Investigation Of Optimum Machining Parameters For Manufacturing Of Disintegrated Castiron Flywheel

K.Prakash Babu, M.Tech, P.V.S.S.M.Sai Mahesh, K.S.V.S.Bharadwaj Sarma M.Malik Aliyaz, R.Mohan Krishna Naik
Assistant professor Dept.of Mechanical Engg., V R Siddhartha College, Vijayawada.

ABSTRACT:
Quality and productivity are two important aspects that are inter-related in any machining operation The objective of this work is to estimate the influence of machining parameters and to determine their optimum conditions in manufacture of cast-iron disintegrated flywheel. The parameters considered are speed, feed and depth of cut where as the response are material removal rate and surface roughness. The experimental trials are conducted based on taguchi L8 orthogonal array with 2 levels of each machining parameters. The signal to noise ratio, the ANOVA and F-test are employed to find the optimum levels and to analyze the effects of machining parameters on MRR&SR.The experimental results indicates that feed has significant effect on MRR and speed has significant on SR.
KEYWORDS: Taguchi, Orthogonal array, ANOVA, material removal rate, surface roughness

1.Introduction:

In this research work material removal rate and surface roughness of the cast-iron work piece prepared on the conventional lathe machine .Lathe is highly used for removing excess material and yielding required component. It is therefore essential to optimize quality and productivity simultaneously as we know that they are inter-related in any machining operation. Productivity can be interpreted in terms of material removal rate in machining operation and quality represents satisfactory yield in terms of product characteristics as desired by the customers.

Taguchi technique is online quality control technique which is a scientifically disciplined mechanism that offers a systematic method for optimization techniques of various parameters with regarding to performance quality and cost by implementing improvements in products, processes and other available facilities to yield the best values.

According to Genichi Taguchi, the best opportunity to eliminate variation is during the design of the product and its manufacturing processes. It is a 3-phase program.

1. System design
2. Parameter design
3. Tolerance design

System design: It involves creativity and innovation of a design engineer to create a functional design. Tooling requirements, production constraints related to capacity are investigated and other issues related to creation and productions of feasible design are dealt with.

Parameter design: It involves determining influential parameters and their settings. The parameters that have linear relationship with the mean response are also to be identified.

Tolerance design: It is to determine tolerances or permissible ranges of parameters and factor settings that are identified in parameter design.

Taguchi method treats optimization problem in 2 methods

1. Static
2. Dynamic

Static: The optimization which involves determining the best control factor levels so that the output is the target value. Such problem is called as Static problem.

Dynamic: If the product to be optimized has a signal input that directly decides the output, the optimization involves determining the best control factors levels so that the “input signal/output” ratio is closest to the desired relationship. Such a problem is called dynamic problem

2. Expermentation:

The experiments were carried out on a conventional lathe machine tool and a high speed steel tool with brazed carbide tip is used. Soluble oil is used as coolant.

Specifications:

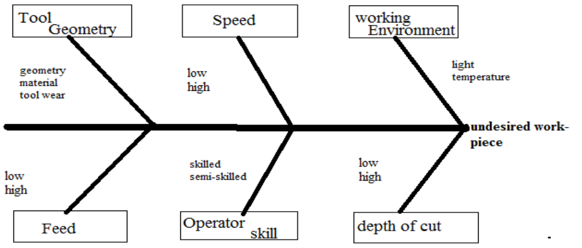
1. Distance between centers Din 806-MT3 750-800mm
2. Turning Length 700-750mm
3. Width of bed 260mm
4. Spindle Bore 35mm
5. Four jaw independent chuck:

Normal Chuck diameter 160mm

6. Lead screw pitch 8mm.
7 Speed range A (50-350) rev/min 8speeds
B (250-2000) rev/min 8speeds

2.1 Design of experiments: Analysis of machining parameters on MRR&SR

The factors which are to believe to influence the performance characteristics are identified by cause-effect diagram.



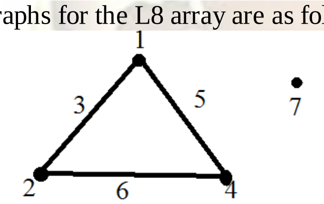
Out of the various factors indicated in cause effect diagram speed, feed & depth of cut are identified as influential control factors.

