A STUDY ON MOLD MATERIAL AND COATING EFFECT IN SAND CASTING PROCESS

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Thesis submitted in fulfillment of the requirements for the award of the degree of Bachelor of Mechanical Engineering

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SUPERVISOR’S AND CO-SUPERVISOR DECLARATION

We hereby declare that we have checked this project and in my opinion, this project is adequate in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering.

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STUDENT’S DECLARATION

I hereby declare that the work in this project is my own except for quotations and summaries which have been duly acknowledged. The project has not been accepted for any degree and is not concurrently submitted for award of other degree

Signature
Name:
ID Number:
Date:
For my beloved parents that give a lot of support to me, my friends that fighting alongside me and my supervisor and co-supervisor that trying hard giving me ideas in completes this thesis.

Your unconditional love means the world to me....
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ABSTRACT

Surface finish is the most desired characteristics to be on product surface. This is because surface finish is a predictor of the performance of a mechanical component, since irregularities in the surface may form nucleation sites for cracks or corrosion. In this study, the impact of mold material and coating on surface finish in sand casting was investigated. By using different kind of material to make the mold and evaluating whether coating give effect to product surface finish, the experiment had been done in 4 different tests by using sand casting process as a method to make the final product. In sand casting process, mold material and coating are two significant concerns, but they have different impact in surface finish. In producing part using sand casting, analyzing test is commonly made between these two features to get good quality surface finish. A result among these two different parameters concerns can be achieved by getting the experiment done which on the other hand, selection of better mold material and use of coating will further provide an improved solution. In this thesis, efforts towards determining good surface finish will be decide using different mold properties and coating. The quality of the surface roughness is determined by using visual and analysis. This Surface Roughness is obtained based on the analyzed using MAHR Perhometer s2. In this present work, the main objective of this study is to analyze the effect of coating between two patterns and decide which one has a better surface finish and to compare mold material whether carbon dioxide, CO₂ molding or Greensand molding with and without coating and their effect in product surface finish. The standard design approach is implemented in this experimental study where it only consists of 2 factors at one time which are coating and mold material.2 patterns and 4 final products are produced, whereby the study output is surface roughness, Ra (µm). In this study, MAHR Perhometer s2 is used to measure the surface roughness. The comparison between pattern and product will be analyzed. From the findings, it is shown that that product that used carbon dioxide CO₂ as mold material and covered with coating has the best surface finish. Based on the study analysis, it is discovered that using green sand as mold material and not using coating produces poor surface finish while carbon dioxide CO₂ with coating produces good surface finish products.
ABSTRAK

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<td>AA</td>
<td>Aluminum alloy</td>
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<tr>
<td>Al</td>
<td>Aluminium</td>
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<tr>
<td>ASTM</td>
<td>American Society for Testing and Materials</td>
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<tr>
<td>CAD</td>
<td>Computer-aided drafting</td>
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<td>CO₂</td>
<td>Linear generator</td>
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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Nowadays, surface finish of the casting product is one important thing to determine the performance of the product. It’s depend on how the product being made whether using machining, casting or any other method to make the product. Although living in an age where new technologies demand exotic manufacturing techniques, most products still require traditional manufacturing processes and carry along their inherent environmental ramifications. Developing countries entering mass production, in particular, are taking on an increased environmental burden in manufacturing. Complex products like semiconductors (Williams, 2002) and cars are frequently subjected to life cycle assessments as a part of or in conjunction with environmental impact analyses. For conventional processes like sand casting, such an evaluation is uncommon. Sand casting is one of the methods that require improvement for surface finish. The design of sand molds, which produce castings with high geometric complexity and material properties, has largely been a reactive engineering endeavor. Typically, mold designs go through iterations before a final configuration is achieved. Much of this is due to the uniqueness and complexity of the process itself; and engineers in this industry are continuously gaining more insight into control of the key variables every day largely through focused experimentation and experience. An ideal situation would be to control all the key influential process variables to produce a mold design robust enough to produce castings to the required specifications.
Apart from that, different mold material and uses of coating will determine whether the final product will have good surface finish in sand casting process.

