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Appendix

A. Figures of experimental equipments

B. Experimenal results

C. Analyzed results by statistic method

Appendix A.

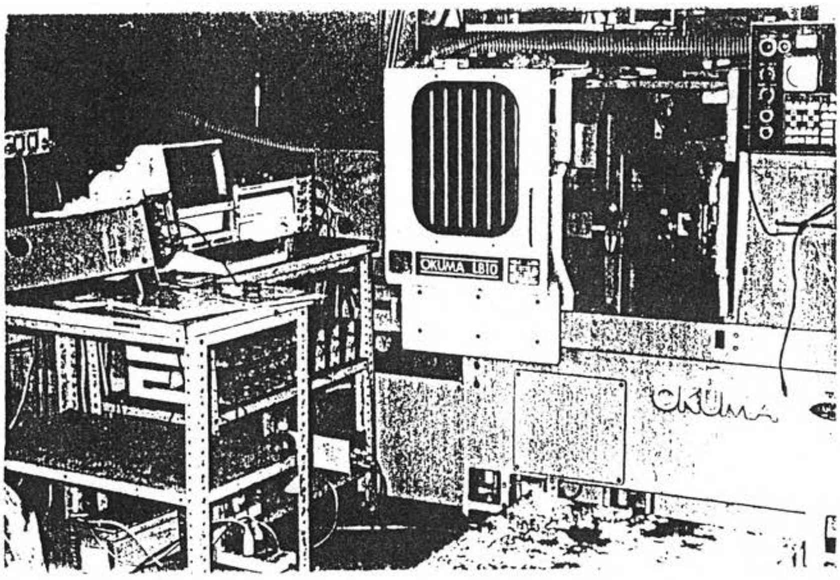


Fig. A.1 NC turning machining (Okuma LB10 CV-12)

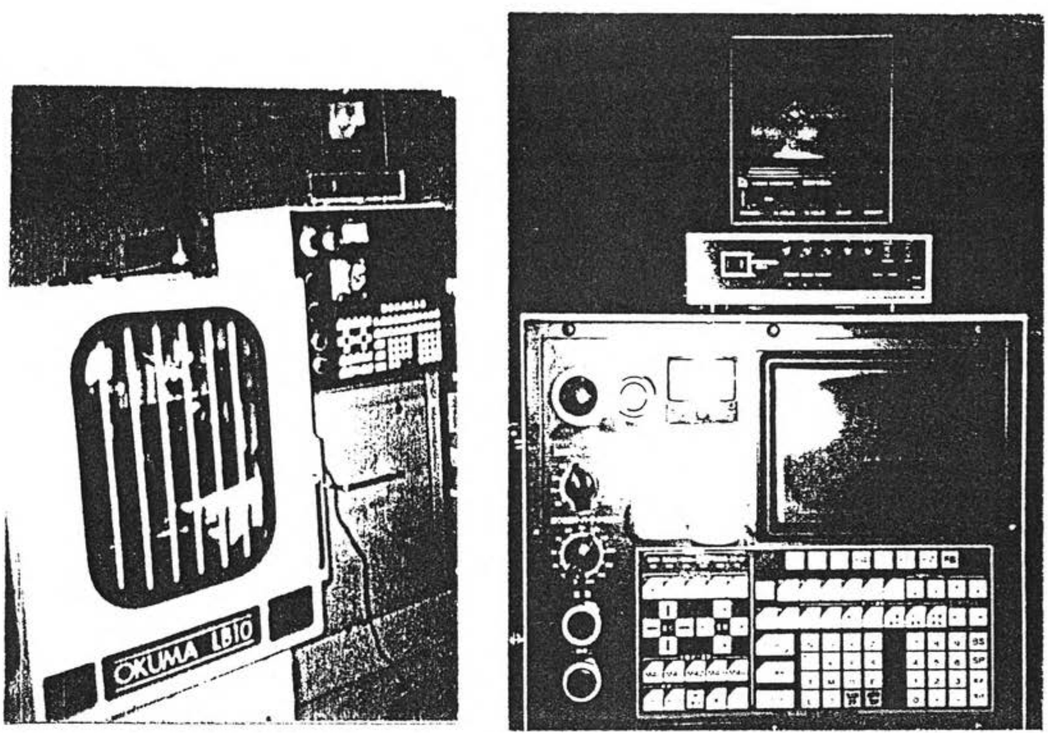


Fig. A.2 Micro camera VC-820

Appendix B.