TABLE: 1

S.no	Factors	Level-1	Level-2
1	Speed	40 rpm	60 rpm
2	Feed	5 mm/min	7.5mm/min
3	Depth of cut	1 mm on dia	0.5 mm on dia

Knowing that the number of parameters is 7 and the number of levels is 2, the L8 orthogonal array is selected from the array selector table shown below Table no.3

The linear graphs for the L8 array are as follows:



The interaction between speed&feed, feed&depth of cut, speed&depth of cut are also considered.

The factor 1 is assigned to column-1, factor 2 to column-2, factor 3 to column-4.The L8 orthogonal array along with factors assigned to columns is given below.

Table No: 2

Factors	column no.						
Trial no.	1(**A**)	2(**B**)	3	4(**C**)	5	6	7
1	1	1	1	1	1	1	1
2	1	1	1	2	2	2	2
3	1	2	2	1	1	2	2
4	1	2	2	2	2	1	1
5	2	1	2	2	2	1	1
6	2	1	2	1	1	2	2
7	2	2	1	2	2	2	2
8	2	2	1	1	1	1	1

Table No:3

Number of Levels	Number of Parameters (P)																													
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
2	L4	L4	L8	L8	L8	L8	L12	L12	L12	L12	L16	L16	L16	L16	L32	L32	L32	L32	L32	L32	L32	L32	L32	L32	L32	L32	L32	L32	L32	L32
3	L9	L9	L9	L18	L18	L18	L18	L27	L27	L27	L27	L27	L36	L36	L36	L36	L36	L36	L36	L36	L36	L36								
4	L'16	L'16	L'16	L'16	L'32	L'32	L'32	L'32	L'32																					
5	L25	L25	L25	L25	L25	L50	L50	L50	L50	L50	L50																			

2.2 ANOVA: It is a statistical hypothesis testing heavily used in analysis of experimental data which means method of making decisions using data.

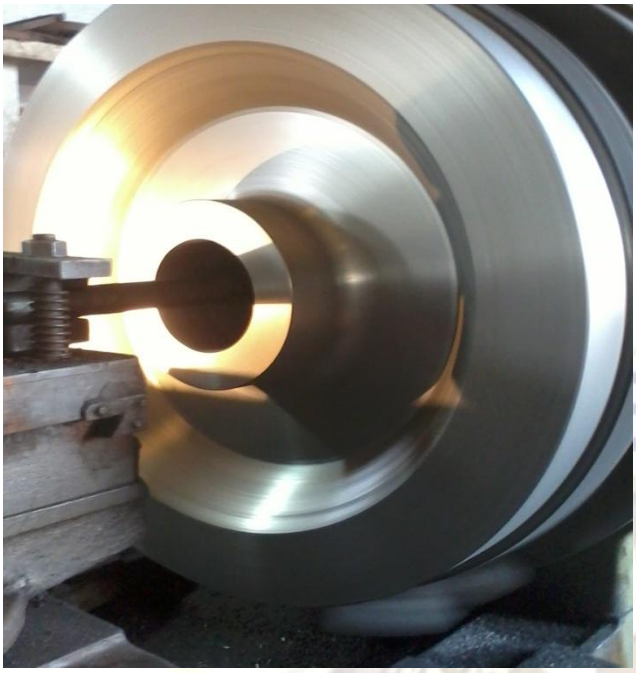


Fig: work piece setup

ANOVA was developed by Sir Ronald Fisher in 1930's.As a way to interpret the results from the agricultural experiments. It is a collection of statistical models and their associated procedures in which the observed variance is partitioned into components due to different source of variation.

ANOVA can be categorized as NO-WAY, ONE-WAY, TWO-WAY and so on. As there are 3 factors THREE-ANOVA is performed. After calculating the total variation from the above number of degrees of freedom is calculated-test for variance comparison id carried out. It provides a decision at some confidence level as to whether these estimates are significantly different.

2.3 Experimental design: Analysis of data can be carried out in 2 ways.

1. Using S/ N analysis
2. Using standard values: (a) standard deviation analysis
   (b) Average value analysis

Here, S/N ratio analysis is implemented.

There are 3 categories of quality characteristics in the analysis of S/N ratio, (a) lower is the better (b) nominal is the better (c) higher is the better. The The MRR values were measured two times of each specimen and then, the material removal rate.
Values were average. The SR values also measured two times on each specimen and SR is measured with a Mitutoyo surf test meter SJ-201 series

3. Experimental conditions and results:

term signal represents the desirable value, and noise represents the undesirable value.
The higher the better is always preferred to calculate the S/N ratio for material removal rate(MRR).

