

**OPTIMIZATION CUTTING PARAMETERS ON TURNING PROCESS  
TO INCREASING SURFACE ROUGHNESS SKT4 MATERIAL WITH  
TAGUCHI METHOD**

By

Martinus Chorda  
21952063

MASTER'S DEGREE  
in

MECHANICAL ENGINEERING - MECHATRONICS  
FACULTY OF ENGINEERING & INFORMATION TECHNOLOGY

SWISS GERMAN UNIVERSITY

SWISS GERMAN UNIVERSITY  
The Prominence Tower  
Jalan Jalur Sutera Barat No. 15, Alam Sutera  
Tangerang, Banten 15143 - Indonesia

FEBRUARY 2021

**Revision After Thesis Defense on January 28<sup>th</sup>, 2021**

### STATEMENT BY THE AUTHOR

I hereby declare that this submission is my own work and to the best of my knowledge, it contains no material previously published or written by another person, nor material which to a substantial extent has been accepted for the award of any other degree or diploma at any educational institution, except where due acknowledgement is made in the thesis.

Martinus Chorda

Student

Date

Approved by:

Dr. Ir. Henry Nasution M.T.

Thesis Advisor

Date

Edi Sofyan, B.Eng., M.Eng., Ph.D

Thesis Co-Advisor

Date

Dr. Maulahikmah Galinium, S.Kom., M.Sc.

Dean

Date

Martinus Chorda

## ABSTRACT

### OPTIMIZATION CUTTING PARAMETERS ON TURNING PROCESS TO INCREASING SURFACE ROUGHNESS SKT4 MATERIAL WITH TAGUCHI METHOD

By

Martinus Chorda

Dr. Ir. Henry Nasution M.T., Advisor  
Edy Sofyan, B.Eng., M.Eng., Ph.D, Co.-Advisor

SWISS GERMAN UNIVERSITY

This experimental is present the best parameter to get increasing surface roughness for JIS SKT4 material. Taguchi method was involved to combine parameter were used in turning process, namely cutting speed, feeding, depth of cut and tool nose radius. This experiment was conducted to find out best parameter combination for turning process which the result is minimum roughness average JIS SKT4 material with carbide cutting tool material. The experimental used was taguchi L<sub>27</sub> with 3 times of replication. Backpropagation Neural network (BPNN) method is used to recognize relation between parameter process and experimental response, while Genetic Algorithm method is used to determine the best combination of process parameter that can optimize the surface roughness of JIS SKT4 material.

BPNN have a 4-8-81 network architecture which consist of 4 input layers, 2 hidden layers with 8 neurons in the output layer. Tansig activation program and training program is used to process the data from taguchi metdod and experimental data. The optimum parameter recommendation from Genetic Algorithm are cutting speed 131.62 m/min, feeding 0.04 mm/rev, depth of cut 0.3 mm and nose radius is 0.39. The optimum parameter recommendation from Genetic Algorithm done with cutting experimental on

turning machine with 3 repetition and the surface roughness average result is 1.5  $\mu\text{m}$ . This experimental improve 301.03% surface quality from the product of guide pin JIS SKT4 material.

*Keywords: Taguchi method, SKT4, Roughnes average, ANN, BPNN, GA*





## DEDICATION

This study is wholeheartedly dedicated to my beloved father and sister, who have been our source of inspiration and gave me strength when I thought of giving up. To Polman Astra who has provided funding and support during the study period. And lastly I dedicated to the God, thank you for the guidance, strength, power of mind, protection and for giving us a healthy life.



## ACKNOWLEDGEMENTS

Praise be to God the Almighty for the blessing of His grace I can complete this thesis. The writing of this thesis is done in order to fulfill one of the requirements to achieve a Master's Degree majoring in Master of Mechanical Engineering, Swiss German University. I realize that in the writing process until the completion of this thesis many people have helped and encouraged me in writing this thesis. Therefore I would like to thank :

1. My beloved father and sister who always provide support.
2. Dr. Ir. Henry Nasution, M.T as the Advisor who has provided the time, energy and thoughts to direct the author in the preparation of this thesis.
3. Mr. Edi Sofyan, B.Eng., M.Eng., Ph.D as the Co-Advisor who has provided the time, energy and thoughts to direct the author in the preparation of this thesis.
4. Astra Manufacturing Polytecnic extended family for the support that has provided learning opportunities and higher motivation.
5. All of my friends in MME Batch 10 in arms who have contributed in writing this thesis.

