200	0.24766	0.4769	0.519	0.631
A 250	-0.03090	0.4769	-0.065	0.951
B 0.08	2.28323	0.4769	4.787	0.009
B 0.12	0.2723	0.4769	0.571	0.599

S = 1.012 R-Sq = 89.7% R-Sq(adj) = 79.5%

Analysis of Variance for SN ratios

Source	DF	Seq SS	Adj SS	Adj MS(V)	F	P
A	2	0.3278	0.3278	0.1639	0.16	0.857
B	2	35.4541	35.4541	17.727	17.32	0.011
Residual Error	4	4.09646	4.09646	1.0236		
Total	8	39.8765				

Linear Model Analysis: Means versus A, B
The regression equation is
Surface roughness (R_a) = 1.4045 - 0.01422A200 + 0.00544A250 – 0.3544 B0.08 - 0.07789 B0.12
Estimated Model Coefficients for Means

Term	Coef	SE Coef	T	P
Constant	1.40456	0.05969	23.531	0.000
A 200	-0.01422	0.08442	-0.168	0.874
A 250	0.00544	0.08442	0.064	0.952
B 0.08	-0.35422	0.08442	-4.196	0.014
B 0.12	-0.07789	0.08442	-0.923	0.408

A (cutting speed)	B(feed rate)	R_a(surface roughness)	SNRA1	MEAN1
200	0.08	0.981	0.16662	0.981
200	0.12	1.180	-1.43764	1.180
200	0.15	2.010	-6.06392	2.010
250	0.08	1.030	-0.25674	1.030
250	0.12	1.330	-2.47703	1.330
250	0.15	1.870	-5.43683	1.870
300	0.08	1.140	-1.13810	1.140
300	0.12	1.470	-3.34635	1.470
300	0.15	1.630	-4.24375	1.630

S = 0.1791 R-Sq = 88.2% R-Sq(adj) = 76.3%

Analysis of Variance for Means

Source	DF	Seq SS	Adj SS	Adj MS (V)	F	P
A	2	0.00093	0.00092	0.000463	0.01	0.986
B	2	0.95478	0.95478	0.47739	14.89	0.014
Residual Error	4	1.12827	1.12827	0.03206		
Total	8	1.08397				

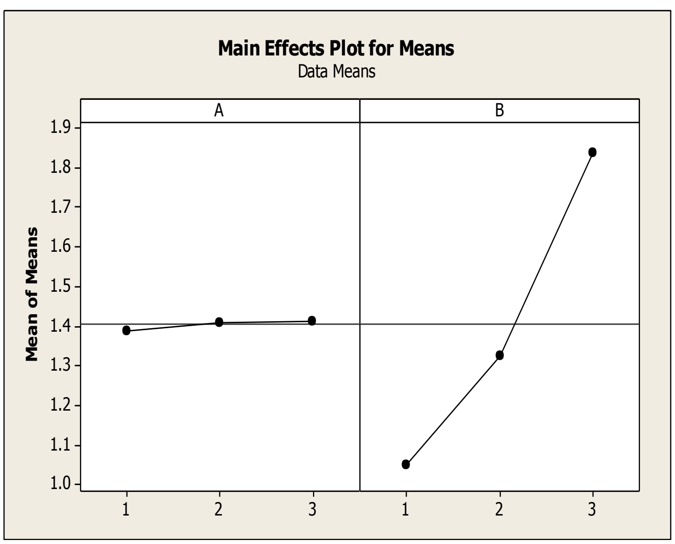
Response Table for Signal to Noise Ratios
Smaller is better

Level	A	B
1	-2.4450	-0.4094
2	-2.7235	-2.4203
3	-2.9094	-5.2482
Delta	0.4644	4.8388
Rank	2	1

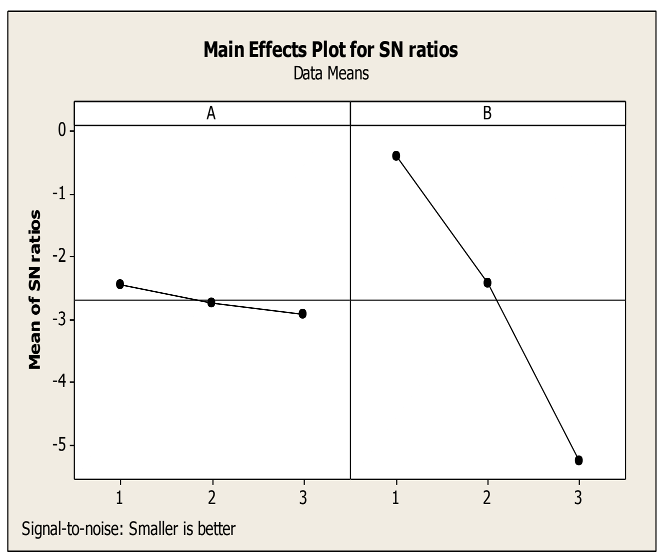
Response Table for Means

Level	A	B
1	1.39	1.050
2	1.41	1.327
3	1.413	1.837
Delta	0.023	0.786
Rank	2	1

Here we got; main affecting factor (rank 1) for surface roughness is feed rate. When the feed rate increases, surface roughness is also increases. We got good surface roughness at minimum feed rate.



Main Effects Plot for Means



Main Effects Plot for SN ratios

Fig. Main Effects Plot for Means & Main Effects Plot for SN ratios (EN-8 material with TN60 tool)

Result and Discussion:

Analysis of variance is shown in Table, which consists of DF (degree of freedom), S (sum of square), V (variance), F (variance ratio) and P (significant factor). The significant value selected was 5% (= 0.05).

Table shows that the significant value of the feed rate (P) is 0.011. It means that the feed rate influences significantly on the surface roughness value at significant value of 0.05.

In addition to P value for the cutting speed is insignificant. From this result, it can be concluded that the feed rate is more significant factor and give most contribution on the surface roughness.

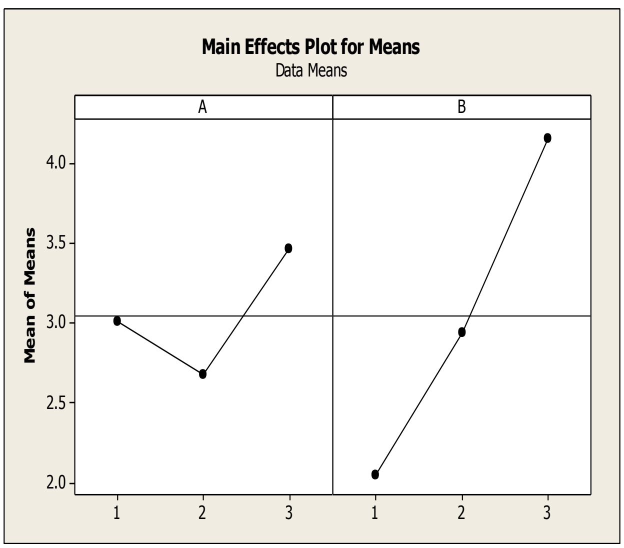
The main effects for each level of parameter on surface roughness are shown in Figure 9.The best choice for machining EN-8 with TN-60 tool is based on S/N ratio as followed; at cutting speed of (A1), feed rate of (B1). The best combination is A1B1 that means at low cutting speed and low feed rate.

