View metadata, citation and similar papers at core.ac.uk
brought to you by CORE
provided by Universiti Teknologi Malaysia Institutional Repository

TABLE OF CONTENT

CHAPTER	TITLE	PAGE
	DECLARATION	**ii**
	DEDICATION	**iii**
	ACKNOWLEDGEMENT	**iv**
	ABSTRACT	**v**
	ABSTRAK	**vi**
	TABLE OF CONTENT	**vii**
	LIST OF TABLES	**x**
	LIST OF FIGURES	**xiv**
	LIST OF ABBREVIATION	**xvi**
	LIST OF SYMBOLS	**xvii**
1	**INTRODUCTION**	**1**
	1.1 Introduction	1
	1.2 Statement of problems	4
	1.3 Objectives of the Study	5
	1.4 Scope of the Study	5
	1.5 Significance of the Study	6
	1.6 Organization of the Report	6
2	**LITERATURE REVIEW**	**7**
	2.1 Minimization of surface roughness	7
	2.2 Optimization of end milling and AWJ machining process	8
	2.3 ABC optimization technique	10
	2.3.1 Flow of ABC algorithm	13

2.3.2 ABC Pseudocode 14
2.3.3 Abilities and limitation of ABC 16
2.4 Previous research on ABC algorithm in various domain 17
2.5 Previous research in optimizing machining process parameters using soft computing technique 21
2.6 Experimental data of case studies 36
2.6.1 End milling machining 36
2.6.1.1 Experimental design 37
2.6.1.2 Experimental results 39
2.6.2 AWJ machining 41
2.6.2.1 Experimental design 41
2.6.2.2 Experimental results 42
2.7 Summary 43

3 METHODOLOGY 44
3.1 Introduction 44
3.2 Research flow 47
3.3 Assessment of real experimental data 47
3.4 Regression modeling development 47
3.4.1 Regression modeling in end milling 48
3.4.1.1 Regression Model for Each Cutting Tool 49
3.4.2 Regression modeling in abrasive waterjet 54
3.5 ABC algorithm for optimization of process parameters 56
3.5.1 Justification of ABC control parameters 59
3.5.2 Steps for determination of the optimal process parameters 59
3.6 Validation and evaluation of ABC results 61
3.7 ABC optimization performances 61
3.7 Summary 65

4 ABC OPTMIZATION 66
4.1 Introduction 66
4.2 ABC optimization execution 67
4.3 Initial Phase 73
4.4 Employed-bee Phase 74

	4.5	Onlooker-bee Phase	75
	4.6	Scout-bee Phase	76
	4.7	Experiment 1 – ABC optimization parameters for end milling	76
		4.7.1 Colony size of 10 and limit of 30	77
		4.7.2 Colony size of 20 and limit of 60	90
		4.7.3 Colony size of 50 and limit of 60	103
		4.7.4 Colony size of 100 and limit of 300	116
	4.8	Experiment 2 – ABC optimization parameters for AWJ	129
		4.8.1 Colony size of 10 and limit of 50	129
		4.8.2 Colony size of 20 and limit of 100	142
		4.8.3 Colony size of 50 and limit of 250	155
		4.8.4 Colony size of 100 and limit of 500	168
	4.9	Summary of end milling experimental results	181
	4.10	Summary of AWJ experimental results	183
5	**ANALYSIS OF RESULTS**		**186**
	5.1	Introduction	186
	5.2	Analysis of results	187
		5.2.1 Validation and evaluation of end milling results	187
		5.2.2 Validation and evaluation of AWJ results	190
	5.3	Summary	195
6	**CONCLUSION AND FUTURE WORK**		**196**
	6.1	Introduction	196
	6.2	Summary of work	197
	6.3	Research summary and conclusion	198
	6.4	Suggestion for future work	201
	6.5	Summary	202
REFERENCES			**203**