Table B.1 Machining cost per workpiece at 160 m/min cutting speed and 0.20 mm/rev feed rate

Cutting Condition Optimization	
Calculation Procedure: Machining cost per workpiece Depth of cut: 2 mm Cutting tool use: carbide tool Model: MCPW = MR * (TTFT+WCT) + (MR*TCT + TC)/N	
1. Known Information	
Price of insert (baht)	P = 133.00
Total cutting edges on tool insert (edges)	E = 6
Machine operation rate (baht/min)	MR = 10.50
Tool changing time (min/cutting edge)	TCT = 0.67
Work changing time (min/workpiece)	WCT = 0.25
Tool cost per cutting edge (TC;baht) = P/E	TC = 22.16
2. Total tool feed time (TTFT)	
Cutting speed (m/min)	V = 160
Feed rate (mm/rev)	F = 0.20
Workpiece length (mm)	L = 170
Before and after cut length (mm)	L_1 = 5
Workpiece diameter (mm)	D = 50
Actual machining time (min) MT = 3.142*D*L/1000*F*V	MT = 0.8345
Total tool feed time (min) TTFT = 3.142*D*(L+L_1)/1000*F*V	TTFT = 0.8590
3. Number of workpiece per cutting edge (N)	
First cut wear (mm)	W_1 = 0.093
Second cut wear (mm)	W_2 = 0.111
Wear rate per workpiece (mm) = W_2 − W_1	WR = 0.018
Wear level at tool failure (mm)	WF = 0.375
Number of workpiece per cutting tool (pieces) N = (WF − W_2)/WR + 2	N = 16.667
4. Tool life (TF;min) = N*MT	TF = 13.908
5. Machining cost per workpiece (MCPW;baht)	MCPW = 13.3969

Table B.2 Machining cost per workpiece at 155 m/min cutting speed and 0.18 mm/rev feed rate

Cutting Condition Optimization		
Calculation Procedure: Machining cost per workpiece Depth of cut: 2 mm Cutting tool use: carbide tool Model: MCPW = MR * (TTFT+WCT) + (MR*TCT + TC)/N		
1. Known Information		
Price of insert (baht)	P =	133.00
Total cutting edges on tool insert (edges)	E =	6
Machine operation rate (baht/min)	MR =	10.50
Tool changing time (min/cutting edge)	TCT =	0.67
Work changing time (min/workpiece)	WCT =	0.25
Tool cost per cutting edge (TC;baht) = P/E	TC =	22.16
2. Total tool feed time (TTFT)		
Cutting speed (m/min)	V =	155
Feed rate (mm/rev)	F =	0.18
Workpiece length (mm)	L =	170
Before and after cut length (mm)	L_1 =	5
Workpiece diameter (mm)	D =	50
Actual machining time (min) MT = 3.142*D*L/1000*F*V	MT =	0.9571
Total tool feed time (min) TTFT = 3.142*D*(L+L_1)/1000*F*V	TTFT =	0.9853
3. Number of workpiece per cutting edge (N)		
First cut wear (mm)	W_1 =	0.090
Second cut wear (mm)	W_2 =	0.105
Wear rate per workpiece (mm) = $W_2 - W_1$	WR =	0.015
Wear level at tool failure (mm)	WF =	0.375
Number of workpiece per cutting tool (pieces) N = (WF − W_2)/WR + 2	N =	20.000
4. Tool life (TF;min) = N*MT	TF =	19.142
5. Machining cost per workpiece (MCPW;baht)	MCPW =	14.4304

Table B.3 Machining cost per workpiece at 165 m/min cutting speed and 0.22 mm/rev feed rate

Cutting Condition Optimization		
Calculation Procedure: Machining cost per workpiece Depth of cut: 2 mm Cutting tool use: carbide tool Model: MCPW = MR * (TTFT+WCT) + (MR*TCT + TC)/N		
1. Known Information		
Price of insert (baht)	P =	133.00
Total cutting edges on tool insert (edges)	E =	6
Machine operation rate (baht/min)	MR =	10.50
Tool changing time (min/cutting edge)	TCT =	0.67
Work changing time (min/workpiece)	WCT =	0.25
Tool cost per cutting edge (TC) = P/E	TC =	22.16
2. Total tool feed time (TTFT)		
Cutting speed (m/min)	V =	165
Feed rate (mm/rev)	F =	0.22
Workpiece length (mm)	L =	170
Before and after cut length (mm)	L_1 =	5
Workpiece diameter (mm)	D =	50
Actual machining time (min) MT = 3.142*D*L/1000*F*V	MT =	0.7356
Total tool feed time (min) TTFT = 3.142*D*(L+L_1)/1000*F*V	TTFT =	0.7573
3. Number of workpiece per cutting edge (N)		
First cut wear (mm)	W_1 =	0.095
Second cut wear (mm)	W_2 =	0.115
Wear rate per workpiece (mm) = W_2 − W_1	WR =	0.020
Wear level at tool failure (mm)	WF =	0.375
Number of workpiece per cutting tool (pieces) N = (WF − W_2)/WR + 2	N =	15.000
4. Tool life (TF;min) = N*MT	TF =	11.035
5. Machining cost per workpiece (MCPW;baht)	MCPW =	12.5231

