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Experimental Investigation and Optimization of Machining Parameters in Turning Process for Green Manufacturing

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Abstract: - Green Manufacturing is a latest technique in production and manufacturing industry. It is implemented for the 21st centuries manufacturing industry. Its aim is to deduct the impact on environment & utilization of appropriate resource for life time application of product. In manufacturing industry, machining shows vital role in which the cutting fluid basic reason for creation of pollutants for environment. In industrial practices the selection of cutting fluid is an implemented technique to reduce the production cost. This helps to reduce the pollution which is generated by cutting fluid. Now a day's green manufacturing is effective way to minimize the palliative impact in product manufacturing processes. The main factor causing impact of cutting fluid is environmental impact. This concept aims to study the effect of different fluids on machining process like turning process. The studies about cutting fluid application in turning processes have been examined. This seminar aims to find new approaches for reducing the cutting fluid consumption in order to eliminate environmental impact. In the end the positive outcomes such as longer tool life, flow rate of chips & better surface finish in the machining processes.

Key Words— ***Cutting Fluids, Green Manufacturing, Process Parameter, Taguchi, Annova.***

I. INTRODUCTION

A. Scenario of Manufacturing Process:

Environmental Pollution is directly affected by the manufacturing industry. Therefore, to reduce this effects is major concern for all manufacturers. In the area of manufacturing, machining plays an important role. The machining processes have an important place in the traditional production industry. But during the machining process, the cutting fluid is the main sources of environmental pollution. Many industrial practices show that an optimal selection for cutting fluid is an effective way to reduce the production cost. The fluids basically have three characteristics. These are:

- Cooling Effect
- Lubrication Effect
- Carrying away the chips

The optimization in fluid selection is way to reduce the production cost to minimize the environmental pollution which is generated by cutting fluid. By optimizing cutting oil consumption organizations can reduce production cost, waste disposal costs, increase productivity of cutting oil and to improve workplace safety and health. Although these fluids can be reused and services cost almost double the purchasing price for disposal. Conventional coolant also poses a health threat to the worker.

B. Cutting Fluids:

According to chemical formulations, cutting fluids are classified into four categories: cutting oils, soluble oils (emulsified oils, emulsions), synthetic (chemical) fluids, and semi-synthetic (semi chemical) fluids. Oils without dilution in metal cutting processes have good lubrication properties, poor cooling properties and increases fire risk. This creates mist or smoke harmful to the health of operator. The application can be limited to low temperature and low speed cutting operations. The concentrate cutting fluids must be stable without separating for a minimum of six months' storage and emulsion stability is the most critical property of soluble oils. The Inclusion of H2O in emulsions induces rust, bacterial growth and evaporation losses. Sulphur, chlorine and phosphorous based chemical additives known as additives are used under extreme pressure conditions.

Cutting fluids are applied to the cutting region in order to improve the cutting performance. The Fluid reduces temperature generated at cutting tool/work piece interface. The hardness and resistance to abrasion of cutting tools are reduced at high temperature. Temperatures generated during machining affect the tool wear. So the reduction of this temperature will cause extending tool life. Cutting fluids also cool the work piece, thus preventing its final dimensions. Cutting fluids' cooling of work piece function is very

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important especially in grinding operations. Cutting fluids should have good lubrication property.

- Good lubricating properties
- High cooling capacity
- Less Viscous to provide free low of liquid
- Chemically stable
- Less Inflammable

C. Green Manufacturing:

By green manufacturing companies can reduce their environmental impact by making green products, using green processes to make things or both. Green manufacturers try to make products less harmful to environment. 'Green Manufacturing' is a successful transformation with tremendous benefits.
Examples of Green manufacturing include:

- Carpets made from recycled plastic bottles.
- Car that use electric power instead of gasoline.
- Light bulbs that consume less electricity

II. PROBLEM DEFINITION

Manufacturing industry related to metal products generates many types of wastes. Wastes tend to increase consumption of resources. Increasing consumption of resources also increases the production cost. In this competitive world, companies are striving hard to bring down the production cost. The composition of cutting oil should be appropriate so as to affect it on the business. Cost reduced will directly impact in increased profits. Neat cutting oil does not face problems due to bacterial activities unlike faced by water based or synthetic coolants. Key property clean oil is heat transfer ability and rust prevention. By reducing cutting oil consumption organizations can reduce production cost, waste disposal cost, increase productivity of cutting oil and to improve work place safety and healthy. Reduction in cost will directly impact on economy of organization.

