Faculty of Mechanical and Manufacturing Engineering Technology

OPTIMIZATION OF RECYCLE WATER JET SAND MOULDING COMPOSITION FOR SAND CASTING

Muhammad Luqman Bin Mohd Khusairi

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This report is submitted to the Faculty of Mechanical and Manufacturing Engineering Technology of the requirements for the degree of Bachelor Degree of Mechanical and Manufacturing Engineering Technology (Process and Technology) with Honours. The member of the supervisory is as follow

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ABSTRAK

Penyediaan pasir pemutus acuan perlu mengambil sifat-sifat mekanikal penting seperti kekuatan hijau, kekuatan ricih dan kebolehtelapan kira. Ciri – ciri acuan pasir ini memainkan peranan penting dalam menentukan kandungan lembapan optimum dan komposisi untuk membuat acuan pasir hijau. Membentuk pasir komposisi pasir, pengikat dan bahan tambahan sebelum penyediaan campuran pasir. Walau bagaimanapun, sisa buangan amat penting disusun dengan menggunakan campuran tanah, jumlah debu dan kuantiti bentonit dan air. Campuran acuan mewakili bahagian terbesar buangan. Kajian ini adalah tentang mengitar semula sisa jet air kasar untuk menghasilkan acuan pasir. Acuan pasir terhasil dari sisa air jet yang kasar yang bercampur dengan pasir silika sebagai pasir dasar kemudian akan menyusun komposisi lain bentonit, debu arang dan air. Kesan kebolehtelapan, kekuatan mampatan hijau dan kekuatan ricih komposisi pasir hijau telah dikenal pasti. Reka bentuk percubaan telah dicipta selepas menetapkan parameter dan nisbah untuk komposisi acuan pasir dari kaedah Taguchi di peranti Minitab. Analisis perisian Minitab bertujuan mengenal pasti bahawa dalam semua eksperimen, bentonit dan air memainkan kesan interaksi. Tambahan pula, ia akan menganalisis sifat-sifat mekanik seperti kebolehtelapan, kekuatan komposisi hijau dan kekuatan ricih hijau acuan pasir yang terbuat dari sisa jet air kasar. Komposisi pasir silika 60%; 40% Sisa air jet air (Kitar semula) didapati mempunyai kekuatan hijau yang optimum dan kebolehtelapan yang berkesan. Untuk memastikan komposisi tersebut bagus atau tidak, ujian telah dibuat berdasarkan beberapa sample uji yang telah di optimasi kan oleh kaedah Taguci. Keputusan tersebut juga berdasarkan analisa dari kesan mean dan nisbah isyarat kepada bunyi. Selepas analisa, keputusan dari minitab itu boleh dibandingkan kepada selang keyakinan. Tambahan pula, keputusan komposisi yang terbaik akan dibandingkan dan di pilih dari kebolehtelapan, kekuatan komposisi hijau dan kekuatan ricih hijau.

ABSTRACT

Preparation of sand casting mould should take the important mechanical properties such as green strength, shear strength and permeability into consideration. This moulding sand properties play a vital role in determining the optimum moisture content and composition for making green sand mould. Moulding sand are a composition of sand, binders and additives prior to the preparation of the sand mix. However, foundry wastes are essentially composed of used sand mixture, amount of dust, quantity of bentonite and water. Moulding mixture represent the largest proportion of wastes. This study is all about recycling the abrasive water jet waste to produce sand mould. The sand mould was made from water jet abrasive waste are mixed with silica sand as a base sand then will compose with other composition bentonite, coal dust and water. The effect on permeability, green compression strength and shear strength of green sand composition had been investigated. The design of experiment had been create after setup the parameter and ratio for sand mould composition from Taguchi Method at Minitab software. Minitab software aim to analysis identified that in all experiments, bentonite and water are the main interaction effect. Furthermore, it will analyze mechanical properties such as permeability, green composition strength and green shear strength of the sand mould made of abrasive water jet waste. 60% Silica sand composition; 40% Abrasive (Recycle) water jet waste was found to have optimum green strength and effective permeability. For the confirmation of the composition good or not, testing have been running based on testing sample that have been optimize by Taguchi Minitab. That result also based on analysis of main effect from Mean and Signal to Noise ratio. After the analysis, the result from Minitab can compare to Confidence interval. In addition, the best composition result will be compare and decide from Permeability, Green Shear Strength and Green Compression Strength.