Table B.4 Machining cost per workpiece at 165 m/min cutting speed and 0.18 mm/rev feed rate

Cutting Condition Optimization	
Calculation Procedure: Machining cost per workpiece Depth of cut: 2 mm Cutting tool use: carbide tool Model: MCPW = MR * (TTFT+WCT) + (MR*TCT + TC)/N	
1. Known Information	
Price of insert (baht)	P = 133.00
Total cutting edges on tool insert (edges)	E = 6
Machine operation rate (baht/min)	MR = 10.50
Tool changing time (min/cutting edge)	TCT = 0.67
Work changing time (min/workpiece)	WCT = 0.25
Tool cost per cutting edge (TC;baht) = P/E	TC = 22.16
2. Total tool feed time (TTFT)	
Cutting speed (m/min)	V = 165
Feed rate (mm/rev)	F = 0.18
Workpiece length (mm)	L = 170
Before and after cut length (mm)	L_1 = 5
Workpiece diameter (mm)	D = 50
Actual machining time (min) MT = 3.142*D*L/1000*F*V	MT = 0.8991
Total tool feed time (min) TTFT = 3.142*D*($L+L_1$)/1000*F*V	TTFT = 0.9256
3. Number of workpiece per cutting edge (N)	
First cut wear (mm)	W_1 = 0.092
Second cut wear (mm)	W_2 = 0.109
Wear rate per workpiece (mm) = $W_2 - W_1$	WR = 0.017
Wear level at tool failure (mm)	WF = 0.375
Number of workpiece per cutting tool (pieces) N = (WF − W_2)/WR + 2	N = 17.647
4. Tool life (TF;min) = N*MT	TF = 15.867
5. Machining cost per workpiece (MCPW;baht)	MCPW = 12.8415

Table B.5 Machining cost per workpiece at 155 m/min cutting speed and 0.22 mm/rev feed rate

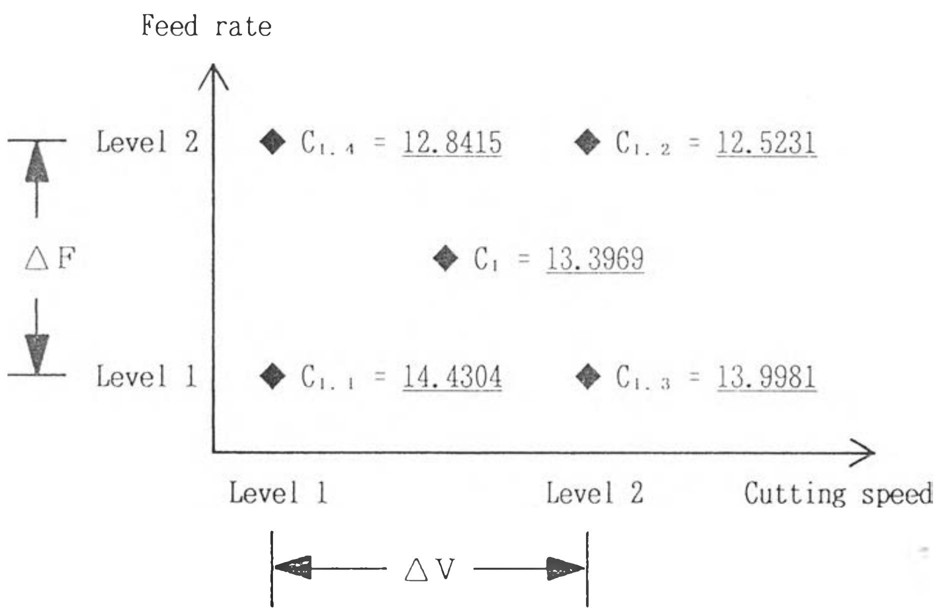
Cutting Condition Optimization		
Calculation Procedure: Machining cost per workpiece Depth of cut: 2 mm Cutting tool use: carbide tool Model: **MCPW** = MR * (TTFT+WCT) + (MR*TCT + TC)/N		
1. Known Information		
Price of insert (baht)	P =	133.00
Total cutting edges on tool insert (edges)	E =	6
Machine operation rate (baht/min)	MR =	10.50
Tool changing time (min/cutting edge)	TCT =	0.67
Work changing time (min/workpiece)	WCT =	0.25
Tool cost per cutting edge (TC;baht) = P/E	TC =	22.16
2. Total tool feed time (TTFT)		
Cutting speed (m/min)	V =	155
Feed rate (mm/rev)	F =	0.22
Workpiece length (mm)	L =	170
Before and after cut length (mm)	L_1 =	5
Workpiece diameter (mm)	D =	50
Actual machining time (min)		
MT = 3.142*D*L/1000*F*V	MT =	0.7831
Total tool feed time (min)		
TTFT = 3.142*D*(L+L_1)/1000*F*V	TTFT =	0.8061
3. Number of workpiece per cutting edge (N)		
First cut wear (mm)	W_1 =	0.093
Second cut wear (mm)	W_2 =	0.111
Wear rate per workpiece (mm) = $W_2 - W_1$	WR =	0.018
Wear level at tool failure (mm)	WF =	0.375
Number of workpiece per cutting tool (pieces)		
N = (WF − W_2)/WR + 2	N =	16.667
4. Tool life (TF;min) = N*MT	TF =	13.052
5. Machining cost per workpiece (MCPW;baht)	MCPW =	12.8415

