Formulation Of A Generalized Field Data Based Model For The Surface Roughness Of Aluminium 6063 In Dry Turning Operation.

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Abstract: This paper highlights the detailed methodology of mathematical model formulation for the surface roughness during the dry turning process. This paper also represents the detailed about the formulation of field data based model to analyze the impact of various machining field parameters on the surface roughness of aluminum 6063 during the dry sturning operation. In Indian scenario where majority of total machining operation are still executed manually which needs to be focused and develop a mathematical relation which simulate the real input and output data directly from the machining field where the work is actually being executed. The advantages and limitations of the developed mathematical models are identified and the models are classified in terms of application range and goals. The findings indicate that the topic understudy is of great importance as no such approach of field data based mathematical simulation is adopted for the formulation of mathematical model.

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Key words: Dry turning; Field data based model; Sensitivity; Optimization; Buckingham's Pi therom

1. Introduction

Aluminum alloys are used extensively in airplane, car, tank and ships etc, because of their excellent combination of small specific weight, high wear-resistance, corrosion resistance, heat conductivity, and absorbing performance in impacting, no spark under shock, non-magnetic, non-toxicity, easy to recycling and reusing. Aluminum's density is about one third of that of iron (7.87 kg/mm3), which is beneficial to lightweight of the traffic conveyance. Today, as far as production of aluminum alloy is concerned, Aluminum is the second highest which is more than total of other nonferrous metals, only less than that of steel. Aluminum-silicon alloys with high strength, the most important aluminum alloys, were ideal engineering materials. It is difficult for machining Aluminum-silicon alloys. Success in the cutting (such as turning, milling, drilling and so on) of Aluminum-silicon alloys depends largely on the overcoming of the principal problems of serious tool wear, poor Surface quality, machining accuracy etc.

Turning is a widely used machining process in manufacturing. Therefore, an optimal selection of cutting parameters to satisfy an economic objective within the constraints of turning operations is a very important task. Traditionally, the selection of cutting conditions for metal cutting is left to the machine operator Surface roughness, Human energy and productivity has received serious attention for many years. A considerable number of studies have investigated the general effects of the speed, feed, and depth of cut on the turning process.

Some researchers studied on the mach inability of aluminum-silicon alloys [2-6]. Liu and Chen compared the influence of several factors (cutting speed, feed rate and depth of cut) on cutting force and surface roughness by orthogonal tests in turning Si-Al alloy. The results showed that the surface roughness could be improved by using diamond tool [2]. Recently, In order to obtain reasonable cutting parameters in turning casting aluminum alloy ZL108.Wei, Wang, et al analyzed main influential factors of cutting force using carbide tool YG8. The results indicated the depth of cut had great influence on stability of whole cutting process in rough machining [6]. Armarego & Brown [3] (1969) investigated unconstrained machine-parameter optimization using differential calculus. Brewer & Rueda (1963) [8] carried out simplified optimum analysis for non-ferrous materials. For cast iron (CI) and steels, they employed the criterion of reducing the machining cost to a minimum. A number of monograms were worked out to facilitate the practical determination of the most economic machining conditions. They pointed out that the more difficult- to-machine materials have a restricted range of parameters over which machining can be carried out and thus any attempt at optimizing their costs are artificial. Brewer (1966) [7] suggested the use of Lagrangian multipliers for optimization of the constrained problem of unit cost, with cutting power as the main constraint. Walvekar & Lambert [31] (1970) discussed the use of geometric programming to selection of machine they optimized cutting speed and feed rate to yield minimum production cost. Petropoulos [23] (1973) investigated optimal selection of machining rate variables, viz. cutting speed and feed rate, by geometric programming. Sundaram [26] (1978) applied a goal-programming technique in metal cutting for selecting levels of machining parameters in a fine operation on AISI 4140 steel using cemented tungsten carbide tools. Ermer & Kromodiharajo [11] (1981) developed a multi-step mathematical Optimization of machining techniques 701 model to solve a constrained multi-pass machining problem. They concluded that in some cases with certain constant total depths of cut, multi-pass machining was more economical than single-pass machining, if depth of cut for each pass was properly allocated. They used high speed steel (HSS) cutting tools to machine carbon steel. Hinduja *et al* [14] (1985) described a procedure to calculate the optimum cutting conditions for machining operations with minimum cost or maximum production rate as the objective function. For a given combination of tool and work material, the search for the optimum was confined to a feed rate versus depth-of-cut plane defined by the chip-breaking constraint. Some of the other constraints considered include power available, work holding, surface finish and dimensional accuracy. Tsai [29] (1986) studied the relationship between the multi-pass machining and single-pass machining. He presented the concept of a breakeven point, i.e. there is always a point, a certain value of depth of cut, at which single-pass and double-pass machining are equally effective. When the depth of cut drops below the break-even point, the single-pass is more economical than the double-pass, and when the depth of cut rises above this break-even point, double-pass is better. Carbide tools are used to machine the carbon steel work material.