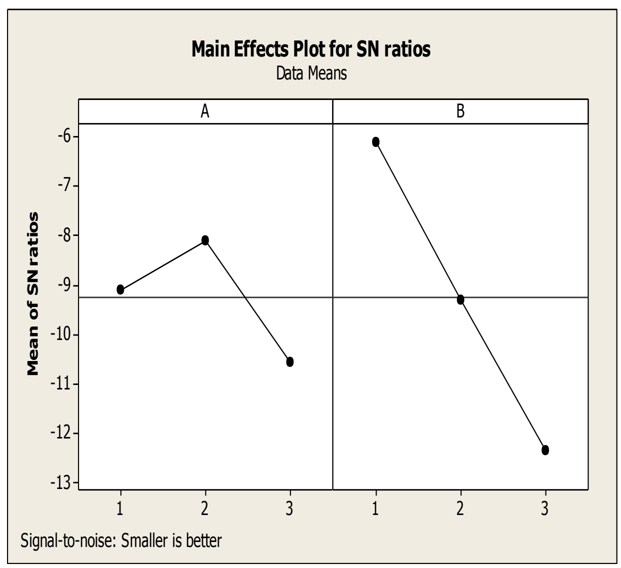
2) **EN-8 work piece with TP0500 Tool**

Taguchi Design

A(cutting speed)	B(feed rate)	R_a(surface roughness)	SNRA1	MEAN1
200	0.08	1.86	-5.3903	1.86
200	0.12	2.95	-9.3964	2.95
200	0.15	4.21	-12.4856	4.21
250	0.08	1.72	-4.7106	1.72
250	0.12	2.53	-8.0624	2.53
250	0.15	3.78	-11.5498	3.78
300	0.08	2.58	-8.2324	2.58
300	0.12	3.34	-10.4749	3.34
300	0.15	4.47	-13.0062	4.47

Taguchi Design analysis for Response Variable





Main Effects Plot for Means **Main Effects Plot for SN ratios**

Fig. 10Main Effects Plot for Means & Main Effects Plot for SN ratios (EN-8 work piece with TP0500 Tool)

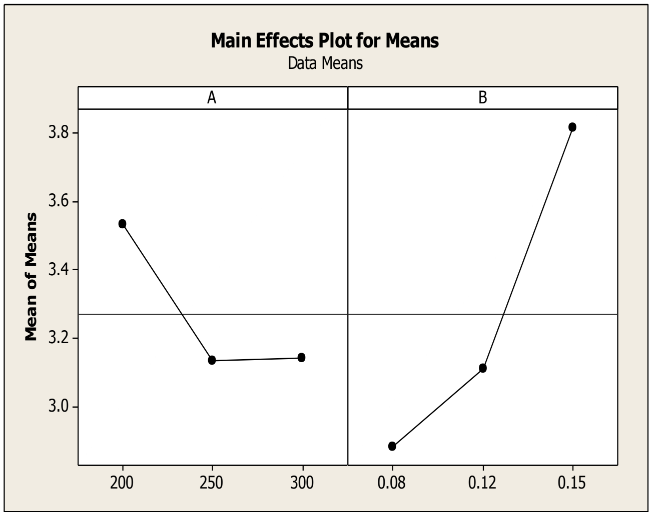
3) **EN-8 material with TT8020 Tool**

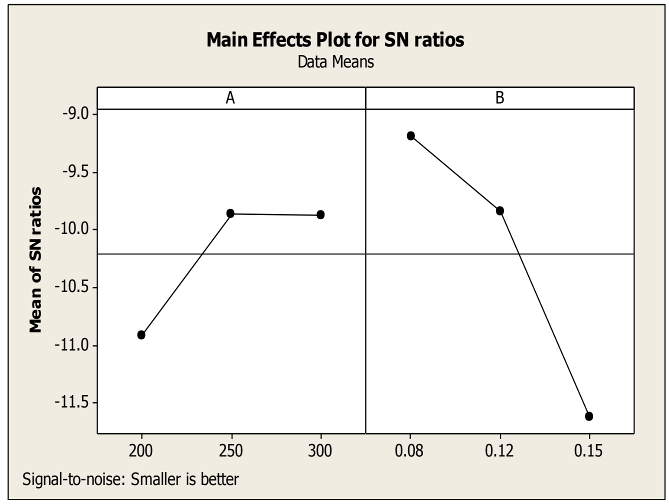
Taguchi Design

A(cutting speed)	B(feed rate)	R_a(surface roughness)	SNRA1	MEAN1
200	0.08	3.11	-9.8552	3.11
200	0.12	3.43	-10.7059	3.43
200	0.15	4.06	-12.1705	4.06
250	0.08	2.90	-9.2480	2.90
250	0.12	2.79	-8.9121	2.79
250	0.15	3.72	-11.4109	3.72
300	0.08	2.65	-8.4649	2.65

300	0.12	3.12	-9.8831	3.12
300	0.15	3.66	-11.2696	3.66

Table No.28 Taguchi Design analysis for Response Variable





Main Effects Plot for Means **Main Effects Plot for SN ratios**

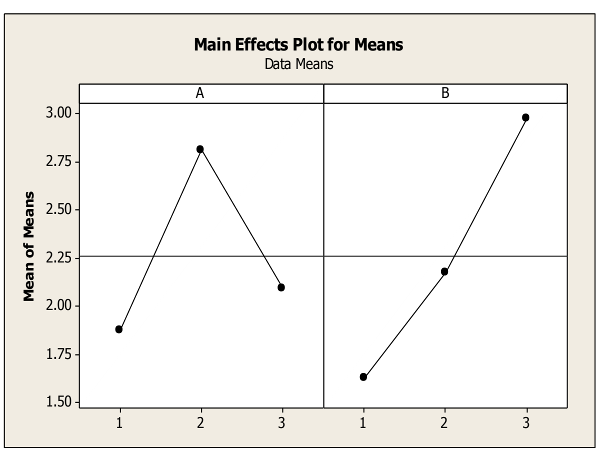
Fig. Main Effects Plot for Means & Main Effects Plot for SN ratios (EN-8 work piece with TT8020Tool)

