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Optimization and Rejection Analysis of IC Engine Rocker Arm

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Abstract: Today, many technical products need high-precision cylindrical bores which are used, e.g. as a fit or as guidance elements for pistons and shafts. They often need geometric and form accuracy with tolerances less than 1 µm, surface qualities with a roughness less than 1 µm and a high wear resistance. To reach higher production accuracy and better process stability in shorter cycle times, new approaches for the regulation of an automated honing process have to be developed. Due to the great demands regarding the surface roughness which has a great influence on the service life and reliability of parts and the researches of the technical and economical performances of finishing processes were made to optimize the process parameters and constructive parameters of the abrasive tools

***Keywords*: Surface roughness, Analysis, Honing, process parameter, Rocker arm**

I. INTRODUCTION

To guarantee solid execution and delayed help life of present-day hardware, its parts need to be fabricated with high dimensional and mathematical precision as well as with high surface completion. The surface completion plays a fundamental part in impacting useful attributes like wear obstruction, exhaustion strength, erosion opposition, and force misfortune because of rubbing. Lamentably, typical machining techniques like turning, processing, or even old-style crushing can't meet this rigid necessity.

The important parameters that affect material removal rate (MRR) and surface roughness (R) are:

1) Unit pressure, p
2) Peripheral honing speed, Vc
3) Honing time, T

II. RESEARCH METHODOLOGY

A. To review the literature to identify the research issues and to define the problem.
B. Identify the process parameters influencing quality.
C. Design of experiments for the selected factors and their levels
D. Conducting the experiments according to the design.
E. Analysis of results to find significant parameters influencing performance measures.
F. Establishing relationship between process parameters and performance measurers using suitable statistical software.
G. Identify optimal set of parameter values for performance measures.
H. Validation of optimal values through confirmation experimentation.

III.ANALYSIS OF DATA

A. Selection of Level of input Process Parameter

Sr. No.	Factors	Level
1	Speed	3
2	Feed	3
3	Tool Grit	2
4	Nozzle Diameter	2

Table No1: Level of process parameters

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Parametric combinations used while conducting experiments are given in table 2.

Exp. Run	Speed (S)	Feed (F)	Tool grit size(TS)	Nozzle dia.(D) (mm)
1	600	450	60/80	5
2	650	450	60/80	5
3	700	450	60/80	5
4	600	450	60/80	8
5	650	450	60/80	8
6	700	450	60/80	8
7	600	450	80/100	5
8	650	450	80/100	5
9	700	450	80/100	5
10	600	450	80/100	8
11	650	450	80/100	8
12	700	450	80/100	8
13	600	500	60/80	5
14	650	500	60/80	5
15	700	500	60/80	5
16	600	500	60/80	8
17	650	500	60/80	8
18	700	500	60/80	8
19	600	500	80/100	5
20	650	500	80/100	5
21	700	500	80/100	5
22	600	500	80/100	8
23	650	500	80/100	8
24	700	500	80/100	8
25	600	550	60/80	5
26	650	550	60/80	5
27	700	550	60/80	5
28	600	550	60/80	8
29	650	550	60/80	8
30	700	550	60/80	8
31	600	550	80/100	5
32	650	550	80/100	5
33	700	550	80/100	5
34	600	550	80/100	8
35	650	550	80/100	8
36	700	550	80/100	8

Table 2: Parametric combinations

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B. Measurement of Response Parameter

Surface roughness will be measured with help of Mitutoyo surface roughness tester on internal wall of the hole on specimen. It is measured in µm. This is it a small, lightweight, and extremely easy to use surface roughness measurement instrument that lets you view surface roughness value on the screen. Surface roughness nomenclature is as shown in Figure.