Table B.6 Gradient calculation at 160 m/min cutting speed and 0.20 mm/rev feed rate

Gradient Calculation

Cutting speed and feed rate change analysis: Turning operation

1. Current operating condition:
   - Cutting speed (m/min) = 160
   - Feed rate (mm/rev) = 0.20
2. Test conditions:
   - Cutting speed: Level 1 = 155 Level 2 = 165
   - Feed rate: Level 1 = 0.18 Level 2 = 0.22
3. Observed results: Machining cost per workpiece (baht)



4. Gradient calculation:
   - Different cutting speed: ΔV = 10
   - Different feed rate: ΔF = 0.04
   - Step move: SM = 1
   - Cutting speed gradient:
     $G_{V1} = (C_{1.1} + C_{1.4} - C_{1.2} - C_{1.3})/2$ = 0.3753
   - Feed rate gradient:
     $G_{F1} = (C_{1.1} + C_{1.3} - C_{1.2} - C_{1.4})/2$ = 1.5320
   - Magnitude gradient:
     $M_p = [G_{V1}^2 + G_{F1}^2]^{1/2}$ = 1.5773
5. New cutting condition:
   - new V = old $V + \Delta V * SM * G_{V1}/M_p$ = 162
   - new F = old $F + \Delta F * SM * G_{F1}/M_p$ = 0.2389

Table B.7 Results (1) using carbide tool at the starting condition 160 m/min cutting speed and 0.20 mm/rev feed rate