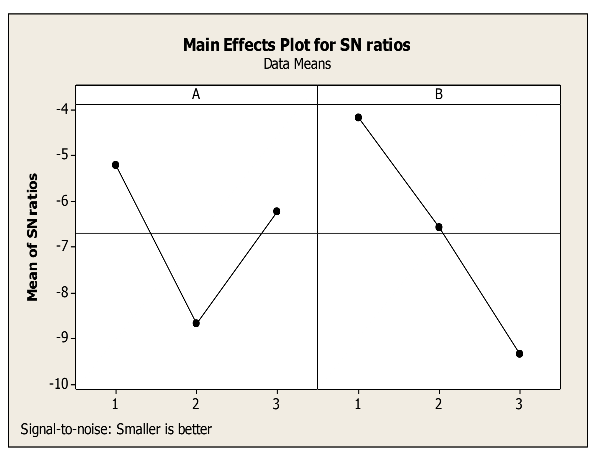
4) **MS work piece with TN-60 Tool.**

Taguchi Design

A(cutting speed)	B(feed rate)	R_a(surface roughness)	SNRA1	MEAN1
200	0.08	1.38	-2.7976	1.38
200	0.12	1.74	-4.8110	1.74
200	0.15	2.52	-8.0280	2.52
250	0.08	1.93	-5.7111	1.93
250	0.12	2.83	-9.0357	2.83
250	0.15	3.67	-11.2933	3.67
300	0.08	1.59	-4.0279	1.59
300	0.12	1.97	-5.8893	1.97
300	0.15	2.73	-8.7233	2.73

Taguchi Design analysis for Response Variable





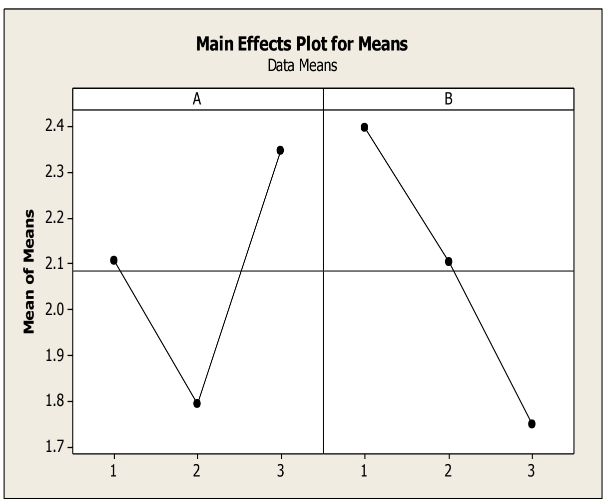
Main Effects Plot for Means **Main Effects Plot for SN ratios**

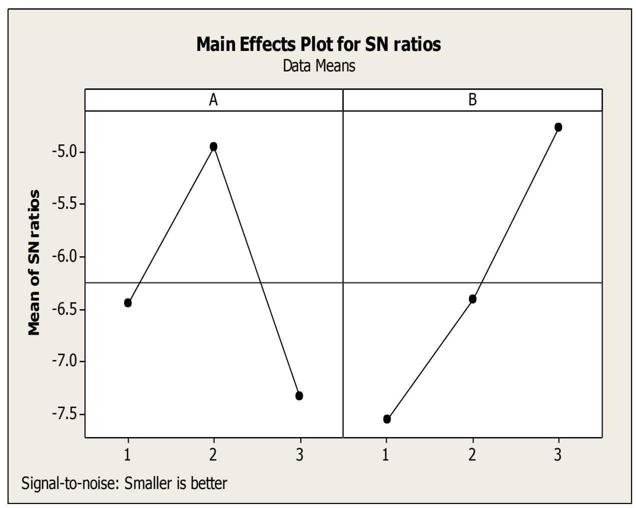
Fig. Main Effects Plot for Means & Main Effects Plot for SNRs (MS work piece with TN-60 Tool)

5) **MS work piece with TP0500 Tool.**
Taguchi Design

A(cutting speed)	B (feed rate)	R_a(surface roughness)	SNRA1	MEAN1
200	0.08	2.32	-7.30976	2.32
200	0.12	2.11	-6.48565	2.11
200	0.15	1.89	-5.52924	1.89
250	0.08	2.16	-6.68908	2.16
250	0.12	1.81	-5.15357	1.81
250	0.15	1.42	-3.04577	1.42
300	0.08	2.71	-8.65939	2.71
300	0.12	2.39	-7.56796	2.39
300	0.15	1.94	-5.75603	1.94

Taguchi Design analysis for Response Variable





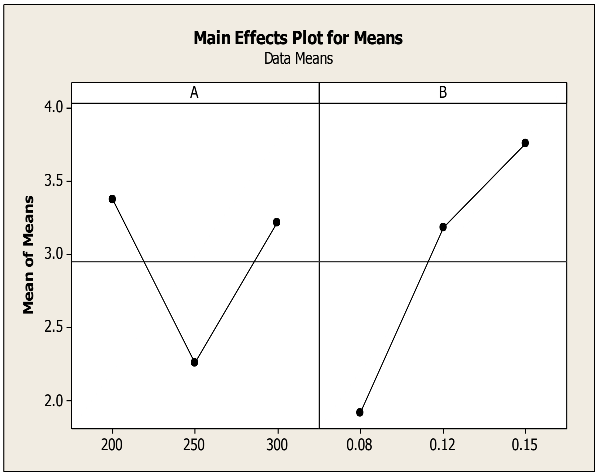
Main Effects Plot for Means **Main Effects Plot for SN ratios**

Fig. Main Effects Plot for Means & Main Effects Plot for SNRs (MS work piece with TP0500 Tool)

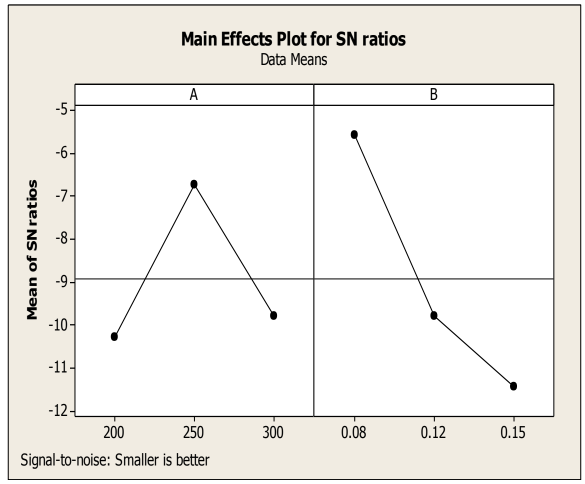
6) **MS work piece with TT8020 Tool**
Taguchi Design

A (cutting speed)	B (feed rate)	R_a(surface roughness)	SNRA1	MEAN1
200	0.08	2.22	-6.9271	2.22
200	0.12	3.75	-11.4806	3.75
200	0.15	4.17	-12.4027	4.17
250	0.08	1.54	-3.7504	1.54
250	0.12	2.13	-6.5676	2.13
250	0.15	3.13	-9.9109	3.13
300	0.08	2.01	-6.0639	2.01
300	0.12	3.68	-11.3170	3.68
300	0.15	3.97	-11.9758	3.97

Table No.49 Taguchi Design analysis for Response Variable



Main Effects Plot for Means



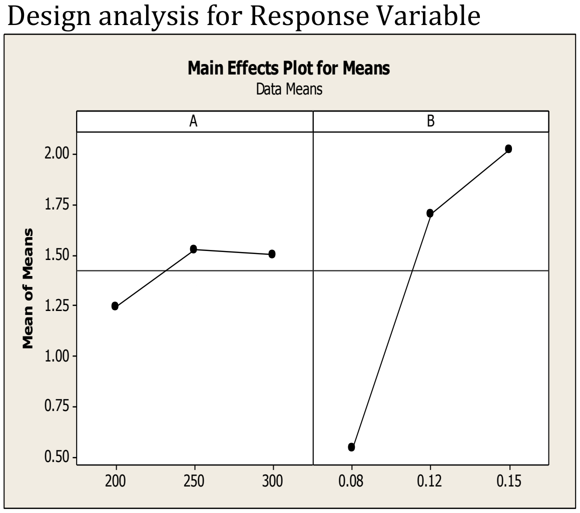
Main Effects Plot for SN ratios

Fig. Main Effects Plot for Means & Main Effects Plot for SN ratios (MS work piece with TT8020 Tool)