Gopalakrishnan & Khayyal [13] (1991) described the design and development of an analytical tool for the selection of machine parameters in drilling. Geometric programming was used as the basic methodology to determine values for feed rate and cutting speed that minimize the total cost of machining SAE 1045 steel with cemented carbide tools of ISO P-10 grade. Surface finish and machine power were taken as the constraints while optimizing cutting speed and feed rate for a given depth of cut. Agapiou [2] (1992) formulated single-pass and multi-pass machining operations. Production cost and total time were taken as objectives and a weighting factor was assigned to prioritize the two objectives in the objective function. He optimized the number of passes, depth of cut, cutting speed and feed rate in his model, through a multi-stage solution process called dynamic programming.

2. Experimental Setup

Turning is carried on a lathe that provides the power to turn the work piece at a given rotational speed and feed to the cutting tool at specified rate and depth of cut. Therefore three cutting parameters namely cutting speed, feed and depth of cut need to be determined in a turning operation The turning operations are accomplished using a cutting tool with high hardness help to sustain the high cutting forces and temperature during machining create a harsh environment for the cutting tool. Surface roughness is another important factor to evaluate cutting performance. The schematic view of the experimental set-up is shown in Figure 1.

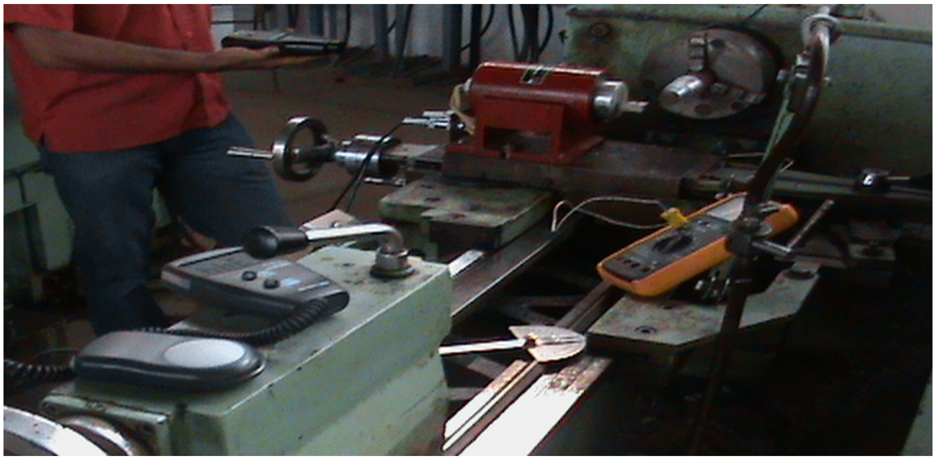

Figure 1. The experimental setup for turning Aluminum 6063

3. Methodology to formulate the field data based model

3.1 Design of Experimentation

A number of experiments were conducted to study the effects of various machining field parameters on surface roughness of the work piece. These studies have been undertaken to investigate the effects of various field parameters such as tool, machine, work piece, process and environmental parameters on the surface roughness. During experimentation, various speed, feed and depth of cut are used for processing the work piece. The output is measured and stored in personal computer for further analysis. In turning operation along with different machining parameters, three shift and seasons is also used during experimentation to analyze the effect of environmental parameters.

3.2 Experimental Approach

A theoretical approach can be adopted in a case. If known logic can be applied correlating the various dependent and independent parameters of the system. Though qualitatively, the relationships between the dependent and independent parameters are known, based on the available literature, the generalized quantitative relationships are not known sometimes. Hence formulating the quantitative relationship based on the logic is not possible in the case of complex phenomenon. Because of no possibility of formulation of theoretical model (logic based), one is left with the Only alternative of formulating experimental data based model. Hence, it is proposed to formulate such a model in the present investigation. The approach adopted for formulating generalized experimental model suggested by Hilbert Schenck Jr. [35] .This is stepwise detailed below

1. Identification of independent, dependent and independent extraneous variables
2. Reduction of independent variables adopting dimensional analysis
3. Test planning comprising of determination of test envelope, test points, test sequence and experimentation
4. Physical design of an experimental set up
5. Execution of experimentation for data collection.
6. Purification of experimentation data
7. Formulation of the field data based model.
8. Model optimization
9. Sensitivity analysis and Reliability of the model.