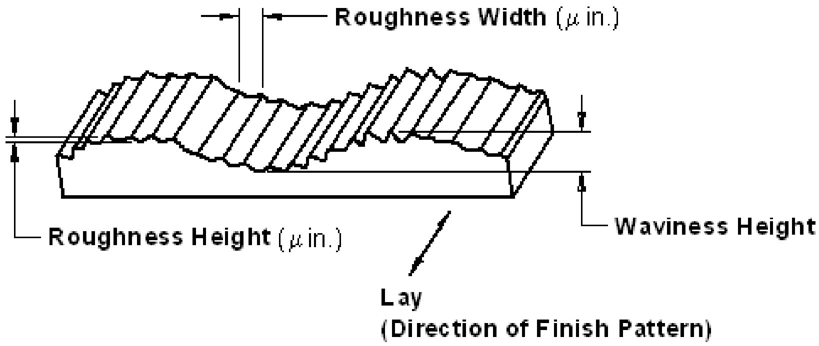

Figure 1: Surface Roughness Nomenclature

C. Experimental Setup

Figure 2: S/F roughness tester

1	Make	Mitutoyo, Japan
2	Type	SJ-210
3	Max. Length Measuring Capacity	0 – 100 mm
4	Least Count	0. 01 µm

Table 3: Surface roughness tester specifications

D. Analysis of Variance (ANOVA)-

This method was developed by Professor R.A.fisher. ANOVA is an extremely useful technique which is used when multiple sample cases are involved. The basic principle of ANOVA is to test the means of the population by examining the amount of variation within each of this sample relative to the amount of relation between the samples. In terms of variation within the given population, it is assumed that the value of (yij) differ from the mean of this population only because of random effects that is there are influences on (yij) which are unexplainable, where as in examining difference between the mean of the jth population and the grand mean is attributable to what is called air treatment effect. Thus it has to make to estimate of population variance viz. one based on between sample variance and the other based on within sample variance. Then these two instruments of population variance are compared with F-test.

$$F=\frac{\text{Estimate of population variance based between sample variance}}{\text{Estimate of population variance based on within sample variance}}$$

This value of F ratio be compared to the F-limit for given degree of freedom. If the F value worked out is equal or exceed the F-limit table value, it may conclude that there are significant differences between the sample means.

E. Selecting Optimum factor Levels

A primary goal in conducting a matrix experiments is to optimize the product or process design, to determine the best or the optimum level for each factor. The optimum level for a factor is the level that gives the highest value of S/N ratio in the experimental region. The estimated main effects can be used for this purpose provided the variation of S/N ratio as a function of the factor level follows the additive model

F. Signal to Noise Ratio

In Taguchi method, the term “signal” represent the desirable value for the output characteristics and “noise” represents the undesirable value of output characteristics. The objective to determine signal to noise ratio is to develop the processes that are insensitive to noise. A process parameter setting with the highest signal to noise ratio always yields optimum quality with minimum variance. In general signal to noise ratio signifies the ratio of mean to the standard deviation.

The Taguchi method includes the noise factors in the experiment for the purpose of identifying control factors settings which are robust against noise, i.e. those settings of the design factors which produce the smallest variation in the response across the different levels of the noise factors. Some combinations of control factor settings may yield output that is affected by the noise factors, thus causing the response to vary around its mean, while for other combinations; the output is insensitive to the changes in the noise factors . Similarly, the quality characteristic might exhibits more variability at, say, the low setting of a certain control factor than it does at the high setting. For other control factor, the variation in the quality characteristic might be nearly constant across the levels of those control factors, while the average quality characteristic might or might not change across the levels of these control factors. For any control factor, there are four possible situations (effect or no effect on the mean, coupled with effect or no effect on the variation).

G. Classification of Parameters

A number of parameters can influence the quality characteristics of the product. These parameters can be classified into the following three classes. Below Figure is representation of a product and parameters.

