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Supplementary Materials

Multi-Response Optimization of Surface Grinding Process Parameters of AISI 4140 Alloy Steel Using Response Surface Methodology and Desirability Function under Dry and Wet Conditions

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1. Regression Analysis

Table S1. Specifications of the workpiece and wheel used in the experiment.

Workpiece Specification		Wheel Specification	
Length (mm)	72	Wheel dia (in)	14
Width (mm)	37	Wheel dia (mm)	355.6
		Wheel thickness (in)	1.5

Table S2. Input parameters, their level and output units of each parameter.

Input Parameters	Levels	Output
Cross-feed	3.6	
Workpiece velocity	5.12	MRR
Wheel velocity	15.25	
Depth of cut	0.07, 0.08, 0.09, 0.095, 0.1	Temp.

Table S3. Formula for calculating wheel velocity and MRR.

Formula
Wheel velocity (Vc) = pi × Wheel Dia × Spindle Speed (N)
MRR = Vc × Depth of Cut × Crossfeed

The thermocouple measures the EMF generated due to the presence of temperature gradient during machining which is transmitted through the thermocouple and is displayed at the digital multimeter. This EMF will be converted to the temperature using the following equation to get the elevated temperature at the contact zone of the grinding wheel and the workpiece:

$$\theta(℃) = 75.28 + 63.05v(mV) - 0.57v^2(mV) \quad \text{(S1)}$$

Table S4. Raw data for the regression analysis under dry condition.

Dry condition						
Cross-feed, f_b (mm)	**Workpiece velocity, v_w (m/min)**	**Wheel velocity, v_s (m/s)**	**Depth of cut, a_p (mm)**	**Multimeter reading(mV)**	**Temperature (°C)**	**MRR (mm^3/min)**
3	5	15	0.07	2.1	205.1713	1050
3	5	15	0.08	2.2	211.2312	1200
3	5	15	0.09	2.5	229.3425	1350
3	5	15	0.095	3	259.3	1425
3	5	15	0.1	3.8	306.6392	1500
3	5	25	0.07	2.3	217.2797	1050
3	5	25	0.08	2.4	223.3168	1200
3	5	25	0.09	2.9	253.3313	1350
3	5	25	0.095	3.3	277.1377	1425
3	5	25	0.1	3.7	300.7617	1500
3	12	15	0.07	1.8	186.9232	2520
3	12	15	0.08	1.95	196.060075	2880
3	12	15	0.09	2.35	220.299675	3240
3	12	15	0.095	2.7	241.3597	3420
3	12	15	0.1	3.5	288.9725	3600
3	12	25	0.07	2	199.1	2520
3	12	25	0.08	2.25	214.256875	2880
3	12	25	0.09	2.6	235.3568	3240
3	12	25	0.095	2.97	257.510587	3420
3	12	25	0.1	3.73	302.526147	3600
6	5	15	0.07	2.25	214.256875	2100
6	5	15	0.08	2.35	220.299675	2400
6	5	15	0.09	2.55	232.351075	2700
6	5	15	0.095	3.06	262.875748	2850
6	5	15	0.1	3.92	313.677152	3000
6	5	25	0.07	2.43	225.125707	2100
6	5	25	0.08	2.51	229.944443	2400
6	5	25	0.09	3.03	261.088387	2700
6	5	25	0.095	3.45	286.018075	2850
6	5	25	0.1	3.81	307.226323	3000
6	12	15	0.07	1.88	191.799392	5040
6	12	15	0.08	2.09	204.564683	5760
6	12	15	0.09	2.4	223.3168	6480
6	12	15	0.095	2.81	247.949723	6840
6	12	15	0.1	3.55	291.924075	7200
6	12	25	0.07	2.09	204.564683	5040
6	12	25	0.08	2.15	208.202675	5760
6	12	25	0.09	2.6	235.3568	6480
6	12	25	0.095	2.99	258.703643	6840
6	12	25	0.1	3.7	300.7617	7200

Table S5. Raw data for the regression analysis under wet condition.