DEDICATION

I dedicate my dissertation work to my family and many friends. A special feeling of gratitude to my parents, who never stop giving of themselves in countless ways. For their endless love, support and encouragement that keep me moving forward. I also dedicate this dissertation to all my dearest relatives, supervisor, lecture and many friends who have supported me throughout the process.

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LIST OF ABBREVIATION

AFS	American Foundry Sand
AWJW	Abrasive Water Jet Waste
ANOVA	Analysis of Variance
DOE	Design Of Experiment
S/N	Signal To Noise
USSM	Universal Sand Strength Machine
UTeM	Universiti Teknikal Malaysia Melaka
UTHM	Universiti Tun Hussein Onn Malaysia

CHAPTER 1

INTRODUCTION

1.0 Introduction

This chapter will discuss briefly about the analysis of sand mould using abrasive water jet waste. The content of this chapter includes background of the study, problem statement, objectives, significance, scope and structure of the study.

1.1 Research background

Casting is among of the earlist metals moulding technique that ever exist in the world. It is one of the least expensive methods utilized for mass production of any part and it is adequately used to make a complex shaped part, which is difficult to create, by other production process (Choudhari et al, 2014). In other journal stated that casting is one of the important and versatile processes of manufacturing. The major purpos e is to form solid or hollow objects parts, or desired shapes and sizes. Incorrect sand condit ion may occurred in the production scraps (Patel et al, 2015).

It is the first step in the production of most products. In sand casting, which until today is the most widely used casting process as the low cost of raw materials, it is recyclable a wide variety of castings in size and compositions and their moulding sand. Sand casting is defined as pouring molten metal into a sand mold (usually molds have a shape cavity to make) and enabling it to solidify within the mold. The "sand" refractory composition usually consists of a mixture of high purity silica sand, bentonite clay, organic additives and water (Patel et al, 2015).

The cavity consists of squeezing and ramming the molding sand around a pattern. Maximum permeability must therefore be achieved and thus helps to remove mould gases through the sand grains. Permeability is the measurement of a porous media's flow capacity to emit gasses from an object. Design of Experiment will be the main media in this project to assess the efficiency of the sand mould's flow capacity. Design of Experiment helps to locate the ideal process for top performance and to discover the optimal product formulations and key process factors (Patel et al. 2015).

1.2 Problem statement

From the mixture of silica sand, coal powder, clay powder (bentonite) and water, each one plays a significant role in reducing and controlling casting deficiencies respectively. Mutations may occur when the maximal value of any of the components is out. First of all, the silica sand is widely used in casting process which the good quality of the sand. On other side, we detect that wasting waterjet moulding composition which commonly in industry. In another words, recycle sands will decrease the permeability value. Water helps to hold the clay together and hence optimize the strength of sand mould. The value is depending on the proportion of silica sand and recyclable sand, it is a compulsory to achieve an optimum value of recycle sand to avoid the silica sand becomes too soft and loses the bonding.

1.3 Objective

The objective of this study is to analyse and develop a sand mould from abrasive water jet waste for sand casting process. The specific research task to fulfil the objectives of this thesis are summarized as follows:

i. To investigate the optimum value of bentonite and coal dust with respect to the amount of water.
ii. To determine the best composition based on permeability, green compression strength and green shear strength between silica sand and abrasive waterjet percentage and eliminate the defects.
iii. To maximize the best green sand on composition of bentonite, coal dust and water to eliminate defects

1.4 Scope

I. Minitab software is used to analyse the effectiveness of new composition of sand through Taguchi Design with different mixture and sample.
II. The recycle abrasive particle of 40 percentage are used and the size of silica sand 60 percentage only will be used to compare its mechanical properties with mixture of bentonite, coal dust and water.
III. Composition effectiveness based on level design and parameter design factor by mean and signal to noise ratio through Taguchi method.
IV. Analyze the design with 3 factor which is Permeability testing, Green Compression Strength testing and Shear strength testing using Anova and confident interval analysis.

1.5 Significance of study

This study's findings will contribute to the study's significance for future use. These are the study's list of significance:

1. To prevent the wastage of sand resource so that it can be reused commonly as green sand by reconditioning it with water, clay and other materials.
2. The changes in the approach to recycling encourage the use of recycled sand as a potential building material.
3. More efficient use of resources, less pollutions, and improved economic competitiveness.
4. Maximize the use of the existing apparatus and machine in the laboratory to reduce cost of the whole project.

