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Optimization of Cutting Parameters for Minimizing Cycle Time in Machining of SS 310 using Taguchi Methodology and Anova.

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Abstract: *This paper presents an experimental study to optimize cutting parameters during machining of SS 304 for simultaneous minimization and maximization of Surface roughness (Ra), machining time, geometrical tolerance of Stainless Steel affect the aesthetical aspect of the final product and hence it is essential to select the best combination values of the CNC turning and CNC Milling process parameters to minimize as well as maximize the responses. An orthogonal array, Signal to noise(S/N) ratio and analysis of variance(ANOVA) were employed to analyze the effects and contributions of depth of cut, feed rate and cutting speed on the response variable. The experiments were carried out on a CNC turning and CNC machining, using coated carbide insert for the machining of Stainless Steel. The experiments were carried out as per L9 orthogonal array with each experiment performed under different conditions of such as cutting speed, depth of cut, and feedrate. te analysis of variance (ANOVA) was employed to identify the level of importance of the machining parameters on Surface roughness (Ra), machining time and geometrical tolerance. The result of this research work showed that feed rate is the most significant factor for minimizing surface roughness. Higher feed rate provides higher surface roughness.*

I. Introduction

1.1 Cnc Machines - An Overview

It has long been recognized that conditions during cutting, such as feed rate, cutting speed and depth of cut, should be selected to optimize the economics of machining operations, as assessed by productivity, total manufacturing cost per component or some other suitable criterion. Since long researchers showed that an optimum or economic cutting speed exists, this could maximize material removal rate. Manufacturing industries have long depended on the skill and experience of shop-floor machine-tool operators for optimal selection of cutting conditions and cutting tools. Considerable efforts are still in progress on the use of handbook based conservative cutting conditions and cutting tool selection at the process planning level. The most adverse effect of such a not-very scientific practice is decreased productivity due to sub-optimal use of machining capability. The need for selecting and implementing optimal machining conditions and the most suitable cutting tool has been felt over the last few decades. Despite early works on establishing optimum cutting speeds in CNC machining, progress has been slow since all the process parameters need to be optimized.

Furthermore, for realistic solutions, the many constraints met in practice, such as low machine tool power, torque, force limits and component surface roughness must be overcome. The non-availability of the required technological performance equation represents a major obstacle to implementation of optimized cutting conditions in practice. This follows since extensive testing is required to establish empirical performance equations for each tool coating work material combination for a given machining operation, which can be quite expensive when a wide spectrum of machining operations is considered.

The F8 large, vertical machining center is designed to provide the power, speed, precision and versatility to attack both large production part applications as well as big die and mold components. The F8 is designed to provide stiffness and rigidity for chatter-free, heavy cutting, roughing and finishing on the same machine, agility for high-speed / hard-milling and accuracies for tight-tolerance blends and matches typical of complex, 3-D contoured geometry associated with die/mold and medical production. The unique machine design provides unparalleled access to ease setup and changeover reducing WIP and overall lead time.

1.2 Cnc Machining Center

Fig 1The F8 large, MAKINO vertical machining center

1.3 Experimental Setup

To attain the main objectives of the present investigation, the experimental work has been planned in the following sequences

- Selection of material for CNC Machining operation
- Studying the effect of process parameter on mechanical properties of SS304
- Establishing relationship between material properties and CNC process parameters
- Manufacturing process of CNC turning operation of selected materials based on the design of experiments.
- Developing mathematical model using DOE, ANOVA, and Regression analysis.

Table 1.*Material Properties of STAINLESS STEEL AISI 304*

COMPOSITION	REPORT
CARBON%	0.08
SILICON%	Max 1
MANGANESE%	2
CHROMIUM%	19
NICKEL%	9
IRON%	BALANCE

Stainless steel is used for jewellery and watches. The most common stainless steel alloy used for this is 316L. It can be re-finished by any jeweller and will not oxidize or turn black

Exhaustive literature survey was carried out and the available relevant information was presented under the following headings. It is the conceptual framework of a methodology for quality improvement and process robustness that needs to be emphasized

- Gilbert(2010) studied the optimization of machining parameters in turning with respect to maximum production rate and minimum production cost as criteria
- Armarego&Brown (2013) investigates unconstrained machine – parameter optimization using differential calculus.
- Carmitacamposeco – negrete(2013) Optimization of cutting parameter for minimize energy consumption inturning of AISI 6061 T6 using taguchi methodology .
- jihongyan,lin li (2013) Multi-objective optimization of milling parameters- the off between energy , production rate and cutting quality
- Shortening cycle times in multi-product , capacitated production environment through quality level improvements and setup reduction(2013) moustaphadiaby , josevruzaaron.
- YingguangLi, WeiWang,WeimingShenWeimingShen 16 November 2012 Afeaturebasedmethod for NC machining time estimation Changqing.