Wet condition						
Cross-feed, f_b (mm)	**Workpiece velocity, v_w (m/min)**	**Wheel velocity, v_s (m/s)**	**Depth of cut, a_p (mm)**	**Multimeter reading (mV)**	**Temperature (°C)**	**MRR (mm^3/min)**
3	5	15	0.07	0.7	119.1357	1050
3	5	15	0.08	0.8	125.3552	1200
3	5	15	0.09	0.9	131.5633	1350
3	5	15	0.095	1.1	143.9453	1425
3	5	15	0.1	1.3	156.2817	1500
3	5	25	0.07	0.75	122.246875	1050
3	5	25	0.08	0.82	126.597732	1200
3	5	25	0.09	0.89	130.943003	1350
3	5	25	0.095	1.3	156.2817	1425
3	5	25	0.1	1.5	168.5725	1500
3	12	15	0.07	0.55	109.785075	2520
3	12	15	0.08	0.62	114.151892	2880
3	12	15	0.09	0.75	122.246875	3240
3	12	15	0.095	1.05	140.854075	3420
3	12	15	0.1	1.1	143.9453	3600
3	12	25	0.07	0.6	112.9048	2520
3	12	25	0.08	0.65	116.021675	2880
3	12	25	0.09	0.85	128.460675	3240
3	12	25	0.095	1.15	147.033675	3420
3	12	25	0.1	1.2	150.1192	3600
6	5	15	0.07	0.7	119.1357	2100
6	5	15	0.08	0.8	125.3552	2400
6	5	15	0.09	0.9	131.5633	2700
6	5	15	0.095	1.1	143.9453	2850
6	5	15	0.1	1.3	156.2817	3000
6	5	25	0.07	0.75	122.246875	2100
6	5	25	0.08	0.82	126.597732	2400
6	5	25	0.09	0.89	130.943003	2700
6	5	25	0.095	1.3	156.2817	2850
6	5	25	0.1	1.5	168.5725	3000
6	12	15	0.07	0.55	109.785075	5040
6	12	15	0.08	0.62	114.151892	5760
6	12	15	0.09	0.75	122.246875	6480
6	12	15	0.095	1.05	140.854075	6840
6	12	15	0.1	1.1	143.9453	7200
6	12	25	0.07	0.6	112.9048	5040
6	12	25	0.08	0.65	116.021675	5760
6	12	25	0.09	0.85	128.460675	6480
6	12	25	0.095	1.15	147.033675	6840
6	12	25	0.1	1.2	150.1192	7200

2. Design of Experiment

Workpiece velocity, wheel velocity, cross-feed, and cutting condition have two levels each while depth of cut has five levels. The multilevel full factorial design ($2^4 \times 5 = 80$) was applied to run 80 experiments for this research work. Design of Experiment (DOE) is shown in the Table S6 below.

Table S6. Data table showing design of experiment.

Condition (1—Dry, 2—Wet)	Cross-feed, f_b (mm)	Workpiece velocity, v_w (m/min)	Wheel velocity, v_s (m/s)	Depth of cut, a_p (mm)	Multimeter reading (mV)	Temperature (°C)	MRR (mm^3/min)	Total cost (BDT)
1	3	5	15	0.07	2.1	205.171	1050	2.97
1	3	5	15	0.08	2.2	211.231	1200	2.89
1	3	12	15	0.09	2.35	220.3	3240	1.31
1	6	12	25	0.07	2.09	204.565	5040	0.67
1	6	12	25	0.08	2.15	208.203	5760	0.76
1	6	5	15	0.095	3.06	262.876	2850	1.6
1	6	5	15	0.1	3.92	313.677	3000	1.68
1	6	5	25	0.07	2.43	225.126	2100	1.68
1	3	12	15	0.08	1.95	196.06	2880	1.22
1	6	12	25	0.09	2.6	235.357	6480	0.86
1	3	12	15	0.095	2.7	241.36	3420	1.25
1	3	5	15	0.1	3.8	306.639	1500	2.94
1	3	5	25	0.07	2.3	217.28	1050	2.91
1	3	5	25	0.08	2.4	223.317	1200	2.97
1	3	12	15	0.07	1.8	186.923	2520	1.25
1	3	12	15	0.1	3.5	288.973	3600	1.28
1	3	12	25	0.09	2.6	235.357	3240	1.23
1	3	5	15	0.095	3	259.3	1425	2.88
1	6	5	25	0.08	2.51	229.944	2400	1.53
1	6	5	25	0.09	3.03	261.088	2700	1.55
1	3	12	25	0.095	2.97	257.511	3420	1.28
1	3	12	25	0.1	3.73	302.526	3600	1.3
1	6	5	15	0.07	2.25	214.257	2100	1.66
1	6	5	15	0.08	2.35	220.3	2400	1.54
1	6	5	25	0.1	3.81	307.226	3000	1.75
1	6	12	15	0.095	2.81	247.95	6840	0.79
1	6	12	15	0.1	3.55	291.924	7200	0.81
1	6	12	25	0.095	2.99	258.704	6840	0.82
1	3	5	25	0.09	2.9	253.331	1350	3
1	3	5	25	0.095	3.3	277.138	1425	2.93
1	3	5	25	0.1	3.7	300.762	1500	2.85
1	6	12	15	0.07	1.88	191.799	5040	0.79
1	6	12	15	0.08	2.09	204.565	5760	0.74
1	6	12	15	0.09	2.4	223.317	6480	0.86
1	6	5	15	0.09	2.55	232.351	2700	1.6
1	3	5	15	0.09	2.5	229.343	1350	3.04
1	6	5	25	0.095	3.45	286.018	2850	1.66
1	3	12	25	0.07	2	199.1	2520	1.36
1	3	12	25	0.08	2.25	214.257	2880	1.36
1	6	12	25	0.1	3.7	300.762	7200	0.79
2	3	5	15	0.07	0.7	119.1357	1050	27.51