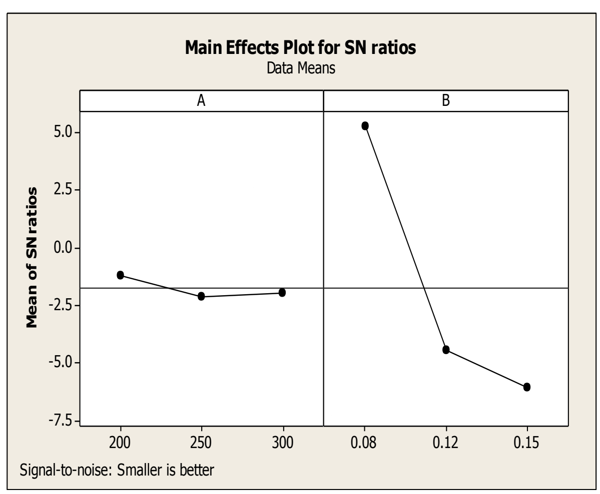
7) **EN-31 work piece with TN-60 Tool**
Taguchi Design

A(cutting speed)	B (feed rate)	R_a(surface roughness)	SNRA1	MEAN1
200	0.08	0.675	3.41392	0.675
200	0.12	1.260	-2.00741	1.260
200	0.15	1.800	-5.10545	1.800
250	0.08	0.502	5.98593	0.502
250	0.12	1.920	-5.66602	1.920
250	0.15	2.160	-6.68908	2.160
300	0.08	0.484	6.30309	0.484
300	0.12	1.930	-5.71115	1.930
300	0.15	2.100	-6.44439	2.100

Taguchi Design analysis for Response Variable



Main Effects Plot for Means



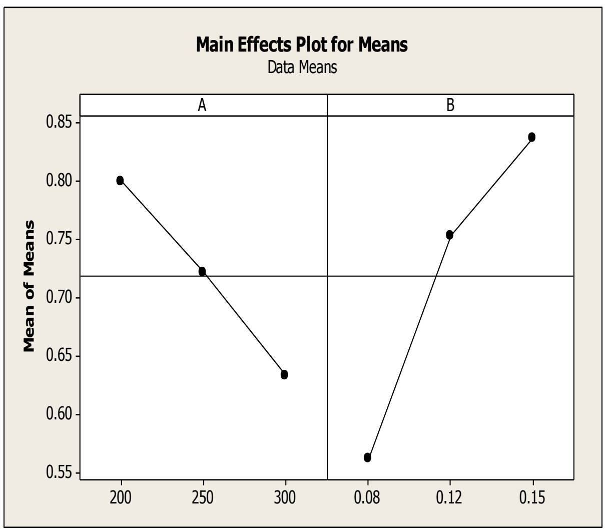
Main Effects Plot for SN ratios

Fig. Main Effects Plot for Means & Main Effects Plot for SN ratios (EN-31 work piece with TN-60 Tool)

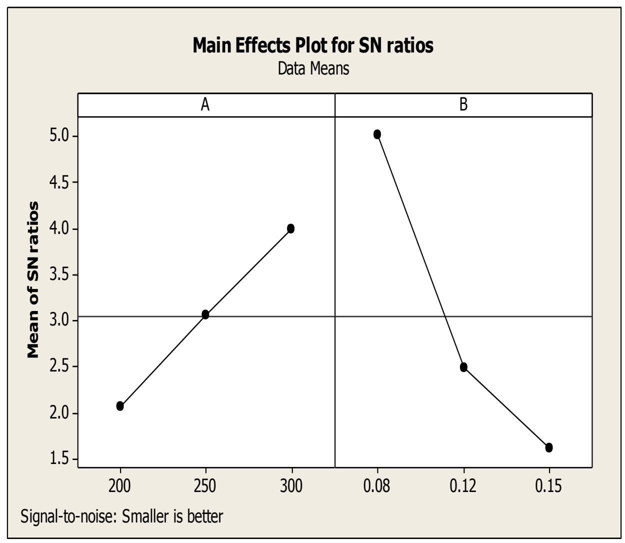
8) **EN-31 work piece with TP0500 Tool**
Taguchi Design

A (cutting speed)	B (feed rate)	R_a (surface roughness)	SNRA1	MEAN1
200	0.08	0.622	4.12419	0.622
200	0.12	0.822	1.70256	0.822
200	0.15	0.956	0.39084	0.956
250	0.08	0.506	5.91699	0.506
250	0.12	0.788	2.06948	0.788
250	0.15	0.872	1.18967	0.872
300	0.08	0.563	4.98983	0.563
300	0.12	0.652	3.71505	0.652
300	0.15	0.687	3.26087	0.687

Table No.63 Taguchi Design analysis for Response Variable



Main Effects Plot for Means



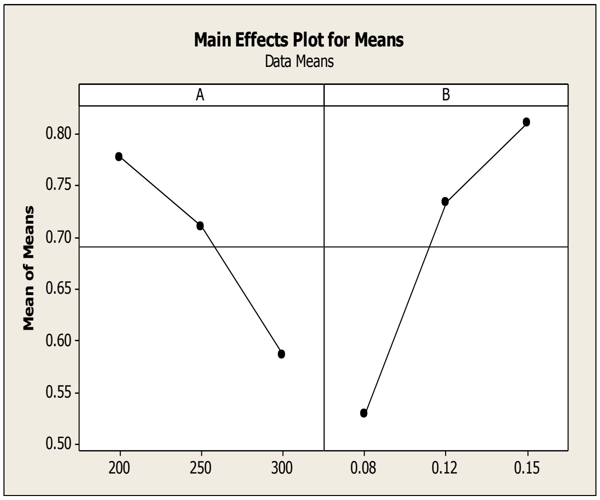
Main Effects Plot for SN ratios

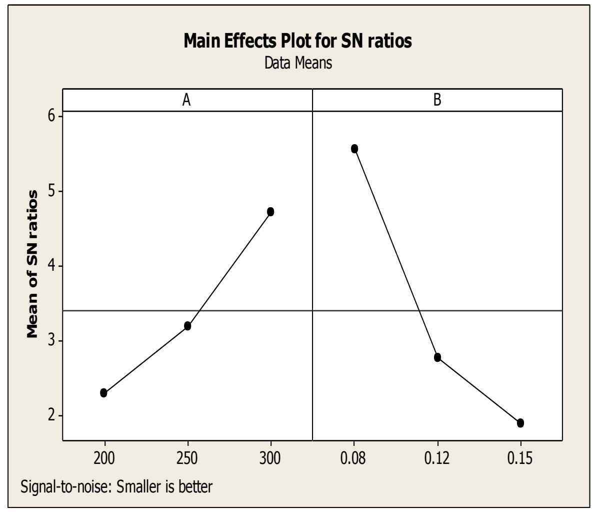
Fig. Main Effects Plot for Means & Main Effects Plot for SN ratios (EN-31 work piece with TP0500 Tool)

