ISSN: 2277-9655
(I2OR), Publication Impact Factor: 3.785
(ISRA), Journal Impact Factor: 2.114

IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

OPTIMISATION OF ROLLER BURNISHING PROCESS PARAMETER ON CYLENDRICAL SURFACE ON ALUMINIUM WORK PIECES

Mr.Ashwin Joshi*, Dr.R.N.Patil
[*] M.Tech. Scholar, B V D U, College of engineering, Pune
Professor & Head of Production Engineering Dept.,B V D U. College of engineering, Pune

ABSTRACT

In a single roller burnishing process, a hardened and polished roller is penetrated against a revolving cylindrical workpiece. Rotation of tool is parallel to the axis of rotation of the workpiece. Roller burnishing process is a superior chipless finishing process. It is done on machined or ground surfaces for both external and internal surfaces. Roller burnishing is used to improve the mechanical properties of surfaces as well as their surface finish.

In this experiment cylindrical Aluminum alloy (Al-6061) workpiece has been burnished using different machining parameters [Speed, Feed, and Depth of Penetration and Number of passes.].The experiment was carried on lathe machine. It is observed that Depth of Penetration is the significant parameter to control the surface finish (Ra value). The AVOVA results are validated using the AHP method. Here regression model also derived and presented. At the end the confirmation tests conducted to confirm results with the actual Ra values.

INTRODUCTION

Burnishing is considered as a chipless cold working finishing process which can be used to improve surface characteristics. Surface roughness of machined components plays vital role in many fields. Surface roughness is very important factor for the functioning of machined components.

As the pressure exceeds the yield point of the work piece material, plastic deformation at surface takes place. Due to this metal displacement takes place i.e. peaks on the machined surface are caused to flow into the valleys, which causes to reduce the height of the peaks in the process of Ra value of the machined surface. In this study surface roughness is the main response its variable and the parameters considered are spindle speed in rpm, tool feed in m/s, Depth of penetration in mm and number of passes.On experimental analysis, it is found that all the process parameters significantly affect the quality of surface

Surface finish is achieved by flattening the rough peaks by compressive force of the rollers. A burnished surface is very smoother than any abrasively finished surface. Using the abrasive metal removal methods we can lower the roughness height. But this process it leaves sharp projections on the machined surface (Murthy R. L., 1981).

Burnishing process is specially used where surface roughness value (Ra) play important roll along with super finish of surface. To control the roughness value (Ra) with different machining parameters burnishing process is used. Roller burnishing process is used produce accurately sized machined components finished with densely compacted surface. It resembles forming or cold working in contrast to micro metal abrasion in the finishing processes like honing and lapping. Two phenomena have been generally associated in the analysis of burnishing. One is flattening by plastic flow of roughness peaks and second is the displacement into adjacent valleys.

Lot of research task on burnishing process was already been carried out was pointed out with the effect of the burnishing process on the surface roughness and surface hardness.Aysun Sagbas[1] analyzed and optimized surface roughness using ball burnishing, Optimization strategy was depend up the desirability function approach (DFA) together with response surface methodology (RSM) . Using Response Surface Method with rotatable central composite design (CCD) quadratic regression model was developed to predict surface roughness values.

ISSN: 2277-9655
(I2OR), Publication Impact Factor: 3.785
(ISRA), Journal Impact Factor: 2.114

El-Khabeery and El-Axir [3] performed experiment on the roller burnishing process to improve surface irregularities for 6061 Aluminum alloy using a vertical milling machine by the optimum combination of burnishing process variables. The experimental design was based on RSM with CCD.

M. Kaladhar, K. V. Subbaiah, Ch. Srinivasa Rao and K. Narayana Rao [10] optimized process parameters using response optimization model based on Taguchi and Utility concept .Further, The ANOVA and F-tests are used to analyze the results.Alsothe confirmation tests are conducted and the results are found to be within the confidence interval

El-Axir et al, [2] studied on the surface finishing of 2014 Aluminum alloy by ball burnishing process. The experiments were designed on the basis of RSM with CCD

Hongyun Luo, Ligiang Wang, Chuang Zhang.[5], studied the effects of various machining parameters on the surface roughness of aluminum alloy

Wit GRZESIK, Krzysztof ZAK [13], compared the surface textures of turning, super finishing and ball burnishing.A set of 3D roughness parameters and real 3D surface topographies produced.