The problem of oil selection for Green Manufacturing is a complex multi-objective decision making problems. The objective factors of the cutting fluid selection are:

1. Ecological Impact: Exhaust Gas emission, solid waste generated and waste water incurred by the use of hazardous waste cutting fluid.
2. Impact of occupational health and safety and sanitation management: Toxicities of additives, decreasing action of mineral, oil etc.

Many production practices show that making an optimal selection for cutting fluid is an effective to exert the capability of the cutting fluid to minimize the environmental pollution.

The objectives that must be carried out in this study of cutting fluid selection are:

- A decision making framework model of cutting fluid selection for green manufacturing.
- New approaches for reducing the cutting fluids in order to eliminate environmental impact.
- To reduce the effect of cutting fluids on human health.
- Ultimately to maximize the material removal rate and minimize the tool wear rate beneficial for Green Manufacturing purpose

III. METHODOLOGY

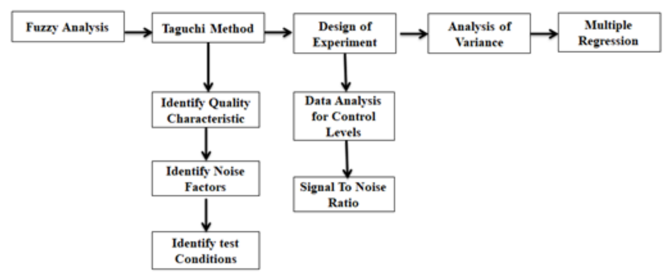

Fig.1. Methodology of Flow work for Experimentation.

A. Taguchi Method:

The experimental design and analyse of the results can be done with less effort and expenses by using the Taguchi approach. Since the method enormously decreases the strep working of experiments, quality loss of results must be taken into account. The primary stage in Taguchi method requires the knowledge about the domain that is examined, since the main function, side effects and failure modes have to be identified. A wrong decision in this step makes all other steps useless. The quality characteristic is a parameter whose variation has a critical effect on product quality. It is the output or the response variable to be observed.

B. Design of Experiment:

In this array, the columns are mutually arranged. The column is arranged for equal intervals. The levels are arranged in four levels. This is called an "L9" design, in 9 Stages the tested are conducted.

The Next Phase is to experiment and form the results. Here implementation of Taguchi Controllable process is done. The controllable process can be an actual hardware experiment, systems of mathematical equations, or compute remodels that can adequately model the response of many products and processes.

The Signal to Noise (S/N) equation depends on quality of

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characteristics. While there are many different possible S/N ratios, three of them are considered standard and are generally applicable in the situations below

- Higher the better quality characteristic
- Lower the better quality characteristic
- Normal the best quality characteristic

C. Analysis of Variance:

ANOVA is used to establish statistical significance of the input parameters and their percentage contribution on the response variables. In this investigation, the effect of four input parameters on MRR and TWR are analysed. The effects showing P-value less than 0.05 is considered statistically significant at 95% confidence interval and have most significant influence on response variables among the selected variables. A mathematical model will be developed using multiple regression analysis technique to formulate voltage, current, pulse on time and pulse off time to the material removal rate and tool wear rate.

IV. EXPERIMENTAL INVESTIGATION

The materials used in experiment were commercially available Mild Steel, widely used in commercial turning process. Its composition is described in the Table 1. Specimens were prepared by the hydraulic cutting process. The sizes of tests specimen are 100mm by 40mm.

Table.1. Chemical composition of work piece materials

Material	C	Mn	Si	P	S	Cr	Mo
Percentage by weight	0.20	0.82	0.21	0.026	0.024	1.07	0.18

The Process parameters are controlled lathe machine was used in experimental works. It has 1300 rpm speed, feed & doc. Specimen were prepared by alteration of cutting speed, feed and doc and fixing specimen diameter having 40 mm, experiments were initially done at dry condition. The standard turning machining parameter applied in experiments is described in Table .2. The Various Factors are:

- Design parameters that influence the performance.
- Input that can be controlled.
- Described in the study for the purpose of determining their influence and control upon the most desirable performance.