Testing Point		Cutting Speed (m/min)	Feed Rate (mm/rev)	M/C Time (min)	Total Feed Time (min)	First Wear (mm)	Second Wear (mm)	Wear per piece (mm)	Number of Workpiece (pieces)	Tool Life (min)
	0	160	0.2000	0.8345	0.8590	0.093	0.111	0.018	16.667	13.908
	1	155	0.1800	0.9571	0.9853	0.090	0.105	0.015	20.000	19.142
1	2	165	0.2200	0.7356	0.7573	0.095	0.115	0.020	15.000	11.035
	3	165	0.1800	0.8991	0.9256	0.092	0.109	0.017	17.647	15.867
	4	155	0.2200	0.7831	0.8061	0.093	0.111	0.018	16.667	13.052
2		162	0.2389	0.6901	0.7104	0.096	0.117	0.021	14.286	9.899
3		164	0.2777	0.5863	0.6036	0.099	0.123	0.024	12.500	7.329
4		166	0.3166	0.5082	0.5231	0.103	0.131	0.028	10.714	5.445
5		168	0.3554	0.4472	0.4604	0.106	0.137	0.031	9.677	4.328
6		170	0.3943	0.3984	0.4101	0.110	0.145	0.035	8.571	3.415
7		172	0.4341	0.3585	0.3690	0.112	0.149	0.037	8.108	2.907
8		174	0.4720	0.3252	0.3347	0.117	0.159	0.042	7.143	2.323
	0	172	0.4331	0.3585	0.3690	0.112	0.149	0.037	8.108	2.907
	1	167	0.4131	0.3871	0.3985	0.109	0.143	0.034	8.824	3.415
7	2	177	0.4531	0.3330	0.3428	0.113	0.151	0.038	7.895	2.629
	3	177	0.4143	0.3652	0.3759	0.111	0.147	0.036	8.333	3.043
	4	167	0.4541	0.3529	0.3633	0.110	0.145	0.035	8.571	3.025
9		171	0.4730	0.3302	0.3399	0.111	0.147	0.036	8.333	2.751
10		170	0.5128	0.3063	0.3153	0.112	0.149	0.037	8.108	2.484
11		169	0.5527	0.2859	0.2943	0.114	0.153	0.039	7.692	2.199
12		168	0.5926	0.2682	0.2761	0.118	0.161	0.043	6.977	1.871
	0	169	0.5527	0.2859	0.2943	0.114	0.153	0.039	7.692	2.199
	1	164	0.5327	0.3057	0.3146	0.113	0.151	0.038	7.895	2.413
11	2	174	0.5727	0.2680	0.2759	0.118	0.161	0.043	6.977	1.870
	3	174	0.5327	0.2881	0.2966	0.113	0.151	0.038	7.895	2.274
	4	164	0.5727	0.2843	0.2927	0.115	0.155	0.040	7.500	2.132
13		172	0.5146	0.3017	0.3106	0.111	0.147	0.036	8.333	2.514
14		175	0.4765	0.3202	0.3297	0.116	0.157	0.041	7.317	2.343
	0	172	0.5146	0.3017	0.3106	0.111	0.147	0.036	8.333	2.514
	1	167	0.4946	0.3233	0.3328	0.113	0.151	0.038	7.895	2.552
13	2	177	0.5346	0.2822	0.2905	0.118	0.161	0.040	6.977	1.969
	3	177	0.4946	0.3050	0.3140	0.113	0.151	0.038	7.895	2.408
	4	167	0.5346	0.2991	0.3079	0.115	0.155	0.040	7.500	2.243

Table B.8 Results (2) using carbide tool at the starting condition 160 m/min cutting speed and 0.20 mm/rev feed rate

Testing Point		Cutting Speed (m/min)	Feed Rate (mm/rev)	Machining Cost/piece (baht)	Cutting Speed Gradient	Feed Rate Gradient	Magnitude Gradient	New Cutting Speed	New Feed Rate
1	0	160	0.2000	13.3969					
	1	155	0.1800	14.4304					
	2	165	0.2200	12.5231	0.3753	1.5320	1.5773	162	0.2389
	3	165	0.1800	13.9981					
	4	155	0.2200	12.8415					
2		162	0.2389	12.1286	0.3753	1.5320	1.5773	164	0.2777
3		164	0.2777	11.2987	0.3753	1.5320	1.5773	166	0.3166
4		166	0.3166	10.8433	0.3753	1.5320	1.5773	168	0.3554
5		168	0.3554	10.4766	0.3753	1.5320	1.5773	170	0.3943
6		170	0.3943	10.3383	0.3753	1.5320	1.5773	172	0.4331
7		172	0.4331	10.1011	0.3753	1.5320	1.5773	174	0.4720
8		174	0.4720	10.2280					
7	0	172	0.4331	10.1011					
	1	167	0.4131	10.1183					
	2	177	0.4531	9.9226	-0.017	0.2129	0.2136	171	0.4730
	3	177	0.4131	10.0766					
	4	167	0.4531	9.8463					
9		171	0.4730	9.6979	-0.017	0.2129	0.2136	170	0.5128
10		170	0.5128	9.5372	-0.017	0.2129	0.2136	169	0.5527
11		169	0.5527	9.5113	-0.017	0.2129	0.2136	168	0.5926
12		168	0.5926	9.7099					
11	0	169	0.5527	9.5113					
	1	164	0.5327	9.6277					
	2	174	0.5727	9.7070	0.0372	-0.117	0.1224	172	0.5146
	3	174	0.5327	9.4378					
	4	164	0.5727	9.5916					
13		172	0.5146	9.3902	0.0372	-0.117	0.1224	175	0.4765
14		175	0.4765	10.0773					
13	0	172	0.5146	9.3902					
	1	167	0.4946	9.8183					
	2	177	0.5346	9.8609					
	3	177	0.4946	9.6209					
	4	167	0.5346	9.7515					