Esme Ugur, Mustafa Kemal Kulekci, Sueda Ozgun and Yigit Kazancoglu [4], Worked on predictive modeling of ball burnishing process using regression analysis and neural network by focusing on two techniques, namely regression and neural network techniques, for predicting surface roughness in ball burnishing process. Values of surface roughness predicted by the two techniques were compared with experimental values.

J.N. Malleswara Rao1, A. Chenna Kesava Reddy and P. V. Rama Rao studied the performance of the ball and roller burnishing tools on lathe, along with the influence of number of passes of burnishing tool on the surface roughness and surface hardness of brass specimens. The results revealed that improvements in the surface finish and increase in the surface hardness are obtained by the increase of the number of burnishing tool passes in both ball burnishing and roller burnishing on the brass specimens

Nemat and Lycons[8],The analysis was designed to assess the effects of burnishing feed, force and speed and the number of tool passes on the surface roughness and surface hardness of mild steel and an aluminum workpiece. It showed that improvement as much as 70% in surface quality was obtained when varying the mix of parameters.

Experimental Setup & Procedure

In this current research paper, an effort is being made to understand the improvement in the surface finish of burnished surface along with the study of the process parameters on Aluminum material. Aluminum 6061 was used because of its divers applications in the industries. Chemical compositions of Al 6061 mentioned in table 1 below.

TABLE 1: Composition of Aluminum in %

Mg	Si	Cu	Zn	Mn	Cr	Fe	Ti
0.2	0.4-0.8	0.15-0.4	0.25	0.15	0.04-0.35	0.7	0.15

Workpieces were holded in between centers and turned. After that burnishing operation performed on a lathe machine. Initially, the raw material in the form of rod Ø30 mm. First, turning operation is being performed using carbide tool. Then burnishing operation carried out. The basic tool and setup used for burnishing are shown in Fig.1 below

ISSN: 2277-9655
(I2OR), Publication Impact Factor: 3.785
(ISRA), Journal Impact Factor: 2.114

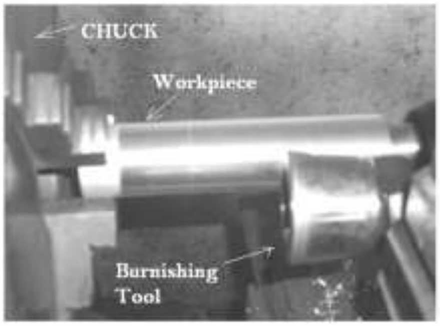


Fig 1: Experimental Set up

Wide ranges of burnishing tools were commercially available in the market. Refer Fig 2, this is single roller burnishing tool .The tool material is 'D3' tool steel. The roller was freely rotating. While machining the axis of tool was parallel to the rotation axis of workpiece.

Fig 2: Burnishing Tool

Design of Experiment (DOE)

Design of experiments (DOE) determines the pattern of observations to be done with a minimum experimental effort, in which effects of multiple factors are studied by running tests at different levels. The levels that should be taken, how to combine them, and how many experiments should be run are subjected to important in DOE. To make comparison of the performance minimum two levels are required and they determine the effect.

Design of Experiments (DOE) technique helps researchers to determine individual level and interactive level effects of different factors that could affect the output results in any research. DOE also helps provide a full insight of interactions between experiments; therefore, it helps to turn any standard design into a robust one. DOE helps to pin point the influencing parameters in design that cause problems. [11]

DOE with Taguchi method helps to improve consistency of performance and reduces the time without doing the full factorial experiments.

In this, fixed number of orthogonal arrays is used to handle many common experimental situations. Taguchi has developed a number of orthogonal arrays to accomplish the experiment design. Each array can be used to suit a number of experimental trials. In this study Taguchi L25 Orthogonal array has been used to check the results of input parameters.

Burnishing process parameters and their different levels are tabulated below in table2.

ISSN: 2277-9655
(I2OR), Publication Impact Factor: 3.785
(ISRA), Journal Impact Factor: 2.114

TABLE 2: Maching parameters and level.

	LEVELS				
	1	2	3	4	5
A = Speed [rpm]	76	105	285	460	725
B =Feed [mm/rev]	0.4	0.5	0.6	0.7	0.8
C= Depth of Penetration(DOP)(mm)	0.01	0.015	0.02	0.025	0.03
D =No .of passes(NOP)	1	2	3	4	5

Various surface roughness parameters are measured; like Ra, Rz, Rmax values by using surface roughness tester (Mitutoyo Surftest 211 model) shown in Fig 3.To check the accuracy of experiment, the analysis of variance (ANOVA) was used. The results of ANOVA for different parameters for surface roughness are shown in table 4. Surface roughness after turning operation and after burnishing operation is measured. The F – Ratio is calculated for the surface roughness.