1.2 PROJECT OBJECTIVES

(i) To analyze the effect of coating between two patterns and decide which one has a better surface finish.
(ii) To compare between 2 mold materials whether carbon dioxide, CO\(_2\) molding or Greensand molding with and without coating and their effect on product surface finish

1.3 PROJECT SCOPES

The scopes of the study include:

(i) Design a model of component part of mechanical vise using Solid Works or CAD software.
(ii) Build a prototype of component part of mechanical vise using selected polystyrene.
(iii) Compare whether coating has effect on surface finish.
(iv) To compare between 2 mold materials whether carbon dioxide, CO\(_2\) molding or Greensand molding with and without coating and their effect on product surface finish

1.4 PROJECT BACKGROUND

Mechanical vise is a clamping device usually consists of two jaws closed or opened by a screw or lever which is used to secure a workpiece to the cross slide. In clamping workpiece, vise is important which is it always been using in some process. The surface of the workpiece that been clamped using vise depends on the surface of the vise where a
good mechanical vise must have good surface so the workpiece do not damaged because of
the clamp.

Using solid work software, component part of mechanical vise will be designed. Then, prototype of the component part of mechanical vise will be built by selected polystyrene using Styrofoam cutter. In this process, two parameters will be tested which are coating effect and mold material. Final product will be made using sand casting process where better surface finish of the final product will be selected between the 2 types of mold material and coating effect.

1.5 PROBLEM STATEMENT

Surface finish is the most desired characteristics to be on machined surface. It’s a predictor of the performance since irregularities may form cracks or corrosions leads to failure. Worst surface finish will effect the performance of the vise where the surface of the vise must have good surface finish to clamp the workpiece, so that the workpiece will not damaged when machining. The aim of this study is to find out the answer whether good surface finish depends on mold material, coating effect or mold design by using sand casting process.
CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter reviews about literature review of some recent project or existing experiment. In this experimental study, there will be two phases. Pattern using selected polystyrene of mechanical vise being make in phase one while mold material and coating effect being investigated in phase two. In this chapter, it will explain about how the pattern being made using polystyrene, sand casting process, surface roughness and material used.

2.2 PRODUCT MEASUREMENT

Process digitizing or measuring component is very important where this process is aimed to find out the product dimensions. There are two types of this product measurement which are called contact method and without contact method. For this experimental study, contact method will be used in measuring the surface roughness. MAHR perthometer s2 will be used for measuring the shaft surface roughness, Ra. This machine is in high level quality, results in the nanometer range and its tolerance monitoring with optic and acoustic signaling. The ranges or resolution of this machine are ± 25 μm/0.8 nm (± 1,000 μin/0.032 μin). This machine is including with PZK drive unit with integrated datum plane for precise measurements up to 20 mm (0.787 in) tracing length (MarSurf, 2007)
2.3 MATERIAL USED

Material that been used in this study will described with detail in below.

2.3.1 Rapid Tooling (RT)

Rapid tooling is a standardized process for building both aluminum and steel injection molds to achieve an expedited delivery. The molds can be built as prototype tools or unit tools. Prototype tools are used when the customer is only concerned with the end product which is a part that meets their specifications. Unit tools are used when the customer requires a part that not only meets the required results, but also processes similar to a production tool. Prototype tools are typically less expensive, faster to build and usually used when volumes are less than 10,000 parts, while unit tools are often used when volumes up to 50,000 or more are required. Unit tools are typically more complex but can
usually be completed within 3 - 5 weeks. Depending on the application both types of tooling can be employed to meet low volume production needs as well.

The criteria to distinguish rapid tooling from conventional tooling include:

(i) Build time is much shorter
(ii) Cost is lower
(iii) Tool life is considerably less
(iv) Tolerances are wider

### 2.3.2 Indirect Tooling

Indirect RT methods are alternatives to traditional mould making techniques. The aim of these RT methods is to fill the gap between RP and hard tooling by enabling the production of tools capable of short prototype runs. The broad range of indirect RT solutions makes it difficult to determine the most appreciate method for a particular project. Most rapid tooling today is indirect: RP parts are used as pattern for making moulds and dies. RP models can be indirect used in a number of manufacturing processes:

(i) Sand casting
(ii) Vacuum casting
(iii) Investment casting
(iv) Injection molding

### 2.4 SURFACE METROLOGY

Surface metrology is the measuring of small-scale features on surfaces, and is a branch of metrology. Surface primary form, surface waviness and surface roughness are the parameters most commonly associated with the field. It is important to many disciplines and is mostly known for the machining of precision parts and assemblies which contain mating surfaces or which must operate with high internal pressures. Surface Metrology is
the study of surface geometry, also called surface texture or surface roughness. The approach is to measure and analyze the surface texture in order to be able to understand how the texture is influenced by its history, (e.g. manufacture, wear, and fracture) and how it influences its behavior (e.g. adhesion, gloss, friction).