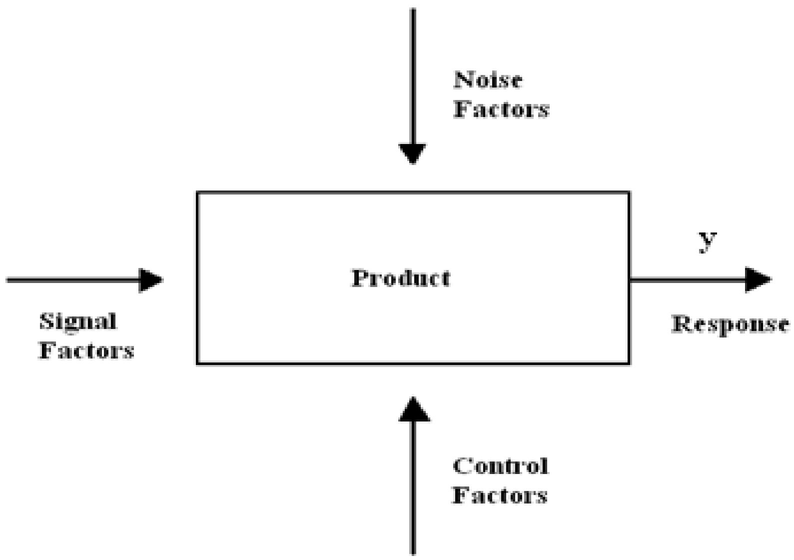

Figure 3: Block diagram of product and parameters

H. Control Factors

These are parameters that can be specified freely by the designer. It is designer’s responsibility to determine the best values of these parameters. Each control factor can take multiples values called levels.

1) *Signal Factor:* These are the parameters set by the designer of the product to express the planned value for the response of the product.
2) *Noise Factor:* These parameters cannot or wishes not to control by designer. Noise factors may control temporarily during an experiment, but in an actual production cannot control at all.

I. Design of Experiments (DOE)

Design of experiment or DOE is a structured and organized method that is used to determine the relationship between the different factors of input variables that affect a process and output or response of that process.

The purpose of design of experimentation is to improve the performance characteristics of the process to customers need and expectations. The DOE process is divided into three phases.

J. Planning phase

To determine the level of each process parameter initial experiments performed in the planning phase with different combination of process parameters.

K. Conducting phase

The level determined in planning phase where used for actual conducting experiment.

1) *Analysis Phase:* In analysis phase, positive or negative information regarding factors and levels are generated. This phase is most statistical in nature of the three phases of the DOE. The results obtained in the conducting phase are analyzed for response parameters.
2) *Full Factorial Experiments:* There are an equal number of test data points under each level of each factor. There are NF (N is level and F is factors) possible combinations that must be tested. A full factorial experiment is acceptable only when a few factors are to be investigated, but not convenient when there are many factors. For present study three factors with two levels and two factors with three levels are used resulting into total 72 experiments. A full factorial experiment is a better test strategy in this case.
3) *Fractional Factorial Designs:* If there are many factors which might influence the investigated process, even a 2k experiment might result in a large number of runs. In these cases fractional factorial designs are often used. In a fractional factorial experiment design, only a fraction of the runs required for a full factorial experiment is performed. For example, if five parameters are to be investigated, a two level factorial design would require 25 =32 runs. If the experimenter wishes to explore these parameters with only eight runs, i.e. a one-fourth fraction of the 32 runs, this is called a quarter fraction of the full factorial design.
4) *Resolution:* The resolution of an experimental design displays the confounding patterns in the design. Confounding refers to when the influence of a factor cannot be estimated independently. This means that an effect might be observed from the analysis of the test responses but that it is not possible to tell which of, for example two factors have affected this response. These two factors are then confounded with each other. The design resolution reveals the order of confounding of the main effects and interactions for a designed experiment. Resolution is an important tool for deciding what fractional factorial design to use for a problem. For these types of experiments, designs of resolution III, IV and V are of great importance. In a resolution III design, no main effect is confounded with other main effects. There is however, confounding between main effects and two factor interactions. Two-factor interactions may also be confounded with other two-factor interactions
5) *Randomization:* There are always several uncontrollable factors affecting the outcome of a process. These factors can be for example be humidity, human factors, power surges and machine wear over time. The impact of such factors cannot be fully controlled or eliminated but there are ways to minimize the risk of them disturbing the experiment results. One of these methods is randomization. Using a randomized run order for the experimental runs allows the experimenter to spread out the effect of the uncontrollable factors and thereby the noise in the process [23]. For example, in a non-randomized experimental design all runs with the high level of a certain factor might be performed in a row.
6) *Screening Tests:* Since conducting a full factorial test with many factors requires many runs and thereby takes a lot of resources, the first step in industrial experimentation is often to identify which factors affect the process outcome the most. This is regularly done through a screening test which is commonly performed as a 2-level factorial experiment [23]. The factors that, through the screening tests, are found to be of significance to the process output can then be subject to further investigation through optimization tests.