2	3	5	15	0.08	0.8	125.3552	1200	28.36
2	3	12	15	0.09	0.75	122.2469	3240	11.95
2	6	12	25	0.07	0.6	112.9048	5040	7.18
2	6	12	25	0.08	0.65	116.0217	5760	6.2
2	6	5	15	0.095	1.1	143.9453	2850	15.1
2	6	5	15	0.1	1.3	156.2817	3000	14.55
2	6	5	25	0.07	0.75	122.2469	2100	15.81
2	3	12	15	0.08	0.62	114.1519	2880	11.82
2	6	12	25	0.09	0.85	128.4607	6480	6.5
2	3	12	15	0.095	1.05	140.8541	3420	11.93
2	3	5	15	0.1	1.3	156.2817	1500	27.65
2	3	5	25	0.07	0.75	122.2469	1050	26.52
2	3	5	25	0.08	0.82	126.5977	1200	28.33
2	3	12	15	0.07	0.55	109.7851	2520	11.78
2	3	12	15	0.1	1.1	143.9453	3600	12.77
2	3	12	25	0.09	0.85	128.4607	3240	13.05
2	3	5	15	0.095	1.1	143.9453	1425	28.35
2	6	5	25	0.08	0.82	126.5977	2400	16.11
2	6	5	25	0.09	0.89	130.943	2700	16.25
2	3	12	25	0.095	1.15	147.0337	3420	12.63
2	3	12	25	0.1	1.2	150.1192	3600	11.12
2	6	5	15	0.07	0.7	119.1357	2100	14.56
2	6	5	15	0.08	0.8	125.3552	2400	14.44
2	6	5	25	0.1	1.5	168.5725	3000	15.43
2	6	12	15	0.095	1.05	140.8541	6840	8.04
2	6	12	15	0.1	1.1	143.9453	7200	7.47
2	6	12	25	0.095	1.15	147.0337	6840	6.05
2	3	5	25	0.09	0.89	130.943	1350	26.55
2	3	5	25	0.095	1.3	156.2817	1425	27.64
2	3	5	25	0.1	1.5	168.5725	1500	28.05
2	6	12	15	0.07	0.55	109.7851	5040	6.74
2	6	12	15	0.08	0.62	114.1519	5760	6.87
2	6	12	15	0.09	0.75	122.2469	6480	7.58
2	6	5	15	0.09	0.9	131.5633	2700	14.45
2	3	5	15	0.09	0.9	131.5633	1350	27.63
2	6	5	25	0.095	1.3	156.2817	2850	15.71
2	3	12	25	0.07	0.6	112.9048	2520	11.24
2	3	12	25	0.08	0.65	116.0217	2880	13.07
2	6	12	25	0.1	1.2	150.1192	7200	6.08

3. RSM calculations

$$\begin{aligned}\mathrm{Temp_{dry}} = {} & 977.242 + 7.25 \times f_b - 3.36 \times v_w + 2.375 \times v_s - 21602.5 \times a_p + 145538 \times {a_p}^2 \\ & - 0.212 \times f_b \times v_w - 0.071 \times f_b \times v_s - 28.223 \times f_b \times a_p - 0.0042 \times v_w \times v_s \\ & + 23.7174 \times v_w \times a_p - 8.89 \times v_s \times a_p\end{aligned} \quad \text{(S2)}$$

$$\begin{aligned}\mathrm{Cost_{dry}} = {} & 9.4224 - 0.978 \times f_b - 0.49943 \times v_w + 0.0043143 \times v_s - 22.83 \times \mathrm{a}_p + 97.1215 \times {a_p}^2 \\ & + 0.0534 \times f_b \times v_w - 0.00007 \times f_b \times v_s + 1.434 \times f_b \times a_p + 0.000157143 \times v_w \times v_s \\ & + 0.1429 \times v_w \times a_p - 0.01552 \times v_s \times a_p\end{aligned} \quad \text{(S3)}$$

$$\begin{aligned}\mathrm{Temp_{wet}} = {} & 423.585 + 4.63\mathrm{E}-14 \times f_b - 0.4011 \times v_w - 1.44345 \times v_s - 7958.2 \times a_p + 52175.4 \times {a_p}^2 \\ & - 2.78\mathrm{E}-16 \times f_b \times v_w - 3.11\mathrm{E}-16 \times f_b \times v_s - 4.36\mathrm{E}-13 \times f_b \times a_p \\ & - 0.0137251 \times v_w \times v_s - 7.89962 \times v_w \times a_p + 23.8998 \times v_s \times a_p\end{aligned} \quad \text{(S4)}$$

$$\begin{aligned}\text{Cost}_{\text{wet}} = {} & 39.7315 - 5.84 \times f_b - 3.1523 \times v_w + 0.2445 \times v_s + 344.873 \times a_p - 1587.53 \times {a_p}^2 \\ & + 0.354143 \times f_b \times v_w + 0.01057 \times f_b \times v_s - 5.1552 \times f_b \times a_p - 0.01133 \times v_w \times v_s \\ & + 0.1195 \times v_w \times a_p - 2.25172 \times v_s \times a_p\end{aligned} \quad \text{(S5)}$$

Table S7. Data table showing the calculation of temperature using Response Surface Methodology (RSM) equations.