Table.2. Standard Machining parameters

Level of Experimental	Experimental Factors		
	Cutting speed (mm/min)	Feed (mm/rev)	Doc (mm)
1.	35	0.35	0.5
2.	55	0.4	1
3.	75	0.45	1.5

Replication – The trails are conducted in random orders. The most desirable way is to run these 24 in random order.

Repetition - Repeat a trial with/without a noise factor (outer array). Easiest and simplified way is to perform the same task with different conditions.

The main criteria for Interaction are,

- Describe each trial condition.
- Decide order and repetition trials.

Table 3. Standard Orthogonal Arrays

No.	Array	Levels
1.	2-Level Arrays	L-4 L-8 L-12 L-16 L-32 L-64
2.	3-Level Arrays	L-9 L-18 L-27 (L-18 has one 2-level column)
3.	4-Level Arrays	L-16 & L-32 Modified.

The experimental trials include the turning of the specimen by using different cutting parameters. The turning is done for nine different sets. Each set consists of different spindle speed, Depth and feed.

Fig.2. Figure:2 Machine Setting for Experimentation

The Specimen properties and composition are explained in section 4.1. The Experiments were conducted on machine as described in above figure. The material of Cutting tool was selected as Right Hand Cutting tool of Material P40. The Type of Cutting Fluid Chosen is Hygrin_SYF_TF_G.

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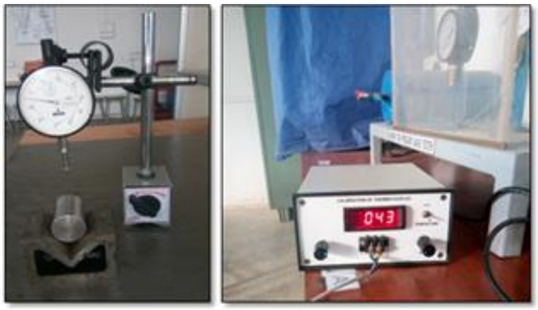
Fig.3. Surface Roughness and Temperature Measurement

At the time of turning, all trials were exposed to Cutting force measurement by using Mechanical dial indicator and surface roughness tests by stylus-type surface roughness testing machine in order to determine the surface roughness. The test is performed by keeping periodic surface roughness profile. As the specimen was going through the experimental process, the temperature of specimen was measured on the regular basis. Continuous temperature of specimen is observed by using ordinary Thermocouple. The aim of measuring the temperature is record the heat carrying away capacity of the coolant fluid that is used during the experimentation. As show in figure 3.

The experimentally obtained values of Cutting Force (FC), Surface Roughness (Ra) and Temperature are also presented in Table 4. OA and GRA is used to find the optimal process parameters with consideration of the multiple performance characteristics are obtained and verified.

Table.4. Experimentation and Results

Ex. No	Levels of parameters			Cutting Force (FC) N	Surface Roughness (Ra) micron	Temp (T) ^{0}C
	Cutting Speed (N) mm/min	Feed (F) Mm/rev	DOC (D) Mm			
1	35	0.35	0.5	150	3.2	28.3
2	35	0.35	1	430	3.15	29.7
3	35	0.35	1.5	710	3.25	26.9
4	35	0.4	0.5	264	3.37	31.6
5	35	0.4	1	584	3.35	30.6
6	35	0.4	1.5	904	3.4	30.1
7	35	0.45	0.5	380	3.52	33.5
8	35	0.45	1	740	3.55	30.0
9	35	0.45	1.5	250	3.59	31.4
10	55	0.35	0.5	124	2.96	32.4
11	55	0.35	1	379	2.99	31.1
12	55	0.35	1.5	659	3.03	31.5
13	55	0.4	0.5	206	3.1	34.1
14	55	0.4	1	526	3.14	32.9
15	55	0.4	1.5	846	3.17	33.2
16	55	0.45	0.5	315	3.25	37.8
17	55	0.45	1	675	3.28	33.1
18	55	0.45	1.5	935	3.32	36.3
19	75	0.35	0.5	116	2.6	31.20
20	75	0.35	1	306	2.63	31.83
21	75	0.35	1.5	586	2.67	25.33
22	75	0.4	0.5	122	2.7	33.70
23	75	0.4	1	442	2.74	29.90
24	75	0.4	1.5	762	2.77	35.90
25	75	0.45	0.5	220	2.8	34.93
26	75	0.45	1	580	2.84	31.27
27	75	0.45	1.5	940	2.88	34.50