LIST OF TABLES

TABLE NO	TITLE	PAGE
2.1	Control parameters of ABC	20
2.2	Previous researches in optimizing process parameters of R_a for traditional machining	23
2.3	Previous researches in optimizing process parameters of R_a for modern machining	30
2.4	Mechanical properties of Ti-6Al-4V	36
2.5	Properties of the cutting tool used in the experiments	37
2.6	Levels of independent variables and coding identification	38
2.7	Specification of the CNC machine	38
2.8	R_a values for real machining experiments	40
2.9	Levels of process parameters and coding identification	41
2.10	R_a values for real machining	42
3.1	Uncoated Tool coeffients value	49
3.2	TiA1N coated Tool coeffients value	49
3.3	SN_{TR} coated Tool coeffients value	50
3.4	R_a predicted values of regression modelling	51
3.5	Statistics and correlations for paired samples	52
3.6	Paired samples test	53
3.7	Predicted R_a values of AWJ Regression model	55
3.8	Justification of ABC control parameters	59
3.9	Parameters used in the numerical benchmark function experiments	62
4.1	Control variables combination with limit of 30	77
4.2	The best value returned from 10 max cycles per run with limit of 30	79

4.3	The best value returned from 20 max cycles per run with limit of 30	81
4.4	The best value returned from 50 max cycles per run with limit of 30	83
4.5	The best value returned from 100 max cycles per run with limit of 30	86
4.6	Control variables combination with limit of 60	90
4.7	The best value returned from 10 max cycles per run with limit of 60	92
4.8	The best value returned from 20 max cycles per run with limit of 60	94
5.9	The best value returned from 50 max cycles per run with limit of 60	96
4.10	The best value returned from 100 max cycles per run with limit of 60	99
4.11	Control variables combination with limit of 150	103
4.12	The best value returned from 10 max cycles per run with limit of 150	105
4.13	The best value returned from 20 max cycles per run with limit of 150	107
4.14	The best value returned from 50 max cycles per run with limit of 150	109
4.15	The best value returned from 100 max cycles per run with limit of 150	112
4.16	Control variables combination with limit of 300	116
4.17	The best value returned from 10 max cycles per run with limit of 300	118
4.18	The best value returned from 20 max cycles per run with limit of 300	120
4.19	The best value returned from 50 max cycles per run with limit of 300	122
4.20	The best value returned from 100 max cycles per run with limit of 300	125
4.21	Control variables combination with limit of 50	129
4.22	The best value returned from 10 max cycles per run with limit of 50	131
4.23	The best value returned from 20 max cycles per run with limit of 50	133
4.24	The best value returned from 50 max cycles per run with limit of 50	135

4.25	The best value returned from 100 max cycles per run with limit of 50	138
4.26	Control variables combination with limit of 100	142
4.27	The best value returned from 10 max cycles per run with limit of 100	144
4.28	The best value returned from 20 max cycles per run with limit of 100	146
4.29	The best value returned from 50 max cycles per run with limit of 100	148
4.30	The best value returned from 100 max cycles per run with limit of 100	151
4.31	Control variables combination with Limit of 250	155
4.32	The best value returned from 10 max cycles per run with limit of 250	157
4.33	The best value returned from 20 max cycles per run with limit of 250	159
4.34	The best value returned from 50 max cycles per run with limit of 250	161
4.35	The best value returned from 100 max cycles per run with limit of 250	164
4.36	Control variables combination with limit of 500	168
4.37	The best value returned from 10 max cycles per run with limit of 500	170
4.38	The best value returned from 20 max cycles per run with limit of 500	172
4.39	The best value returned from 50 max cycles per run with limit of 500	174
4.40	The best value returned from 100 max cycles per run with limit of 500	177
4.41	Summary of ABC optimization results using different colony size and limit in end milling	183
4.42	Summary of ABC optimization results using different colony size and limit in end milling	185
5.1	Conditions to define the scale for optimal process parameters of end milling	189
5.2	Comparison of the optimal process parameters in end milling	190
5.3	Conditions to define the scale for optimal process parameters of AWJ	192

