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Metal Casting Process and Defect Analysis on Pulley B3 × 7 inches

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***Abstract* - Metal recycling casting is an alternative for the development of the foundry industry in Indonesia. The use of scrap metal as industrial raw material is increasing, so that it becomes a trading commodity and encourages the development of metal smelting businesses. The objective is to study the metal casting process of the B3 × 7 inches pulley using the sand casting method and to analyze the defects that appear on the B3 × 7 inch pulley. Pulley is one of the casting products with materials from cast iron which is used as a machine propulsion tool. The raw material from cast iron which is produced itself consists of scrap left over from smelting, gram, charcoal, silica and the addition of slag remover. The resulting cast iron is melted in an induction furnace at a temperature of 1350 – 1450˚C. The smelting results are then poured into wet sand molds using a ladle, then the castings are cleaned and checked for defects (quality control) prior to machining and finishing processes. Carried out product analysis and found casting defects that occurred due to external and internal factors such as defects in air voids, crack defects, and collapsed molds (kataochi).**

Keywords: Casting, Defect Analysis, Pulley, Sand Casting.

I. INTRODUCTION

Metal casting is a process of creating parts or products made from liquid metal by filling a previously determined mold. This process can be used to make various products from various types of metal such as iron, aluminum, copper, and others. Metal casting can be done using various methods such as sand casting, metal casting, and plastic casting. The metal casting process is very important in the manufacturing industry as it can be used to make products with high accuracy and can be used to make products in large quantities.

The process of metal casting using the sand mold method is one of the methods of metal casting that uses a mold made of sand as the base material. In this process, sand mold is used to create the desired product shape, then filled with liquid metal. After the liquid metal solidifies, the sand mold is opened and the resulting product is removed [4]. Singh et al, it discusses how the process of metal casting using the sand mold method can be used to make products with complex shapes and can be used to make products in large quantities at a relatively low cost. The journal also presents various variations of the process of metal casting using the sand mold method such as vertical sand casting, horizontal sand casting, semi-automatic sand casting and automatic sand casting [5].

The sand casting method is the oldest known and utilized casting method by humans since 4000 B.C. Sand casting and its branches have now developed rapidly, with more than 90% of casting products being produced using the sand casting process [2].

Sand casting is the most widely used metal casting process and it is also the simplest, most economical and versatile casting method. It is a process by which a sand mold is formed by packing sand around a pattern. The mold is then separated, and the solidified casting is removed. The process is capable of producing castings with good surface finish and dimensional accuracy [6]. Surdia et al, it discusses how simulation models can be used to predict the solidification and cooling process of products produced from metal casting process using sand. The journal also presents how the sand casting process can improve the quality of the produced products [7].

The temperature required to melt iron and other metals varies depending on the type of metal used. Iron casting requires a temperature of around 1,538 degrees Celsius to melt. Other metals, such as copper and silver, require lower temperatures to melt. In a journal article about the temperature of iron melting by Agrahari et al, it states that the melting temperature of metal is 1800˚C at normal atmospheric pressure [1].

Pulley is a mechanical device consisting of a large-diameter wheel equipped with a belt or rope. The belt or rope can be moved around the wheel, thereby transmitting power from one shaft to another. Pulleys are used to transmit power, increase output power, reduce torque, and change the direction of rotation. Pulleys are used in a variety of applications such as machinery, transportation, and construction.

Reject casting is a product that is produced from metal casting process that does not meet the specified specifications

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or standards. Reject casting can be caused by various problems such as casting defects, errors in the manufacturing process, or errors in design. Products that are considered as reject casting usually have to be discarded or repaired before they can be used. Reject casting can cause cost and time losses, so it is necessary to have good quality control in metal casting process to reduce the number of reject casting produced.

Lu and Mofty has discuss about examines the factors affecting defects in the metal casting process, including the quality of raw materials, mold design, mold-making process, temperature control, pressure, and speed of pouring molten metal [3].

II. RESEARCH METHODOLOGY

The following is a flowchart of the steps involved in the metal casting process.

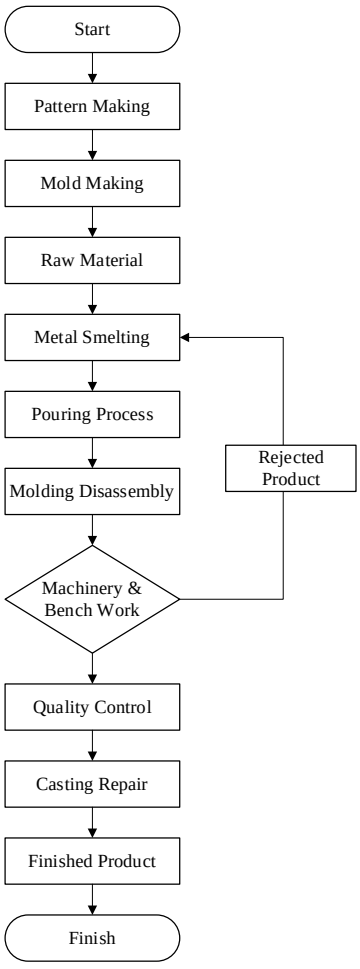

Figure 1: Flow chart of metal casting process

2.1 Pattern Making Process

The process of creating a pattern in metal casting involves several steps, including:

a) Designing: creating a detailed design of the desired final product, taking into account factors such as size, shape, and function.
b) Modeling: creating a physical representation of the design, usually using materials such as wood, metal, or plastic.
c) Patternmaking: creating a replica of the model, which will be used as a mold for the molten metal.
d) Finishing: polishing and smoothing the surface of the pattern to ensure a smooth finish for the final product.
e) Cores making: creating cores, which are internal shapes or cavities that will be incorporated into the mold.
f) Assembly: Putting together all the parts of the pattern and cores to create the complete mold.
g) Cleaning: cleaning the surface of the pattern to remove any impurities or debris before casting.

