UNIVERSITI TEKNIKAL MALAYSIA MELAKA

EFFECT OF RESIN RATIO ON MECHANICAL PROPERTIES OF RESIN BONDED SAND MOULD

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Manufacturing Process) (Hons.)

by

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APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Manufacturing Process) (Hons.). The member of the supervisory committee is as follow:

……..

(Dr. Nur Izan Syahriah Bt. Hussien)

ABSTRAK

Proses tuangan pasir sering digunakan di dalam industri untuk membuat produk seperti besi, gangsa, tembaga, dan aluminium. Logam pilihan dicairkan di dalam relau dan dituangkan ke dalam rongga acuan yang dibentuk daripada pasir.Di dalam industri,ia tidak mempunyai persamaan bagi merekodkan percampuran diantara bahan-bahan pada nisbah yang tertentu.Bagi kajian ini, pasir silika, PVA dan urea yang diubahsuai dijadikan sebagai pengikat resin terbiodegradasidan haba sebagai pengeras telah disediakan dengan nisbah pengeras / resin yang berbeza, dan sifat kelembapanpasir telah dikaji dengan menggunakan ujian kelembapan. Kekuatan tegangan, kekuatan mampatan, kekuatan lenturan, kekerasan, dan kehilangan pencucuhan diukur melalui proses tuangan pasir. Ujian telah dijalankan di dalam suhu bilik.Maklumat yang dikumpul kemudiannya ditukar ke dalam bentuk grafik iaitu carta bar, kesan plot utama, interaksi plot dan analisis plot untuk mendapatkan nisbah yang terbaik bagi proses tuangan pasir yang terbiodegradasi.

ABSTRACT

Sand casting is frequently utilized in the industry to make parts that are compromised of iron, bronze, brass and at times aluminum. The metal of choice is melted in a furnace and poured into a mould cavity formed out of sand. In industry, it has no recorded understanding regarding mixing all the material at different ratios. For this case study,silica sand and biodegradable resin are used for sand casting. PVA and modified urea as resin binder and heat as a hardener were prepared with different hardener/resin ratios, and their moisture content is investigated by using themoisture content instrument. Resin bonded sand casting process were proceeding for developed resin. The tests were carried out at room temperature.The collected data was then converted into graphical form that consists of bar chart, main effects plot and interaction plots. Then, all the plots are analyzed.

DEDICATION

For my father, Abdullah Bin Hasan and my mother, Rokiah Binti Yunus who provides the most supportive atmosphere of loving and caring that help me cope with the situationand for my friend.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

AFS	- American Foundry Society
AFS GFN	- Grain Fineness Number sand
PVA	-Polyvinyl Alcohol
UTM	-Universal Testing Machine
ALS	-ammonium Lignin Sulfonate
F	- Fahrenheit
g	- gram
LOI	- Loss on Ignition
kg/cm_2	- Kilogram over centimeter square
Ra	- Surface roughness
SIRIM	- Institut Piawaian dan Penyelidikan Perindustrian Malaysia
SiO_2	- Silica sand
SO_2	- Sulfur dioxide
°C	- Degree celsius
%	- Percent
μm	- micrometer

CHAPTER 1
INTRODUCTION

This chapter will describe the general information about the study of the process in resin bonded sand casting with a brief introduction to the background of the research area. The problem statement, objective and scope also included in this chapter.

1.1 Background

In general, we can describe the casting process as the leakage of a liquid metal into a mould containing a cavity with the geometry of the desired part. As a major advantage over other forming processes, is the possibility of obtaining parts of complex geometries economically.

Casting is also one of the oldest known manufacturing processes. It requires preparation of a cavity usually in refractory material to resemble closely the final object to be made (Rao, 2009). In casting, there a followed few basic primary steps. It starts with pattern making followed by making a mould base in the sand, pouring the molten metal into the mould cavity and allows it to solidify. After solidification, the mould is shakeout in order to take out the casting product. Then, the inspection will be done to identify defect present in the product. The casting process is universal process used for the manufacture of a wide variety product (Rao, 2009). There are few types of casting pro is sand casting, die casting, investment casting, permanent mould casting, centrifugal casting, shell mould casting and many more (Rao, 2009).

Green sand is the moulding sand which has been freshly prepared from silica grains, clay and moisture. It is the least expensive of all (Rao, 2009). In the resin bonded sand casting, green sand mixture is mixed with thermosetting resin (PVA and modified urea). During baking of the mould, the resin and polymerizes around the sand particle, thus bonding them together (Sharma, 2007). Phenolic sand casting or phenolic ester system is a new no bake binder technology has introduced recently to the metal casting industry (Iyer, 1987). The system is based on the alkaline phenolic resin in conjunction with an organic ester that acts as a co-reactant (Iyer, 1987). This system will be used in our case study.