Fig 3:Mitutoyo Surftest (Model No.211)

RESULTS AND DISCUSSION

According Taguchi orthogonal array L25the experiments were planned. As per the levels and factors mentioned TABLE 2; the experiments were carried out.

The results of Surface Roughness were obtained after performing burnishing operations for all twenty five workpieces. Each workpiece represented one experiment in the orthogonal array TABLE 3. The experimental results for burnishing test under the application of four parameters are summarized. Latter, the results were analyzed by employing main effects, and the signal-to-noise ratio (S/N) analyses. Confirmation tests were carried out to compare the experimental results with the estimated results.

TABLE 3: Observation Table

A	B	C	D	Ra (µ)	s/n ratio
1	1	1	1	0.255	11.87
1	2	2	2	0.31	10.17
1	3	3	3	0.44	7.13
1	4	4	4	0.55	5.19
1	5	5	5	0.69	3.22
2	1	2	3	0.32	9.9
2	2	3	4	0.45	6.94
2	3	4	5	0.52	5.68
2	4	5	1	0.64	3.88

2	5	1	2	0.282	11
3	1	3	5	0.41	7.74
3	2	4	1	0.51	5.85
3	3	5	2	0.61	4.29
3	4	1	3	0.3	10.46
3	5	2	4	0.35	9.12
4	1	4	2	0.53	5.51
4	2	5	3	0.68	3.35
4	3	1	4	0.245	12.22
4	4	2	5	0.34	9.37
4	5	3	1	0.43	7.33
5	1	5	4	0.62	4.15
5	2	1	5	0.28	11.06
5	3	2	1	0.37	8.64
5	4	3	2	0.46	6.74
5	5	4	3	0.56	5.04

From the above results it is found that minimum Ra value is observed in experiment no 18. and maximum Ra value observed in experiment no 5.

From the trials, it is observed that there are significant changes in surface roughness due to the variation in parameters.

Table 4: ANOVA table for surface roughness

Factor	dof	SS	SS %	MS	F
A	4	0.0029	5.47	0.0007	1.0717
B	4	0.0028	5.27	0.0007	1.0340
C	4	0.0370	69.16	0.0093	13.5601
D	4	0.0056	10.43	0.0013	1.9423
error	8	0.0053	9.95	0.0007	
total	24	0.0535	100.00	0.0048	

It can be seen from ANOVA table that for the surface roughness (Ra), the contribution of depth of penetration (69.16%) and Number of passes (10.43%) are more significant than Speed (5.47%) and Feed (5.27). Effect of error (9.95%) on surface roughness is very low as compared to the control factors.

From the F-table, For $F_{95\%, 4, 8}$ is 3.84.
Taguchi Orthogonal Array is designed in Minitab17 to calculate S/N ratio. Taguchi method stresses the importance of studying the response variation using the signal–to–noise (S/N) ratio, resulting in minimization of quality characteristic variation due to uncontrollable parameter.

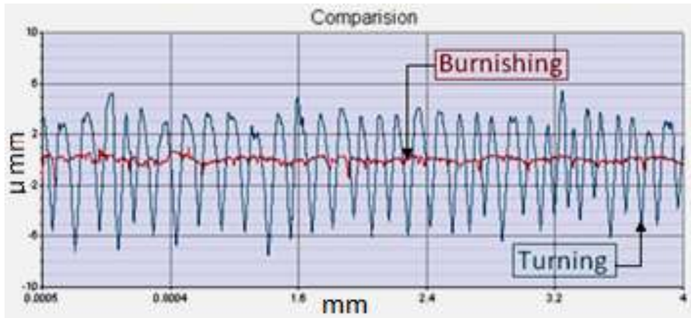
Surface roughness is being a “smaller is better” type of machining quality characteristic, the S/N ratio for this type of response was used and recorded.

$$S/N = -10 * \log (\Sigma (Y2)/n))$$

The effect of different process parameters on surface roughness are calculated and plotted. The S/N ratios have been calculated to find out the effects of different parameters as well as their levels. The use of both ANOVA technique and S/N ratio approach makes it easy to analyze the results and easy to reach conclusion.

