
## Faculty of Manufacturing Engineering

# MOISTURE, CLAY AND ADDITIVE EFFECT IN ALUMINUM STRENGTH AND SURFACES ROUGHNESS USING SAND CASTING

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# MOISTURE, CLAY AND ADDITIVE EFFECT IN ALUMINUM STRENGTH AND SURFACES ROUGHNESS USING SAND CASTING

**ANIZA BINTI MD. LATIFF**

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TAJUK: **Moisture, Clay and Additive Effect in Aluminum Strength and Surfaces Roughness using Sand Casting**

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# DEDICATION

To my beloved husband, Mohd Fitri Bin Ismail, my mother, Aisha Binti Daud and all my family

## ABSTRACT

The Aluminum alloys have reveled in a huge expansion over the past few decades as a result of their accessible casting temperatures, lightweight and low melting temperature compared to cast iron. The automotive industry is the largest market for aluminum casting. However, the wet sand has a high moisture content, low strength, and air permeability; the castings can easily have the porosity, coarse, sticky sand and expansion defect. The problem of surface roughness is the major problem during the production process in internal-combustion engines and greatly affects the quality of the product. Using RSM with the box-bennken model in order to identify the correlations between response parameters and the total of 17 experiments were conducted. The result collected was optimized using response surface (RSM) and p-value and R-square; calculated using analysis of variance (ANOVA). According to the result, best mixing ratio, the optimized parameters values were 40 ml water, 45.76 g clay, and 34.65 g corn husk. These optimized parameters have 0.7078 on desirability and achieve the maximum value of tensile strength and the minimum value of surface roughness. From the optimized set of parameters, the predicted value of achievable tensile strength was equal to 122.296 kg/mm² and surface roughness was equal to 1.5770 µm. From the result of the experimental, it was found that the most influential parameters were water, followed by corn husk for surface roughness response. Meanwhile, for tensile strength response corn husk largely influence the outcome where the relation of tensile strength increase with the increasing of corn husk value.

## *ABSTRAK*

*Penggunaan Aluminium aloi telah berkembang pesat sejak beberapa dekad yang lalu kerana mudah diakses, ringan, takat lebur yang rendah berbanding besi tuangan. Industri automotif merupakan pasaran terbesar bagi penggunan aluminium aloi di dalam proses tuangan. Walau bagaimanapun, di dalam proses tuangan pasir, pasir basah mempunyai kandungan lembapan yang tinggi, kekuatan rendah, dan kebolehtelapan udara; dengan ini boleh menyebabkan kecacatan seperti mempunyai keliangan, kasar, pasir melekit dan kecacatan pengembangan pasir. Masalah utama bagi proses tuangan pasir adalah kekasaran permukaan semasa proses tuangan yang terjadi di dalam produk enjin pembakaran dalaman dan sangat mempengaruhi kualiti produk. Dengan menggunakan RSM dengan model box-bennken untuk menganalisa korelasi antara parameter dan respon. 17 eksperimen telah yang dilaksanakan. Hasil eksperimen dioptimumkan dengan menggunakan permukaan tindak balas (RSM) dan p-nilai dan R-square dikira dengan menggunakan analisis varians (ANOVA). Hasil dapatan eksperimen, nisbah pencampuran terbaik yang dioptimumkan ialah 40 ml air, tanah liat 45.76 g, dan 34.65 g abu kulit jagung. Parameter yang dioptimumkan ini mempunyai 0.7078 yang sesuai dan mencapai nilai maksimum kekuatan tegangan dan nilai minimum kekasaran permukaan. Dari set parameter yang dioptimumkan, nilai ramalan kekuatan tegangan yang boleh dicapai adalah sama dengan 122.296 kg / mm² dan kekasaran permukaan adalah sama dengan 1.5770 μm. Dari hasil eksperimen, didapati bahawa untuk tindak balas kekasaran permukaan, parameter yang paling berpengaruh adalah air, diikuti oleh abu kulit jagung. Sementara itu, untuk kekuatan tegangan tindak balas abu kulit jagung sebahagian besarnya mempengaruhi hasil di mana hubungannya adalah peningkatan kekuatan tegangan.*