Tangerang, February 2021

Martinus Chorda

---

Martinus Chorda

## TABLE OF CONTENTS

	Page
STATEMENT BY THE AUTHOR.....	2
ABSTRACT.....	3
DEDICATION.....	6
ACKNOWLEDGEMENTS.....	7
TABLE OF CONTENTS.....	8
LIST OF FIGURES.....	12
LIST OF TABLES.....	14
LIST OF APPENDICES.....	15
CHAPTER 1 – INTRODUCTION.....	16
1.1. Background.....	16
1.2. Research Problem.....	19
1.3. Research Objectives.....	19
1.4. Significance of Study.....	20
1.5. Research Questions.....	20
1.6. Hypothesis.....	20
CHAPTER 2 - LITERATURE REVIEW.....	21
2.1. Turning Process.....	21
2.1.1. Working principle.....	21
2.1.2. Turning components.....	22
2.1.3. Cutting force on turning process.....	24
2.1.4. Turning cutting tool geometry.....	26
2.1.5. Cutting tool wear.....	29
2.2. Chip Formation.....	30
2.2.1. Discontinuous chips.....	31
2.2.2. Continuous chips.....	31
2.2.3. Continuous chips with built up edge.....	32
2.3. Tool Dynamometer.....	33
2.3.1. General principle of measurement.....	33
2.3.2. Design requirements for tool dynamometer.....	33



2.3.3	Measuring cutting force by monitoring elastic strain caused by force .....	34
2.4	Roughness Average (Ra) .....	34
2.5	JIS SKT4 Material .....	36
2.6	Taguchi Method .....	36
2.6.1	Orthogonal array .....	37
2.6.4	Replication .....	40
2.6.5	Randomization .....	40
2.7	Artificial Neural Network (ANN).....	40
2.7.1	Basic concept of Artificial Neural Network.....	41
2.7.2	Component of artificial neural network .....	41
2.8	Backpropagation Neural Network .....	45
2.8.1	Network initialization.....	46
2.8.2.	Initialize weights .....	47
2.8.3	Network simulation.....	47
2.8.4	Backpropagation Network standard training .....	47
2.8.5	Backpropagation Neural Network training termination criteria .....	49
2.8.6.	Selection of Neural Network Backpropagation training functions .....	50
2.8.7	Experimental data preprocessing.....	51
2.9	Algorithm Genetic Optimization Method.....	51
2.9.1	Selection process .....	52
2.9.2	Crossover process.....	52
2.9.3	Mutation process .....	54
2.9.4	Confirmation experiments.....	54
2.10	Previous Research .....	54
CHAPTER 3 – RESEARCH METHODS .....		56
3.1	Research Flow.....	56
3.2	Process data identification .....	57
3.2.1	JIS SKT4 Material.....	57
3.2.2	Tool Geometry .....	58
3.2.3	Lathe machine .....	59
3.2.4	Parameter of process .....	60
3.2.5	Response Parameters.....	60

3.2.6	Constant Parameters.....	60
3.3	Experimental Design.....	61
3.4	Preparation for cutting process .....	62
3.4.1	Specimen .....	62
3.4.2	Arduino.....	63
3.4.3	HX711 Module.....	64
3.4.4	Tool dynamometer program.....	65
3.4.5	Tool dynamometer calibration .....	70
3.4.6	Machine preparation.....	70
3.5	Training Backpropagation Neural Network.....	72
3.6	Optimization using Genetic Algorithm.....	73
3.7	Confirmatory Experiment.....	74
CHAPTER 4 – RESULTS AND DISCUSSIONS.....		75
4.1	Data Analysis.....	75
4.1.1	Tool dynamometer calibration result .....	75
4.1.2	Roughness average value result .....	76
4.2	Data processing with Backpropagation Neural Network .....	79
4.2.1	Pre-processing Data .....	79
4.2.2	Network Determination.....	82
4.2.3	Number of Neurons on Hidden Layer.....	82
4.2.4	Network Initialization .....	83
4.2.5	Initialize Weight and Bias Values.....	83
4.2.6	Termination criteria.....	83
4.2.7	Percentage of Training Data and Test Data .....	84
4.2.8	Learning Rate .....	85
4.2.9	Network Architecture Forms.....	85
4.2.10	Backpropagation Neural Network Results .....	86
4.3	Optimization of Response Parameters Using Genetic Algorithm Method....	87
4.3.1	Determination of Process Parameter Boundaries.....	88
4.3.2	Representation of Each Chromosome.....	88
4.3.3	Determination of Fitness Functions .....	88
4.3.4	Determination of the Options Structure .....	88