9) **EN-31 with TT8020 Tool**
Taguchi Design

A (cutting speed)	B (feed rate)	R_a (surface roughness)	SNRA1	MEAN1
200	0.08	0.611	4.27918	0.611
200	0.12	0.820	1.72372	0.820
200	0.15	0.900	0.91515	0.900
250	0.08	0.500	6.02060	0.500
250	0.12	0.780	2.15811	0.780
250	0.15	0.850	1.41162	0.850
300	0.08	0.480	6.37518	0.480
300	0.12	0.600	4.43697	0.600
300	0.15	0.680	3.34982	0.680

Table No.70 Taguchi Design analysis for Response Variable





Main Effects Plot for Means **Main Effects Plot for SN ratios**

Fig. Main Effects Plot for Means & Main Effects Plot for SNRs (EN-31 work piece with TT8020Tool)

RESULT & CONCLUSION:-

1) MS workpiece Result and Discussion

 In previous chapter, Experimental work, experiment no. 4 to 6 on MS work piece with three tool, we can say the main affecting factor for surface roughness is feed rate .We got the minimum surface roughness by TN60 Tool at low and medium feed rate, TP0500 is best tool at high feed rate. So, when depth of cut is constant.

Surface Roughness of three different tools

Feed Rate	TN60	TP0500	TT8020
0.08	1.38	2.71	2.22
0.12	1.74	2.39	3.75
0.15	2.52	1.94	4.17

Table No.77 Surface Roughness of three different tools

For the first and second step of step turning, the roughness value for TN60 is least, showing the optimal value. For third step TP0500 is best tool. Hence giving the optimum value for surface roughness. Thus from above observation, we conclude that the optimality of TN60 is acceptable reason being the constancy for first two step , as well as lesser that Ra value of TP0500 and TN60.

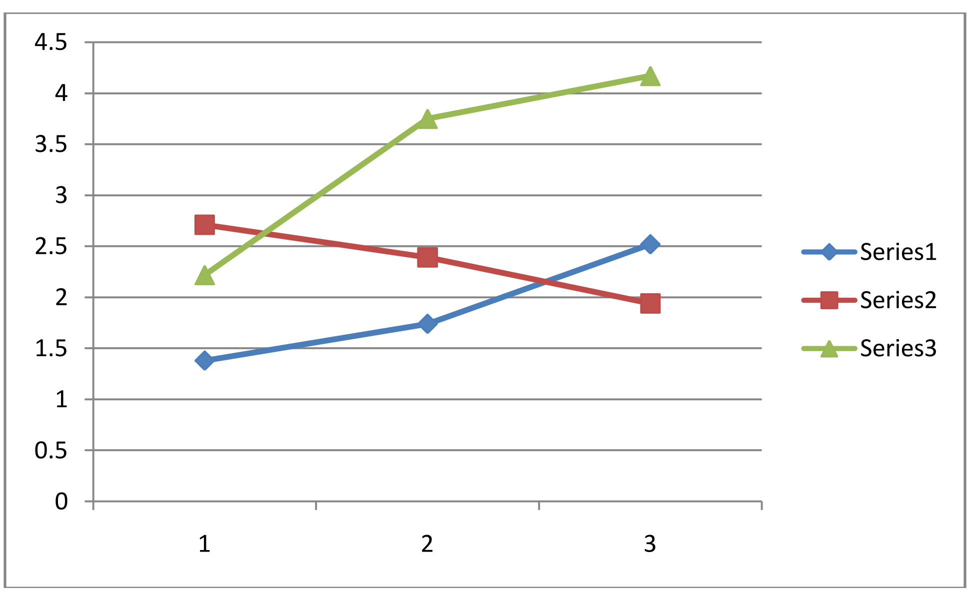


Fig. 18 Surface Roughness Comparison of Three Different Tool

Below images are obtained by surface measuring machine Wyko NT9100Optical Profiling System on MS workpiece by Turning 3 Different Tools.

