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Date :……

APPLICATION OF DESIGN OF EXPERIMENT FOR BELL CASTING PROCESS

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This report is submitted to the Faculty Mechanical Engineering in partial to fulfill the requirement for Bachelor Mechanical Engineering (Design and Innovation)

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"I hereby declared that this report is a result of my own work except for the works that have been cited clearly in the references."

Signature : ……

Name : Nurul Farha Bt. Abdul Rahman

Date : ……

My parents, supervisor and friends.

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ABSTRAK

Projek ini bertujuan untuk menghasilkan operasi standard yang akan digunakan di bengkel Fakulti Kejuruteraan Mekanikal. Projek ini merangkumi kajian terhadap operasi di dalam *Bell casting* yang mana ianya adalah salah satu operasi di dalam S*and Casting* untuk mengenalpasti proses parameter. Tiga faktor kawalan iaitu jenis-jenis paten, masa isian dan suhu tuangan telah dipilih, direka dan diaplikasikan dalam *Taguchi Method* yang mana *Taguchi Method* adalah salah satu aplikasi dalam Minitab. Beberapa eksperimen telah dijalankan mengikut faktor kawalan yang dipilih. Kemudian, data yang diambil daripada eksperimen dimasukkan da dianalisis menggunakan perisian Minitab. Sebagai hasilnya, operasi standard dalam Bell Casting boleh dihasilkan dan digunakan di dalam bengkel FKM.

ABSTRACT

This project aim is to generate Standard of Operation which will be used at the FKM's workshop lab. This project includes the study on operation in Bell casting which is part of the operation in sand casting to identify its process parameters. Three control factors which are type of patterns, filling time and casting temperature have been chosen and been designed and applied in Taguchi Methods in Minitab software application. Several experiments have been carried out according to the control parameter chose. Then, all the data result collected from the experiments was entered and being analyzed using Minitab software. As a result from this software, the Standard of Operation can be generated and thus will be use in FKM's workshop lab.

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ABBREVIATION

FKM	Fakulti Kejuruteraan Mekanikal
DOE	Design of Experiment
B.C	Before Century
OA	Orthogonal Array
C-E	Cause Effect
S/N	Signal to Noise
I/O	Input and Output
ANOVA	Analysis of Variance

CHAPTER 1

INTRODUCTION

1.1 Background

In manufacturing process, productivity and quality of casting depend mainly on its process parameters such as casting temperature, filling time, holding pressure, holding time, and cooling rate. To estimate the most influential parameters in casting process, many trial and errors is used to identify the best parameters to manufacture a quality cast product. However, these methods demands extensive experimental work and result in a great waste of time and money. Thus, design of experiment appears to be an important way in estimation the most process parameters and process optimization in Bell casting operation for this project because this method can save both labor cost and time spent.

1.2 Problem Statement

In manufacturing process, many problems may be faced in casting process. Bell casting process was part of the equipment in sand casting process. The quality of casting is not depends on the microstructure, but also supported by the good appearance and the casting process defects related to the process parameters in manufacturing.

Failure to control one of the process parameters can lead to give an impact in Bell casting operation. In order to overcome this failure, this project was to estimate the most influential process parameters and process optimization in Bell casting operation.

1.3 Objectives of project

The objective of this project is to estimate the most influential process parameters and process optimization in expandable mold casting which is sand casting using Bell casting operation and equipment.

1.4 Scopes of project

The main scope of this project was:

1.4.1 To study Bell casting process and its process parameters.

1.4.2 To study DOE and Minitab software.

1.4.3 To carry out empirical study on Bell casting process parameters that to be used as a Standard of Operation in FKM's workshop lab.

1.5 Significant of project

To come out with Standard of Operation in Bell casting process parameters that will be use in FKM's lab.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Literature review is the most important step to retrieve information related with the topic chooses. Literature review can be done by searching all the information from internet, journals, books, and other sources. It is important to study or research before starting any development for better understanding regarding the topic chooses.

2.2 Casting

Casting was the oldest method that is available to shape metals into useful products. Casting is a solidification process in which molten metal is poured into a mold and allowed to cool. It's basically involves pouring molten metal into a molten mold cavity where it takes the shape of the cavity. Casting was first used around 4000 B.C to make ornaments, copper arrowheads, and various other things.

As in all manufacturing, each casting process has its own characteristics, applications, advantages, limitations and costs. Casting process are most often selected over other manufacturing methods because casting can produce complex shapes and with internal cavities or hollow sections. From casting, a very large part also can be produced in one piece.

Almost all the metal can be cast in the final shape desired, often with only minor finishing operation required and because of this capabilities, it places casting among the most important net-shape manufacturing technologies. With modern processing techniques and the control of chemical composition, mechanical properties of castings can equal those made by other manufacturing process. Figure 2.1 below cited three methods of metal casting process used in manufacturing.