L. Determination of Significant Process Parameters for Surface Roughness by ANOVA Method.

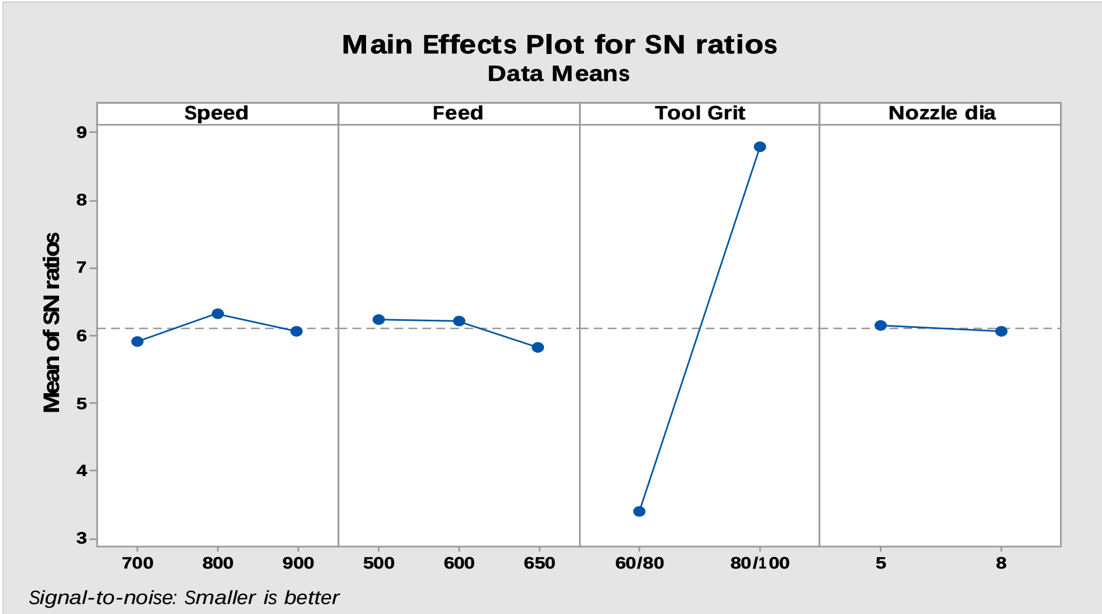

Figure 4: Main effect plot of S/N ratio for surface roughness.