2.4.1 Surface Roughness

Finest surface roughness is the most desired characteristic to be on machined surface. Good quality surfaces improve the fatigue strength, corrosion and wear resistance of the workpiece. The roughness of the surface can be measured by calculating the arithmetic mean value (Ra) as the best estimate for the true value of a set of experimental measurements (Alp Mithat Ozanoğuz, 2000). In this research, there are two separate directions of surface roughness measurement taken to determine the different value from both sides. Average surface roughness on horizontal direction measurement is expected more critical than vertical direction due to the position of the lay direction. Roughness is a measure of the texture of a surface. It is quantified by the vertical deviations of a real surface from its ideal form. If these deviations are large, the surface is rough; if they are small the surface is smooth. Roughness is typically considered to be the high frequency, short wavelength component of a measured surface. Roughness plays an important role in determining how a real object will interact with its environment. Rough surfaces usually wear more quickly and have higher friction coefficients than smooth surfaces. Roughness is often a good predictor of the performance of a mechanical component, since irregularities in the surface may form nucleation sites for cracks or corrosion.

Although roughness is usually undesirable, it is difficult and expensive to control in manufacturing. Decreasing the roughness of a surface will usually increase exponentially its manufacturing costs. This often results in a trade-off between the manufacturing cost of a component and its performance in application. In this project, a study of roughness parameters obtained through the use of these manufacturing processes will be made. For roughness height, it is the height of the irregularities with respect to a reference line. It is
measured in millimeters or microns or micro inches. It is also known as the height of unevenness. While for roughness width, the roughness width is the distance parallel to the nominal surface between successive peaks or ridges which constitute the predominate pattern of the roughness. It is measured in millimeters.

For waviness, this refers to the irregularities which are outside the roughness width cut off values. Waviness is the widely spaced component of the surface texture. This may be the result of work piece or tool deflection during machining, vibrations or tool run out. For example, Figure 2.2 shows sandpapers of different Bgrits.

![Figure 2.2: Surface roughness. These are photographs of pieces of sandpaper of varying grit painted the same shade of gray](image_url)

Source: Dr. Caleb M. Li 1999

The resultant roughness produced by a machining process can be thought of as the combination of two independent quantities which are ideal roughness and normal roughness.
2.4.2 Ideal roughness

Ideal surface roughness is a function of only feed and geometry. It represents the best possible finish which can be obtained for a given tool shape and feed. It can be achieved only if the built-up-edge, chatter and inaccuracies in the machine tool movements are eliminated completely.

![Diagram of surface roughness parameters](image)

- $f$: feed
- $\phi$: major cutting edge angle
- $\beta$: working minor cutting edge angle

**Figure 2.3**: Idealized Model of Surface Roughness

Source: Dr. Mike S. Lou 1999

2.4.3 Natural Roughness

In practice, it is not usually possible to achieve conditions such as those described above, and normally the natural surface roughness forms a large proportion of the actual roughness. One of the main factors contributing to natural roughness is the occurrence of a built-up edge. Thus, larger the built up edge, the rougher would be the surface produced, and factors tending to reduce chip-tool friction and to eliminate or reduce the built-up edge would give improved surface finish.
2.4.4 Surface Texture

The terms surface finish and surface roughness are used very widely in industry and are generally used to quantify the smoothness of a surface finish. In 1947, the American Standard B46.1-1947, “Surface Texture”, defined many of the concepts of surface metrology and terminology which overshadowed previous standards. A few concepts are discussed and shown as follows (Brosheer, 1948; Hommel, 1988; Olivo, 1987; ASME, 1988):

(i) Surface texture: Surface texture is the pattern of the surface which deviates from a nominal surface. The deviations may be repetitive or random and may result from roughness, waviness, lay, and flaws.

(ii) Waviness: Waviness should include all irregularities whose spacing is greater than the roughness sampling length and less than the waviness sampling length.

(iii) Lay: Lay is the direction of the predominant surface pattern, normally determined by the production method.

(iv) Flaws: Flaws are unintentional, unexpected, and unwanted interruptions in the topography typical of a part surface.

(v) Roughness sampling length: The roughness sampling length is the sampling length within which the roughness average is determined. This length is chosen, or specified, to separate the profile irregularities which are designated as roughness from those irregularities designated as waviness.