ANALYSIS OF VARIANCE(ANOVA)

1. **Data collection**

The goal of this analysis is to obtain optimal operating points for the stepper motor which provides linear feed to the dc motor station and the dc motor speed which provides rotary feed to the workpiece.

The two hypotheses in the experiment:

Null hypothesis: There is no significant difference in the mean quality of drilling across different levels of linear feed speed provided by the stepper motor and rotary speed determined by the DC motor.

Alternative hypothesis: There is a significant difference in the mean quality of drilling across different levels of linear feed speed provided by the stepper motor and rotary speed determined by the DC motor.

	Stepper Motor Speed (RPM)	DC Motor Speed (RPM)	Drill performance
E0	26.7	7958	0
E1	30.0	9422	0
E2	24.2	9422	0
E3	17.4	9604	3
E4	17.8	9775	3
E5	17.4	9712	2
E6	9.8	9778	8
E7	9.9	9671	5
E8	9.4	9733	8
E9	31.1	9785	5
E10	21.4	9836	5
E11	4.5	9706	3

2. **ANOVA analysis**

Drill performance extremes: 0- does not drill

10- drills efficiently

ANOVA: Two-Factor Without Replication

SUMMARY	*Count*	*Sum*	*Average*	*Variance*
E0	2	7984.7	3992.35	31452760
E1	2	9452	4726	44104832
E2	2	9446.2	4723.1	44159322
E3	2	9621.4	4810.7	45951450
E4	2	9792.8	4896.4	47601476
E5	2	9729.4	4864.7	46992635
E6	2	9787.8	4893.9	47708866
E7	2	9680.9	4840.45	46668427
E8	2	9742.4	4871.2	47274198
E9	2	9816.1	4908.05	47569283

E10	2	9857.4	4928.7	48163187
E11	2	9710.5	4855.25	47059551
Stepper Motor Speed (RPM)	12	219.6	18.3	75.45818
DC Motor Speed (RPM)	12	114402	9533.5	264111

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Stepper*DC Motor	1434252	11	130386.5	0.974489	0.516708	2.81793
Stepper and DC Motor Separately	5.43E+08	1	5.43E+08	4060.048	1.76E-15	4.844336
Error	1471799	11	133799.9			
Total	5.46E+08	23				
Total	7.28E+08	35				

3. Interpretation of ANOVA results

- The p-values indicate the significance of each factor and their interactions.
- Stepper Motor Speed has a p-value of <0.05, indicating that it has a significant effect on Optimal Drilling Performance.
- Drill Motor Speed also has a p-value of <0.05, suggesting a significant effect on Optimal Drilling Performance.
- Both the stepper motor speed and the drill motor speed independently significantly impact the quality or efficiency of the drilling process for PMMA material.
- The interaction between Stepper Motor Speed and Drill Motor Speed has a p-value of 0.516708, which is not statistically significant. Therefore, the interaction does not have a significant effect on Optimal Drilling Performance.
- The p- value of interaction between stepper motor speed and dc motor speed is greater than 0.5, thus we fail to reject null hypothesis; this means there is no significant difference in the mean quality of drilling across different levels of linear feed speed provided by the stepper motor and rotary speed determined by the DC motor. This means that the two variables can be controlled independent of each other to obtain best quality drilling.

From the analysis, the number of times the station is able to carry out a successful drilling operation is limited. The station exhibits a successful drilling operation when a starting hole is provided. Failure to drill can be attributed to the melting of PMMA and the sticking of the melted PMMA on the drill bit, making further drilling difficult. The new PMMA used melts

when heated during heating. Using the current setup as it is, the optimal operating parameters is at 200 pulses/rev setting for stepper motor, where it operates at 21.6 rpm and for the dc motor, at 255PWM, which is equivalent to 9778rpm, which can be conditioned separately, with one of the variables held constant.

Recommendations

Using a geared dc motor for the drill station with operating speed limit of 300 rpm will provide sufficient torque to drill the PMMA as it melts. Temperature should also be control variable in the system due to thermal behavior of the PMMA strip.