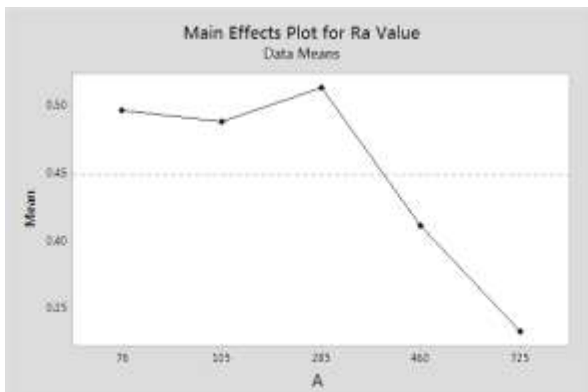
ISSN: 2277-9655
(I2OR), Publication Impact Factor: 3.785
(ISRA), Journal Impact Factor: 2.114

Graph 1, below shows comparison between surface roughness before burnishing and after burnishing operation. Ra value obtained after turning operation was 2.645µmm.

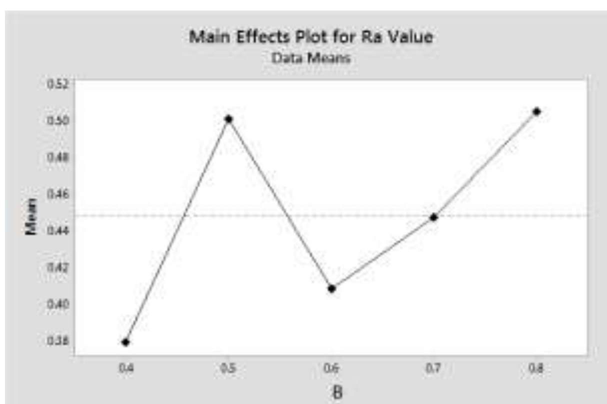


Graph 1: Superimposed recordings of the surface profile.

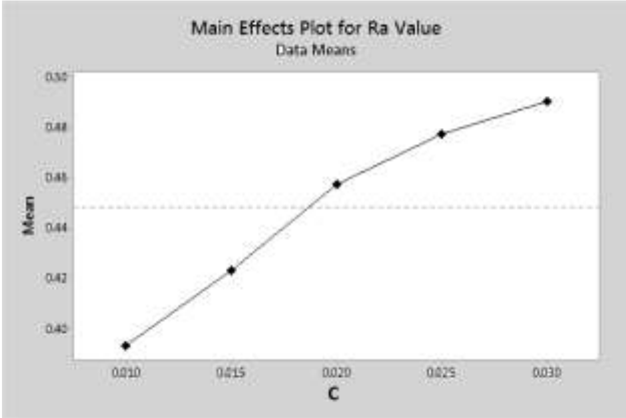
A. Main Effect: A main effect is present when different levels of a factor affect the response differently. A main effects plot the response mean for each parameter level. The values of surface roughness for each parameter i.e. A, B, C and D at each level obtained from Minitab 16.0.



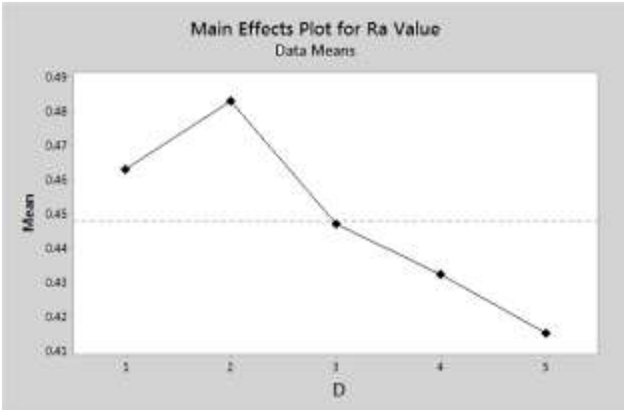
Graph 2 (a) Main effects plot of Speed Vs Surface Roughness