The first six steps mentioned above constitute design of experimentation. The seventh step constitutes of model formulation where as eighth and ninth steps are respectively optimization and sensitivity and reliability of model.

3.3 Identifications of variables

The term variables are used in a very general sense to apply any physical quantity that undergoes change. If a physical quantity can be changed independent of the other quantities, then it is an independent variable. If a physical quantity changes in response to the variation of one or more number of independent variables, then it is termed as dependent or response variable. If a physical quantity that affects our test is changing in random and uncontrolled manner, then it is called an extraneous variable. The variables affecting the effectiveness of the phenomenon under consideration are single point cutting tool, lathe machine, work piece, process parameters and the environmental parameters. The dependent or the response variables in this case of turning operation is surface roughness. The various dependent and independent variables are as shown in table 1.

3.4. Reduction of variables

3.4.1 Selection of primary dimensions

According to Theories of Engineering experimentation by H. Schenck Jr., chapter 4, "The choice of Primary Dimensions" Most systems require at least three primaries, but the analyst is free to choose any reasonable set he wishes, the only requirement being that his variables must be expressible in his system. There is really nothing basis or fundamental about the primary dimensions. As in this research all the variables are expressed in mass(M), length(L) , time(T) hence M , L , and T are choose for the dimensional analysis.

3.4.2 Dimensional Analysis

The process variables, their symbols and dimensions are listed in Table 1

M , L and T are the symbols for the mass, length, time respectively.

$$Ra = f(\mathrm{AR, r, Lo, BHN, Di, L, D0, VB, SUT, DEN, SPC, VC, f, D, FC, FT, SP, HP, HUM, DTO}) \quad (1)$$

General form can be defined as

$$f(\mathrm{AR, r, Lo, BHN, Di, L, D0, VB, SUT, DEN, SPC, VC, f, D, FC, FT, SP, HP, HUM, DTO, Ra}) = 0 \quad (2)$$

Reduction of variables through dimensional analysis: The various independent and dependent variables of the system with their symbols and dimensional formulae are given in nomenclature. There are several quite simple ways in which a given test can be made compact in operating plan without loss in generality or control. The best known and the most powerful of these is dimensional analysis. In the past dimensional analysis was primarily used as an experimental tool whereby several experimental Variables could be combined to form one.

Table 1. List of different Process Variables

S.N	Process Variables	Symbol	Dimensions
1	Cutting Tool angles ratio.	AR	$M^0 L^0 T^0$
2	Tool nose radius	r	$M^0 L^1 T^0$
3	Tool overhang length	Lo	$M^0 L^1 T^0$
4	Work piece Hardness	BHN	$M^0 L^0 T^0$
5	Initial Diameter of the Work piece	D_i	$M^0 L^1 T^0$
6	Length to be turned	L	$M^0 L^1 T^0$
7	Finished Diameter	D_o	$M^0 L^1 T^0$
8	Vibration acceleration	VB	$M^0 L^1 T^{-2}$
9	Tensile stress of the work piece material	SUT	$M^1 L^{-1} T^{-2}$
10	Density of the work piece material	DEN	$M^1 L^{-3} T^0$
11	Specific Cutting Energy	SPC	$M^{-1} L^{-1} T^{-3}$
12	Cutting Speed	VC	$M^0 L^1 T^{-1}$
13	Feed	f	$M^0 L^1 T^0$
14	Depth of cut	D	$M^0 L^1 T^0$
15	Cutting force	FC	$M^1 L^1 T^{-2}$
16	Tangential Force.	FT	$M^1 L^1 T^{-2}$
17	Machine Specification ratio	SP	$M^0 L^0 T^0$
18	Horse power of the Machine motor	HP	$M^1 L^2 T^{-3}$
19	Atmospheric Humidity	HUM	$M^0 L^0 T^0$
20	Atmospheric Temperature	DTO	$M^0 L^0 T^0$
21	Surface Roughness	Ra	$M^0 L^1 T^0$

Table 2. List of different Dimensional Pi terms formulated by Buckingham's Pi theorem

S.N	Independent dimensionless ratio	Independent dimensionless ratio	Nature of basic Physical Quantities
1	$\Pi 1$	$\Pi_1 = AR \times r \times Lo / D^2$	Single point cutting tool
2	$\Pi 2$	$\Pi_2 = BHN \times Di \times L \times Do \times VB \times DEN \times SUT \times SPC \times D^5 / VC \times FC^3$	Work piece material
3	$\Pi 3$	$\Pi_3 = f \times FT / D \times FC$	Cutting process parameters
4	$\Pi 4$	$\Pi_4 = SP \times HP / VC \times FC$	Machine Specification
5	$\Pi 5$	$\Pi_5 = HUM \times DTO$	Working environmental parameters
S.N	**Dependent dimensionless ratio**	**Dependent dimensionless ratio**	**Nature of basic Physical Quantities**
1	Π_{D1}	$\Pi_{D1} = Ra / D$	Surface Roughness