Dry condition						Wet condition						Predicted Temperature	
Cross-feed, f_b (mm)	**Workpiece velocity, v_w (m/min)**	**Wheel velocity, v_s (m/s)**	**Depth of cut, a_p (mm)**	**Temp. (°C)**	**MRR (mm³/min)**	**Workpiece velocity, v_w (m/min)**	**Wheel velocity, v_s (m/s)**	**Depth of cut, a_p (mm)**	**Multimeter reading (mV)**	**Temp. (°C)**	**MRR (mm³/min)**	**RSM Equation, Temp_{dry} (°C)**	**RSM Equation, Temp_{wet} (°C)**
3	5	15	0.07	205.17	1050	5	15	0.07	0.70	119.14	1050	205.12	121.61
3	5	15	0.08	211.23	1200			0.08	0.80	125.36	1200	206.41	123.47
3	5	15	0.09	229.34	1350			0.09	0.90	131.56	1350	236.81	135.78
3	5	15	0.10	259.30	1425			0.10	1.10	143.95	1425	262.92	145.84
3	5	15	0.10	306.64	1500			0.10	1.30	156.28	1500	296.31	158.52
3	5	25	0.07	217.28	1050		25	0.07	0.75	122.25	1050	220.31	123.21
3	5	25	0.08	223.32	1200			0.08	0.82	126.60	1200	220.71	127.46
3	5	25	0.09	253.33	1350			0.09	0.89	130.94	1350	250.22	142.16
3	5	25	0.10	277.14	1425			0.10	1.30	156.28	1425	275.89	153.42
3	5	25	0.10	300.76	1500			0.10	1.50	168.57	1500	308.83	167.29
3	12	15	0.07	186.92	2520	12	15	0.07	0.55	109.79	2520	188.33	116.01
3	12	15	0.08	196.06	2880			0.08	0.62	114.15	2880	191.28	117.33
3	12	15	0.09	220.30	3240			0.09	0.75	122.25	3240	223.33	129.08
3	12	15	0.10	241.36	3420			0.10	1.05	140.85	3420	250.28	138.87
3	12	15	0.10	288.97	3600			0.10	1.10	143.95	3600	284.50	151.27
3	12	25	0.07	199.10	2520		25	0.07	0.60	112.90	2520	203.22	116.65
3	12	25	0.08	214.26	2880			0.08	0.65	116.02	2880	205.28	120.36
3	12	25	0.09	235.36	3240			0.09	0.85	128.46	3240	236.45	134.50
3	12	25	0.10	257.51	3420			0.10	1.15	147.03	3420	262.95	145.48
3	12	25	0.10	302.53	3600			0.10	1.20	150.12	3600	296.72	159.07
6	5	15	0.07	214.26	2100	5	15	0.07	0.70	119.14	2100	214.57	121.61
6	5	15	0.08	220.30	2400			0.08	0.80	125.36	2400	215.01	123.47
6	5	15	0.09	232.35	2700			0.09	0.90	131.56	2700	244.56	135.78
6	5	15	0.10	262.88	2850			0.10	1.10	143.95	2850	270.25	145.84
6	5	15	0.10	313.68	3000			0.10	1.30	156.28	3000	303.21	158.52
6	5	25	0.07	225.13	2100		25	0.07	0.75	122.25	2100	227.63	123.21
6	5	25	0.08	229.94	2400			0.08	0.82	126.60	2400	227.18	127.46
6	5	25	0.09	261.09	2700			0.09	0.89	130.94	2700	255.84	142.16
6	5	25	0.10	286.02	2850			0.10	1.30	156.28	2850	281.08	153.42
6	5	25	0.10	307.23	3000			0.10	1.50	168.57	3000	313.60	167.29
6	12	15	0.07	191.80	5040	12	15	0.07	0.55	109.79	5040	193.31	116.01
6	12	15	0.08	204.56	5760			0.08	0.62	114.15	5760	195.41	117.33
6	12	15	0.09	223.32	6480			0.09	0.75	122.25	6480	226.62	129.08
6	12	15	0.10	247.95	6840			0.10	1.05	140.85	6840	253.14	138.87
6	12	15	0.10	291.92	7200			0.10	1.10	143.95	7200	286.94	151.27
6	12	25	0.07	204.56	5040		25	0.07	0.60	112.90	5040	206.08	116.65
6	12	25	0.08	208.20	5760			0.08	0.65	116.02	5760	207.29	120.36
6	12	25	0.09	235.36	6480			0.09	0.85	128.46	6480	237.61	134.50
6	12	25	0.10	258.70	6840			0.10	1.15	147.03	6840	263.68	145.48
6	12	25	0.10	300.76	7200			0.10	1.20	150.12	7200	297.04	159.07

Table S8. Data table showing cost calculation under dry and wet condition using Response Surface Methodology (RSM) equations.