Graph 2 (b) Main effects plot of Feed Vs Surface Roughness

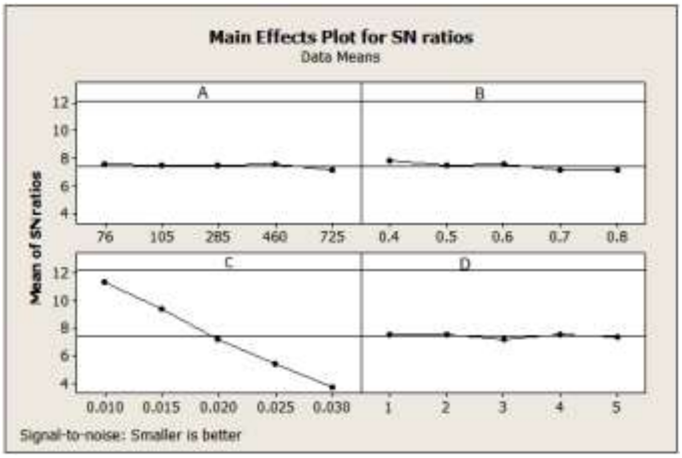


Graph 2 (c) Main effects plot of DOP Vs Surface Roughness



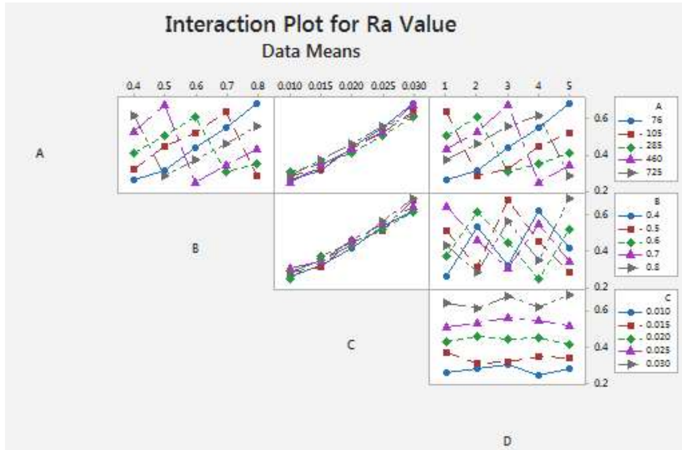
Graph 2 (d) Main effects plot of NOP Vs Surface Roughness

B. S/N Ratio: The signal-to-noise (S/N) ratio used to measure responses relative to the nominal or target value under different different noise conditions. The response quality characteristic used in this study was "smaller-is-better" i.e. the smaller surface roughness is better in experiment. S/N ration for all 25 trials are calculated and graphs plotted using Minitab 16.0



Graph3: Effects of Process Parameters on Surface Roughness

C: Interaction Graph: Below graph shows the interaction graph for different parameters and there levels.



Graph4: Interaction graph for Surface Roughness

REGRESSION EQUATION

The proposed multiple regression model is a two-way interaction equation:

Ra Value = 0.0061+0.000018A+0.0828B+18.944C+0.00186D

Where,

A = Speed in rpm.

B = mm/rev,

C = Depth of Penetration in mm

D =Number of passes

In this model, the criterion variable is the surface roughness (Ra) and the predictor variables are spindle speed, feed rate, and Depth of Penetration. Because these variables are controllable machining parameters, they can be used to predict the surface roughness which will then enhance product quality. A commercial statistical package Minitab 16.0 was used to draw the regression equation.

AHP

Analytic Hierarchy Process (AHP) is one of Multi Criteria decision making method that was originally developed by Prof. Thomas L. Saaty.It is a method to derive ratio scales from paired comparisons. The number of criteria is between 1 to 15 .The input can be obtained from actual measurement or from subjective opinion such as satisfaction feelings and preference. The ratio scales are derived from the principal Eigen vectors and the consistency index is derived from the principal Eigen value.

The AHP is a very flexible and powerful tool because the scores, and therefore the final ranking, are obtained on the basis of the pair wise relative evaluations of both the criteria and the options provided by the user.

Steps below shows the AHP optimization,

Priority of Requirements

	A	B	C	D
A	1	1	3	2
B	1	1	3	2
C	1/3	1/3	1	2
D	1/2	1/2	1/2	1

Normalized comparison matrix

	A	B	C	D
A	0.3529	0.3529	0.4	0.2857

B	0.3529	0.3529	0.4	0.2857
C	0.1176	0.1164	0.1333	0.2857
D	0.1764	0.1764	0.0667	0.1428

Scores for requirements

	A	B	C	D	**Value(V)**
A	0.3530	0.3534	0.4000	0.2857	0.3480
B	0.3530	0.3534	0.4000	0.2857	0.3480
C	0.1176	0.1166	0.1333	0.2857	0.1633
D	0.1764	0.1766	0.0667	0.1428	0.1406

	A	B	C	D	**Value(V)**	**Product(P)**	**Ratio(P/V)**
A	1	1	3	2	0.3480	1.4673	4.2160
B	1	1	3	2	0.3480	1.4673	4.2160
C	1/3	1/3	1	2	0.1633	0.6766	4.1433
D	1/2	1/2	1/2	1	0.1406	0.5703	4.0549
						CI	0.0525
						CI/RI	0.0584

CI/RI is smaller than 0.10, then the degree of consistency is satisfactory.
RI (random index) values are taken from standard table which depends on the no. of factors associated with experiments.