The field of fluid mechanics fluid mechanics and heat transfer were greatly benefited from the application of this tool. Almost every major experiment in this area was planned with its help. Using this principle modern experiments can substantially improve their working techniques and be made shorter requiring less time without loss of control. Deducing the dimensional equation for a phenomenon reduces the number of independent variables in the experiments. The exact mathematical form of this dimensional equation is the targeted model. This is achieved by applying Buckingham's π theorem (Hibert, 1961).

When we apply this theorem to a system involving n independent variables, (n minus number of primary dimensions viz. L, M, T) i.e. (n-3 numbers of π terms are formed.; From equation (2) total number of variables n = 21; All these variables can be expressed in terms of three primary dimensions i.e. mass (M), Length (L) and Time (T), m = 3

According to Bucking ham's theorem

Number of Pi terms = n – m = 21 – 03 = 18 dimensionless terms

$$f(\Pi_1, \Pi_2, \Pi_3, \Pi_4 \text{----------} \Pi_{21}) = 0 \qquad (3)$$

Number of repeating variables are r =m = 3; Choosing D, VC, FC, DT and α are the repeating variables we get following Pi terms as shown in table2.

3.5. Determination of plan for Experimentation

Many discrete extraneous variables like group of men, different machines and instruments, different days of week or seasons of the year can be taken care of by concept of randomized blocks like Latin squares, or Greco-Latin squares, which are among the general family of factorial plans (Logothesisi, 1977). For multifactor experiments two types of plans viz. classical plan or full factorial and factorial plan are available in this experimentation conventional plan of experimentation is recommended. The experimental value for all the variables are as shown in table 3.

3.6. Model Formulation

It is necessary to correlate quantitatively various independent and dependent terms involved in this very complex phenomenon. This correlation is nothing but a mathematical model as a design tool for such situation. The Mathematical model for step turning operations is as given below:

For Step Turning operation Five independent pi terms (π_1, π_2, π_3, π_4 and π_5) and one dependent pi terms (π_{D1}) are decided during experimentation and hence are available for the model formulation. Each dependent π term is the function of the available independent terms,

$$\Pi_{D1} = f(\Pi_1, \Pi_2, \Pi_3, \Pi_4, \Pi_5) \qquad (4)$$

A probable exact mathematical form for the dimensional equations of the phenomenon could be relationships assumed to be of exponential form [5]. For example, the model representing the behavior of dependent pi term π_{D1} with respect to various independent pi terms can be obtained as under.

$$\Pi_{D1} = K_1 \times \Pi_1^a \times \Pi_2^b \times \Pi_3^c \times \Pi_4^d \times \Pi_3^e \qquad (5)$$

The values of exponent are a, b, c, d, e are established independently at a time, on the basic of data collected through classical experimentation. There are six unknown terms in the equation (5) curve fitting constant K1 and indices a, b, c, d, e to get the values of these unknowns we need minimum a set of five set of all unknown dimensionless pi terms .

$$Z = A + bX + CY \text{------} \qquad (6)$$

The equation (5) can be brought in the form of equation (6) by taking log on both sides. Model of dependent pi term πD1 for surface roughness

$$\Pi_{D1} = K_1 \times \Pi_1^a \times \Pi_2^b \times \Pi_3^c \times \Pi_4^d \times \Pi_5^e \qquad (5)$$

Taking log on the both sides of equation for π D1

$$LOG\Pi_{D1} = LOGK_1 + aLOG\Pi_1 + bLOG\Pi_2 + cLOG\Pi_3 + dLOG\Pi_4 + eLOG\Pi_3 \qquad (7)$$