- Fabrício José Pontes, Anderson Paulo de Paiva , Pedro Paulo Balestrassi, João Roberto Ferreira , Messias Borges da Silva b 2012 Elsevier Ltd. Optimization of Radial Basis Function neural network employed for redaction of surface roughness in hard turning process using Taguchi's orthogonal arrays .
- EmelKurama, Babur Ozcelik , MahmutBayramoglu, ErhanDemirbas c, BilginTolgaSimsek Available online 15 November 2012 Optimization of cutting fluids and cutting parameters during end milling by using D-optimal design of experiments .
- B. MoetakefImania, M. Pourb, A. Ghoddosianb, M. Fallah accepted 14 February 2012. Improved dynamic simulation of end-milling process using time series analysis .
- R. Venkata Rao, V.D. Kalyankar accepted 27 October 2012 Multi-pass turning process parameter optimization usingteaching–learning-based optimization algorithm.
- Rajarshi Mukherjee, Shankar Chakraborty, SumanSamanta Available online 3 April 2012 Selection of wire electrical discharge machining process parameters using non-traditional optimization algorithms .
- K. Schützera, E. Uhlmannb, E. Del Contea, J. Mewisb 2012, Improvement of surface accuracy and shop floor feed rate smoothing through open cnc monitoring system and cutting simulation.
- SubramaniamJayantia, KalyanMavuletia, Brian Beckera, Ethan Ericksona, Jon Wadella, Troy D. Marusicha,ShujiUsuia, Kerry Marusicha 2012 Modeling of Cutting Forces
- Arunkumarpandey, Ainashkumardubey 1 Dec 2011,Taguchi based fuzzy logic optimization of multiple quality, characteristics in laser cutting of Duralumin sheetand Cycle Times for Micromachined Components
- Anil Gupta, Harisingh, Amanaggarwal 2010Taguchi-fuzzy multi output optimization(MOO) in high speed cnc turning of AISI P-20 tool steel.
- Firmanridwan, Uun-xu.17- JUNE 2012.Advanced CNC system with in-process feed-rate optimization.
- Chanquingliu,YingguangLi,Weiwang,Weiming shen.16-nov-2012.A feature-based method for NC machining time estimation.
- Rajarshi Mukherjee, Shankar Chakraborty, SumanSamanta 3rd APRIL 2012. Selection of wire electrical discharge machining process parameters using non-traditional optimization algorithms

II. Optimization Of Multiple Performance Characteristics

2.1 Introduction

Optimization of process parameters is the key step in the Taguchi method in achieving high quality without increasing the cost. This is because optimization of process parameters can improve performance characteristics and the optimal process parameters obtained from the Taguchi method are insensitive to the variation of environmental conditions and other noise factors. Basically, classical process parameter design is complex and not easy to use. Especially, a large number of experiments have to be carried out when the number of the process parameters increases.

2.2Taguchi method for optimization of process parameters

Analysis of the S/N ratio

The Taguchi method uses S/N ratio instead of the average value to infer the trial results data into a value for the evaluation characteristics in the optimum setting analysis. This is because S/N ratio can reflect both average and variation of the quality characteristics. In the present work, the optimization of CNC TURNING and CNC MACHINING process parameters using Taguchi's robust design methodology with multiple characteristics is proposed. In order to optimize the multi performance characteristics, namely Cycle Timeand Surface roughness (R_a) while machining in CNC of Stainless Steel304material. Here performances namely Ra and cycle time are to be minimized .Most of the investigations presented in section2 employed Taguchitechniques, such as orthogonal arrays and S/N ratio analysis to optimize values of cutting parameters that minimize the response variable.Taguchi methodology allows obtaining results using fewer experimental runs than other techniques.

2.2.1analysis Of Cnc Process Parameters

Introduction

The statistical procedure used most often to analyze data is known as the analysis of variance (ANOVA). This technique determines the effects of the treatments, as reflected by their means, through an analysis of their variability.