Binders were developed to strengthen the cores, which are the most fragile part of a mould assembly. Paul *et al.* (2007) classify a binder is the second most important component after sand in the mould. Inorganic binders, such as clay or cement, are materials that have long been used in the production of foundry moulds and cores (James and Richard, 1986). PVA and modified urea are a new one as an organic binder that being selected as a resin binder in our case study. Polyvinyl alcohol protects the active ingredients from moisture, oxygen and other environmental components, while simultaneously masking their taste and odour (Saxena, 2004).

Hardener that's been used of biodegradable resin are not found, thus use heat as a hardener. Quality of castings in a sand mould is influenced significantly by its properties, such as compression strength, permeability, mould hardness and others which depend on input parameters like sand grain size and shape, binder, water and others (Mahesh, 2008).

1.2 Problem Statement

Nowadays, resin bonded sand casting is one of the most versatile among other casting processes. Many industries use sand casting process to produce a wide variety of metal components with complex geometries. Quality of products is very important for determining the efficiency of a process performed. The parameter setting plays an important role for the mould characteristic. Amount of resin and hardener included will also influence the quality of the mould and resulting products. Resin plays an important role in order to make the mould tougher and high strength to withstand the thermal expansion when molten metal is poured into the mould and hardened used to fasten the hardening process. There is varied range of parameters involved in resin bonded sand casting process.

In industry, it has no recorded understanding regarding mixing all the material at different ratios. The easiest way to do the set-up on the parameter is based on the operator or technician's experience, or trial and error method (SIRIM, 2012). Proper mould properties will give castings a better surface finish in the range 5-25μm of surface roughness, R_a (Kalpakjian and Schmid, 2006), more accurate dimensions and reduced penetration, drops and swells.

For this case study, analyze the moisture content of new resin bonded sand casting. Resin bonded sand casting was develop using a green sand, consist of silica grain, new resin binder as PVA and modified urea and heat as a hardened. Besides that, the suitable parameter or ratio of green sand, resin binder and hardened has been tested to get a good resin bonded sand casting.

1.3 Objective of Study

i. To study the effect of resin binder ratio to the moisture content of the mould specimens.

ii. To suggest the optimum of biodegradable resin binder ratio for the resin bonded sand mould .

iii. To perform casting process using the developed resin bonded sand mould.

1.4 Scope of Study

This study focus on resin bonded sand casting process that uses silica sand, PVA and modified urea resin as a binder, and heat as a hardener. These materials were blended together with sand within nine set of parameters with different percentage of resin to catalyst. Parameters selected that will affect the quality of the mould is the percentage of resin and hardener. The range of resin that used is 2% - 3% while the range of a hardener is 150ºC, 175 ºC and 200 ºC. After the process, a detailed study was conducted on the mould based on characteristics of moisture content and performs casting process using developed resin bonded sand mould. At the end of the experiment, all data were collected and further discussion was made to obtain a final conclusion.

Chapter Summary

In this chapter, it describes the purpose of the study on resin bonded sand casting, including objectives, problem statement and scope. More information will be discussed in great detail in the next chapter.

CHAPTER 2
LITERATURE REVIEW

This chapter describes about the articles, books and other sources that is on significant condition on resin bonded sand casting. It discusses about the process used in this study included the characteristic in the process work, method of process and type of testing used for determined characteristic of the material. The purpose to have this literature review is to offer an overview of significant literature published on the related topic.

2.1 Foundry

Shehu and Bhatti (2012) classify foundry is the mother of all industries for the reason that it provides components and raw materials for all other industries. Foundry is the most ancient industry deals with the manufacturing of metal casting (Rao, 2002). Foundry is some facilities will be found to be a useful addition to any workshop. These facilities commonly use to produce components from the cast iron, steel, copper alloys, aluminum alloys magnesium alloys and many more (Beeley, 2001). Foundry is facilities used the method casting the molten metal into the mold and created the product. The foundry can be an end in itself even when no machining is contemplated and small decorative objects can cast purely for the pleasure of making them. Cores are required for hollow castings and must be removed after the metal has solidified (James and Richard, 1986).

The metal casting process involves several stages of the casting process, starting with the melting process, followed by a pouring the molten metal into the cavity, then leaving the metal until solidified, after that removes the solidified metal from the mould. The casting process can be used to produce complex components as a complete component alone including the components of the cavity on the inside. The components in a small until the large size in several meters can be produced by a certain casting technique such as sand casting die casting, and pressure casting.