Cross-feed, f_b (mm)	Workpiece velocity, v_w (m/min)	Wheel velocity, v_s (m/s)	Depth of cut, a_p (mm)	MRR (mm^3/min)	Machining time (s)	Measured Machining time (s)	Power consumption, kW	Power cost, (8 BDT/kW)	Cutting Fluid Cost, (0.5 BDT/s)	Labor cost, (0.06 BDT/s)	Total cost (Utility + Labor + CF) (BDT)	Total cost (rounded) (BDT)	RSM equation for cost, $Cost_{dry}$ (BDT)
3	5	15	0.07	1050	46.8	49.37	493.7	1.10	0	2.96	4.06	4.06	4.08
3	5	15	0.08	1200	46.8	48.13	481.3	1.07	0	2.89	3.96	3.96	4.04
3	5	15	0.09	1350	46.8	50.58	505.8	1.12	0	3.03	4.16	4.16	4.03
3	5	15	0.095	1425	46.8	47.9	479	1.06	0	2.87	3.94	3.94	4.03
3	5	15	0.1	1500	46.8	48.9	489	1.09	0	2.93	4.02	4.03	4.03
3	5	25	0.07	1050	46.8	48.37	483.7	1.07	0	2.90	3.98	3.98	4.12
3	5	25	0.08	1200	46.8	49.39	493.9	1.10	0	2.96	4.06	4.07	4.08
3	5	25	0.09	1350	46.8	49.87	498.7	1.11	0	2.99	4.10	4.11	4.06
3	5	25	0.095	1425	46.8	48.81	488.1	1.08	0	2.93	4.01	4.02	4.06
3	5	25	0.1	1500	46.8	47.36	473.6	1.05	0	2.84	3.89	3.9	4.07
3	12	15	0.07	2520	19.5	20.78	207.8	0.46	0	1.25	1.71	1.71	1.79
3	12	15	0.08	2880	19.5	20.3	203	0.45	0	1.22	1.67	1.67	1.77
3	12	15	0.09	3240	19.5	21.76	217.6	0.48	0	1.31	1.79	1.79	1.76
3	12	15	0.095	3420	19.5	20.83	208.3	0.46	0	1.25	1.71	1.72	1.76
3	12	15	0.1	3600	19.5	21.26	212.6	0.47	0	1.28	1.75	1.75	1.77
3	12	25	0.07	2520	19.5	22.53	225.3	0.50	0	1.35	1.85	1.86	1.84
3	12	25	0.08	2880	19.5	22.51	225.1	0.50	0	1.35	1.85	1.86	1.81
3	12	25	0.09	3240	19.5	20.35	203.5	0.45	0	1.22	1.67	1.68	1.81
3	12	25	0.095	3420	19.5	21.26	212.6	0.47	0	1.28	1.75	1.75	1.81
3	12	25	0.1	3600	19.5	21.58	215.8	0.48	0	1.29	1.77	1.78	1.82
6	5	15	0.07	2100	25.2	27.54	275.4	0.61	0	1.65	2.26	2.27	2.24
6	5	15	0.08	2400	25.2	25.54	255.4	0.57	0	1.53	2.10	2.1	2.25
6	5	15	0.09	2700	25.2	26.52	265.2	0.59	0	1.59	2.18	2.19	2.28
6	5	15	0.095	2850	25.2	26.53	265.3	0.59	0	1.59	2.18	2.19	2.30
6	5	15	0.1	3000	25.2	27.96	279.6	0.62	0	1.68	2.30	2.3	2.33
6	5	25	0.07	2100	25.2	27.96	279.6	0.62	0	1.68	2.30	2.3	2.28
6	5	25	0.08	2400	25.2	25.49	254.9	0.57	0	1.53	2.10	2.1	2.29
6	5	25	0.09	2700	25.2	25.72	257.2	0.57	0	1.54	2.11	2.12	2.31
6	5	25	0.095	2850	25.2	27.55	275.5	0.61	0	1.65	2.27	2.27	2.33
6	5	25	0.1	3000	25.2	29.01	290.1	0.64	0	1.74	2.39	2.39	2.36
6	12	15	0.07	5040	10.5	13.05	130.5	0.29	0	0.78	1.07	1.08	1.08
6	12	15	0.08	5760	10.5	12.27	122.7	0.27	0	0.74	1.01	1.01	1.09
6	12	15	0.09	6480	10.5	14.3	143	0.32	0	0.86	1.18	1.18	1.13
6	12	15	0.095	6840	10.5	13.06	130.6	0.29	0	0.78	1.07	1.08	1.16
6	12	15	0.1	7200	10.5	13.34	133.4	0.30	0	0.80	1.10	1.1	1.19
6	12	25	0.07	5040	10.5	11.04	110.4	0.25	0	0.66	0.91	0.91	1.12
6	12	25	0.08	5760	10.5	12.58	125.8	0.28	0	0.75	1.03	1.04	1.14
6	12	25	0.09	6480	10.5	14.3	143	0.32	0	0.86	1.18	1.18	1.18
6	12	25	0.095	6840	10.5	13.53	135.3	0.30	0	0.81	1.11	1.12	1.20
6	12	25	0.1	7200	10.5	13.07	130.7	0.29	0	0.78	1.07	1.08	1.23
3	5	15	0.07	1050	46.8	49.11	491.1	1.09	24.555	2.95	28.59	28.6	28.01
3	5	15	0.08	1200	46.8	50.63	506.3	1.13	25.315	3.04	29.48	29.48	28.59
3	5	15	0.09	1350	46.8	49.33	493.3	1.10	24.665	2.96	28.72	28.73	28.86
3	5	15	0.095	1425	46.8	50.62	506.2	1.12	25.31	3.04	29.47	29.48	28.87
3	5	15	0.1	1500	46.8	49.37	493.7	1.10	24.685	2.96	28.74	28.75	28.80
3	5	25	0.07	1050	46.8	47.34	473.4	1.05	23.67	2.84	27.56	27.57	28.63
3	5	25	0.08	1200	46.8	50.58	505.8	1.12	25.29	3.03	29.45	29.45	28.99
3	5	25	0.09	1350	46.8	47.4	474	1.05	23.7	2.84	27.60	27.6	29.03
3	5	25	0.095	1425	46.8	49.35	493.5	1.10	24.675	2.96	28.73	28.74	28.93
3	5	25	0.1	1500	46.8	50.08	500.8	1.11	25.04	3.00	29.16	29.16	28.75
3	12	15	0.07	2520	19.5	21.02	210.2	0.47	10.51	1.26	12.24	12.24	12.25
3	12	15	0.08	2880	19.5	21.09	210.9	0.47	10.545	1.27	12.28	12.28	12.84
3	12	15	0.09	3240	19.5	21.33	213.3	0.47	10.665	1.28	12.42	12.42	13.11
3	12	15	0.095	3420	19.5	21.29	212.9	0.47	10.645	1.28	12.40	12.4	13.13
3	12	15	0.1	3600	19.5	22.79	227.9	0.51	11.395	1.37	13.27	13.27	13.07