Let, Z = log π D1, K = log k1, A = log π 1,
B = log π 2, C =log π 3, D = log π 4, E = log π 5,
Putting the values in equations 4, the same can be written as

$$Z = K + aXA + b \times B \text{------} \qquad (8)$$

Equation (8) is a regression equation of Z on A, B, C, D and E in a dimensional co-ordinate system

$$\sum Z = n \times K + a \times \sum A + b \times \sum B + c \times \sum C + d \times \sum D + e \times \sum E$$

$$\sum ZA = K\sum A + a \times \sum A \times A + b \times \sum B \times A + c \times \sum C \times A + d \times \sum D \times A + e \times \sum E \times A$$

$$\sum ZB = K\sum B + a \times \sum A \times B + b \times \sum B \times B + c \times \sum C \times B + d \times \sum D \times B + e \times \sum E \times AB$$

$$\sum ZC = K\sum C + a \times \sum A \times C + b \times \sum B \times C + c \times \sum C \times C + d \times \sum D \times C + e \times \sum E \times C$$

$$\sum ZD = K\sum D + a \times \sum A \times D + b \times \sum B \times D + c \times \sum C \times D + d \times \sum D \times D + e \times \sum E \times D$$

$$\sum ZE = K\sum E + a\times\sum A\times E + b\times\sum B\times E + c\times\sum C\times E + d\times\sum D\times E + e\times\sum E\times E \quad (9)$$

In the above set of equations the values of the multipliers k, a, b, c, d and e are substituted to compute the, a, b, c, d and e in the set of equations are calculated. After substituting these values in the equations (9) one will get a set of five equations, which are mutinously to get the values of k , a, b, c, d and e The above equations can be verified in the matrix form and further values of k , a, b, c, d and e can be obtained by using matrix analysis.

$$X1 = inv(W)\times P1 \quad (10)$$

Solving these equations using 'MATLAB' is given below.
W = 5 x 5 matrix multipliers of k, a, b, c, d and e
P1 = 5 x 1 matrix of the terms on L H S and
X1 = 5 x 1 matrix of values of k, a, b, c, d and e
After solving we get
k = 137.9444,
a = 0.4075 ,
b = 0.1562,
c = 0.3595,
d =-0.2591 and
e = 0.0414
Hence the model is

$$\Pi_{D1} = 4.9268\times\Pi_1^{0.4075}\times\Pi_2^{0.1562}\times\Pi_3^{0.3595}\times\Pi_4^{-0.2591}\times\Pi_5^{0.0414} \quad (11)$$

4. Result Analysis

4.1 Model Sensitivity Analysis

The influence of the various independent π terms has been studied by analyzing the indices of the various π terms in the models. Through the technique of sensitivity analysis, the change in the value of a dependent π term caused due to an introduced change in the value of individual π term is evaluated. In this case, of change of ± 10 % is introduced in the individual independent π term independently (one at a time).Thus, total range of the introduced change is ±20 %. The effect of this introduced change on the change in the value of the dependent π term is evaluated .The average values of the change in the dependent π term due to the introduced change of ± 10 % in each independent π term. This defines sensitivity. The total % change in output for ±10% change in input is shown in Table 4
The graphical distribution of the sensitivity analysis of the formulated model with respect to different pi terms is shown in figure 2.

Table 4. Sensitivity analysis and Indices of model :

Pi terms	Step turning process.	
	% Change	Indices Of the Model
∏1	8.15 %	0.4075
∏2	3.14 %	0.1562
∏3	8.19 %	0.3595
∏4	-5.21 %	-0.2591
∏5	+0.82%	0.0414

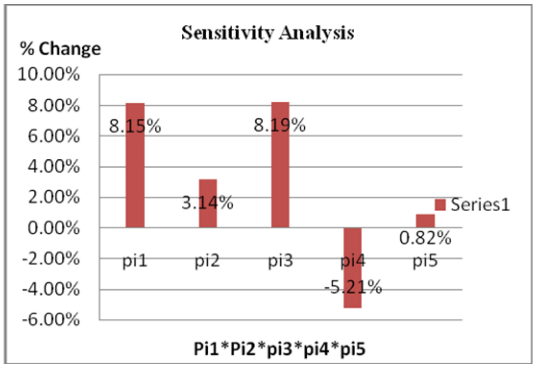

Figure 2. The Sensitivity analysis of the formulated model for turning Aluminum 6063

4.2 Model optimization for the minimum surface Roughness

The ultimate objective of this work is not merely developing the models but to find out best set of independent variables which will result in minimization of the objective functions. In this case

There is one objective functions corresponding to surface roughness models. The objective functions for the surface roughness need to minimize. The models have non-linear form; hence, it is to be converted into a linear form for optimization purpose. This can be achieved by taking the log of both the sides of the model. The linear programming technique is applied which is detailed as below for turning Operation.