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# LIST OF SYMBOLS

| | | |
|---|---|---|
| $g$ | - | Gram |
| kg | - | Kilogram |
| N | - | Newton |
| ml | - | Milliliter |
| μm | - | Micrometer |
| Rα | - | Respon Surface |

# LIST OF ABBEREVIATIONS

| | | |
|---|---|---|
| RSM | - | Response Surface Methodology |
| DOE | - | Design of Experiment |
| ANOVA | - | Analysis of Variance |
| Ra | - | Surface Roughness |

# CHAPTER 1

# INTRODUCTION

## 1.1 Background of study

Aluminum is the most abundant metallic element in the earth's crust (combined with other elements). The properties of aluminum are low density, form strong alloys, high thermal and electrical conductivity, non-magnetic and highly ductile. This material is so critical to modern mobility, increasing sustainability and the national economy that without it, many of the conveniences of today's world would simply not exist. Aluminum is already the second-most-used material by automakers and protecting from hazards on the road. Engineers know how to work with aluminum to make parts that perform well or better than steel parts – all while reducing vehicle weight. This material is highly effective in absorbing crash energy, protecting passengers in the event of an accident.

The use in automobiles saves 44 million tons of $CO_2$ emissions. Lightweight, strong and highly recyclable, value-added aluminum products can lower energy costs and carbon emissions in dozens of applications. Because of that, from sand casting process, it is better to make use aluminum to produce the automobile product, aerospace product, electrical and electronics industries which is stronger and has a good surface roughness. However, the properties of aluminum need to be study to ensure the amount of water, sand, clay and additive with corn husk can give effect to surface roughness and strength. The mechanical properties can be determined by

conducting tensile test and impact test on the aluminum with different rate of composition in water, temperature and mix sand order to find the best to surface roughness and strength of Aluminum.

In order to help the environment for future, many products will be produced from aluminum material. Aluminum gives low impact to environment, nontoxic and can be recycled. Major source for information are found from other researches in material and process as well as journal from library. Information can also be optained from the person who study about material and the environmental issue. For this project to successed, finding the best mixing amount silica, clay (bentonite), water and additive (corn husk) for aluminum can give best result for surface roughness and strength. However this research in not entirely original since there was a research done by others but the difference is not conducted do not use corn husk as an additive sand for casting effect the material surface roughness and strength. This study will use equipment required and be conducted at Muadzam Shah Polytechnic. This research would contribute to the environment by using the aluminum to save 44 million tons of $CO_2$ emissions compared to steel in automotive industry. This research would support sustainability for the natural surroundings.

## 1.2 Problem Statement

In an ideal setting, sand molding is used to manufacture complex shape castings of various sizes depending upon the requirements and it is very ancient technique of manufacturing the product (Mohammed *et al*., 2014). However, casting is a process which carries risk of failure occurrence during all of the process for accomplishment of the finished product (Rajesh and Khan, 2014). According to the

article, necessary action should be taken while manufacturing of cast product so that defect free parts are obtained. The article also state, mostly casting defects are concerned with process parameters. This argument is supported by Mohamad *et al*. (2014) who stated that controlled parameter is crucial to improve the quality of both casting process and the product. Thus, good parameter in casting process (amount of water, sand, clay and additive) will be determined. Additives are the materials usually added to the molding and core sand mixture to improve some special property in the sand. Some common used additives for enhancing the properties of molding and core sands are coal dust, dextrin, pitch, wood floor (Rajender, 2006). Due to that, the properties of molding can be optimized and negative impact on environment in sand casting can be reduced. The purpose of this research is to mix sand mould in sand casting with corn husk, which the corn husk is a natural waste that usually discarded and burned. Aluminum casting is a process of pouring molten aluminum, heated to proper temperature and it is then poured into the cavity of a mold and allowed to solidify into a required shape. It is one of the most demanding engineering applications. Combinations of properties provided by the aluminum and its alloys make aluminum one of the most versatile, economical and attractive metallic materials for a broad range of uses (Davis, 2001). Using aluminum casting in this research would support the needs in saving environment especially for automobiles industries. Aluminum casting in automobiles saves 44 million tons of $CO_2$ emissions (The Aluminum Association, 2016). For keeping the increase of demand for the use of aluminum in manufacturing of various components, aluminum foundries have to focus on producing quality castings (Mohamad *et al.*, 2014). In order to make the aluminum casting into a useful item, mould that consists of good parameter (amount

of water, sand, clay and additive) and corn husk has to be studied. In addition, as to determine the mould effectiveness, a study on tensile and surface roughness behavior of this aluminum casting will be conducted.