3	12	25	0.07	2520	19.5	20.07	200.7	0.45	10.035	1.20	11.69	11.69	12.08
3	12	25	0.08	2880	19.5	23.33	233.3	0.52	11.665	1.40	13.58	13.59	12.44
3	12	25	0.09	3240	19.5	23.29	232.9	0.52	11.645	1.40	13.56	13.56	12.49
3	12	25	0.095	3420	19.5	22.55	225.5	0.50	11.275	1.35	13.13	13.13	12.39
3	12	25	0.1	3600	19.5	19.85	198.5	0.44	9.925	1.19	11.56	11.56	12.22
6	5	15	0.07	2100	25.2	25.99	259.9	0.58	12.995	1.56	15.13	15.14	15.20
6	5	15	0.08	2400	25.2	25.78	257.8	0.57	12.89	1.55	15.01	15.01	15.62
6	5	15	0.09	2700	25.2	25.79	257.9	0.57	12.895	1.55	15.02	15.02	15.73
6	5	15	0.095	2850	25.2	26.96	269.6	0.60	13.48	1.62	15.70	15.7	15.67
6	5	15	0.1	3000	25.2	25.98	259.8	0.58	12.99	1.56	15.13	15.13	15.52
6	5	25	0.07	2100	25.2	28.22	282.2	0.63	14.11	1.69	16.43	16.44	16.13
6	5	25	0.08	2400	25.2	28.76	287.6	0.64	14.38	1.73	16.74	16.75	16.34
6	5	25	0.09	2700	25.2	29.01	290.1	0.64	14.505	1.74	16.89	16.9	16.22
6	5	25	0.095	2850	25.2	28.04	280.4	0.62	14.02	1.68	16.33	16.33	16.04
6	5	25	0.1	3000	25.2	27.55	275.5	0.61	13.775	1.65	16.04	16.05	15.79
6	12	15	0.07	5040	10.5	12.03	120.3	0.27	6.015	0.72	7.00	7.01	6.87
6	12	15	0.08	5760	10.5	12.26	122.6	0.27	6.13	0.74	7.14	7.14	7.31
6	12	15	0.09	6480	10.5	13.52	135.2	0.30	6.76	0.81	7.87	7.88	7.43
6	12	15	0.095	6840	10.5	14.35	143.5	0.32	7.175	0.86	8.35	8.36	7.37
6	12	15	0.1	7200	10.5	13.33	133.3	0.30	6.665	0.80	7.76	7.77	7.23
6	12	25	0.07	5040	10.5	12.81	128.1	0.28	6.405	0.77	7.46	7.46	7.02
6	12	25	0.08	5760	10.5	11.06	110.6	0.25	5.53	0.66	6.44	6.44	7.23
6	12	25	0.09	6480	10.5	11.59	115.9	0.26	5.795	0.70	6.75	6.75	7.12
6	12	25	0.095	6840	10.5	10.79	107.9	0.24	5.395	0.65	6.28	6.29	6.95
6	12	25	0.1	7200	10.5	10.84	108.4	0.24	5.42	0.65	6.31	6.32	6.69

Table S9. Data table showing the calculation of desirability at dry condition.