Taking log of both the sides of the Equation 8, we get, the objective function is taking log of both the sides of the Equation (11), we get, the objective function is

$$MinZ = LOG(4.9268) + 0.4075LOG(\Pi_1) + 0.1562LOG(\Pi_2)$$
$$+ 0.3595LOG(\Pi_3) - 0.2591LOG(\Pi_4) + 0.0414LOG(\Pi_5)$$

Subject to the following constraints

$$1X_1 + 0X_2 + 0X_3 + 0X_4 + 0X_5 \le LOG(Max\Pi_1)$$
$$1X_1 + 0X_2 + 0X_3 + 0X_4 + 0X_5 \ge LOG(Min\Pi_1)$$

$$0X_1 + 1X_2 + 0X_3 + 0X_4 + 0X_5 \le LOG(Max\Pi_2)$$
$$0X_1 + 1X_2 + 0X_3 + 0X_4 + 0X_5 \ge LOG(Min\Pi_2)$$
$$0X_1 + 0X_2 + 1X_3 + 0X_4 + 0X_5 \le LOG(Max\Pi_3)$$
$$0X_1 + 0X_2 + 1X_3 + 0X_4 + 0X_5 \ge LOG(Min\Pi_3)$$
$$0X_1 + 0X_2 + 0X_3 + 1X_4 + 0X_5 \le LOG(Max\Pi_4)$$
$$0X_1 + 0X_2 + 0X_3 + 1X_4 + 0X_5 \ge LOG(Min\Pi_4)$$
$$0X_1 + 0X_2 + 0X_3 + 0X_4 + 1X_5 \le LOG(Max\Pi_5)$$
$$0X_1 + 0X_2 + 0X_3 + 0X_4 + 1X_5 \ge LOG(Min\Pi_5)$$

On solving the above problem by using MS solver we get values of X1, X2, X3,X4,X5 and Z. Thus ΠD1 min =Antilog of Z and corresponding to this value of the ΠD1min the values of the independent π terms are obtained by taking the antilog of X1,X2,X3,X4,X5 and Z. The optimized values are tabulated in table 5.

The variation of the various surface roughness due to increase in the values of independent pi terms for the turning operation is as shown in table 6.

Table 5. Optimized values of response variables for dry turning operation

	Surface Roughness	
	Log values of π terms	Antilog of π terms
Z	1.127255	3.087171
X1	-0.02765	0.972728
X2	-21.2132	6.13E-10
X3	0.190853	1.210281
X4	2.561441	12.95447
X5	3.067629	21.49088

Table 6: Nature of variation in response variables due to increase in the values of independent pi terms

Response Variables	Independent Pi terms				
	Π_1	Π_2	Π_3	Π_4	Π_5
Surface Roughness	High	Moderate	high	high	low

Table 7. Experimental and simulated values of all pi terms:

Exp.No	**Input parameters**					**Output parameter**	
	π1	**π2**	**π3**	**π4**	**π5**	**πD1Exp**	**πD1 Model**
1	10.27	1.5E-21	4.67	358.7	1478.4	0.02	0.0364
2	2.56	7.89432E-20	2.36	354.4	1478.4	0.01	0.0302
3	1.14	5.39023E-19	1.55	338.3	1473.6	0.03	0.0255
4	10.27	2.33076E-21	7.30	364.2	1478.4	0.03	0.0457
5	2.56	7.21896E-20	3.72	363.3	1452.3	0.04	0.0348
6	1.14	6.37526E-19	2.48	362.4	1452.3	0.02	0.030
7	10.2	1.75813E-21	9.80	338.3	1452.3	0.04	0.049
8	2.56	6.96564E-20	4.87	334.3	1452.3	0.03	0.0390
9	1.14	4.55392E-19	3.27	332.0	1476.8	0.02	0.0326
10	9.63	1.23742E-21	4.75	235.8	1476.8	0.02	0.0387
11	2.40	3.81085E-20	2.35	234.2	1476.8	0.02	0.0292
12	1.07	2.53314E-19	1.58	233.2	1476.8	0.01	0.0245
13	9.63	1.04697E-21	7.28	237.9	1849.2	0.04	0.0442
14	2.40	3.6945E-20	3.66	238.4	1849.2	0.03	0.0342
15	1.07	2.62381E-19	2.43	238.9	1870	0.01	0.02889
16	9.63	1.10134E-21	9.54	230.7	1849.2	0.06	0.0495
17	2.40	4.10539E-20	4.71	227.7	1238.3	0.01	0.0379
18	1.07	3.1685E-19	3.26	226.8	1230	0.01	0.0329
19	8.44	6.17971E-22	4.81	177.6	1250.5	0.02	0.0353
20	2.11	2.26057E-20	2.43	176.2	1250.5	0.02	0.0276
21	0.93	2.67168E-19	1.59	174.7	1168.5	0.03	0.0250
22	8.44	6.83667E-22	7.37	174.7	1235.4	0.03	0.0419
23	2.11	2.9417E-20	3.54	175.4	1235.4	0.02	0.0329
24	0.93	1.92184E-19	2.43	174.7	1214.1	0.03	0.027
25	8.44	6.12067E-22	9.62	177.6	1348.1	0.03	0.045
26	2.11	2.11626E-20	4.86	176.2	1326	0.02	0.0351
27	0.93	1.93179E-19	3.19	175.4	1326	0.03	0.0307

4.3 Validitation of the Formulated generalized field data based model

The validity of the formulated model can be checked by comparing the actual experimental value of the pi term related with surface roughness and its simulated value obtain from the formulated mathematical model. Figure 3. Shows the variation of the actual and simulated result. The error may occur due to error in the measuring instruments.