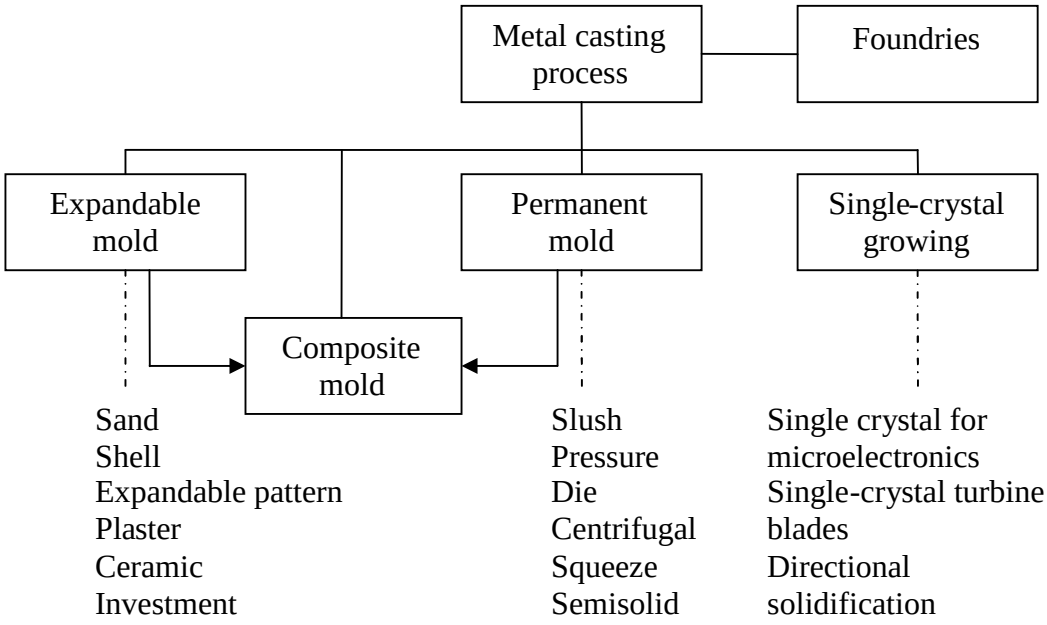

Figure 2.1 Outline of metal casting processes

(Source: Serope Kalpakjian & Steven Schmid)

2.3 Casting Processes

Various casting process have been developed over time, each with its own characteristics and applications, to meet specific engineering and service requirements. Large variety of parts and components are made by casting such as engine blocks, crankshafts, automotive components and powertrains.

There are 3 major classifications in casting practices. These classifications are related to mold materials, molding processes and methods of feeding the mold with molten metal.

The major categories are:

a) Expendables molds

It is typically made of sand, plaster, ceramics, and similar materials and generally is mixed with various binders for improved in mechanical, physical and chemical properties.

b) Permanent molds

Permanent mold are made of metals that maintain their strength at high temperatures. As the name implies, they are used repeatedly and are designed in such a way that the casting can remove easily and the mold used for the next casting.

c) Composite molds

Composite molds are made of two or more different materials such as sand, graphite and metal combining the advantages of each material. These molds have a permanent and an expandable portion and are used in various casting process to improved mold strength, control the cooling rates, and optimize the overall economics for casting process.

All casting process, its advantages, disadvantages and examples can be summarized as shown in Table 2.1 below:

Table 2.1 Summarize of different types of casting, advantages, disadvantages and examples
(Source: http://d.scribd.com/docs/1fm1ats4fjks6pn3ksin.pdf) [9]

Process	Advantages	Disadvantages	Examples
Sand	Wide range of metals, sizes, shapes, low cost	Poor finish, wide tolerance	Engine block, cylinder heads
Shell mold	Better accuracy, finish, higher production rate	Limited part size	Connecting rods, brake components
Expandable pattern	Wide range of metals, size, shape	Patterns have low strength	Cylinder heads, brake components
Plaster mold	Complex shapes, good surface finish	Non-ferrous metal, low production rate	Prototype of mechanical parts
Ceramic mold	Complex shapes, high accuracy, good finish	Small sizes	Impellers, injection mold tooling
Investment	Complex shapes, excellent finish	Small parts, expensive	Jewellery
Permanent mold	Good finish, low porosity, high production rate	Costly mold, simpler shapes only	Gears, gears housing
Die	Excellent dimensional accuracy, high production rate	Costly dies, small parts, non-ferrous metals	Precision gear, camera bodies, car wheels
centrifugal	Large cylindrical parts, good quality	Expensive, limited shapes	Pipes, boilers, flywheels

2.4 Sand Casting and Its Operation

Sand casting was one of other method in casting processes and has been used for millennia. Sand casting is still the most prevalent form of casting. Molten metal is poured into a mold cavity formed out of sand (natural or synthetic). Basically, sand casting consist of placing a pattern in sand to make an imprint, incorporating a gating system, removing the pattern and filling the mold cavity with molten metal, allowing the metal to cool until it solidifies, breaking away the sand mold and lastly removing the casting. Figure 2.2 below illustrate the production flow in a typical sand casting operation.