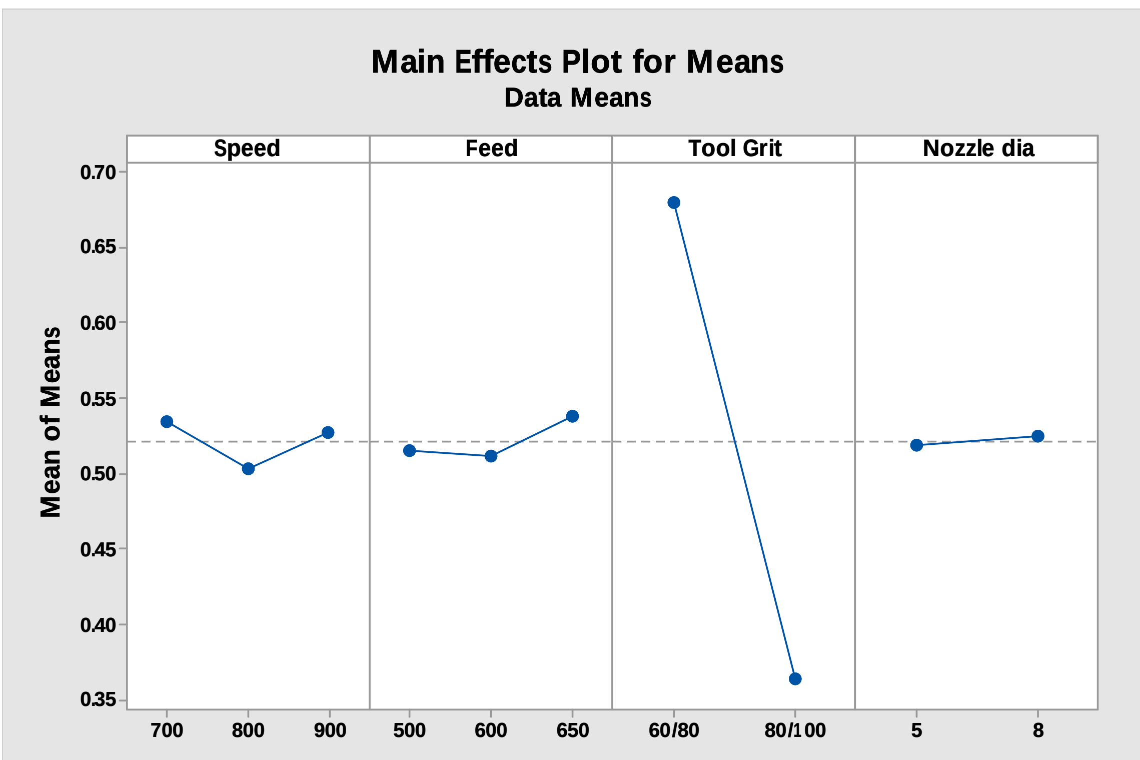

Figure 5: Main effect plot for means.

In main effect plot of S/N ratio for surface roughness, X-Axis indicates different levels of process parameters and Y-Axis shows average of S/N ratio. It can be observed from Figure that surface roughness decreases up to the speed of 650 rpm, as speed increases beyond 650rpm surface roughness start increasing with increase in feed initially surface roughness decreases and later on it start increasing. Surface roughness is minimum for tool grit 80/100. Nozzle diameter has no significant effect on surface roughness.

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Source	DF	Adj.SS	Adj.MS	F value	P value	% contribution
Speed	2	0.006260	0.003130	1.23	0.308	0.3438
Feed	2	0.005135	0.002567	1.00	0.378	0.2836
Tool Grit	1	0.894601	0.894601	350.16	0.000	99.33
Nozzle	1	0.000306	0.000306	0.12	0.732	0.03
Error	29	0.074090	0.002555			
Total	35	0.980391				

Table 4:Analysis of variance for surface roughness

Level	Speed	Feed	Tool Grit	Nozzle diameter
1	0.5342	0.5146	0.6792	0.5186
2	0.5033	0.5117	0.3639	0.5244
3	0.5271	0.5383		
Delta	0.0308	0.0267	0.3153	0.0058
Rank	2	3	1	4

Table 5: Response Table for S/N Ratios for Ra value, Smaller is better

M. Predicted result by Taguchi Method

When the optimal level of process parameters is determined then next step is to predict and validate the improvement of the performance measures with help of optimal level. The optimal level for different performance parameters are given below.

a) For surface roughness: -S2-F2-T2-N1

By using confirmation experiment, we can verify the conclusion that obtained from analysis.

Prediction of optimal value of surface roughness by using following regression equation.

Once the optimal level of the geometry parameters is identified, the final step is to predict and validate the improvement of the performance measures using the optimal level, i.e. for surface roughness S2-F2-T2-N1. The purpose of the confirmation experiment is to verify the conclusions drawn during the analysis phase.

The response was correlated with the factors using the first order polynomial. The relationship between surface roughness and process parameters as shown in table

Term	Coefficient
Constant	0.303
S	-0.000035
F	0.000132
Tool grit	-0.3153
Nozzle diameter	0.00194

Table 6: Coefficient of factor for surface roughness

Regression Equation

Ra value =

1. Tool Grit 60/80 = 0.618 - 0.000035 Speed + 0.000132 Feed + 0.00194 Nozzle dia.
2. 80/100 = 0.303 - 0.000035 Speed + 0.000132 Feed + 0.00194 Nozzle dia.

