

**GROUP PROJECT**

**BSD3433 EXPERIMENTAL DESIGN ANALYSIS**

**TITLE**: The Strength of Ceramic

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# Case study



A ceramic tile manufacturing by UBA Ceramic Sdn. Bhd. was facing issues with their ceramic tile product line. The tiles were breaking easily during installation and customers were complaining about the poor quality of the tiles. The company realized that they needed to increase the strength of their ceramic tiles to meet the demands of their customers and to improve their reputation in the market.

The ceramic tiles produced by the company were weak and prone to breaking easily. This was causing a high rate of customer complaints and product returns, which was affecting the company's revenue and reputation.

The company decided to invest in research and development to increase their ceramic tiles’ strength. They suspect the machining factor of ceramic production influences the strength of the ceramic tile. Thus, they wish to investigate the machining factors that influenced the strength of the ceramic during their production. The five factors thought to influence the strength of the ceramic are table speed (A), down feed rate (B), wheel grit ( C ), direction (D) and batch (E). The experiment would involve using a 2^5 factorial design, with each factor having two levels. This would result in 32 different combinations of the five factors, each of which would be tested to determine the strength of the ceramic during production. The results of the experiment would then be analyzed using statistical methods to identify which factors have the greatest effect on the strength of the ceramic and in what combination and levels. The data from the experiment has been collected are shown in Table 1.

# Description of Experiment

Response and Factors

**Purpose**: To determine the effect of machining factors on ceramic strength

**Response variable** : Mean (over 15 repetitions) of the ceramic strength

**Number of observations** : 32 (a complete 2^5 factorial design)

**Dependent Variables :-**

Factor 1 : Table Speed (2 levels: slow (0.025 m/s) and fast (0.125 m/s))

Factor 2 : Down Feed Rate (2 levels: slow (0.05 mm) and fast (0.125 mm))

Factor 3 : Wheel Grit (2 levels: 140/170 and 80/100)

Factor 4 : Direction (2 levels: longitudinal and transverse)

Factor 5 : Batch (2 levels: 1 and 2)

|  |  |  |
| --- | --- | --- |
| Factor | Low | High |
| speed | 0.025 m/s | 0.125 m/s |
| rate | 0.05 mm | 0.125 mm |
| grit | 140/170 | 80/100 |
| direction | longitudinal | transverse |
| batch | 1 | 2 |

Factor A : speed

Factor B : rate

Factor C : grit

Factor D : direction

Factor E : batch

# Dataset

Table 1 Mean of the Ceramic Strength

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Factor | | | | | Treatment Combination | strength |
| A | B | C | D | E |
| -1 | -1 | -1 | -1 | -1 | (1) | 680.45 |
| 1 | -1 | -1 | -1 | -1 | a | 722.48 |
| -1 | 1 | -1 | -1 | -1 | b | 702.14 |
| 1 | 1 | -1 | -1 | -1 | ab | 666.93 |
| -1 | -1 | 1 | -1 | -1 | c | 703.67 |
| 1 | -1 | 1 | -1 | -1 | ac | 642.14 |
| -1 | 1 | 1 | -1 | -1 | bc | 692.98 |
| 1 | 1 | 1 | -1 | -1 | abc | 669.26 |
| -1 | -1 | -1 | 1 | -1 | d | 491.58 |
| 1 | -1 | -1 | 1 | -1 | ad | 475.52 |
| -1 | 1 | -1 | 1 | -1 | bd | 478.76 |
| 1 | 1 | -1 | 1 | -1 | abd | 568.23 |
| -1 | -1 | 1 | 1 | -1 | cd | 444.72 |
| 1 | -1 | 1 | 1 | -1 | acd | 410.37 |
| -1 | 1 | 1 | 1 | -1 | bcd | 428.51 |
| 1 | 1 | 1 | 1 | -1 | abcd | 491.47 |
| -1 | -1 | -1 | -1 | 1 | e | 607.34 |
| 1 | -1 | -1 | -1 | 1 | ae | 620.8 |
| -1 | 1 | -1 | -1 | 1 | be | 610.55 |
| 1 | 1 | -1 | -1 | 1 | abe | 638.04 |
| -1 | -1 | 1 | -1 | 1 | ce | 585.19 |
| 1 | -1 | 1 | -1 | 1 | ace | 586.17 |
| -1 | 1 | 1 | -1 | 1 | bce | 601.67 |
| 1 | 1 | 1 | -1 | 1 | abce | 608.31 |
| -1 | -1 | -1 | 1 | 1 | de | 442.9 |
| 1 | -1 | -1 | 1 | 1 | ade | 434.41 |
| -1 | 1 | -1 | 1 | 1 | bde | 417.66 |
| 1 | 1 | -1 | 1 | 1 | abde | 510.84 |
| -1 | -1 | 1 | 1 | 1 | cde | 392.11 |
| 1 | -1 | 1 | 1 | 1 | acde | 343.22 |
| -1 | 1 | 1 | 1 | 1 | bcde | 385.52 |
| 1 | 1 | 1 | 1 | 1 | abcde | 446.73 |

# Model of Experiment

Where :

|  |  |
| --- | --- |
|  | are parameters whose values are to be determined |
|  | Table Speed |
|  | Down Feed Rate |
|  | Wheel Grit |
|  | Direction |
|  | Batch |
|  | Random Error |
|  |  |

# 

# Coding

# Refine Model

# Conclusion

In the conclusion, the strength of ceramic can increase by changing the machine factor grit (C), direction (D) and batch (E). Use the factor at low level, that’s means use grit at 140/170, direction in longitudinal and batch in level 1.

Follow the single replicate analysis for , the factor A and B will be discarded because both factors not significant. The graphical qq plot show just factors C, D and E not in the line of graph.

The interaction between factor not occur because that is not have the cross between the line factor and the interaction factors all is not significant.

We can conclude the machine factor for the ceramic strength not have interaction relationship between the factor. So, we can recommend the highest one to make the ceramic more strength which is use all the factor that significant (grit, direction and batch) at their low level.

# Reference

*5.4.7.1. Full factorial example*. (2023). Nist.gov.

https://www.itl.nist.gov/div898/handbook/pri/section4/pri471.htm

[5.4.7.1. Full factorial example (nist.gov)](https://www.itl.nist.gov/div898/handbook/pri/section4/pri471.htm)

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