Number of Requirements	**2**	**3**	**4**	**5**	**6**
RI	***0***	***0.58***	***0.90***	***1.12***	***1.24***

CONFIRMTION TEST

The experimental confirmation test is the final step in verifying the results drawn based on Taguchi's design approach. Numbers of confirmation tests conducted are two and the observations are recorded below.

A	B	C	D	Ra_{actual}	$Ra_{theoretical}$
2	3	2	3	0.353	0.34
5	4	1	5	0.28	0.27

CONCLUSION

In this study, Master Burnishing Tool consisting of single roller having material 'D3 too steel' is used. The present work has lead to the following conclusions.

1. The Master Burnishing Tool can successfully used to finish operation for outer surface of –Aluminum Al-6061.
2. It has been established that taguchi analysis is an effective optimization technique.
3. Mathematical model for surface finish, burnishing response is identified by taguchi method considering speed, feed, DOP & NOP.
4. The established model is useful in predicting the response which by selecting proper input parameters that were used in this research work before performing the burnishing process.
5. The extent of influence of selected variable on burnished surface roughness can be deduced quantitatively from the model.

ISSN: 2277-9655
(I2OR), Publication Impact Factor: 3.785
(ISRA), Journal Impact Factor: 2.114

6. The ANOVA has revealed that the DOP is much more pronounced than the effect of burnishing speed /feed/NOP on surface roughness. This fact is confirmed by AHP method.
7. It has been found that the optimal cutting parameters machining process;

a. **Depth of Penetration**:
As DOP increases surface roughness improves, the graph shows linearity trend.

b. **Number of Passes:**
As no. of passes increases, surface roughness increases to high value and further increase in speed roughness reaches to its lowest.

c. **Speed**:
As Speed increases, small change in surface roughness value and further increase in speed surface roughness decreases to lowest

d. **Feed**:
As Feed increases, surface roughness reaches to high value, further increase in feed it reaches to lower surface roughness, further it reaches to higher value; there is no proper trend of flow in roughness variation.

REFERENCES

[1] Aysun Sagbas, T.-M. (2011). Analysis and optimization of surface roughness in the ball burnishing process using response surface methodology and desirability function. Advances in Engineering Software , 992–998.
[2] El-Axir, O. O. (2008). Study on the inner surface finishing of Aluminum alloy 2014 by ball burnishing process. Journal of Materials Processing Technology , 435–442.
[3] El-Khabeery, E.-A. (2001). Experimental techniques for studying the effects of milling roller burnishing parameters on surface integrity. International Journal of Machine Tools Manufacturing , 175–179.
[4] Esme Ugur, M. K. (2013). Predictive Modeling of Ball Burnishing Process. MP Materials Testing , 187-192.
[5] Hongyun Luo, L. W. (2009). Study on the aluminum alloy burnishing processing and the existence of the outstripping phenomenon. Journal of Materials Processing Technology , 88-90
[6] .J.Ross, P. (2014). Taguchi Techniques for Quality Engineering. Tata McGraw Hill.
[7] Krishankant, J. T. (2012). Application of Taguchi Method for Optimizing Turning Process by the effects of Machining Parameters. International Journal of Engineering and Advanced Technology , 117-122.
[8] Lycons, N. a. (2001). An investigation of the surface topography of ball burnished mild steel and aluminum. International Journal of Advanced Manufacturing Technology , 469-473.
[9] M. Kaladhar, K. V. (2011). Application of Taguchi approach and Utility Concept in solving the Multi-objective Problem when turning AISI 202 Austenitic Stainless Steel. Journal of Engineering Science and Technology , 55-61.
[10] M. Kaladhar, K. V. (2011). Application of Taguchi approach and Utility Concept in solving the Multi-objective Problem when turning AISI 202 Austenitic Stainless Steel. Journal of Engineering Science and Technology , 55-61.
[11] S. Thamizhmanii, B. S. (2007). A study of multi-roller burnishing on non-ferrous metals. Journal of Achievements in Materials and Manufacturing Engineering , 95-98.
[12] Serope Kalpakjian, S. R. Manufacturing Engineering And Technology.
[13] Wit Grzesik, K. Z. (2013). Comparison of surface textures produced by finish cutting, Abrasive and burnishing operations in terms of their Functional properties. Journal of Machine Engineering , 178-183.