# Effect of waterjet abrasive waste on compression strength in sand casting by Taguchi approach

Nur Farah Bazilah Wakhi Anuar[1*], Ban Lai Khee[1], Muhammad Luqman Mohd Khusairi[1], Rahaini Mohd Said[2], Salleh Aboo Hassan[1], Amir Hamzah Abdul Rasib[1]

[1]Fakulti Teknologi Kejuruteraan Mekanikal dan Pembuatan, Universiti Teknikal Malaysia Melaka, Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia
[2] Fakulti Teknologi Kejuruteraan Elektrik dan Elektronik, Universiti Teknikal Malaysia Melaka, Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia

[*]Corresponding e-mail: nurfarah@utem.edu.my

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**ABSTRACT** – Sand casting process continues to remain nowadays due to the economic process, but silica sand is prominent in environmental degradation due to mining activity, and it is lead to a negative impact on the environment. However, waterjet cutting sand waste of ferrous and non-ferrous metals are practically unhazardous and potentially used for utilization in the sand casting mould. This study aims to optimize the addition proportion of coal dust, water and bentonite in silica sand with waterjet cutting sand waste mixture as a new way of consumption in sand casting manufacturing. The method was used in this optimization based on Taguchi L9 orthogonal array, and the quality of composition was measured using a green compression strength. The confirmation test was conducted for the optimum proportion. This study concluded the optimum proportion for silica sand with waterjet cutting sand waste for green compression strength was bentonite-12%, coal dust-5%, and water-7% with 84.778 kN/m$^2$ and the result for the confirmation test was 85.576 kN/m$^2$.

## 1. INTRODUCTION

Sand casting commonly used in the manufacturing process in the metal casting industry. The essential compositions of the sand casting process are silica sand, coal dust and clay powder. At the same time, water plays a vital role in reducing and controlling the defects in the casting [1]. However, silica sand mining activities and its transportation process to each foundry lead to harm to the ecosystem, rendering this metal casting process ecologically unsustainable and untenable [4]. Many researchers attempt for decreasing environmental damage including finding new ways as an alternative to reduce wastes [2-3]. Recently, a few investigations have been done on sand waste from waterjet cutting as an alternative resource with added value, and according to Federal Classification Catalog of Waste 2017, the sand waste from waterjet cutting of ferrous and non-ferrous metals are practically unhazardous [5]. By adding waterjet cutting sand waste in the composition of sand casting, the expenditure of sand will be declined, thus giving an opportunity of raw material for sand casting, which is economically advantageous while maintaining the quality of casting [4]. Nonetheless, if the composition of silica sand and waterjet sand waste with bentonite, coal dust, and water is not being appropriately managed; the result will lead to poor quality and defect.

Table 1 L$^9$ orthogonal array data

| Experiment | Bentonite (A) | Coal Dust (B) | Water (C) |
|---|---|---|---|
| | Wt. % | Wt. % | Wt. % |
| 1 | 6 | 4 | 5 |
| 2 | 6 | 5 | 6 |
| 3 | 6 | 6 | 7 |
| 4 | 9 | 4 | 6 |
| 5 | 9 | 5 | 7 |
| 6 | 9 | 6 | 5 |
| 7 | 12 | 4 | 7 |
| 8 | 12 | 5 | 5 |
| 9 | 12 | 6 | 6 |

Hence, to overcome this problem in composition, the optimization of the parameters should be done. In this study, the design composition of bentonite, coal dust and water were used to investigate the optimization in silica sand and waterjet sand waste mixture to get the optimal proportion levels by using Taguchi L9 orthogonal array which makes the process design is coherent.