For this model R2 value = 91.56%, R2 (adj) = 90.47% this indicate that the model is desirable and 90.47 % variability is explained by the model after considering significant parameters.

Ra value = 0.303 - 0.000035 *650 + 0.000132 *600 + 0.00194 *5
= 0.3639 µm

	Prediction	Experiment
Level	S2-F2-T2-N1	
surface roughness (µm)	0.3639	0.34

Table 7: Confirmation of experiments for surface roughness

Experiments are conducted by using optimal level for each parameter. Table shows the comparison of the predicted and the actual responses obtained during experimental trial. The predicated and actually measured response for surface roughness isin good agreement, indicating that optimization of the control parameters was appropriate.

IV. CONCLUSIONS

Taguchi's design of experiment is used tool for conducting analysis in current experimentation. Most significant parameters and their contributions for surface roughness and ovality is determined with help of ANOVA. Effect of process parameters on different performance characteristics is identified. The optimal value and optimal level for performance characteristics is also finding out.

The following are conclusions obtained from the experimentation.

The process parameters like speed, feed and tool grit are significant and nozzle diameter is less significant for surface roughness. Response table for surface roughness indicates that speed, feed and tool grit. The second level of speed is 650rpm, first level of feed is 450 mm/min, first level of tool grit 60/80, (S2-F1-T1) indicates minimum value of surface roughness. By ANOVA the percentage contribution of speed is 0.3438%, feed is 0.2836%, tool grit is 99.33%, nozzle is 0.03%

REFERENCES

[1] Scania AB. Scania Year-end Report January–December 2014. Södertälje:Scania AB; 2014.
[2] Scania AB. Products & Services. [Internet] Södertälje: Scania AB; 2013. Cited 150316. Available: http://www.scania.com/products-services/.
[3] Scania AB. Scania Euro 6 - setting the standard. [Internet]. Södertälje: Scania AB. Cited 150319. Available: http://www3.scania.com/sv/Scania-Euro6/Scania-Euro6/.
[4] European Comission. Reducing CO2 emissions from Heavy-Duty Vehicles. [Internet]. European Comission. Cited: 150316. Updated: 150210. Available: http://ec.europa.eu/clima/policies/transport/vehicles/heavy/index_en.htm.
[5] Sadeghi F, Bolander N. Deterministic Modeling of Honed Cylinder Liner Friction. Tribology Transactions. 2007;50(2): 248-56
[6] Feng CX, Wang X, Yu Z. Neural Networks Modeling of Honing Surface Roughness Parameters Defined by ISO 13565. Journal of Manufacturing Systems. 2002; 21(5):395-408
[7] El-Hofy AH, Youssef H. Machining technology, machine tools and operations. CRC Press; 2008.
[8] Goeldel B, Voisin J, Dumur D, El Mansori M, Frabolot M. Flexible right sized honing technology for fast engine finishing. CIRP Annals. 2013;62(1):327-330
[9] Bähre D, Schmitt C, Moos U. Analysis of the Differences between Force Control and Feed Control Strategies during the Honing of Bores. Procedia CIRP.2012;1:377 –81
[10] Webster J, Tricard M. Innovations in Abrasive Products for Precision Grinding. CIRP Annals - Manufacturing technology. 2004;53(2):597–617
[11] Klocke F. Manufacturing processes 2. Berlin: Springer-Verlag; 2009.
[12] Kanthababu M, Shunmugam MS, Singaperumal M. Tool condition monitoring in honing process using acoustic emission signals. Int. J. Automation and Control. 2008;2(1):99-112
[13] Buj-Corral I, Vivancos-Calvet J. Roughness variability in the honing process of steel cylinders with CBN metal bonded tools. Precision Engineering. 2011;35(2):289-93
[14] Lee J, Malkin S. Experimental investigation of the Bore Honing Process. Journal of Engineering for Industry. 1993;115(4):406-9
[15] Griffiths B. Manufacturing Surface Technology [Internet]. Elsvier Ltd, 2001[150223] Available from: http://www.sciencedirect.com.focus.lib.kth.se/science/book/9781857180299
[16] ISO 4287:1997.Geometral Product Specifications (GSP) - Surface texture: Profile method - Terms, definitions and surface texture parameters.
[17] Sahoo P. Surface topography. In: Paulo Davim J, editor. Tribology for Engineers, Cambridge, UK: Woodhead Publishing Limited; 2011.
[18] ISO 13565-2:1996. Geometrical product specifications (GPS) - Surface texture: Profile method; Surfaces having stratified functional properties - Part 2: Height characterization using the linear material ratio curve.
[19] Leach R (Editor), Introduction to surface topography. In: Leach R, editor. Charaterisation of Areal Surface Texture. Berlin: Springer- Verlag; 2013.
[20] MKS Umetrics AB. MODDE, 10.1[Computer software]. MKS Umetrics AB.
[21] Montgomery DC. Design and Analysis of Experiments. 5th edition. New York: John Wiley & Sons, Inc.; 2001.
[22] Mee R. A Comprehensive Guide to Factorial Two-Level Experimentation. London/New York: Springer Dordrecht Heidelberg; 2009.