## 1.3 Objectives Of Study

The objectives of this study are:

i. To study the effect of moisture, clay and additive (corn husk) to the tensile and surface roughness to aluminium casting.

ii. To suggest optimization of parameters for aluminium casting.

## 1.4 Research Scope

The idea to study about corn husk as an additive mix with sand casting that (amount of water, sand, clay) affects aluminum surface roughness and strength using sand casting might be a new finding or solution to reduce defect in sand casting process for aluminum material. The paper plan for this research is experimental type of research by controlling the variable in order to find the surface roughness behavior result and tensile behavior. The variable would be the ratio of water, green sand, clay (bentonite) and corn husk in order to have the best mixing and 4 hour to cooling time is consistent during solidification.

## 1.5 Importance of Study

The importance of this study is it would contribute to the environment by using the aluminum to save 44 million tons of $CO_2$ emissions as compared to steel in automotive industry. This research would support sustainability for the natural

surroundings. The significance of this study is to reduce defect in sand casting process for aluminum material. It is better to make use aluminum to produce the automobile product, aerospace product, electrical and electronics industries which is good surface finish and stronger.

## 1.6 Research Activity

Research activity or planning cited in Gantt chart and K-chart in appendix

# CHAPTER 2

# LITERATURE REVIEW

This research paper is about moisture effect in aluminum surface roughness and strength using sand casting. The suitable mixing ratio of water, sand, clay and additive (corn husk) will be determined to find the best surface roughness and strength of Aluminum.

## 2.1 Aluminum Alloy ADC 12

Aluminum is a metal of choice for many applications like aerospace, architectural construction and marine industries, as well as many domestic uses. Lightweight, durable and infinitely recyclable, value-added aluminum products can lower energy costs and carbon emissions in dozens of applications. (The Aluminum Association, 2016). It is also stated that, Aluminum is often referred to as a long list of inherent properties, lightweight, corrosion resistant, easily formed, highly conductive, highly reflective, non-toxic, durable and recyclable, gives manufacturers and designers a wide range of options for product innovation and process improvements. This argument is supported by Rajesh *et al*. (2016) stated that depending on the surface roughness; Aluminum is a soft, durable, lightweight, ductile and malleable metal with appearance ranging from silvery to gray. Aluminium is the most abundant metal in the earth's crust, and the third most abundant element, after oxygen and silicon. The chief source of Aluminum is bauxite ore and atomic number is 13. An aluminum alloy product is provided that includes an ADC12 aluminum alloy. ADC12

aluminum alloy is cast into the product using a high pressure, slow velocity casting technique (Richard and Rattihdra, 2003). According the article, The ADC12 alloy is stronger than the 356 secondary and A356.2 aluminum alloys and more suitable for products requiring high strength for example, components of braking systems, such as master cylinders and ABS components. The ADC12 alloy is cheaper as compared to 356 secondary and A356.2 aluminum alloys.

## 2.2 Sand Casting

The sand casting process involves the use of a furnace, metal, pattern, and sand mold (sand, water, clay and additive). Moulds are formed by ramming sand onto a pattern. The pattern is removed leaving a cavity in the sand. Internal cavities for the casting may be made with sand cores. Molten metal is poured into the mould and after it has solidified the mould is broken to remove the casting. Castings produced using sand mould is known to have peculiar microstructures depending on average size, distribution and shape of the moulding sand grains and the chemical composition of the alloy where a study by Wasiu (2012) and state that these affect the surface finish, permeability and refractoriness of all the castings. The sand mixture for sand casting is the ratio of sand, clay and water. The ratio is important because it affects the mechanical properties of a material.

Large capital costs needed for die casting process because of the casting equipment and the metal dies. It is used for low volume production suited for a large quantity of small to medium sized castings. Manufacturing of parts using die casting is relatively simple, with a very good surface finish and dimensional consistency. Die casting process can be designed to produce complex shapes with high degree of