Cross-feed, f_b (mm)	Workpiece velocity, v_w (m/min)	Wheel velocity, v_s (m/s)	Depth of cut, a_p (mm)	Temp. (°C)	MRR (mm³/min)	Total cost (BDT)	Individual desirability			Overall Desirability		
							Temp. (°C)	MRR (mm³/min)	Total cost	33:33:33 (Equal Weightage)	40:40:20	15:25:60
3	5	15	0.07	205.171	1050	4.06	0.533	0	0.89	0	0	0
3	5	15	0.08	211.231	1200	3.96	0.527	0.025	0.891	0.228	0.193	0.338
3	5	15	0.09	229.343	1350	4.16	0.377	0.049	0.891	0.255	0.236	0.38
3	5	15	0.095	259.3	1425	3.94	0.249	0.061	0.891	0.239	0.237	0.377
3	5	15	0.1	306.639	1500	4.03	0.086	0.074	0.891	0.179	0.207	0.337
3	5	25	0.07	217.28	1050	3.98	0.458	0	0.888	0	0	0
3	5	25	0.08	223.317	1200	4.07	0.456	0.025	0.89	0.217	0.187	0.33
3	5	25	0.09	253.331	1350	4.11	0.312	0.049	0.89	0.24	0.227	0.369
3	5	25	0.095	277.138	1425	4.02	0.186	0.061	0.89	0.217	0.223	0.361
3	5	25	0.1	300.762	1500	3.9	0.024	0.074	0.89	0.117	0.16	0.278
3	12	15	0.07	186.923	2520	1.71	0.615	0.24	0.969	0.524	0.507	0.639
3	12	15	0.08	196.06	2880	1.67	0.601	0.298	0.97	0.559	0.55	0.673
3	12	15	0.09	220.3	3240	1.79	0.444	0.357	0.97	0.537	0.557	0.672
3	12	15	0.095	241.36	3420	1.72	0.311	0.386	0.97	0.489	0.535	0.65
3	12	15	0.1	288.973	3600	1.75	0.144	0.415	0.97	0.388	0.472	0.59
3	12	25	0.07	199.1	2520	1.86	0.542	0.24	0.968	0.502	0.494	0.627
3	12	25	0.08	214.257	2880	1.86	0.532	0.298	0.969	0.536	0.537	0.66
3	12	25	0.09	235.357	3240	1.68	0.379	0.357	0.969	0.509	0.539	0.656
3	12	25	0.095	257.511	3420	1.75	0.249	0.386	0.969	0.454	0.511	0.628
3	12	25	0.1	302.526	3600	1.78	0.084	0.415	0.969	0.324	0.424	0.544
6	5	15	0.07	214.257	2100	2.27	0.487	0.171	0.954	0.431	0.42	0.562
6	5	15	0.08	220.3	2400	2.1	0.484	0.22	0.953	0.467	0.463	0.597
6	5	15	0.09	232.351	2700	2.19	0.339	0.269	0.953	0.444	0.468	0.595
6	5	15	0.095	262.876	2850	2.19	0.213	0.293	0.951	0.391	0.441	0.567
6	5	15	0.1	313.677	3000	2.3	0.052	0.318	0.951	0.251	0.344	0.468
6	5	25	0.07	225.126	2100	2.3	0.423	0.171	0.953	0.411	0.408	0.55
6	5	25	0.08	229.944	2400	2.1	0.425	0.22	0.952	0.447	0.451	0.585
6	5	25	0.09	261.088	2700	2.12	0.284	0.269	0.951	0.418	0.451	0.579
6	5	25	0.095	286.018	2850	2.27	0.16	0.293	0.95	0.355	0.416	0.542
6	5	25	0.1	307.226	3000	2.39	0.001	0.318	0.95	0.068	0.156	0.259
6	12	15	0.07	191.799	5040	1.08	0.591	0.649	0.995	0.726	0.756	0.827
6	12	15	0.08	204.565	5760	1.01	0.58	0.766	0.994	0.762	0.805	0.86
6	12	15	0.09	223.317	6480	1.18	0.427	0.883	0.992	0.721	0.8	0.85
6	12	15	0.095	247.95	6840	1.08	0.297	0.942	0.992	0.653	0.764	0.818
6	12	15	0.1	291.924	7200	1.1	0.132	1	0.991	0.508	0.665	0.735
6	12	25	0.07	204.565	5040	0.91	0.528	0.649	0.993	0.699	0.739	0.813
6	12	25	0.08	208.203	5760	1.04	0.522	0.766	0.992	0.735	0.787	0.845
6	12	25	0.09	235.357	6480	1.18	0.373	0.883	0.991	0.689	0.779	0.832
6	12	25	0.095	258.704	6840	1.12	0.246	0.942	0.99	0.613	0.735	0.794
6	12	25	0.1	300.762	7200	1.08	0.082	1	0.989	0.434	0.604	0.683

Table S10. Data table showing the calculation of desirability at wet condition.

