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Optimization Of Axial Force In Drilling Process On Mild Steel By Taguchi's Approach

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Abstract:- The objective of the paper is to obtain an optimal setting of the drilling process parameter (cutting speed ,feed) resulting in an optimizing axial force in drilling on mild steel. The effect of drilling process parameter on axial force using Taguchi's parameter design approach. Results indicates that the selected process parameter affect the machining characteristics. The result indicate that the selected process parameter affect the mean and the variance of the optimal force. The percent contribution of parameters as quantified in the S/N pooled AVOVA .The percentage contribution of the parameters reveal that the influence of the feed (64.72%) in controlling both mean and variation of axial force is significantly larger than that of cutting speed(33.38%).The predicted optimum axial force is (720N).The result have been validated by confimation experiments.

Index terms:- Design of experimnets, Taguchi method, drilling process, work piece material mild steel and tool material high speed steel.

Introduction:

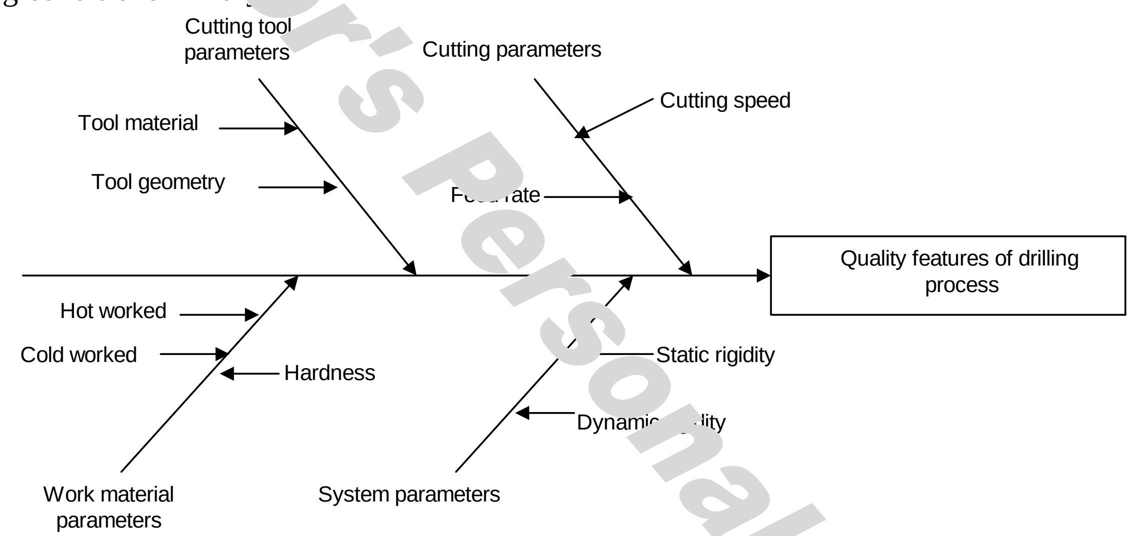
To provide the customer satisfaction and to deliver competitive market, a producer has to controlling quality at the design stage itself instead of manufacturing stage or by the inspection of the finish products. This is basic idea of off line quality control, Taguchi's method is one of the most comprehensive and effective system of off line quality control.

Taguchi recommends three stage processes to achieve desirable product quality by design.-system design, parameter design and tolerance design to provide the best performance of the product under study. The optimum condition is selected with the help of noise factor, orthogonal arrays, variance and signal to noise analysis are the essential tool of parameter design. The objective of the machining is to produce high quality product with minimum cost. A careful selection of the process for a given problem is essential: this machining process is non thermal, non chemical, non electrical and creates no change in metallurgical.

The Taguchi's method of offline quality control has been successfully used in design and selection of optimal process parameters in many areas of manufacturing processes.

In order to identify the process parameters depends on ishikawa cause effect diagram. To identify drilling process parameter- (1) cutting tool parameters- tool geometry, tool material (2) work piece base parameter, composition structure, strength and hardness (3)- cutting parameters- cutting speed, feed, depth of cut, wet cutting or dry cutting.