V. Results and Discussion

A. GRA Data Preprocessing:

It is the process in which the comparison of original and optimized sequence is done. For which the results are normalized in the range between zero and one. Cutting Force, Surface Roughness & Temp. is the dominant response in Turning which decides the quality as well as Surface Finish. For the "smallest-the-better" characteristic like FC, the original sequence can be normalized.

Table.5. the Phases of Data Processing Operations.

Ex. No	FC	Ra	^{0}C
1	0.04	0.61	0.24
2	0.38	0.56	0.35
3	0.72	0.66	0.12
4	0.18	0.78	0.50
5	0.57	0.76	0.42
6	0.96	0.81	0.38
7	0.32	0.93	0.65
8	0.76	0.96	0.37
9	0.16	1.00	0.48
10	0.01	0.36	0.57
11	0.32	0.39	0.46
12	0.66	0.43	0.50
13	0.11	0.51	0.70
14	0.50	0.55	0.60
15	0.89	0.58	0.63
16	0.24	0.66	1.00
17	0.68	0.69	0.62
18	0.99	0.73	0.88

19	0.00	0.00	0.47
20	0.23	0.03	0.52
21	0.57	0.07	0.00
22	0.01	0.10	0.67
23	0.40	0.14	0.37
24	0.78	0.17	0.85
25	0.13	0.20	0.77
26	0.56	0.24	0.47
27	1.00	0.28	0.73

B. Grey Relational Coefficient:

It is defined as follows:

$$y\left(x_0^*(k), x_i^*(k)\right) = \frac{\Delta min + \vartheta \Delta max}{\Delta_{0i}(k) + \vartheta \Delta max}$$

Where

$\Delta_{0i}(k)$ = the deviation sequence

$x_0^*(k)$ = reference sequence

$x_i^*(k)$ = Comparability sequence of distinguishing or identification coefficient.

Table.6. Phases of GRC

No.	Grey relational coefficient			Grey relational grade
	FC	Ra	^{0}C	
1	0.34	0.56	0.40	0.43
2	0.45	0.53	0.43	0.47
3	0.64	0.59	0.36	0.53
4	0.38	0.69	0.50	0.52
5	0.54	0.67	0.46	0.56
6	0.92	0.72	0.45	0.70
7	0.42	0.88	0.59	0.63
8	0.67	0.93	0.44	0.68
9	0.37	1.00	0.49	0.62
10	0.34	0.44	0.54	0.44
11	0.42	0.45	0.48	0.45
12	0.59	0.47	0.50	0.52
13	0.36	0.50	0.63	0.50
14	0.50	0.52	0.56	0.53
15	0.81	0.54	0.57	0.64
16	0.40	0.59	1.00	0.66
17	0.61	0.61	0.57	0.60
18	0.99	0.65	0.81	0.81
19	0.33	0.33	0.49	0.38
20	0.39	0.34	0.51	0.41
21	0.54	0.35	0.33	0.41
22	0.33	0.36	0.60	0.43
23	0.45	0.37	0.44	0.42
24	0.70	0.38	0.76	0.61
25	0.36	0.39	0.68	0.48
26	0.53	0.40	0.49	0.47
27	1.00	0.41	0.65	0.69

After data pre-processing, a GRA is find with the pre-processed sequence. Is describes the original and normalized results. The grey relational coefficient for each experiment of the L27 OA can be calculated using Equation and the same is presented in Table 6.