Cross-feed, f_b (mm)	Workpiece velocity, v_w (m/min)	Wheel velocity, v_s (m/s)	Depth of cut, a_p (mm)	Temp. (°C)	MRR (mm³/min)	Total cost (BDT)	Individual desirability			Overall Desirability		
							Temp. (°C)	MRR (mm³/min)	Total cost	33:33:33 (Equal Weightage)	40:40:20	15:25:60
6	12	25	0.1	300.762	7200	1.08	0.082	1	0.989	0.434	0.604	0.683
3	5	15	0.07	119.136	1050	28.6	0.951	0	0.052	0	0	0
3	5	15	0.08	125.355	1200	29.48	0.942	0.025	0.031	0.091	0.057	0.05
3	5	15	0.09	131.563	1350	28.73	0.882	0.049	0.022	0.099	0.064	0.047
3	5	15	0.095	143.945	1425	29.48	0.832	0.061	0.022	0.104	0.069	0.049
3	5	15	0.1	156.282	1500	28.75	0.77	0.074	0.024	0.112	0.076	0.054
3	5	25	0.07	122.247	1050	27.57	0.943	0	0.03	0	0	0
3	5	25	0.08	126.598	1200	29.45	0.923	0.025	0.018	0.075	0.046	0.036
3	5	25	0.09	130.943	1350	27.6	0.85	0.049	0.016	0.088	0.056	0.039
3	5	25	0.095	156.282	1425	28.74	0.795	0.061	0.02	0.1	0.066	0.046
3	5	25	0.1	168.573	1500	29.16	0.727	0.074	0.026	0.113	0.077	0.056
3	12	15	0.07	109.785	2520	12.24	0.991	0.24	0.603	0.524	0.461	0.517
3	12	15	0.08	114.152	2880	12.28	0.985	0.298	0.583	0.556	0.496	0.534
3	12	15	0.09	122.247	3240	12.42	0.927	0.357	0.573	0.575	0.523	0.548
3	12	15	0.095	140.854	3420	12.4	0.879	0.386	0.572	0.58	0.533	0.553
3	12	15	0.1	143.945	3600	13.27	0.818	0.415	0.575	0.581	0.542	0.559
3	12	25	0.07	112.905	2520	11.69	0.988	0.24	0.61	0.526	0.463	0.52
3	12	25	0.08	116.022	2880	13.59	0.97	0.298	0.597	0.558	0.499	0.54
3	12	25	0.09	128.461	3240	13.56	0.9	0.357	0.595	0.577	0.527	0.558
3	12	25	0.095	147.034	3420	13.13	0.847	0.386	0.598	0.581	0.539	0.565
3	12	25	0.1	150.119	3600	11.56	0.78	0.415	0.605	0.582	0.548	0.572
6	5	15	0.07	119.136	2100	15.14	0.951	0.171	0.5	0.434	0.371	0.422
6	5	15	0.08	125.355	2400	15.01	0.942	0.22	0.485	0.466	0.404	0.44
6	5	15	0.09	131.563	2700	15.02	0.882	0.269	0.481	0.486	0.431	0.456
6	5	15	0.095	143.945	2850	15.7	0.832	0.293	0.484	0.491	0.442	0.464
6	5	15	0.1	156.282	3000	15.13	0.77	0.318	0.489	0.494	0.451	0.471
6	5	25	0.07	122.247	2100	16.44	0.943	0.171	0.467	0.423	0.36	0.404
6	5	25	0.08	126.598	2400	16.75	0.923	0.22	0.46	0.455	0.394	0.425
6	5	25	0.09	130.943	2700	16.9	0.85	0.269	0.465	0.475	0.422	0.444
6	5	25	0.095	156.282	2850	16.33	0.795	0.293	0.471	0.48	0.433	0.453
6	5	25	0.1	168.573	3000	16.05	0.727	0.318	0.48	0.481	0.443	0.461
6	12	15	0.07	109.785	5040	7.01	0.991	0.649	0.792	0.799	0.765	0.78
6	12	15	0.08	114.152	5760	7.14	0.985	0.766	0.776	0.837	0.81	0.802
6	12	15	0.09	122.247	6480	7.88	0.927	0.883	0.772	0.859	0.845	0.821
6	12	15	0.095	140.854	6840	8.36	0.879	0.942	0.774	0.863	0.859	0.829
6	12	15	0.1	143.945	7200	7.77	0.818	1	0.779	0.861	0.87	0.836
6	12	25	0.07	112.905	5040	7.46	0.988	0.649	0.787	0.797	0.763	0.776
6	12	25	0.08	116.022	5760	6.44	0.97	0.766	0.779	0.834	0.809	0.802
6	12	25	0.09	128.461	6480	6.75	0.9	0.883	0.783	0.854	0.845	0.824
6	12	25	0.095	147.034	6840	6.29	0.847	0.942	0.789	0.858	0.86	0.834
6	12	25	0.1	150.119	7200	6.32	0.78	1	0.798	0.854	0.87	0.842