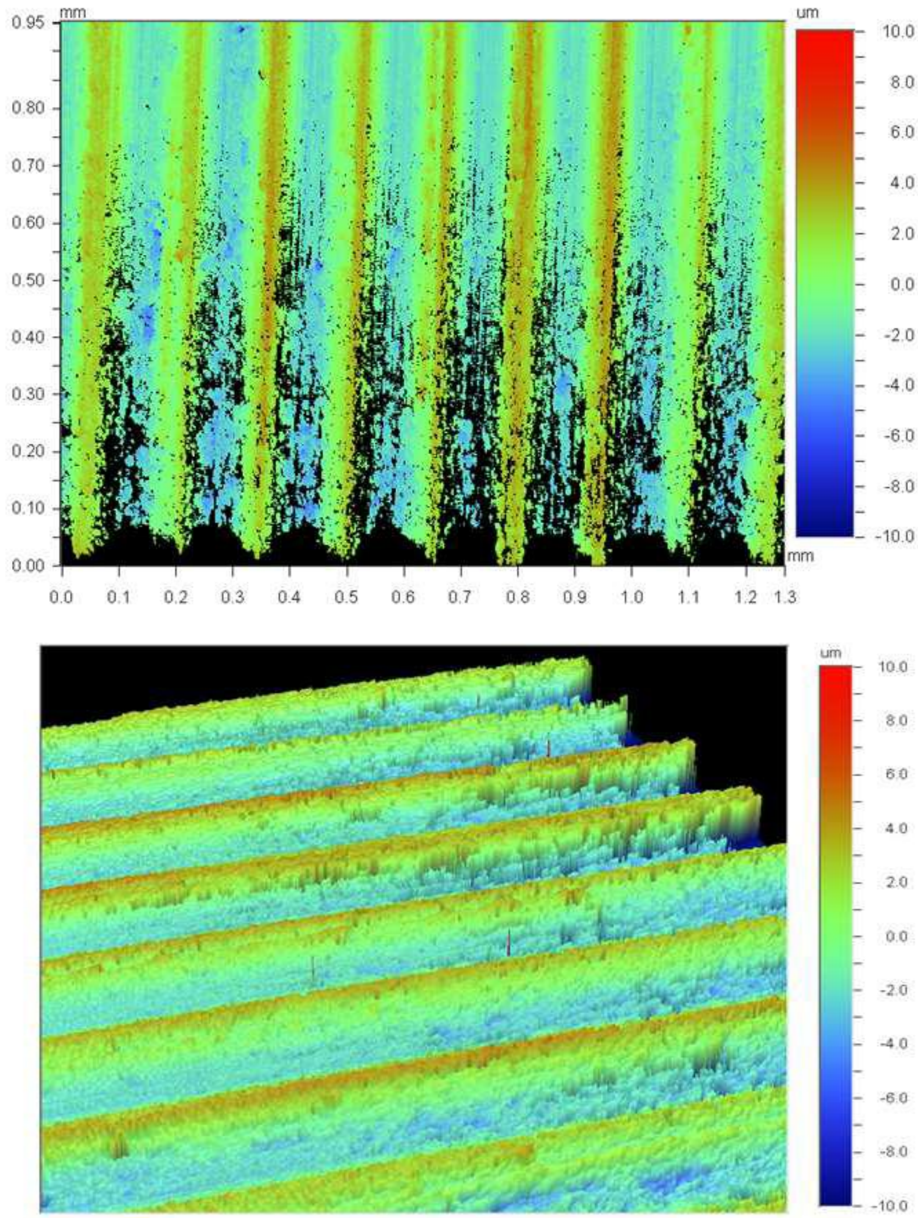


Fig. 19 Surface Roughness on MS workpiece by 3 different Tool

2) EN-8 Work piece Result and Discussion

In previous chapter, Experiment no. 1 to 3 on EN-8 work piece with three Tools, we can say the main affecting factor for surface roughness is feed rate. When the feed rate increases, surface roughness is also increases. We got good surface roughness at minimum feed rate. We got the minimum surface roughness by TN-60 Tool at all cutting speed. So, TN-60 tool is best for EN-8 material at all cutting speed & feed rate when depth of cut is constant.

Surface Roughness of three different tools on EN-8 Work piece

Feed Rate	TN60	TP0500	TT8020
0.08	0.981	1.86	3.11
0.12	1.180	2.95	3.43
0.15	2.010	4.21	4.06

Table No.78 Surface Roughness of three different tools

From the first step of step turning to last third step, the roughness value for TN60 is least, showing the optimal value. Hence giving the optimum value for surface roughness. Thus from above observation, we conclude that the optimality of TN60 is acceptable reason being the constancy from all step, as well as lesser that Ra value of TP0500 and TT8020.

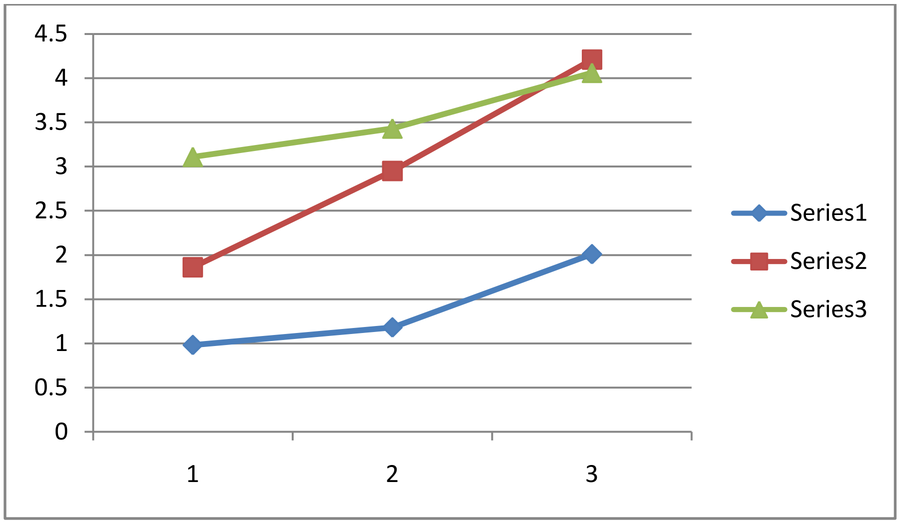


Fig.20 Surface Roughness Comparison of Three Different Tool

Below images are obtained by surface measuring machine Wyko NT9100Optical Profiling System on EN8workpiece by Turning 3 Different Tools.

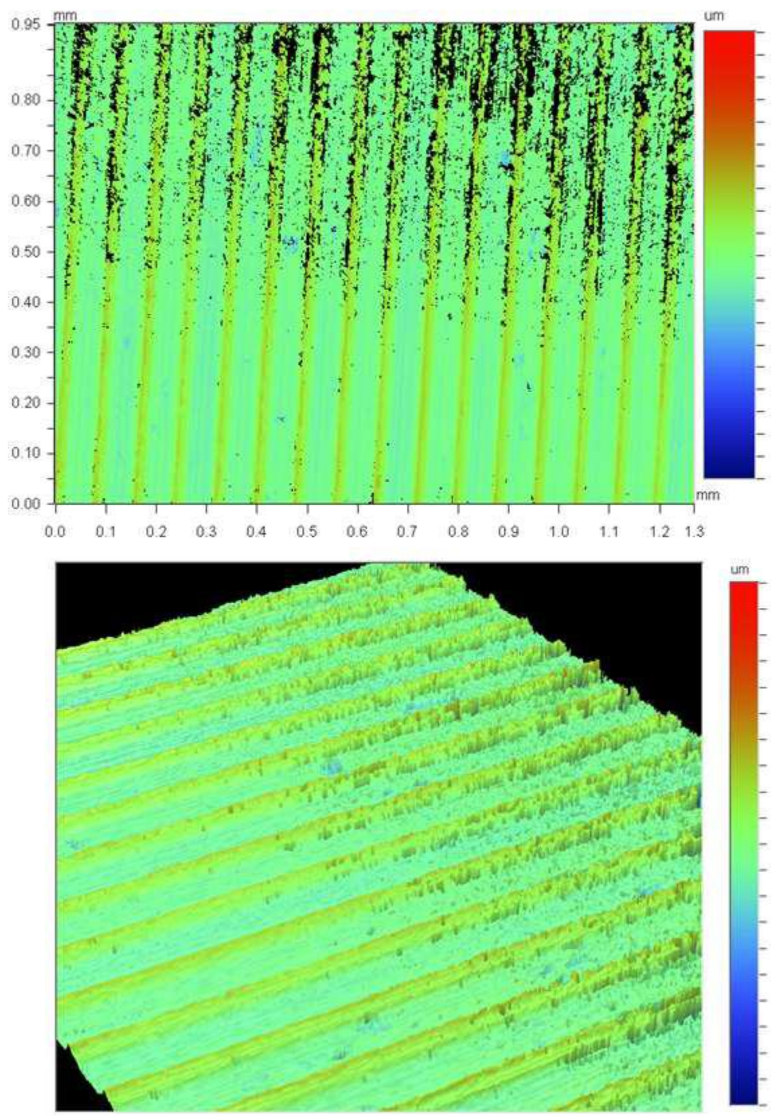


Fig. 21 Surface Roughness on EN-8workpiece by 3 different Tool

3) EN-31 Work piece Result and Discussion

In previous chapter, Experiment no. 7 to 9 on EN-31 work piece with three Tool, we can say the main affecting factor for surface roughness is feed rate. We got the minimum surface roughness by TT8020 Tool at all cutting speed.So,TT8020 tool is best for EN-31 material at all cutting speed & feed rate when depth of cut is constant.