The following parameters where kept constant in the entire experimentation. Work material- Mild Steel(contains 0.16 – 0.29 % carbon)
Cutting tool Material- High Speed Steel(0.65- 0.80% carbon)
Radial Drilling Machine with Dynomometer fitted.
cutting conditions - dry



(a) Ishikawa cause – effect diagram of a drilling process

Drilling process Parameters- The process parameters that may affect the machining characteristics of drilled parts, an Ishikawa cause effect diagram was constructed. The identified process parameter affecting the characteristics of drill parts are

Work material mild steel has been selected because of its wide application in the manufacturing of automobile and machine tool parts. The following process parameters were thus selected for present work: cutting speed-(A), feed-(B), tool material- High Speed Steel(HSS), work material Mild Steel (M.S) and environment- dry cutting.

Selection of an orthogonal array(O.A):-In selecting an appropriate OA (1) selection of process parameter and interaction to be evaluated and (2) selection of number of levels for parameters. Each parameters are analyzed at three levels are given in table (1). It also decides interaction of two factors. As variable having three levels are being taken so degree of freedom associated one variable is 2(No. of levels-1). The DOF associated with the two variables is 4.The interaction study between the variables required and additional D.O.F. of two factors interaction is equal to the product of D.O.F of the factors. An orthogonal array having at least 8 D.O.F is required. In present case study , the O.A. selected is L9. the raw data analysis and S/N data analysis are done. Material selected tool bit (H.S.S) and the work material is mild steel(M.S.).

Experimental Analysis:- Mild steel rod 50mm diameter and 30mm length were drilled on radial drilling machine. The trial condition is given in table -1. The ranges of the selected process variables were decided by conducting experiments using one variable at a time approach. The process parameters, their designation and three levels are given in Table-1.

Process Parameters	**Notations (units)**	**Designation**	**Level Of Factors**		
			L1	**L2**	**L3**
Cutting Speed	v (m/min)	A	21	25	29
Feed	f (mm/rev.)	B	0.12	0.18	0.30

Table-1

Signal to noise (S/N) ratio:- Taguchi created a transform for the loss function which is called signal to noise. The S/N ratio consolidated several repetitions (at least two data points are required) into one value. The equation for calculating S/N ratio for lower the better (LB), higher the better (HB) and nominal the better (NB).

In this case study the performance characteristics lower the better(LB). Such factors are cutting forces, surface roughness etc. the following equation is used to calculate the S/N ratio for lower the better type of characteristics.

$$(S/N)_{LB} = -10 \log \frac{1}{R}\left[\sum_{j=1}^{R} y_j^2 \right]$$

where

y_j =value of the characteristic in an observation j R= number of repetitions in a trial.

Alternately, $$(S/N)_{LB} = -10 \log (MSD_{LB})$$

Where $$MSD_{LB}= [y_1^2 + y_2^2 + \text{---------} y_R^2]/R$$

Here the target value (m) =0

Result of axial force:- Experimental results of axial force obtained with the help of dynamometer the above discuss experiments. The experiments repeated three times R1, R2 and R3 denotes repetitions. The Raw data& S/N data of the axial force ar given below in table 2.

Column	Response (Raw Data)			S/N Ratio (db)
Trial No.	R1(N)	R2(N)	R3(N)	
1	730	710	720	-57.14
2	860	850	860	-58.42
3	1440	1400	1400	-63.10
4	1000	1050	1000	-60.20
5	1320	1350	1320	-62.67

6	2000	1940	2100	-66.08
7	1090	1050	940	-60.24
8	1540	1570	1650	-64.08
9	2400	2370	2490	-67.67

Table-2 L_9 OA with responses (Raw Data & S/N Ratios)

Data Analysis:- In this section includes the basic steps followed for analysis through Taguchi Technique for results obtained from the experiments discussed in last article.