In statistics, analysis of variance (ANOVA) is a collection of statistical model, and their associated procedures, in which the observed variance in a particular variable is partitioned into components attributable to different sources of variation. In its simplest form, ANOVA provides a statistical test of whether or not the means of several groups are all equal, and therefore generalizes t-test to more than two groups. Doing multiple two-sample t-tests would result in an increased chance of committing type-1 error. For this reason, ANOVAs are useful in comparing two, three, or more means

III. Machining process:experimental procedure

Table 2 Machining parameters

I	SPEED	
II	FEED	
III	DEPTH OF CUT	
IV	MATERIAL	AISI STAINLESS STEEL 304
V	Insert/TOOL	XNMU 0906 ANTRMTT9080

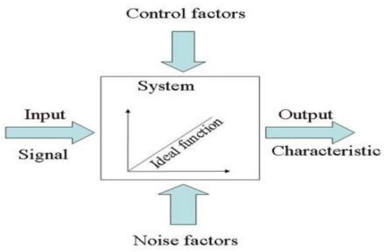

Fig 2 Existing Taguchi Methods

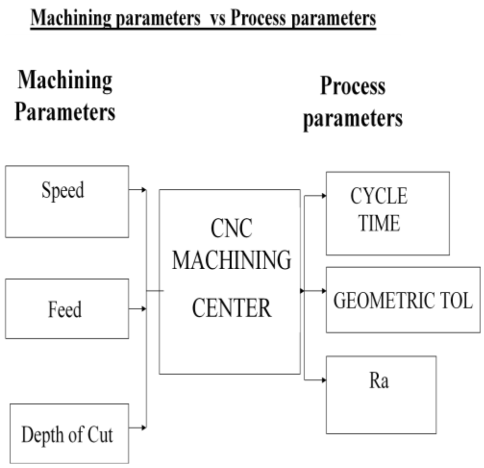

Fig 3 Machining parameters vs Processparameters

Table 3machining parameters and their levels

Symbols Used	Process parameter	Unit	Level- I	Level-2	Level-3
A	Spindle Speed	RPM	477	488	500
B	Feed rate	mm/rev	143	150	155
C	Depth of cut	Mm	0.25	0.30	0.35

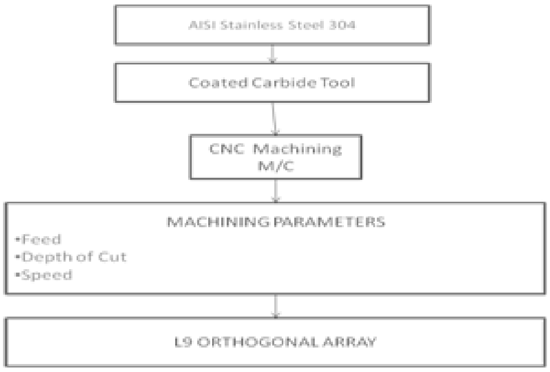

Fig 4 Methodology

Table 4Taguchi L9 Orthogonal Array

Job No	Spindle Speed (rpm)	Feed Rate (mm/rev)	Depth of Cut (mm)
1	1	1	1
2	1	2	2
3	1	3	3
4	2	1	2
5	2	2	3
6	2	3	1
7	3	1	3
8	3	2	1
9	3	3	2

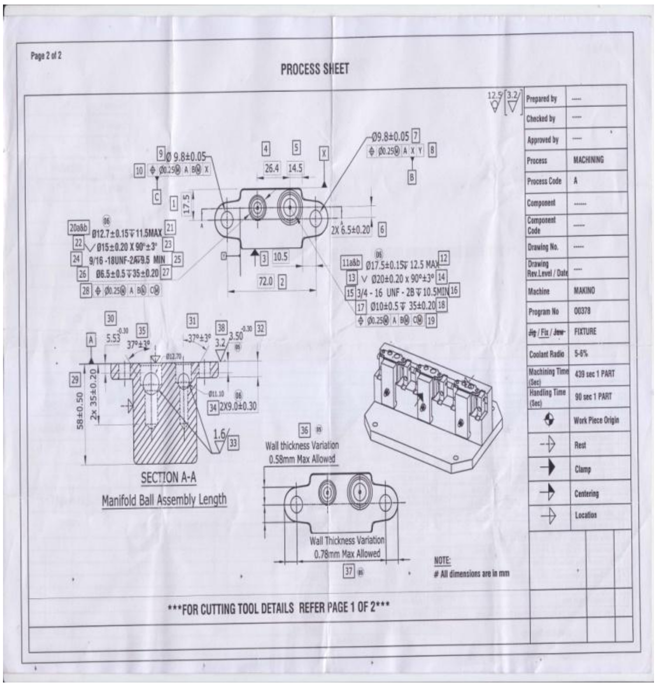

Fig 5 Part Drawing For Minimum Cycle Time and Surface Roughness Component

Operation Breakup

There are 18 options in this component. We are using Taguchi method for Optimising Cutting Parameters in Operation Number 01.