5.4	Comparison of the optimal process parameters in AWJ	193
5.5	Comparison of optimal R_a in end milling and AWJ machining	194
6.1	Reduction percentage of minimum surface roughness in end milling	198
6.2	Reduction percentage of minimum surface roughness in AWJ	199
6.3	Summary of minimum bee colony size and max number of cycles	200
6.4	Summary of level of the optimal process parameters	201

LIST OF FIGURES

FIGURE NO	TITLE	PAGE
1.1	Parameters that affect R_a	2
2.1	Categories of milling	8
2.2	AWJ major components	9
2.3	Flow of ABC optimization	13
3.1	Flow of searching for optimum process parameters	46
3.2	Evolution of mean best values for Rosenbrock function	63
4.1	ABC Matlab program interface	68
4.2	Results of 10 max cycles per run with limit of 30	78
4.3	Results of 20 max cycles per run with limit of 30	80
4.4	Results of 50 max cycles per run with limit of 30	82
4.5	Results of 100 max cycles per run with limit of 30	85
4.6	Results of 10 max cycles per run with limit of 60	91
4.7	Results of 20 max cycles per run with limit of 60	93
4.8	Results of 50 max cycles per run with limit of 60	95
4.9	Results of 100 max cycles per run with limit of 60	98
4.10	Results of 10 max cycles per run with limit of 150	104
4.11	Results of 20 max cycles per run with limit of 150	106
4.12	Results of 50 max cycles per run with limit of 150	108
4.13	Results of 100 max cycles per run with limit of 150	111
4.14	Results of 10 max cycles per run with limit of 300	117
4.15	Results of 20 max cycles per run with limit of 300	119
4.16	Results of 50 max cycles per run with limit of 300	121
4.17	Results of 100 max cycles per run with limit of 300	124
4.18	Results of 10 max cycles per run with limit of 50	130

4.19	Results of 20 max cycles per run with limit of 50	132
4.20	Results of 50 max cycles per run with limit of 50	134
4.21	Results of 100 max cycles per run with limit of 50	137
4.22	Results of 10 max cycles per run with limit of 100	143
4.23	Results of 20 max cycles per run with limit of 100	145
4.24	Results of 50 max cycles per run with limit of 100	147
4.25	Results of 100 max cycles per run with limit of 100	150
4.26	Results of 10 max cycles per run with limit of 250	156
4.27	Results of 20 max cycles per run with limit of 250	158
4.28	Results of 50 max cycles per run with limit of 250	160
4.29	Results of 100 max cycles per run with limit of 250	163
4.30	Results of 10 max cycles per run with limit of 500	169
4.31	Results of 20 max cycles per run with limit of 500	171
4.32	Results of 50 max cycles per run with limit of 500	173
4.33	Results of 100 max cycles per run with limit of 500	176
4.34	Comparison of the effect of colony size in end milling experiment	181
4.35	Comparison of the effect of colony size in AWJ Experiment	184

LIST OF ABBREVIATIONS

ABC	-	Artificial Bee Colony
AI	-	Artificial Intelligence
ANN	-	Artificial Neural Network
AWJ	-	Abrasive Waterjet
BP	-	Backpropagation
DE	-	Differential Evolution
EA	-	Evolutionary Algorithm
GA	-	Genetic Algorithm
NFL	-	No Free Lunch
NN	-	Neural Network
PSO	-	Particle Swarm Optimization
RSM	-	Response Surface Methodology
SA	-	Simulated Annealing
SNTR	-	Supernitride
TiAlN	-	Titanium Aluminum Nitrate

LIST OF SYMBOLS

γ	-	Radial rake angle
d	-	Abrasive grit size
f	-	Feed rate
h	-	Standoff distance
m	-	Abrasive flow rate
P	-	Waterjet pressure
R_a	-	Surface Roughness
v	-	Cutting speed
V	-	Traverse speed