Table B.9 Results (1) using carbide tool at the starting condition 170 m/min cutting speed and 0.40 mm/rev feed rate

Testing Point		Cutting Speed (m/min)	Feed Rate (mm/rev)	M／C Time (min)	Total Feed Time (min)	First Wear (mm)	Second Wear (mm)	Wear per piece (mm)	Number of Workpiece (pieces)	Tool Life (min)
1	0	170	0.4000	0.3927	0.4043	0.107	0.139	0.032	9.375	3.682
	1	165	0.3800	0.4259	0.4384	0.105	0.135	0.030	10.000	4.259
	2	175	0.4200	0.3633	0.3740	0.108	0.141	0.033	9.091	3.303
	3	175	0.3800	0.4016	0.4134	0.107	0.139	0.032	9.375	3.765
	4	165	0.4200	0.3853	0.3967	0.105	0.135	0.030	10.000	3.853
2		170	0.4400	0.3570	0.3675	0.108	0.141	0.033	9.091	3.246
3		170	0.4800	0.3273	0.3369	0.110	0.145	0.035	8.571	2.805
4		170	0.5200	0.3021	0.3110	0.111	0.147	0.036	8.333	2.517
5		170	0.5600	0.2805	0.2888	0.114	0.153	0.039	7.692	2.518
4	0	170	0.5200	0.3021	0.3110	0.111	0.147	0.036	8.333	2.517
	1	165	0.5000	0.3237	0.3332	0.112	0.149	0.037	8.108	2.625
	2	175	0.5400	0.2826	0.2909	0.118	0.161	0.043	6.977	1.972
	3	175	0.5000	0.3052	0.3142	0.114	0.153	0.039	7.692	2.348
	4	175	0.5400	0.2997	0.3085	0.115	0.155	0.040	7.500	2.248

Table B.10 Results (2) using carbide tool at the starting condition 170 m/min cutting speed and 0.40 mm/rev feed rate

Testing Point		Cutting Speed (m.min)	Feed Rate (mm/rev)	Machining Cost/piece (baht)	Cutting Speed Gradient	Feed Rate Gradient	Magnitude Gradient	New Cutting Speed	New Feed Rate
1	0	170	0.4000	9.9845	0.0072	0.3772	0.3773	170	0.4400
	1	165	0.3800	10.1486					
	2	175	0.4200	9.7642					
	3	175	0.3800	10.0802					
	4	165	0.4200	9.7102					
2		170	0.4400	9.6960	0.0072	0.3772	0.3773	170	0.4800
3		170	0.4800	9.5692	0.0072	0.3772	0.3773	170	0.5200
4		170	0.5200	9.3944	0.0072	0.3772	0.3773	170	0.5600
5		170	0.5600	9.4533					
4	0	170	0.5200	9.3944					
	1	165	0.5000	9.7253					
	2	175	0.5400	9.8650					
	3	175	0.5000	9.7200					
	4	165	0.5400	9.7581					

Table B.11 Results (1) using carbide tool at the starting condition 180 m/min cutting speed and 0.50 mm/rev feed rate

Testing Point		Cutting Speed (m/min)	Feed Rate (mm/rev)	M/C Time (min)	Total Feed Time (min)	First Wear (mm)	Second Wear (mm)	Wear per piece (mm)	Number of Workpiece (pieces)	Tool Life (min)
1	0	180	0.5000	0.2967	0.3054	0.117	0.159	0.042	7.143	2.119
	1	175	0.4900	0.3114	0.3206	0.116	0.157	0.041	7.317	2.279
	2	185	0.5100	0.2830	0.2914	0.120	0.165	0.045	6.667	1.887
	3	185	0.4900	0.2946	0.3032	0.116	0.157	0.041	7.317	2.156
	4	175	0.5100	0.2992	0.3080	0.114	0.153	0.039	7.692	2.302
2		170	0.5053	0.3109	0.3200	0.111	0.147	0.036	8.333	2.591
3		160	0.5106	0.3269	0.3365	0.110	0.145	0.035	8.571	2.802
2	0	170	0.5053	0.3109	0.3200	0.111	0.147	0.036	8.333	2.591
	1	165	0.4953	0.3268	0.3364	0.110	0.145	0.035	8.571	2.801
	2	175	0.5153	0.2961	0.3048	0.115	0.155	0.040	7.500	2.221
	3	175	0.4953	0.3081	0.3172	0.114	0.153	0.039	7.692	2.370
	4	165	0.5153	0.3141	0.3233	0.113	0.151	0.038	7.895	2.480