[23] Antony J. Design of Experiments for Engineers and Scientists. 2nd edition. London: Elsevier Ltd.; 2014.
[24] Mason R, Gunst R, Hess J. Statistical Design and Analysis of Experiments: With Applications to Engineering and Science. 2nd edition. John Wiley & Sons, Inc.; 2003.
[25] Box G, Hunter J, Hunter W. Statistics for Experimenters - Design, Innovation and Discovery. 2nd edition. Hoboken, New Jersey: John Wiley & Sons, Inc.; 2005.
[26] Eriksson L, Johansson E, Kettaneh-Wold N, Wikström C, Wold S. Design of Experiments, Principles and Applications, 3rd rev. and enlarged edition, Umeå: MKS Umetrics AB; 2008.
[27] MKS Umetrics AB, ”www.umetrics.com,” 10 02 2014. [Online]. Available: http://www.umetrics.com/sites/default/files/downloads/1/user_guide_to_modde_10.1.pdf. [Använd 30 03 2015].
[28] Kanthababu M, Shunmugam M, Singaperumal M. Identification of significant parameters and appropriate levels in honing of cylinder liners. Int. J. Machinability of Materials. 2009;5(1):80-96
[29] Vrac DS, Sidjanin LP, Balos SS. Mechanical finishing honing: cutting regimes and surface texture. Industrial Lubrication and Tribology. 2011;63(6):427-32
[30] Gafarov AM, Gafarov V, Aliev GS. Surface roughness in honing with dosed removal of surface layer. Russian engineering research. 2011;31(10):1030-33
[31] Rosén B, Thomas T. Relationship of the plasticity index to machining parameters. International Journal of Machine Tools & manufacture. 2001;41(13):2061-69
[32] Pawlus P, Cieslak T, Mathia T. The study of cylinder liner plateau honing process. Journal of Materials Processing Technology. 2009;209(20):6078-86vol. 209, pp. 6078-6086, 2009.
[33] Santochi M, Giusti F, Vignale M. A study on the functional properties of a honed surface. CIRP Annals - Manufacturing Technology. 1982;31(1):431-34
[34] Vrac DS, Sidjanin LP, Kovac PP, Balos SS. The influence of honing process parameters on surface quality, productivity, cutting angle and coefficients of friction. Industrial Lubrication and Tribology. 2012;64(2):77-83
[35] Cabanettes F, Dimkovski Z, Rosén B. Roughness variations in cylinder liners induced by honing tool's wear. Precision Engineering. 2015;41:40-46
[36] El Mansori M, Goedel M, Sabri L. Performance impact on honing dynamics on surface finish of precoated cylinder bores. Surface & Coatings Technology. 2013;215:334-39
[37] Saljé E, von See M. Process-Optimization in Honing. Annals of the CIRP. 1987;36(1):235-39