Source	**SS**	**DOF**	**Variance**	**F-Ratio**	**P-Contribution**
A	2191842.3	2	1095921.15	317.80	28.80%
B	4976362.18	2	2488181.09	721.55	65.39%
A×B	379263.26	4	94815.815	27.49	4.98%
T	7609538	26			99.17%
e	62070.75	18	3448.37		0.87%

Table-3 **ANOVA** (Raw Data: Axial Force)

* significant at 95% Confidence Level

SS= Sum of Squares DOF=Degree of Freedom P=Percentage Contribution

V=Variance T=Total e=Error

Source	SS	DOF	Variance	F-Ratio	P-Contribution
A	32.54	2	16.27	35.36	33.38%
B	63.08	2	31.54	68.56	64.72%
T	97.46	8			
e	1.84	4	0.46		1.88%

* significant at 95% Confidence level

Table- 4 **ANOVA** (S/N data: Axial Force)

Predicted mean (Optimal Value):- the optimal force is to predicted at selected optimal setting of the process parameters. This mean is estimated only for the significant parameters. The ANOVA identifies the significant parameters A and B are significant A1 B1 is optimum condition. The mean at the optimum condition is estimated as:-

A1, B1 represent average values of response first level of parameter A and first level of parameter B. it may also happen the prescribed combination of parameter level is identical to one of those in the experiments. The confidence interval for the predicted mean on confirmation run can be calculated using the following equation-

$\mathbf{(CI)_{CE}} = \sqrt{F\alpha(1,fe)Ve[1/n_{eff}+1/R]}$ R = sample size for confirmation experiment

If $R \to \infty, 1/R \to 0$ and $(CI)_{CE} = (CI)pop$

Estimation of optimal value of the axial force:- After analyzing S/N response graphs and the average plots for the raw data the optimal cutting conditions for the selected quality characteristic *i.e., Axial Force* is:

Cutting Speed (A, Level 1) : 21m/min
Feed (B, Level 1) : 0.12 mm/rev

μ_{AF} = Predicted mean (optimal value) of Axial force

$$= \overline{A1B1}$$

$$= \frac{720+710+730}{3} = \mathbf{720N}$$

- The confidence interval is a maximum and the minimum value between which the true average should fall at some stated percentage of confidence. From Table 3.
  f e=18 V e=3448.37 At 95% confidence level:
- Fα(1,fe)=The F-ratio at confidence level of α against DOF of mean and error DOF
- n_{eff} = effective number of replications = *N*/{1 + [Total DOF associated in the estimate of mean]*}* *N* = total number of experiments.
- $F_{0.05};(1,18)=4.41$(Tabulated F-ratio) $n_{eff} = 27/(1+4) = 5.4$
- The expression for computing $(CI)_{CE}$ (Confidence interval for a sample group) for confirmation experiments;

  $\mathbf{(CI)_{CE}} = \sqrt{F\alpha(1,fe)Ve[1/neff+1/R]}$ R = sample size for confirmation experiment

  $\mathbf{(CI)_{CE}} = \sqrt{4.41 \times 3448.37[1/5.4+1/3]} = 88.06$

- $(\mu_{AF} - (CI)_{CE}) < \mu AF < (\mu_{AF} + (CI)_{CE})$
- (720–88.06)< 720< (720+ 88.06)
- 631.94 < μ_{AF} (N) < 808.06 (predicted optimal range for sample size of 3, of axial force)
- $(CI)\ pop = \sqrt{F\alpha(1,fe)Ve/\ neff}$ $(CI)pop = \sqrt{4.41 \times 3448.37/\ 5.4} = 53.06$
- The predicted optimal range for the entire population of axial force is:
- $(\mu_{AF} - (CI)_{CE}) < \mu_{AF} < (\mu_{AF} + (CI)_{CE})$
- (720–53.06)< μ_{AF} < (720+ 53.06)
- 666.94 < μ_{AF} (N) < 773.06
- Trial No.1of L9 OA corresponds to these cutting conditions. The average response to three repetitions of this trial is 720N.Thus the predicted range of the optimum cutting force i.e. 666.94 < μ_{AF} (N) < 773.06 entire population is satisfied.