## 2. METHODOLOGY

The level and the factor for composition bentonite as a binder, coal dust and water parameters in 60% silica sand and 40% waterjet cutting sand waste mixture were decided based on the available literature. It is tabulated as shown in Table 1 by using Taguchi L9 orthogonal array. Larger is better characteristic is used for green compression test (kN/m$^2$) with Equation (1) and nine experiments were performed in three repetitions with a random order. Each mixed composition prepared with a range weight around 145g to 170g in a muller and fixed in specimen tube. The specimen was rammed three times to obtain the specimen height 50mm ± 1mm with 50mm diameter and tested directly in Universal Sand

Strength Machine (USSM) until specimen break to prevent it from drying and cause a decrease in strength.

$$\frac{S}{N}_{larger} = -10\log\left[\frac{\sum \frac{1}{Y_i^2}}{n}\right] \quad (1)$$

where $n$ is the number of trial tests, $Y_i$ is the $i$th number of quality characteristics or performance value.

## 3. RESULTS AND DISCUSSION

The quality of the composition mixtures was identified and characterized significantly in terms of green compression strength. Figure 1 shows the S/N ratio response, changes in factors and its levels affecting the green compression strength using the Taguchi method. At the optimum level for the composition in terms of green compression strength is the amount of bentonite-12%, coal dust-5%, and water-7% which is "A3-B2-C3" with a predicted green compression strength is 84.778 kN/m$^2$.

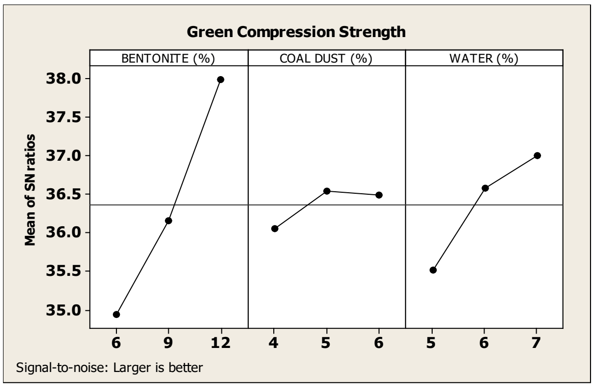

Figure 1 S/N ratio values for compression strength

As a result of experimental studies, it is seen that the green compression strength increased as the proportion of bentonite increased but decreased as the content of moisture decremented. This result also agreed with the previous result experimental research[1], where bentonite expanding the value of green compression strength with the traditional composition of the sand mould. The development can be discovered in terms of bonding for bentonite with the silica, and waterjet waste mixture sand mould where the mixing process allows a thin coating of binders on individual sand particle and this process leads a crosslink with each other to form a resin bridge. However, the recycle sand waste required the addition of binder bentonite as a strength to withstand the heat of the molten metal. It clarifies that increasing content of bentonite spread the value of the compression for silica and waterjet waste sand mixture. Moreover, the result also observed that increasing the content of water influence the value of compression strength while increasing content of clay with an inaccurate proportion of water declining the value of strength. Water and clay are essential for moisture where it must be balanced with a binder to create a better and higher green strength. However, trends show that too low content of moisture with the rising value of bentonite gives a low value of binding strength and this leads mould to decline the mixture to develop the acceptable plasticity and strength.

Table 2 Confirmation test

| | **Optimum controlled conditions (kN/m$^2$)** | |
|---|---|---|
| | **Predicted** | **Experimental** |
| Level | A3-B2-C3 | A3-B2-C3 |
| Green Compression Strength | 84.778 | 85.576 |

The experimental trial must be conducted if the optimum obtained is not from the experimental design suggested by the Taguchi method. Also, the confirmation test required to provide the essential of the optimum parameter. The comparison of the predicted optimum and confirmation experimental is shown in Table 2.

## 4. CONCLUSIONS

In general, the results achieved are as follows:

1. Choosing the optimum factor and level is important in the Taguchi method to maximizing of green compression strength in silica and waterjet sand waste mixture.
2. The optimum result for green compression strength was 12% of bentonite, 5% of coal dust and 7% of water at 84.778 kN/m$^2$ and 85.576 kN/m$^2$ for confirmation test on average where the value within the range of typical strength from 30-100 kN/m$^2$.
3. Green compression strength in silica and waterjet sand waste can be maximized with increasing of bentonite with a suitable amount of moisture.
4. The positive participant of waterjet sand waste in mould sand casting provides the positive economically feasible for sand casting raw materials.

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