01.Face Milling Maintain the Height 58.0 and Flange Thickness 9.0mm.

IV. Results And Data Analysis

Three Categories of Performance Characteristics,
The lower-the-better,
The higher –the-better, and
The nominal-the-best

To obtain the optimal machining performance, the lower- the- better performance characteristic for surface roughness and cycle time have been taken for obtaining optimal machining performances.

Analysis of S/N Ratio:

$\eta=-10\log_{10}[ra^2]$

$\eta=-10\log_{10}[\text{cycle time}]^2$

where η=multi response signal to noise ratio

The results obtained from the experimental runs carried out, according to the orthogonal array shown in Table 4.Table 5 contains data for cycle time, surface roughness and S/N ratio for each Response and Data.The main effect plots are used to study the trend of the effects of each of the factors. Main effects plots for the three factors for Spindle speed, feed rate and Depth of cut versus surface roughness and cycle time have been shown in Figs.

Table 5 Experimental Result and Corresponding S/N Ratio

Spindle speed (rpm)	Feed rate (mm/rev)	Depth of cut (mm)	Surface roughness (Ra)	Cycle time (Secs)	S/N Ratio1	S/N Ratio2
477	143	0.25	1.85	108	-5.34343	-40.6685
477	150	0.3	1.9	102	-5.57507	-40.172
477	155	0.35	1.9	99	-5.57507	-39.9127
488	143	0.3	1.7	97	-4.60898	-39.7354
488	150	0.35	1.85	95	-5.34343	-39.5545
488	155	0.25	1.75	93	-4.86076	-39.3697
500	143	0.35	1.7	91	-4.60898	-39.1808
500	150	0.25	1.9	90	-5.57507	-39.0849
500	155	0.3	1.95	87	-5.80069	-38.7904

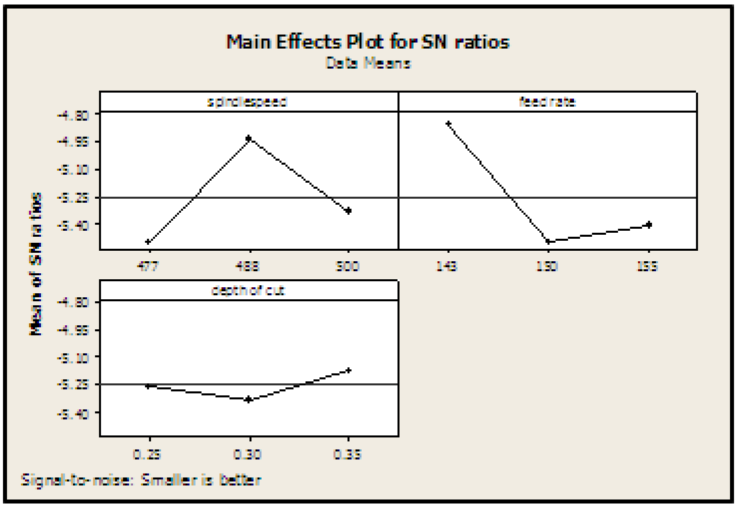

Fig 6 Surface Roughness graph

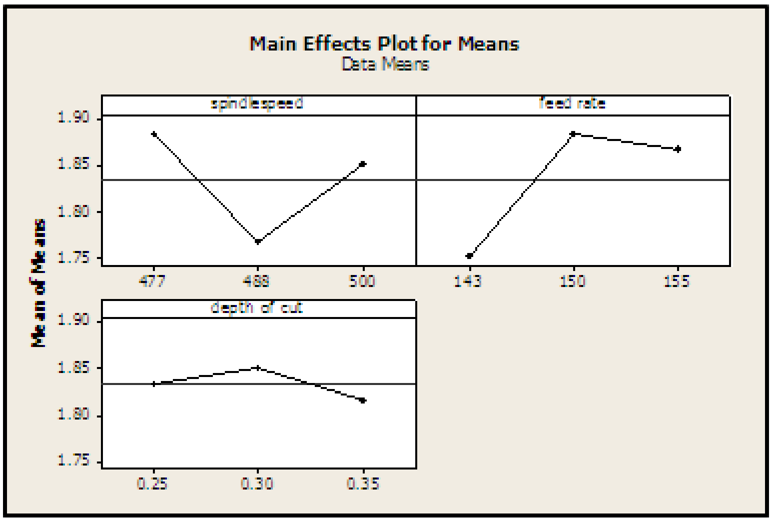

Fig 7 Surface Roughness graph

Analysis Of Variance(ANOVA) And main effects plots

Table 6General Linear Model: Surface Roug, Cycle Time versus Spindle spee, Feed Rate,