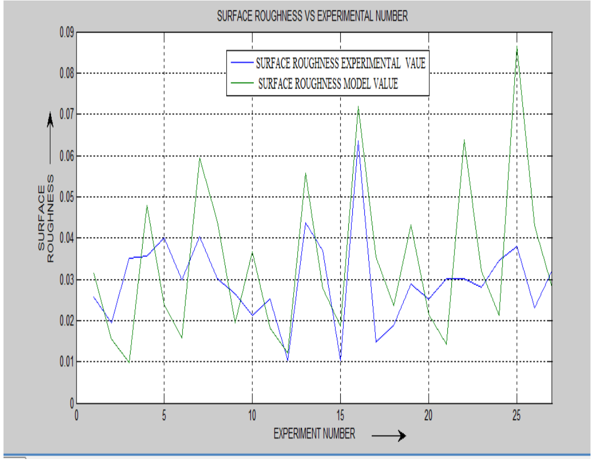

Figure 3. Graph for Experimental and Simulated value of pi term related with the surface roughness.

5. Discussion

In this study, a generalized field data based model was developed to simulate the dry turning process for aluminum 6063. The approach of generalized model formulation model provided an excellent and simple way to alalyse the engineering complex process where the impact of field data is dominating the performance .It can be seen from the equation that this model of pi terms containing surface roughness as response variable.

The following primary conclusions appear to be justified from the above model.

1. The absolute index of π1 is highest viz. 0.4075 Thus in π_1 the terms related to the single point cutting tools which the most influencing factors in this phenomenon. The value of this index is positive indicating πD1 is directly varying with respect to π 1.

2. The absolute index of π 4 is lowest viz. -0.2591, then π 4 related to machine specifications is the least influencing pi term in the model. The value of the index is negative indicating π D1 is inversely varying with respect to π 4.

3. The sequence of influence of the other independent pi terms present in the model is π 1, π 3, π 2, π 5, π 4 having absolute indices 0.4075, 0.3595, 0.1562,0.0414 and -0.2591 respectively. The index of π 4 is negative indicating that π D1 inversely proportional with respect to π 4.

4. The curve fitting constant in the model is 4.9268508. This value represents the effect of clearances and other factors which affect the phenomena

5. Sensitivity analysis of dry cutting operation indicates single point cutting tool and the cutting process parameters are most sensitive and work piece parameter, lathe machine specification as well as machining environmental parameters are least sensitive for model ΠD1and hence needs strong improvement.

6. The comparison of experimental, mathematical model is shown in the figure 3.

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References

1. Adler Y P, Markova E V, Granovsky Y V (1975) the design of experiments to find optimal Conditions (Moscow: Mir Publishers).
2. Agapiou J S (1992) the optimization of machining operations based on a combined criterion, Part 1 The use of combined objectives in single-pass operations, Part 2: Multi-pass operations. *J. Eng Ind., Trans. ASME* 114: 500–51
3. Armarego E J A, Brown R H (1969) *the machining of metals* (Englewood Cliffs, NJ: Prentice Hall) ASME 1952 Research committee on metal cutting data and bibliography. *Manual on cutting of metals with single point tools* 2nd end.
4. Barker T B *Engineering quality by design* (New York: Marcel Dekker) (1990)
5. Benton W C Statistical process control and the Taguchi method: A comparative evaluation. *Int. J.Prod. Res.* 29: 1761–1770 (1991)
6. Box G E P, Hunter J S Multifactor experimental Design. *J. Ann. Math. Stat.* 28: (1957**)**
7. Brewer R C; Parameter Selection Problem in Machining. *Ann. CIRP (*1966) 14: 11
8. Brewer R C, Rueda R; A simplified approach to the optimum selection of machining parameters. *Eng Dig.* 24(9): (1963) 133–150