Table B.12 Results (2) using carbide tool at the starting condition 180 m/min cutting speed and 0.50 mm/rev feed rate

Testing Point		Cutting Speed (m/min)	Feed Rate (mm/rev)	Machining Cost/piece (baht)	Cutting Speed Gradient	Feed Rate Gradient	Magnitude Gradient	New Cutting Speed	New Feed Rate
1	0	180	0.5000	9.9203	-0.114	0.0311	0.1178	170	0.5053
	1	175	0.4900	9.9819					
	2	185	0.5100	10.0644					
	3	185	0.4900	9.8000					
	4	175	0.5100	9.6552					
2		170	0.5053	9.4894	-0.114	0.0311	0.1178	160	0.5106
3		160	0.5106	9.5652					
2	0	170	0.5053	9.4894					
	1	165	0.4953	9.5638					
	2	175	0.5153	9.7194					
	3	175	0.4953	9.7513					
	4	165	0.5153	9.7187					

Table B.13 Results (1) using coated tool at the starting condition 160 m/min cutting speed and 0.20 mm/rev feed rate

Testing Point		Cutting Speed (m/min)	Feed Rate (mm/rev)	M/C Time (min)	Total Feed Time (min)	First Wear (mm)	Second Wear (mm)	Wear per piece (mm)	Number of Workpiece (pieces)	Tool Life (min)
1	0	160	0.2000	0.8345	0.8590	0.064	0.078	0.014	21,429	17.882
	1	155	0.1800	0.9571	0.9853	0.062	0.074	0.012	26.000	23.928
	2	165	0.2200	0.7356	0.7573	0.065	0.080	0.015	20.000	14.713
	3	165	0.1800	0.8991	0.9256	0.064	0.078	0.014	21.429	19.267
	4	155	0.2200	0.7831	0.8061	0.063	0.076	0.013	23.077	18.071
2		161	0.2393	0.6932	0.7136	0.065	0.080	0.015	20.000	13.865
3		162	0.2785	0.5918	0.6092	0.066	0.082	0.016	18.750	11.097
4		163	0.3178	0.5155	0.5307	0.068	0.086	0.018	16.667	8.592
5		164	0.3570	0.4561	0.4695	0.069	0.088	0.019	15.789	7.201
6		165	0.3963	0.4084	0.4204	0.070	0.090	0.020	15.000	6.126
7		166	0.4355	0.3693	0.3802	0.072	0.094	0.022	13.636	5.036
8		167	0.4748	0.3368	0.3467	0.073	0.096	0.023	13.043	4.393
9		168	0.5141	0.3092	0.3183	0.076	0.102	0.026	11.538	3.568
8	0	167	0.4748	0.3368	0.3467	0.073	0,096	0.023	13.043	4.393
	1	162	0.4548	0.3624	0.3731	0.072	0.094	0.022	13.636	4.942
	2	172	0.4948	0.3138	0.3230	0.074	0.098	0.024	12.500	3.922
	3	172	0.4548	0.3414	0.3514	0.072	0.094	0.022	13.636	4.655
	4	162	0.4948	0.3331	0.3429	0.074	0.098	0.024	12.500	4.164
10		176	0.4871	0.3115	0.3206	0.075	0.100	0.025	12.000	3.738
11		185	0.4994	0.2890	0.2975	0.076	0.102	0.026	11.538	3.335
12		194	0.5117	0.2690	0.2769	0.078	0.106	0.028	10.714	2.882
11	0	185	0.4994	0.2890	0.2975	0.076	0.102	0.026	11.538	3.335
	1	180	0.4794	0,3095	0.3186	0.075	0.100	0.025	12.000	3.714
	2	190	0.5194	0.2706	0.2786	0.079	0.108	0.029	10.345	2.799
	3	190	0.4794	0.2932	0.3018	0.078	0.106	0.028	10.714	3.141
	4	180	0.4194	0.2856	0.2940	0.077	0.104	0.027	11.111	3.174

Table B.14 Results (2) using coated tool at the starting condition 160 m/min cutting speed and 0.20 mm/rev feed rate