---

4.3.5	Result of Optimization of Genetic Algorithm.....	89
4.4	Confirm Trial .....	90
4.4.1	Optimization Results .....	91
CHAPTER 5 – CONCLUSIONS AND RECOMENDATIONS.....		93
5.1	Conclusions.....	93
5.2	Recommendations.....	93
GLOSSARY.....		95
REFERENCES.....		96
APPENDIX.....		101
CURRICULUM VITAE.....		112

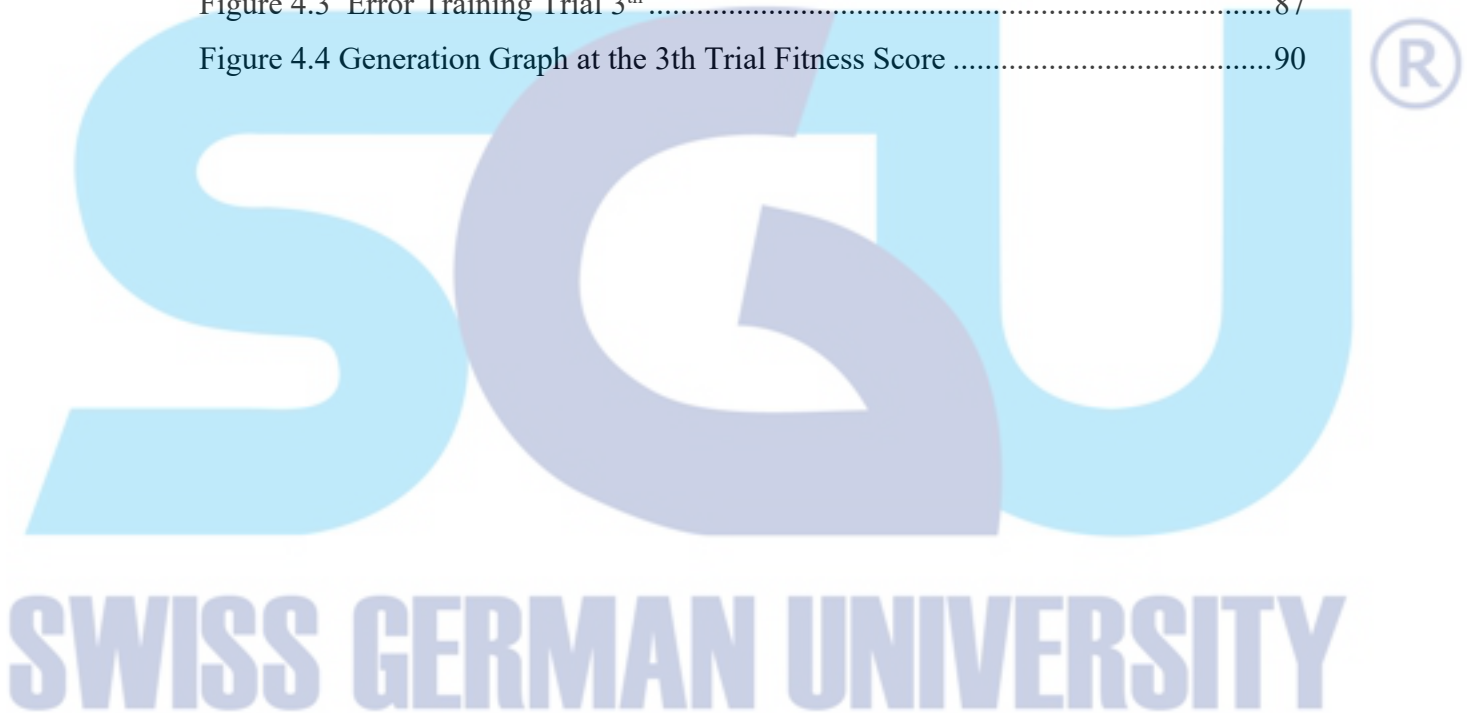


## LIST OF FIGURES

Figures	Page
Figure 1.1 Cutting tool cut workpiece on turning process.....	16
Figure 1.2 Metal removal process classification.....	17
Figure 1.3 Guide pin for mould base .....	18
Figure 2.1 Basic principle of turning process .....	21
Figure 2.2 Lathe machine.....	22
Figure 2.3 Chip deformation during cutting process .....	24
Figure 2.4 Three force on turning cutting process .....	25
Figure 2.5 Cutting tool geometry .....	26
Figure 2.6 Negative and positive rake angle.....	27
Figure 2.7 Lead angle on cutting tool .....	28
Figure 2.8 Nose radius on cutting tool.....	28
Figure 2.9 Cutting tool wear .....	29
Figure 2.10 Chip formation a. discontinuous b. continuous c. continuous with BUE.	31
Figure 2.11 Built up edge formation.....	32
Figure 2.12 Bending moment on tool dynamometer .....	34
Figure 2.13 Roughness Average (Ra).....	35
Figure 2.14 Neuron .....	41
Figure 2.15 Artificial Neural Network Architecture.....	42
Figure 2.16 Sigmoidal Curve as Activation Function.....	43
Figure 2.17 One Point Crossover Model .....	53
Figure 2.18 Two Point Crossover Model.....	53
Figure 3.1 Research flowchart for optimization cutting parameters.....	56
Figure 3.2 ISO 6 carbide 12x12 JOE .....	58
Figure 3.3 Leishin 500x1100 .....	59
Figure 3.4 Specimen for experimental.....	63
Figure 3.5 Arduino Uno .....	63
Figure 3.6 HX711 modul .....	64

---

Figure 3.7 flow process of arduino program.....	66
Figure 3.8 Schematic diagram tool dynamometer .....	66
Figure 3.9 Tool Dynamometer calibration.....	70
Figure 3.10 Tool dynamometer preparation .....	71
Figure 3.11 Flow Chart of The Data Training Process .....	72
Figure 3.12 Flow Chart of The Decision-Making Process .....	73