2.2 Sand Casting

Sand casting is a basic industry in which is responsible for great part of the industrial growth and extremely versatile process. Sand cast consists of pouring a molten metal or alloy into a mould of earth or sand and allowing it to solidify (Ammen, 1979). Sand casting process at the foundry is utilized expendable sand moulds to form complex metal parts. The sand casting process is to make the medium to large part such as valve bodies, plumbing fixtures, locomotive components and construction machinery (Flood, 2000.).

Sand casting is the most widely used casting process, utilizes expendable sand moulds to form complex metal parts that can be made of nearly any alloy. Because the sand mould must be destroyed in order to remove the part, called the casting, sand casting typically has a low production rate. The sand casting process involves the use of a furnace, metal, pattern, and sand mould. The metal is melted in the furnace and then ladled and poured into the cavity of the sand mould, which is formed by the pattern. The sand mould separates along a parting line and the solidified casting can be removed (Kalpakjian and Schmid, 2006).

The pattern is usually made from wood, metal and plastic (Rao, 2009). The most commonly used pattern material is wood, because the main reason being the easy availability and the low weight and also be easy to shape and is relatively cheap (Rao, 2009). The pattern may also include core prints, gates and risers, although in some cases these features can cut into the moulding sand by hand (Wang, 1999). Figure 2.1 explain about the steps in the production sequence in sand casting and can also the step to pattern-making and mold making.

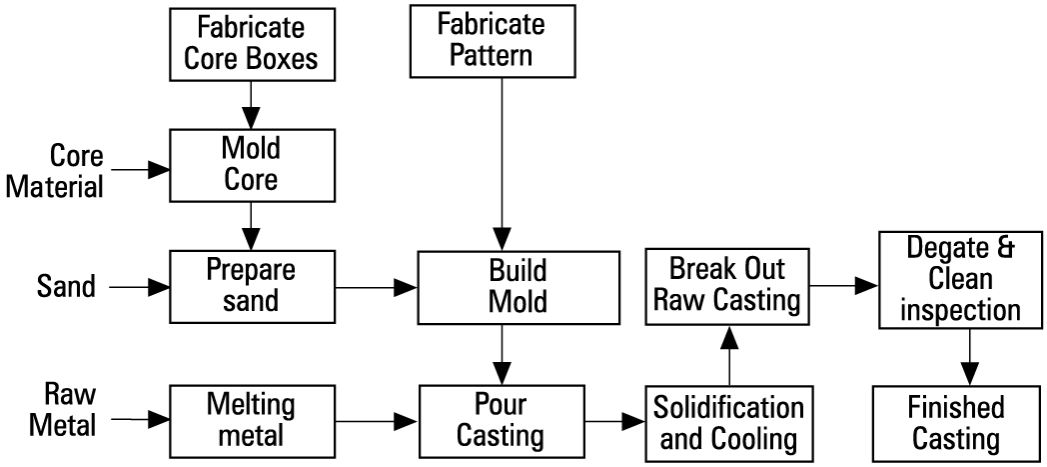

Figure 2.1: The steps in the production sequence in sand casting (Wang, 1995).

Figure 2.2 shows the terms used in the casting process. Every each term have the own functioning. The main item used is cope and drag where there are functioning as one which hold the sand mould intact and it's called as a Flask (Rao, 2009). Sprue it is used as a passage through which the molten metal from the pouring basin reaches the mold cavity (Rao, 2009). For the pouring basin functioning as a small funnel shaped cavity at the top of the mould into which the molten metal is poured (Rao, 2009).