9. Byrne D M, Taguchi S ; The Taguchi approach to parameter design. *Quality Progress (*1987) 20:19–26
10. Chen M, Chen K Y Determination of optimum machining conditions using scatter search. *New Optimization techniques in engineering*, pp 681–697 ;(2003)
11. Ermer D S, Kromordihardjo S, Optimization of multi-pass turning with constraints. *J. Eng. Ind.*(1981) 103: 462–468
12. Gilbert W, Economics of machining. In Machining – Theory and practice. *Am. Soc. Met. (19*50) 476–480
13. Gopala Krishna, Alluru Mallikarjuna Rao, K. Optimisation of machining parameters for milling operations using a scatter search approach *International Journal of Advanced Manufacturing Technology, 3-4, 219-224(6)*
14. Hinduja S, Petty D J, Tester M, Barrow G, Calculation of optimum cutting conditions for turning operations. *Proc. Inst. Mech. Eng.* 199(B2): 81–92, (1985).
15. Jeong-Du Kim, Dong Sik Kim, Theoretical analysis of micro-cutting characteristics in ultra-precision machining, Journal of Materials Processing Technology 49 (1995) 387-398
16. Jiwang Yana,Katsuo Syoji, Tsunemoto Kuriyagawa, Hirofumi Suzuki, Ductile regime turning at large tool feed, Journal of Materials Processing Technology 121 (2002) 363–372
17. Kackar R N, Shoemaker A C , Robust design: A cost effective method for improving Manufacturing processes. *AT & T Tech. J.* 65(Mar–Apr): 39–50, (1986)
18. Klir G J, Yuan B, *Fuzzy system and fuzzy logic – theory and practice* (Englewood Cliffs, NJ:Prentice Hall), (1998)
19. Kosko B, *Neural network and fuzzy systems – A dynamic approach to machine intelligence* (New Delhi: Prentice Hall of India), (1997)
20. Lin, Paul K H, Sullivan L P, Taguchi G, Using Taguchi methods in quality engineering. *Quality Progress, (*1990), 55–59
21. Liu X., DeVor R.E. and Kapoor S.G., "An Analytical Model for the Prediction of Minimum Chip Thickness in Micromachining", Journal of Manufacturing Science and Engineering, MAY 2006, Vol. 128, pp. 474-481
22. N. Fang, P. Dewhurst, Slip-line modeling of built-up edge formation in machining, International Journal of Mechanical Sciences 47 (2005) 1079–1098
23. Petropoulos P G , Optimal selection of machining rate variable by geometric programming. *J Prod. Res.* 11: 305–314, (1973).
24. Pignatiello J J , An overview of the strategy and tactics of Taguchi. *Inst. Ind. Eng. Trans.* 20: (1988),247–254
25. Prasad A.V.S.R.K, U.R.K. , Optimal selection of process parameters for turning operations in a CAPP system. *Int. J. Prod. Res.* 35: 1495–1522, (1997).
26. Sundaram R M , An application of goal programming technique in metal cutting. *Int. J. Prod. Res*16: 375–382, (1978)
27. Taylor F W, on the art of cutting metals. *Trans. ASME* 28: 31–35, (1907)
28. T.P. Leung, W.B. Lee, X.M. Lu, Diamond turning of silicon substrates in ductile-regime, Journal of Materials Processing Technology 73 (1998) 42–48
29. Tsai P, An optimization algorithm and economic analysis for a constrained machining model. PhD thesis, West Virginia University, (1986).
30. Tsui K L, Robust design optimization for multiple characteristics problems. *Int. J. Prod. Res.* 37:(1999), 433–445
31. Walvekar A G, Lambert B K, An application of geometric programming to machining variable selection. *Int. J. Prod. Res.* 8: 3, (1970)
32. Wang X, Jawahir I S, Web based optimization of milling operations for the selection of cutting conditions using genetic algorithms. *Proc. Inst. Mech. Eng.* 218: 212–223, (2004)
33. Wu V, Off-line quality control: Japanese quality engineering (Dearborn, MI: American Supplier Institute), (1982)
34. .Z.J. Yuan , M. Zhou, S. Dong, Effect of diamond tool sharpness on minimum cutting thickness and cutting surface integrity in ultra precision machining, Journal of Materials Processing Technology 62 (1996) 327-330
35. H.Schenck Jr.: Theories of Engineering a experimentation, McGraw Hill Book Co, New York.
36. V.H.Tatwawadi, Dr.J.P.modak and Chibule: Mathematical Modelling and simulation of working of an enterprise manufacturing electric motor, International journal of industrial engineering,17(4),2010,PP 341-359.
37. *K.F.H.* Muwell, "Nature of Ergonomics." Ergonomics (Man In His Working Environment), Chapman and Hall, London, New York, 1956.

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