The equation for calculation of the S/N ratio for higher the better characteristic is given below:

$$\frac{S}{N}_{(Bigger)} = -10 \log\left(\frac{\Sigma\left(1/y_i^2\right)}{n}\right)$$

n = -10 Log_{10} [mean of sum squares of reciprocal of measured data]
The lower the better is always preferred to calculate the S/N ratio for surface roughness (SRR). The equation for calculation of the S/N ratio for lower the better characteristic is given below

$$\frac{S}{N}_{(Smaller)} = -10 \log\left(\frac{\Sigma y_i^2}{n}\right)$$

n = -10 Log_{10} [mean of sum of squares of {measured - ideal}]

Fig:Mitiutoyo Surface Roughness Meter

The surface roughness meter used is of following specifications:

Maximum probe amplitude: 5mm
Adapter: 9volts, DC supply
500mA current

Table 4 for SR values:

Factors	column no.							Surface Roughness(SR) $*10^{-7}$ m		
Trial no.	1(**A**)	2(**B**)	3	4(**C**)	5	6	7	Trail:1	Trail:2	S/N Ratio
1	1	1	1	1	1	1	1	22.6	22.4	-27.0437
2	1	1	1	2	2	2	2	22.1.	22.5	-26.9664
3	1	2	2	1	1	2	2	22.5	22.7	-27.0822
4	1	2	2	2	2	1	1	26.1	24.1	-28.0003
5	2	1	2	2	2	1	1	19.7	19.3	-25.8011
6	2	1	2	1	1	2	2	21.5	22.1	-26.7699
7	2	2	1	2	2	2	2	29.4	29.8	-29.4260
8	2	2	1	1	1	1	1	29.2	28.8	-29.2481

Table 5 for MRR values:

Factors	column no.							Material Removal Rate(MRR) $*10^{-7}$ m^3/min		
Trial no.	1(**A**)	2(**B**)	3	4(**C**)	5	6	7	Trail:1	Trail:2	S/N Ratio
1	1	1	1	1	1	1	1	15.59	14.966	-23.683
2	1	1	1	2	2	2	2	15.9	15.6	-23.946
3	1	2	2	1	1	2	2	23.38	22.44	-27.202
4	1	2	2	2	2	1	1	23.86	23.35	-27.46
5	2	1	2	2	2	1	1	15.98	15.57	-23.96
6	2	1	2	1	1	2	2	15.56	16.024	-23.97
7	2	2	1	2	2	2	2	23.92	23.41	-27.48
8	2	2	1	1	1	1	1	23.34	24.04	-27.49

3.1 Percent Contribution: The portion of the total variation observed in an experiment attributed to each significant factor and the interaction is reflected in the percent contribution. The percent contribution is a function of sum of squares of significant factor. The percent contribution indicates the relative power of factor and interaction to reduce variation.

Fig: High speed steel tool with brazed carbide tip

factor	Sum of squares	D.O.F	variance	F-ratio	F_{tab}	% contribution	inference
A	0.475	1	0.475	2.761	4.60	2.12*	Sub-significant
B	244.531	1	244.531	1419.6	4.60	90.885**	**Significant**
A*B	0.022	1	0.022	0.133	4.60	1.5*	Sub-significant
C	0.365	1	0.365	2.119	4.60	1.078*	Sub-significant
A*C	0.316	1	0.316	1.835	4.60	1.008	In significant
B*C	0.013	1	0.013	0.079	4.60	0.85	In significant
A*B*C	0.011	1	0.011	0.065	4.60	1.15	In significant
error	1.337	8	1.337	-------	4.60	.1.409	-------
total	247.114	15	--------	-------		100	-------

4. Results and Discussion:
Surface roughness (SR) and material removal rate (MRR) for two samples of each run are shown in the above table.
ANOVA table is constructed using the following formulae:

$$SS_{A=}\{\sum_{i=1}^{k}(A^2_i/n_i)\}-T^2/N\ldots(1)$$

$$SS_{B=}\{\sum_{i=1}^{k}(B^2_i/n_i)\}-T^2/N\ldots(2)$$

$$SS_{A*B}=[\sum_{i=1}^{k}(\sum_{j=1}^{k}(A*B)^2/n_{ij})]-T^2/N-(SS_A+SS_B)]\ldots(3)$$

$$SS_T=[\sum_{i=1}^{n}y_i^2]-T^2/N\ldots(4)$$

Total d.o.f=N-1

factor	Sum of squares	D.O.F	variance	F-ratio	F_{tab}	% contribution	inference
A	13.689	1	13.689	43.091	4.60	7.346*	Sub-significant
B	102.011	1	102.011	321.11	4.60	55.869**	**Significant**
A*B	51.839	1	51.839	163.18	4.60	26.305*	Sub-significant
C	3.999	1	3.999	12.589	4.60	2.022*	Sub-significant
A*C	0.089	1	0.089	0.282	4.60	1.13	In significant
B*C	0.009	1	0.009	0.030	4.60	0.87	In significant