Surface Roughness of three different tools

Feed Rate	TN60	TP0500	TT8020
0.08	0.675	0.622	0.611
0.12	1.26	0.822	0.820
0.15	1.8	0.956	0.900

Table No.79 Surface Roughness of three different tools

From the first step of step turning to last third step, the roughness value for TT8020 is least, showing the optimal value. Hence giving the optimum value for surface roughness.Thus from above observation, we conclude that the optimality of TT8020 is acceptable reason being the constancy from all step , as well as lesser that Ra value of TP0500 and TN60.

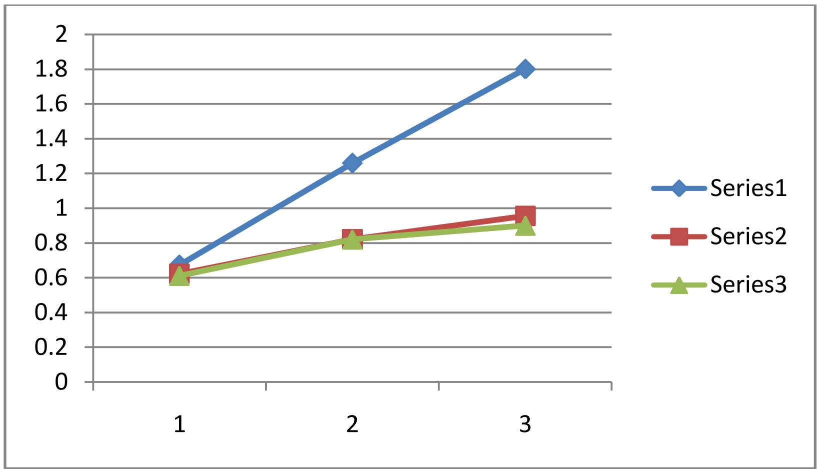
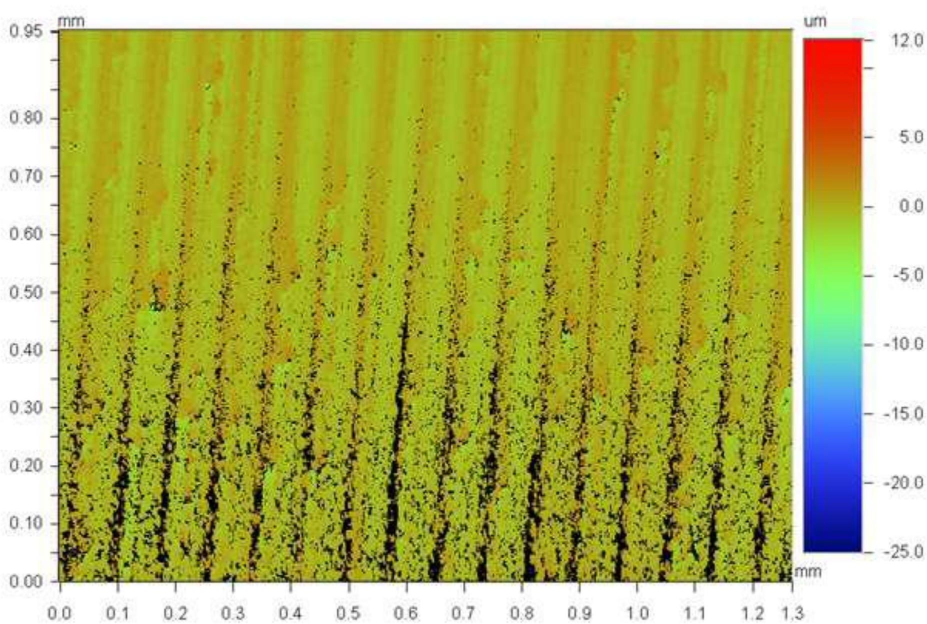


Fig.22 Surface Roughness Comparison of Three Different Tool

Below images are obtained by surface measuring machine Wyko NT9100Optical Profiling System on EN31workpiece by Turning 3 Different Tools.



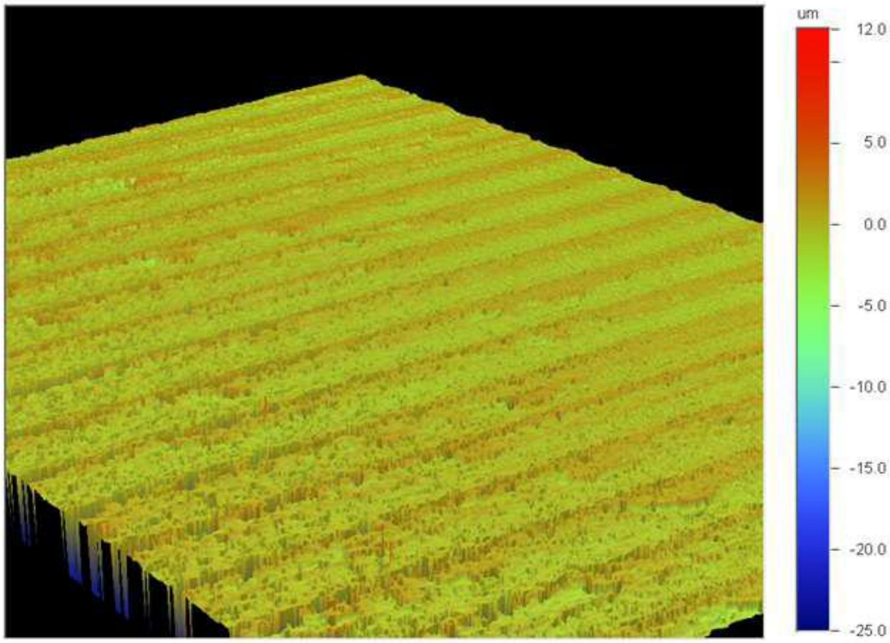


Fig. 23 Surface Roughness on EN-31workpiece by 3 different Tool

VALIDATION

1) EN-8 Material with TN60 Tool

Prediction of optimum quality characteristic (QC)

From the analyses of S/N ratio and the mean response characteristic, the optimum levels of the control factors are determined as: A_1, B_1. Hence, the predicted mean of the quality characteristic (surface roughness) has been computed

$$\mu_{Ra} = A_1 + B_1 - T_{Ra}$$

$$\mu_{Ra} = 1.3903 + 1.0503 - 1.4046$$

$$\mu_{Ra} = 1.036$$

$$\mu_{S/N} = -0.16175$$

Where T_{Ra}= overall mean of surface roughness. A_1, B_1, are the mean values of the surface roughness with parameters at optimum levels.

An important step in Taguchi's optimization technique is to conduct confirmation experiments for validating the predicted results. Thus a 95% confidence interval (CI) for the predicted mean of optimum QC on a confirmation test is estimated using the following two equations:

$$CI = \sqrt{F(\alpha, 1, f_e) V_e \left[\frac{1}{N_{eff}} + \frac{1}{R}\right]}$$

Where, $F\alpha$ (1, fe) is the F – ratio required for α, α is the risk,$f_e$is the error DOF, V_e is the error variance, N_{eff} is the effective number of replications and is equal to

$$N_{eff} = \frac{N}{1 + T_{DOF}}$$

R is the number of repetitions for confirmation experiment =1 and

N is the total number of experiments.