Testing Point		Cutting Speed (m/min)	Feed Rate (mm/rev)	Machining Cost/piece (baht)	Cutting Speed Gradient	Feed Rate Gradient	Magnitude Gradient	New Cutting Speed	New Feed Rate
1	0	160	0.2000	13.3031	0.3331	1.7055	1.7377	161	0.2393
	1	155	0.1800	14.3917					
	2	165	0.2200	12.3531					
	3	165	0.1800	14.0016					
	4	155	0.2200	12.6292					
2		161	0.2393	11.8947	0.3331	1.7055	1.7377	162	0.2785
3		162	0.2785	10.9173	0.3331	1.7055	1.7377	163	0.3178
4		163	0.3178	10.3295	0.3331	1.7055	1.7377	164	0.3570
5		164	0.3570	9.8050	0.3331	1.7055	1.7377	165	0.3963
6		165	0.3963	9.4082	0.3331	1.7055	1.7377	166	0.4355
7		166	0.4355	9.2230	0.3331	1.7055	1.7377	167	0.4748
8		167	0.4748	8.9895	0.3331	1.7055	1.7377	168	0.5141
9		168	0.5141	9.0468					
8	0	167	0.4748	8.9895	0.2186	0.0706	0.2297	176	0.4871
	1	162	0.4548	9.1484					
	2	172	0.4948	8.8592					
	3	172	0.4548	8.9206					
	4	162	0.4948	9.0686					
10		176	0.4871	8.9531	0.2186	0.0706	0.2297	185	0.4994
11		185	0.4994	8.8289	0.2186	0.0706	0.2297	194	0.5117
12		194	0.5117	8.8493					
11	0	185	0.4994	8.8289					
	1	180	0.4794	8.9312					
	2	190	0.5194	8.9849					
	3	190	0.4794	9.1105					
	4	180	0.5194	8.9105					

Table B.15 Conventional wear test using carbide cutting tool at 172 m/min cutting speed and 0.5146 mm/rev feed rate

Time (min)	Flank wear (mm)		Average flank wear (mm)
	First testing	Second testing	
0.3017	0.112	0.111	0.1115
0.6034	0.147	0.149	0.1480
0.9051	0.179	0.182	0.1805
1.2068	0.221	0.219	0.2200
1.5058	0.254	0.256	0.2550
1.8102	0.287	0.290	0.2885
2.1119	0.326	0.324	0.3250
2.4136	0.362	0.360	0.3610

Table B.16 Conventional wear test using coated cutting tool at 185 m/min cutting speed and 0.4994 mm/rev feed rate

Time (min)	Flank wear (mm)		Average flank wear (mm)
	First testing	Second testing	
0.2890	0.074	0.075	0.0745
0.5780	0.101	0.103	0.1020
0.8670	0.126	0.128	0.1270
1.1560	0.153	0.154	0.1535
1.4450	0.178	0.180	0.1790
1.7340	0.205	0.207	0.2060
2.0230	0.232	0.231	0.2315
2.3120	0.256	0.258	0.2570
2.6010	0.290	0.284	0.2870
2.8900	0.315	0.311	0.3130
3.1790	0.328	0.336	0.3320

Appendix C.

Table C.1 Analysis of variance of the lack of fit for carbide cutting tool (α=0.05)

Source of variation	Sum of squares	Degrees of freedom	Mean square	F_0	$F\alpha(\nu_1, \nu_2)$
Regression Residual	0.106464 4.25E-05	1 14	0.1064640 3.039E-06	35034.54	4.60
Lack of fit Pure error	2.30E-05 1.95E-05	6 8	3.841E-06 2.438E-06	1.575629	3.58
Total	0.106507	15	7.100E-03		

Table C.2 Analysis of variance of the lack of fit for coated cutting tool (α=0.05)

Source of variation	Sum of squares	Degrees of freedom	Mean square	F_0	$F\alpha(\nu_1, \nu_2)$
Regression Residual	0.149866 1.45E-04	1 20	0.1498660 7.229E-06	20732.29	4.35
Lack of fit Pure error	7.51E-05 6.95E-05	9 11	8.341E-06 6.318E-06	1.320224	2.90
Total	0.150011	21	7.143E-03		

Table C.3 Hypothesis testing in linear wear model

(α=0.05)

Cutting tool	Variable	Hypothesis	n	t_0	$t_{\alpha/2, n-2}$
carbide cutting tool	wear rate	$H_0: W_R = 0.1193$ $H_1: W_R \neq 0.1193$	16	-2.04026	2.145
	initial wear level	$H_0: W_o = 0.075$ $H_1: W_o \neq 0.075$	16	1.04767	2.145
coated cutting tool	wear rate	$H_0: W_R = 0.0899$ $H_1: W_R \neq 0.0899$	22	0.65594	2.086
	initial wear level	$H_0: W_o = 0.050$ $H_1: W_o \neq 0.050$	22	-0.74685	2.086

Vita

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