A*B*C	7.839	1	7.839	24.677	4.60	4.132*	Sub-significant
error	2.541	8	0.317	-------	4.60	2.326	---------
total	2.541	15	-------	-------		100	---------

d.o.f of any factor=K-1

d.o.f of error=Total d.o.f- $\sum$ d.o.f of factors

V=(S)/(d.o.f)

F=V/V_E.....(5)

P=SS/SS_T….(6)

WhereSS_A,SS_B,SS_C,SS_{A*B}, SS_{B*C},SS_{A*C},SS_{A*B*C} are the sum of the squares of factor-A, factor-B, factor-C and their interactions respectively.SS_T and SS_E are the sum of the squares of total and errors respectively. Where K is the number of levels.n_i is the number of trials for factor A,B,&C at the i^{th} level in the equations as shown above(similar calculations for SS_C and other interactions).A_i,B_i&C_i are sum of observations of factor A and factor B respectively.

V is the variance of the factor V_E is the variance of the error,d.o.f is the degrees of freedom is the % contribution is the test value that determines a decision at some confidence level as to whether these estimates are significantly different. Three way ANOVA is carried out for material removal rate and surface roughness.

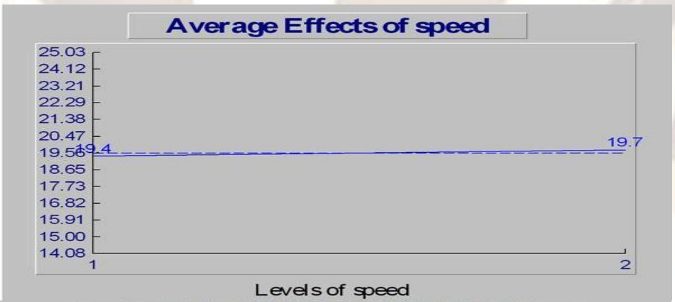
Analysis of variance and F-test for MRR:

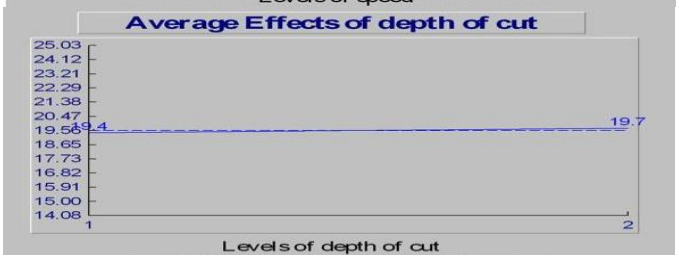
Analysis of variance and F test for SR

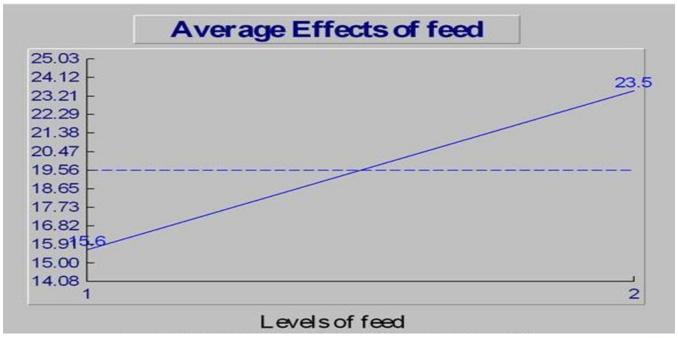
In this paper, analysis based on the taguchi method is done by software Qualitiek-4 to determine the main effects of the process parameters, to perform the analysis of variance (ANOVA) and to establish the optimum conditions.