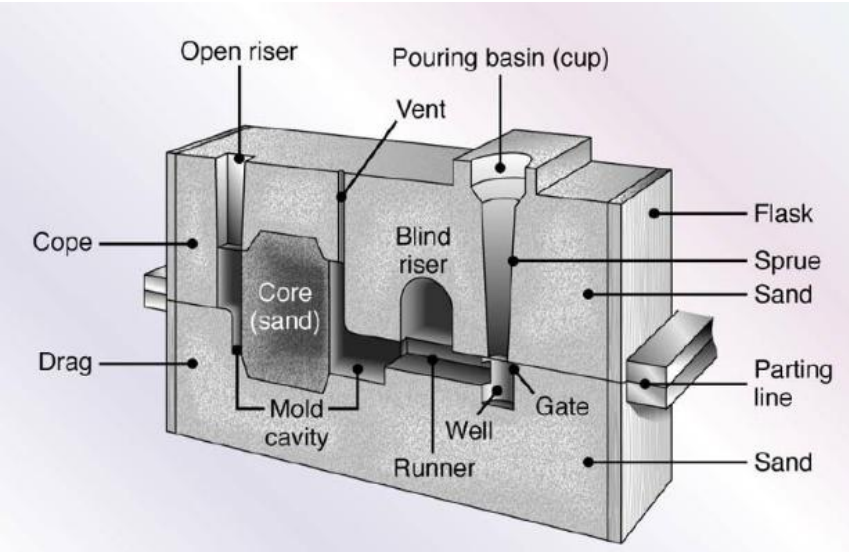

Figure 2.2: Schematic illustration of a sand mould, showing various features (Kalpakjian and Schmid, 2006).

2.3 Resin bonded sand casting

It's also known as chemically bonded sand and no bake process .Resin bonded sand casting is the same as sand casting but it uses a resin as a binder in the process. A wide variety of chemical binders are available for making sand moulds and cores (Brown, 2000). Binders were developed to strengthen the cores, which are the most fragile part of a mould assembly. Fayomi *et al.* (2011) classify suitable binder for foundry core must not only hold a grain of sand together but also be sufficiently resistant to high temperatures, in order to collapse and allow the sand to be easily removed from the casting surface to leaving it smooth. Curing of the binder system begins immediately after all components are combined (James and Richard, 1986).

Fayomi (2006) classify the ability of the binder to collapse on cooling is known as breakdown and this property is very important to cores hole, which are inaccessible to felting. Binders can be used in two ways which is a self-hardening mixture. Sand, binder and a hardening chemical are mixed together, the binder and the hardener start to react immediately with sand. Second is with trigger hardening which is the sand

and binder are mixed and blown or rammed into a core box (Brown, 2000). In general, resin bonded sand casting has a better dimensional accuracy a cast product rather than green sand casting process (Nigbo Ruican Machinery Company, 2010).

2.3.1 Mould

Mould is item to make the material into the mould shaped by cavity. Mould is the second thing important after sand to make the cavity for shaped the material form (Brown, 2000). In conventional sand casting, the mould is formed around a pattern by ramming sand, mixed with the proper bonding agent, onto the pattern. Molten metal is poured into the mould, and after the bit has solidified the mould is broken to remove the casting (Davis, 1993). The main component of mould making is flask box. The lower box knows as drag and the upper one is cope. The gating system such as riser, sprue, runner, and pouring cup is one of the channels or passages thought when molten metal enters the mould cavity as shown in the figure 2.3

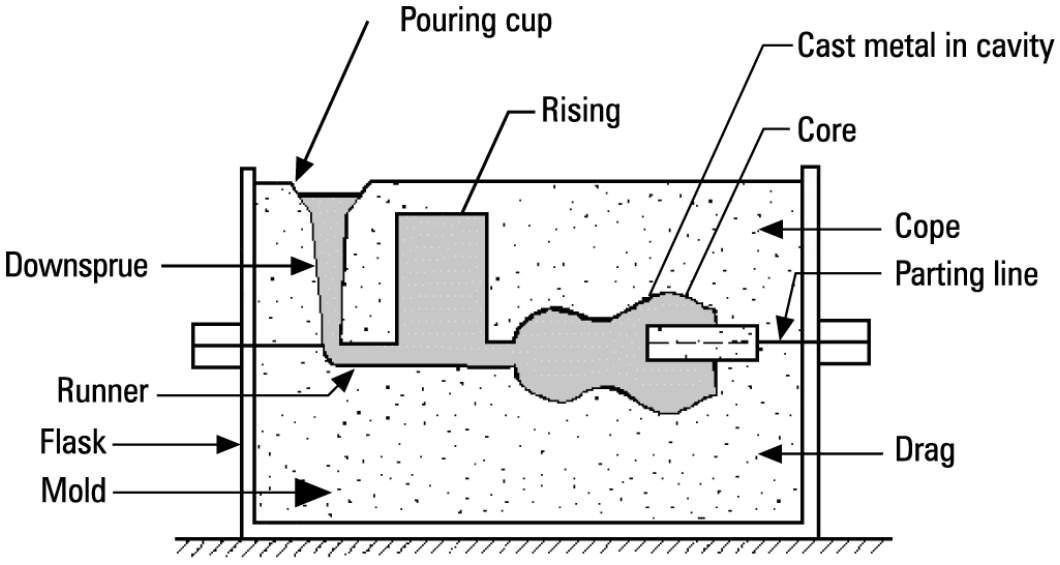

Figure 2.3 Mould components (Brown, 2000).