Using the values of S/N ratios

V_e = 1.0236 and f_e= 4 from Table 16, the C.I. was calculated.

Total DOF associated with the mean (μ_{Ra}) = 2 * 2 = 4.

Total trials = 9;

N = 1 * 9 = 9;

N_{eff} = 9/ (1+4) = 1.8

α = 0.05.

F0.05 (1,4) = 7.71 (tabulated).

The calculated Confidence Interval = ± 3.5037.

The 95 % confidence interval of the predicted optimum S/N ratio is:

$$(\mu_{S/N} - C.I) < \mu_{S/N} < (\mu_{S/N} + C.I)$$

$$-3.6656 < \mu_{S/N} < 3.34195$$

For optimum surface roughness:

$$-2.4801 < \mu_{Ra} < 4.5273$$

Confirmation experiment

In order to test the predicted result, confirmation experiment has been conducted by running another test near at the optimal settings of the process parameters determined from the analysis. Here, considering A_1, B_2 (R_a= 1.180) which falls within the predicted 95% confidence interval.

Overall Confirmation Result:

Sr. No	Material with Tool	Result	Predicted Range	Confirmation Expt. Result
1	**EN-8 with TN60 Tool**	1.036	$-2.480 < \mu_{Ra} < 4.527$	1.180
2	**EN-8 with TP0500 Tool**	1.6811	$-0.618 < \mu_{Ra} < 3.981$	2.53
3	**EN-8 with TT8020 Tool**	2.65	$1.15 < \mu_{Ra} < 4.37$	3.12
4	**MS with TN-60 Tool**	1.251	$-0.218 < \mu_{Ra} < 2.7204$	1.74
5	**MS with TP0500 Tool**	1.457	$-0.196 < \mu_{Ra} < 3.109$	1.81
6	**MS with TT8020 Tool**	1.54	$-1.558 < \mu_{Ra} < 4.01$	2.01
7	**EN-31 with TN-60 Tool**	0.675	$-6.14 < \mu_{Ra} < 6.89$	1.26
8	**EN-31 with TP0500 Tool**	0.563	$-7.87 < \mu_{Ra} < 8.83$	0.652
9	**EN-31 with TT8020 Tool**	0.480	$-1.41 < \mu_{Ra} < 2.27$	0.500

FUTURE SCOPE

Further investigation is needed to explore more parameters and operating conditions to develop a general model for more material types by using the combination of the Design of

Experiment technique and Taguchi Method. A combination of both techniques can be used in order to achieve a higher level of verification and to reduce the cost of the necessary experimental effort. Taguchi Method will aid in guiding the selection of the proper combination of the process parameters at their specified levels.

REFERENCES

1. Joseph Emmanuel, Rahul Davis,"An experimental study of the effect of control parameters on the surface roughness in turning operation of en 353 steel", IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), Volume 8, Issue 4 (Sep. - Oct. 2013), PP 33-38.
2. JakhalePrashant P, Jadhav B. R., "Optimization of surface roughness of alloy steel by changing operational parameters and insert geometry in the Turning process", Int. J. Adv. Engg. Res. Studies / II/ IV/July-Sept., 2013/17-21
3. N.E. Edwin paul, P. Marimuthu, R. VenkateshBabu, "Machining Parameter Setting For Facing EN8 Steel with TNMG Insert", American International Journal of Research in Science, Technology, Engineering & Mathematics, 3(1), June-August, 2013, pp. 87-92.
4. KanaseTanaji. S. and Jadhav D. B., "Enhancement of Surface Finish for CNC turning Cutting Parameters by Using Taguchi Method", Paripex-Indian Journal Of Research, Volume : 3 | Issue : 5 | 88-91,June 2013.
5. VikasSudhansuRanjan Das, Amaresh Kumar, and DebabrataDhupal, "Effect of Machining Parameters on Surface Roughness in Machining of Hardened AISI 4340 Steel Using Coated Carbide Inserts", International Journal of Innovation and Applied Studies, Vol. 2 No. 4 Apr. 2013, pp. 445-453, 2013.
6. 6.AshishBhateja, JyotiBhardwaj, Maninder Singh and Sandeep Kumar Pal, "Optimization of Different Performance Parameters i.e. Surface Roughness, Tool Wear Rate & Material Removal Rate with the Selection of Various Process Parameters Such as Speed Rate, Feed Rate, Specimen Wear , Depth Of Cut in CNC Turning of EN24 Alloy Steel – An Empirical Approach", The International Journal of Engineering And Science (IJES), Volume-2,Issue-1,Pages-103-113,2013
7. 7.Neeraj Sharma andRenu Sharma, "Optimization of Process Parameters of Turning Parts: A Taguchi Approach", Journal of Engineering, Computers & Applied Sciences (JEC&AS) Volume 1, No.1, October 2012.
8. 8. H. K. Dave, L. S. Patel and H. K. Raval, "Effect of machining conditions on MRR and surface roughness during CNC Turning of different Materials Using Tin Coated Cutting Tools – A Taguchi approach", International Journal of Industrial Engineering Computations 3 (2012) 925–930.
9. 9.JitendraVerma, PankajAgrawal, LokeshBajpai, "Turning parameter optimization for surface roughness of ASTM a242 type-1 alloys steel by Taguchi method, International Journal of Advances in Engineering & Technology, Vol. 3, Issue 1, pp. 255-261 March 2012.
10. 10.Marinkovic Velibor and Madic Milos; Optimization of surface roughness in turning alloy steel by using Taguchi method", Scientific Research and Essays Vol. 6(16), pp. 3474-3484, 19 August, 2011.
11. 11. YigitKazancoglu,UgurEsme, MelihBayramoglu, OnurGuven,SuedaOzgun; "Multi objective optimization of the cutting forces in turning operations using the grey-based Taguchi method", Original scientific article, MTAEC9, 45(2)105(2011)

12. 12.H. Yanda, J.A. Ghani, M.N.A.M. Rodzi, K. Othman and C.H.C. Haron, "Optimization of material removal rate, surface roughness and tool life on conventional dry turning of fcd700", International Journal of Mechanical and Materials Engineering (IJMME),Vol.5(2010), No.2,182-190.
13. 13. Dr. E. Daniel Kirby, "Optimizing the Turning Process Toward an Ideal Surface Roughness Target", Journal of Industrial Technology , Volume 26, Number 1, March 2010.
14. 14.G. Akhyar, C.H. CheHaron, J.A. Ghani, "Application of Taguchi Method in the Optimization of Turning Parameters for Surface Roughness", Int. J. Sci. Eng. Tech. Vol. 1, No. 3, 2008, 60-66
15. 15. S. Thamizhmanii, S. Saparudin, S. Hasan,"Analyses of surface roughness by turning process using Taguchi method", Journal of Achievements in Materials and Manufacturing Engineering ,Volume 20, Issues 1-2, 503-506,January-February 2007.

BIBLIOGRAPHY

1. Minitab software. It was developed at the Pennsylvania State University by researchers Barbara F. Ryan, Thomas A. Ryan, Jr., and Brian L. Joiner in 1972.