Hence the selected optimal values of machining parameter for optimal axial force are implemented**.**

The following sections gives the conclusions obtained from the results of the analysis of axial force data obtained from experimentation using Taguchi Technique.

Conclusions

- (1) After analyzing S/N response graphs and the average plots for the raw data the optimal cutting conditions for the selected quality Characteristic, axial force, are:
  Cutting Speed (A, Level -1) : 21 m/min Feed (B, Level-1) : 0.12 mm/rev
- (2) The following are the percentage contributions of the parameters to the variations of axial force in drilling of Mild Steel part using HSS drill.

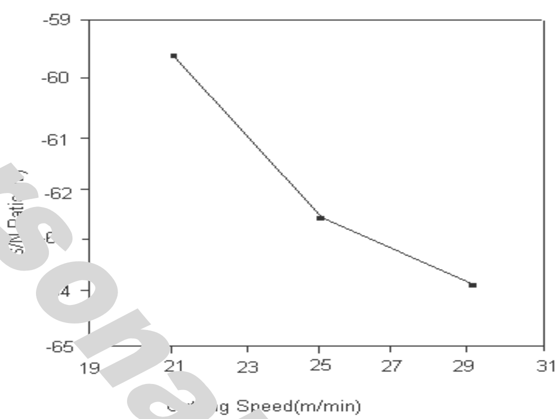
FOR RAW DATA:- Cutting Speed - 28.80% Feed - 65.39 %

Interaction between cutting speed and feed - 4.98%

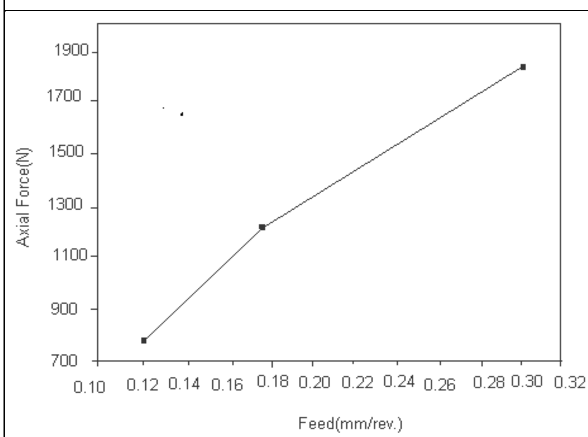
FOR S/N DATA:

- Cutting Speed - 33.38 % Feed - 64.72 %
- The percentage contribution of the parameters reveal that the influence of the feed rate in controlling both mean and variation of axial force is significantly larger than that of cutting speed.
- The interaction between cutting speed and feed rate (A × B) is significant at 95% confidence level in ANOVA for raw data. Thus it affects the mean values.
- The predicted optimum range of axial force is: $666.94 < \mu_{AF}$ (N) < 773.08

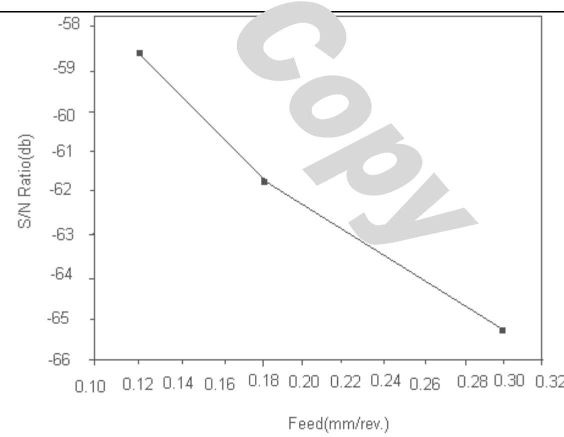
(a)Cutting Speed vs Axial Force



(c) Cutting Speed vs S/N Ratio



(b)Axial Force vs Feed



(d) Feed vs S/N Ratio

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