C. Grey Relational Grade:

After obtaining the grey relational coefficient, the grey relational grade is computed by averaging the grey relational coefficient corresponding to each performance characteristic. The overall evaluation of the multiple performance characteristics is based on the grey relational grade, that is:

$$\gamma_i = \frac{1}{n}\sum_{k=1}^{n} \vartheta_i(k)$$

Table.7. Analysis for Grey Relation Grade

Nota tion	Para meter	GRG			Main effect (max-min)	Ra nk
		1	2	3		
A	Spee d	0.5717 41026	0.5722 1771*	0.47871 8742	0.0934 98967	3
B	Feed	0.4502 29638	0.5453 07785	0.62714 0054*	0.1769 10416	1
C	DoC	0.4973 73089	0.5103 22112	0.61498 2277*	0.1176 09188	2
Total mean value of the GRG =0.129339524 *Levels for optimum grey relational grade A3B1C2						

The mean of GRG for each parameter is shown by straight line. The Large value is desired for optimum performance. Therefore, the optimal parameters setting for better FC, Ra & T are (A3B1C2) as presented in Table 8.

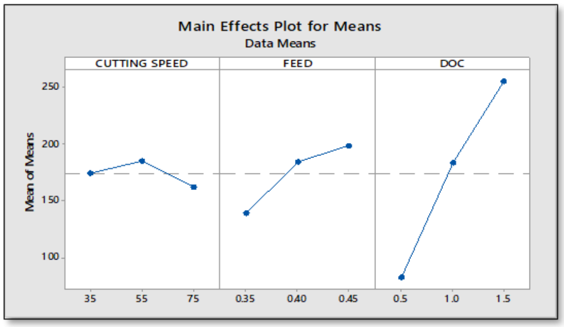

Fig. 4. Graph Effect of turning parameters on the multi-performance characteristics.

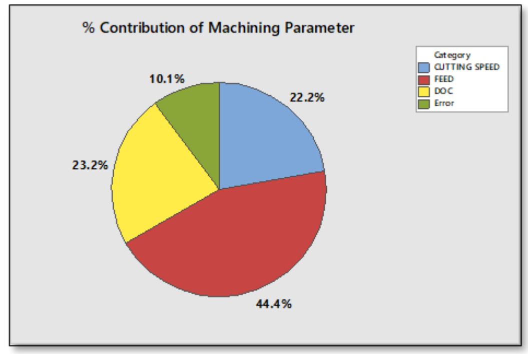

Fig.5. Percentage contributions of factors on the grey relational grade

D. Annova Methodology:

The aim of this method is to check the parameters significantly affecting the performance. This is done by bifurcating the total variability of the grey relational grades, which is measured by GRG. First, the total sum of the squared deviations SST from the total mean of the grey relational grade γ_m can be calculated as,

$$SS_T = \sum_{j=1}^{p} (\gamma_j - \gamma_m)^2$$

Table.8. ANOVA of GRG

Parameter	Degree of freedom	Sum of Squares	Mean squares	F ratio	Percentage contribution
Cutting Speed (A)	2	0.05219	0.02609	0.19055	22.2
Feed (B)	2	0.1411	0.07055	0.5152	44.4
DoC (C)	2	0.07486	0.03743	0.27333	23.2
5 Error	18	0.05157	0.00286		10.1
Total	26	0.31972	0.13694		100

It can be seen that cutting speed is the most significant factor that affects the grey relational grade. Electrode Force & Surface Roughness is directly proportional to the amount of Fees, Doc & Cutting Speed applied during the turning.

VI. CONCLUSION

- The Tagichi analysis response has been proposed as a way implementation for selection of turning process parameters for MS rod of 40mm.
- The optimal machining parameters have been determined by the grey relational grade for multi performance characteristics that is Cutting Force, Surface Roughness and Temp.
- 27 tests which are based on OA's have been performed.
- The work checks and evaluates the flexibility of Finish Operation produced during the turning.
- From the low value of grey relational grade for Cutting Speed, Fees and DoC are 8 mm/min, 10 mm/rev, 400 mm, respectively. These are the recommended levels of controllable process factors when better Surface Finish are obtained.
- The ANOVA of GRG for multi-performance characteristics reveals that the cutting speed is the most significant parameter.
- Optimum process parameter will have optimized by GRA.
- It is shown that the performance characteristics of the Turning process such as FC, Ra and T are improved together by using the method proposed by this study.
- The effectiveness methodology is successfully established by validation experiment.

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