Figure 4.1 Measuring process with digital roughness tester .....	76
Figure 4.2 Architecture of Network Formation 4-8-8-1 .....	86
Figure 4.3 Error Training Trial 3 <sup>th</sup> .....	87
Figure 4.4 Generation Graph at the 3th Trial Fitness Score .....	90



LIST OF TABLES

Table	Page
Table 1.1 Guide pin measuring sheet.....	19
Table 2.1 Roughness average standard.....	35
Table 2.2 Chemical composition of JIS SKT4 Material.....	36
Table 2.3 Recommendation of matrix orthogonal array.....	38
Table 2.4 Orthogonal array (three-level, $L_{27}$ ).....	39
Table 2.5 Recommendation of matrix orthogonal array.....	40
Table 2.6 Previous research study related increasing surface roughness.....	54
Table 3.1 SKT 4 specification.....	57
Table 3.2 Specifications of ISO 6 JOE.....	58
Table 3.3 Specification data Leishin lathe machine.....	59
Table 3.4 Parameter of cutting process.....	60
Table 3.5 Degree of freedom.....	61
Table 3.6 Orthogonal Array $L_{27}$ ( $3^4$ ) for experimental cutting.....	61
Table 3.7 Arduino Uno Specification.....	63
Table 3.8 HX77 specification.....	65
Table 3.9 Table of RPM for machining.....	71
Table 4.1 Tool dynamometer calibration result.....	75
Table 4.2 Experimental data from cutting process.....	76
Table 4.3 Pre-processing Result Data on Backpropagation Neural Network Training .....	79
Table 4.4 Combination of Error Calculation Parameters.....	85
Table 4.5 Variable Limit of the Genetic Algorithm Testing Process.....	88
Table 4.6 Recommendation Parameters for cutting process.....	90
Table 4.7 Optimal Composition of Parameters for the cutting process.....	91
Table 4.8 Surface roughness optimization percentage.....	91

## LIST OF APPENDICES

Appendix	Page
Appendix 1 Cutting Speed recommendation .....	101
Appendix 2 Script Program.....	103
Appendix 3 Result of Analysis with MATLAB .....	106
Appendix 4 Neural Network Training for Architecture 4-8-8-1.....	108
Appendix 5 Best Training Performance for Architecture 4-8-8-1 .....	109
Appendix 6 Training State for Architecture 4-8-8-1 .....	110
Appendix 7 Regression for Architecture 4-8-8-1 .....	111