The machining performance for each experiment of the L8 can be calculated by taking the observed values of the MRR. The ANOVA and F test results for MRR. F0.05; n1, n2 is quoted from Statistical Tables. If the calculated Fz values exceed F0.05; n1, n2 then the contribution of the input parameters, such as Spindle speed, is defined as significant. Thus, the significant parameters can be categorized into two levels which is significant and sub-significant. All of them are based on the fact that the Fz values are much larger than F0.05; n1, n2 and denoted as ** and * respectively.

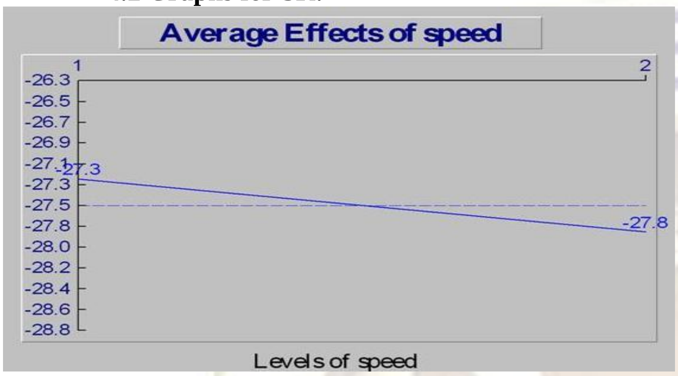
4.1 Graphs for MRR:

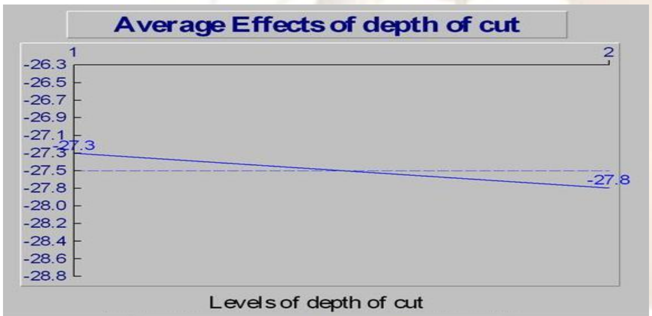


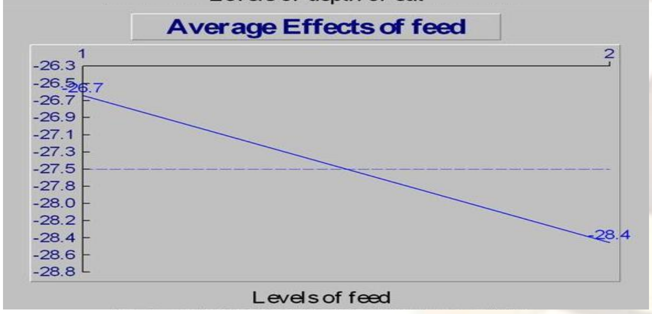




4.2 Graphs for SR:







5. Conclusion:

This paper has discussed the feasibility of machining of cast iron fly-wheel on a conventional lathe machine with a HSS tool with brazed carbide tip. The following conclusions can be enumerated from the presented work.

From the above results, it is observed that feed alone has significant effect on both material removal rate (MRR) and surface roughness (SR). The remaining factors and their interactions seem to be less influential.

Therefore feed is SIGNIFICANT (**) factor.

Lower speeds, lower feeds at higher depth of cut are resulted as optimum conditions for better surface roughness. Higher speeds, higher feeds at lower depth of cut are resulted as optimum conditions for more material removal rate.

Bibliography:

- *Genichi Taguchi, Elsayed A Elsayed, "Taguchi techniques for quality engineering", McGraw hill international editions.*
- *Pulak chakravarthy, "Quantitative methods for management and economics"*
- *Kanishka Bedi, "Quality management"*
- *R Anburaj:J Uday Prakash;C Ezilarasan "Investigation effect of the machning parameters on the MRR in the WEDM of AISI D3 tool steel"*
- *Dr.P.V.R.Ravindra Reddy; P.Radhakrishna Prasad;Dr.G Chandramohan Reddy;A Sarotham Reddy;K Srikanth "Experimental investigation on friction stir welding of AA6082 alloy using taguchi technique"*
- *J.Pradeep Kumar;K.Umanath "Experimental investigation and analysis of proces robustness in electric discharge machining of titanium alloy(Ti-6AL-4V)*
- *Qualitek-4 software, www.rkroy.com*
- *Yogendra Tyagi, Vedansh Chaturvedi and Jyoti Vimal "parametric optimization of driling machining process using taguchi design and ANOVA approach."*