There were several important factors in the selection of sand for mold with respect to its properties. Sand is fine, round grains that can be pack closely and thus form a smooth mold surface. But fine-grained sand can lower the mold permeability. Good permeability of mold and cores allows gases and stream evolved during the casting to escape easily. Furthermore, mold also should be in good collapsibility to allow the casting to shrink while cooling and to avoid defects in casting such as hot tearing and cracking.

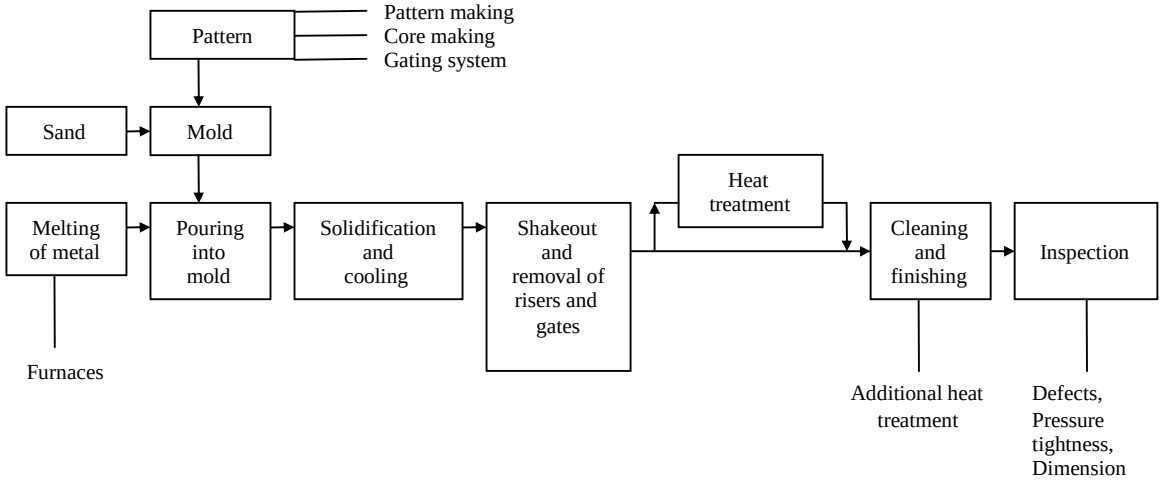

Figure 2.2 Outline of production steps in a typical sand-casting operation
(Source: Serope Kalpakjian & Steven Schmid) [1]

2.4.1 Type of Sand Molds

Sand mold can be characterized by the types of sand and by the method used to produce them. There are three basic types of sand molds: green-sand, cold-box, and no-bake molds. The most common mold material is green molding sand, which is mixture of sand in the mold is moist or damp while the metal is being poured into it. Green-sand molding is the least expensive method of making molds, and the sand is recycled easily for subsequent use. In the skin-dried method, the mold surfaces are dried, either by storing the mold in air or by drying it with torches. Because of their higher strength, these molds generally are used for large casting.

In the cold-box process, various organic and inorganic binders are blended into the sand to bond the grains chemically for greater strength. These molds are more accurate dimensionally than green-sand mold but are more expensive. In the no-bake mold process, a synthetic liquid resin is mixed with the sand, and the mixture hardens at room temperature. It was called as cold-setting processes because the bonding of the mold in this and in the cold-box process takes place without heat.

Pattern

Patterns are used to mold the sand mixture into the shape of the casting which is typically made out of wood, plastics and sometimes metal. Pattern can be design with a variety of features to fit the specific applications and economic requirements. The pattern design is a critical aspect of the entire total casting process. The design should be provide for metal shrinkage, ease of removal from the sand mold by mean of a taper or draft and proper metal flow in the mold cavity.

Core

Core is a sand shape inserted into the mold to produce the internal features of the part such as holes or internal passages. Cores are placed in the cavity to form holes of the desired shapes. The common problem with core is that they may lack sufficient structural support in the cavity. A riser is an extra void created in the mold to contain excessive molten material. The purpose of this is feed the molten metal to the mold cavity as the molten metal solidifies and shrinks, and thereby prevents voids in the main casting.

2.4.2 The Sand Casting Operation

After the mold had been shaped and the cores have been placed in position, the two halves (cope and drag) are closed, clamped, and weight down to prevent the separation of the mold section under the pressure exerted when the molten metal is poured into the mold cavity. A complete sequence of operation in sand casting is shown in Figure 2.3 below.