Factor	Type	Levels	Values
Spindle speed	random	3	477, 488, 500
Feed Rate	random	3	143, 150, 155
Depth Of Cut	random	3	0.25, 0.30, 0.35

Table 7Analysis of Variance for Surface Roughness, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Spindle speed	2	0.021667	0.021667	0.010833	1.44	0.409
Feed Rate	2	0.031667	0.031667	0.015833	2.11	0.321
Depth Of Cut	2	0.001667	0.001667	0.000833	0.11	0.900
Error	2	0.015000	0.015000	0.007500		
Total	8	0.070000				

S = 0.0866025 R-Sq = 78.57% R-Sq(adj) = 14.29%

Table8Analysis of Variance for Cycle Time, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Spindle speed	2	282.889	282.889	141.444	79.56	0.012
Feed Rate	2	48.222	48.222	24.111	13.56	0.069
Depth Of Cut	2	6.889	6.889	3.444	1.94	0.340
Error	2	3.556	3.556	1.778		
Total	8	341.556				

S = 1.33333 R-Sq = 98.96% R-Sq(adj) = 95.84%

Table 9 Percentage of influence of factors spindle speed, feed rate and depth of cut.

Factor	case 1	case 2
Spindle speed	39.39%	83.69%
Feed Rate	57.57%	14.27%
Depth Of Cut	3.03%	2.04

Case 1 : surface roughness
Case 2 : cycle time

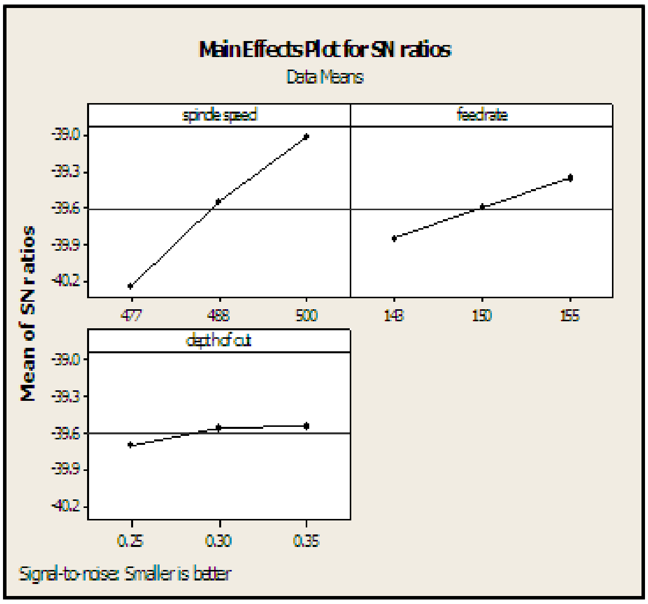

Fig 8 cycle Time Graph

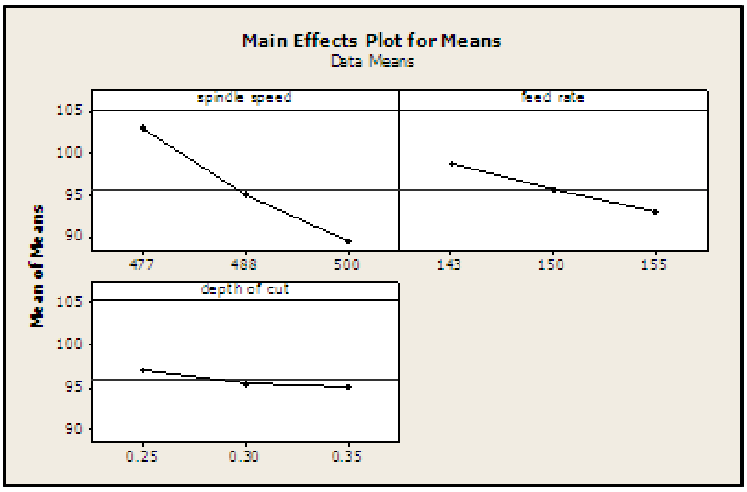

Fig 9 cycle Time Graph

V. Confirmation test

In order tovalidate conclusions obtainedin thissection, an experimental run was done with the optimum cutting parameters according to main effects and S/N ratio analysis.