1.6 Structure of study

Chapter 1 describes the study's problem and background. This chapter also discussed the project's goal and scope. In addition, Chapter 1 also indicated the significance of the study. This allows the reader to get an initial idea of what the project is all about.

Chapter 2 describes the study's literature review in detail. It consists of the basic principles of casting sand in the manufacture of sand moulds and uses together with the benefits. It also consists if this study tries to overcome the general problem. It explains the major tasks to be considered in the stage of embodiment analysis. Also discussed here is the method pf completing the phase of the embodiment analysis.

Chapter 3 explains the methodology of this study. There are four stages in this study:

Step 1: The Planning stage

Step 2: Sample preparation

Step 3: Experimental Testing

Step 4: Report Preparation and Present

Chapter 4 is the chapter of analysis and discussion. The outcome of the Phase 1 survey and Phase 2 experiments are analyzed here. The result of the experiment is divided into two stages. The first focuses on sand mould preparation using water jet abrasive waste and the second focuses on permeability testing, green compression strength and sand mould shear strength. In this chapter, all the results and data will be recorded.

Chapter 5 is conclusion chapter. It conclude findings from this study. Generally, this chapter will conclude the project and will suggest the future work for this Abrasive Water Jet Waste (AWJW).

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

This chapter mainly explains about all findings obtained from many literature reviews, which may come from internet journals, articles, and books about the topic related to this study. Related green sand strength and its process information of previous studies is extracted as references and discussion based on their findings of the overview about sand mould, permeability, green sand strength and its process.

2.1 Sand mould

Based on journal of impact of Cement-Silica Ratio on Molding Properties of Portland Cement Bonded Sand Stated that, "Moulding sand is one of the materials used particularly in metal foundries for making mould and cores. Despite its name, moulding sand is not sand alone but a composite material made from several others materials to give some amount of heat resistance, porosity, strength and binding quality necessary to creates moulds and cores" (Ajibola et al, 2015).

2.2 Silica Sand

The primary use of silica sand is that it is readily available and inexpensive. Silica sands (silicon dioxide, SiO2) are very refractory and usually contain a small amount of

organic component. The silicon oxide is characterized by having very high softening temperature and thus having high thermal stability. The grains of silica sand will not melt and fuse together easily, they will not split into smaller particles when they contact with molten metal (Abolarin et al, 2010).

However, silica sand is not appropriate for moulding alone as it lacks binding chara cteristics. Therefore, to attain the binding property the silica paper should be comprised of bentonite and other components. The grain size of silica sand determines the permeability and refractoriness of green sand, the finer the silica sand, the poorer the permeability and refractoriness of the green sand AFS increase size 50-60 Silica Sand generally is used in the combination of green sand. The size of sand grain differs greatly between 50 and 3360 microns, and the sand is categorized appropriately as fine, medium or coarse seeds (J. P. Kaushish, 2010).

According to the article of Greensand System, the major benefits of silica sand lies in unrivalled refractoriness and permeability, consistency and the preparation in which their properties to be controlled, especially in reclamation systems. As the naturally bonded sands with their more prominent scope of moisture content and to some higher green strength, the moulder man hand worked the silica sand promptly (“Greensand System,” 2018)

The shape of sand grains can be categorized into angular, round, sub-angular or compounded. The type of green sand based on

Table 2.1 Properties of non-silica sands (compared with silica)

Property	**Silica**	**Zircon**	**Chromite**	**Olivine**
AFS grain size no.	60	102	74	65
Grain shape	Rounded	Rounded	Angular	Angular
Specific gravity	2.65	4.66	4.52	3.3
Bulk density(kg/m3)	1490	2770	26700	1700
(lb/ft3)	93	173	167	106
Thermal expansion 201200°C	1.9% Non-linear	0.45%	0.6%	1.1%
Application	General	Refractoriness Chill	Resistance to penetration Chill	Steel
Non-linear	Non-linear	Non-linear	Non-linear	Non-linear

The shape of sand grains can be categorized into angular, round, sub-angular or compounded. The type of green sand based on the density. The density of sand property main the application to assume the suitable sand to apply into the type of mixture. The grain shape of the have some characteristic of every grain shape. Table 2.2 show the characteristic of every grain shape of the sand.