VI. Conclusions

Taguchi methodology was employed for optimizing a finish machining process, involving AISI SS 304 as the material to be machined and a T-max Cutter of dia100 with coated inserts. Optimum values of cutting parameters were found out in order to minimize cycle time and Surface roughness during the machining process.

The cycle time is the response variable that should be analysed. According to the analysis showed in table 9,Spindle speed is the most significant factor (83.69%)followed by feed rate(14.27%) and depth of cut(2.04%).The most optimal results for cycle time were found when the spindle speed was set at 500rpm,feed rate of 155mm/rev and depth of cut of 0.35mm.Higher spindle speed, feed rate and depth of cut leads to minimum cycle time.

For minimising surface roughness, feed rate is the most significant factor(57.57%).The most optimal results for this response variable were found when the spindle speed was set at 488rpm,feed rate143mm/rev,and depth of cut 0.35mm.In order to increase accuracy and find the values that lead to a reduction of the response variables studied, it is necessary to conduct in machining operations.

References

[1]. Aggarwal,, A.singh,.H.kumar,P.singh..M etal...2008 optimising power consumption for cnc turned parts using response surface methodology and Taguchi's technique-a comparative analysis.journal of materials processing technology 200373-384.

[2]. Asilturk, and Neseli.s, 2011 Multi response optimization of cnc parameters via Taguchi method-based response surface analysis. Measurement45, 785-794.

[3]. Balogun and V.A.Mativenga p.t.2013 modelling of direct energy requirements in mechanical machining process.Journal of cleaner production 41,179-186.

[4]. D. Baji, I. Majce, Optimization of parameters of turning process, International Scientific Conference on Production Engineering, Lumbarda, 2006, 129-136.

[5]. Bhattacharya,A.Das,S..Majumber,P.Batish, etal.,2009. Estimating the effect of cutting parameters on surface finish and power consumption during high machining of AISI 1045 steel using Taguchi design and Anova. Production Engineering:Research& Development 3,31-40.

[6]. Bhushan. R.K.,2013 Optimisation of cutting parameters for minimizing power consumption and maximizing toollife during machining of AI alloy Sic paticle composites. Journal of cleaner production 39.242-254.

[7]. Yih-fong TZENG and Fu-Chen., Optimization of the high-speed CNC Turning process using two-phase parameter design strategy by Taguchi methods

[8]. Z. Car, B. Barisic, M. Ikonic. GA Based CNC Turning Center Exploitation Process Parameters Optimization., METABK 48(1) 47-50 (2009)

[9]. R.A. Ekanayake and P. Mathew. An Experimental Investigation of High Speed End turning.

[10]. Shu-Gen Wang, Yeh-Liang Hsu. One-pass turning machiningparameter optimization to achieve mirror surface roughness., Journal of Engineering Manufacture, Vol. 219, p. 177 – 181.

[11]. Lee, B.Y., Tarng, Y.S., 2000.Cutting-parameterselection for maximizing productionrateor minimizing production cost in multistage turning operations.JournalofMaterials Processing Technology 105, 61e66.

[12]. Li, W., Zein, A., Kara, S., Herrmann, C., 2011. An Investigation into fixed energyconsumption of Machine tools. In:Glocalized Solutions for Sustainability inManufacturing: Proceedings of the 18th CIRP InternationalConferenceon LifeCycle Engineering, pp. 268e273.

[13]. Mativenga, P.T., Rajemi, M.F., 2011. Calculation of Optimum cuttingparametersbasedonminimum Energy footprint. CIRP Annals e Manufacturing Technology60, 149e152.

[14]. 2001. Design of ExperimentsUsing the Taguchi Approach: 16 Steps toProduct and Process Improvement. John Wiley & Sons, Inc., New York, USA. Rutherford, A., 2001. Introducing ANOVA and ANCOVA. A GLM Approach, SAGE Publications, London, England.

[15]. Fratila, D., Caizar, C., 2011. Application of Taguchi method to selection of optimallubrication and cutting conditions in face milling of AlMg3.Journal of CleanerProduction 19, 640e645.

[16]. Hanafi, I., Khamlichi, A., Mata Cabrera, F., Almansa, E., Jabbouri, A., 2012. Optimizationof cutting conditions for sustainable machining of PEEK-CF30 using TiNtools.Journal of Cleaner Production 33, 1e9.