The process of creating a pattern is an important step in the metal casting process, as it determines the quality and accuracy of the final product.

2.2 Casting Making Process

The process of creating a mold in sand casting involves several steps, including:

a) Creating a pattern: a physical representation of the desired final product is created using materials such as wood, metal, or plastic.
b) Building a flask: a box-like frame, called a flask, is used to contain the sand mold during casting.
c) Pouring the molding sand: The flask is filled with molding sand, which is packed around the pattern to create the mold.
d) Removing the pattern: Once the molding sand has hardened, the pattern is removed, leaving a hollow space in the shape of the final product.
e) Making cores: if the final product has internal shapes, cores are created and placed in the mold.
f) Closing the mold: The two halves of the flask are closed, and the sand mold is now ready for casting.
g) Pouring the molten metal: The molten metal is poured into the mold through a sprue, and allowed to cool and solidify.
h) Knockout: After the metal has cooled and solidified, the sand mold is broken and the casting is removed.
i) Finishing and cleaning: The casting is cleaned and finished to remove any sand or impurities and achieve the desired surface finish.

This process of creating a mold in sand casting is a cost-effective method and can create complex shapes, but it is less accurate than other casting methods.

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2.3 Metal Smelting

The process of melting metal using induction heating involves several steps, including:

a) Loading the metal: The metal to be melted is loaded into a container, such as a crucible, which is placed in the induction heating machine.
b) Generating an electromagnetic field: The induction heating machine generates an electromagnetic field by passing an alternating current through a coil.
c) Inducing eddy currents: The electromagnetic field induces eddy currents in the metal, which generates heat and melts the metal.
d) Temperature control: The temperature of the metal is controlled by adjusting the power of the electromagnetic field.
e) Melting the metal: The metal is heated until it reaches its melting point and is fully melted.
f) Pouring the molten metal: The molten metal is poured into molds or castings for solidification.
g) Cooling and solidifying: The molten metal is cooled and solidified to obtain the final product.

Induction heating is a precise and efficient method for melting metal, it also allows for a more accurate temperature control compared to other melting methods. It is often used for the production of small to medium size castings and is a suitable method for both ferrous and nonferrous metals. The temperature required for iron casting in the metal casting process ranges from 1350˚C - 1600˚C.

2.4 Pouring Process

Before the pouring process, the temperature of the molten metal is measured using a thermometer and the temperature of the molten metal should be around 1350 – 1450 ˚C (for iron casting). If the pouring temperature is less than 1300 ˚C, it will result in reduced fluidity and casting defects such as less precise size of the casting due to the rapid solidification process. But, if the pouring temperature is above 1350 ˚C, it will result in casting defects such as pinholes.

2.5 Mold Disassembly

The shakeout process is done in two steps, after the shakeout is completed, about 15 minutes (the casting is in a solid state), the casting is immediately removed from the sand mold.

2.6 Bench work and Finished Product

After the shakeout process, the casting is then subjected to bench work such as turning and grinding, in order to achieve the desired final result. If there is any remaining sand adhered to the casting during the shakeout process, it is cleaned using a shot blasting machine to remove any remaining liquid metal sand.

III. RESULTS AND DISCUSSION

3.1 Product Specifications

Product Name: Pulley
Type: B3 × 7 inches

The product can be seen in the following Figure. 2.

Figure 2: Pulley B3 × 7 inches

3.2 Reject Casting

In some casting processes, a number of products produced can have various types of defects depending on their condition. Many defects are commonly found in castings. Producing castings involves many processes, and in these processes, there are many factors that cause defects, so it is difficult to determine the causes of these defects.

3.2.1 Porosity

Porosity: is a condition where the metal does not melt completely and leaves air pockets in the cast metal. So, after solidifying it will form holes on the surface of the cast and some even inside the cast. This defect can reduce the strength of the cast; the product is shown in Figure 3.

Figure 3: Porosity

The causes of this defect include:

a) Incompatible sand permeability.
b) Improperly made channels.
c) Sand being too wet.

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Prevention methods include:

a) Ensuring that the metal does not stay in an oxidizing area when the coke bottom is melted.
b) Making sure that the pouring temperature of the metal is appropriate and handled quickly.
c) Careful mold-making with proper permeability, adequate compaction, and enough vent holes.
d) Using high pressure on the top of the part.

3.2.2 Crack Defect

Cracks can be caused by shrinkage or residual stress. Due to uneven cooling during solidification. The shape of the defect can be seen in Figure 4.

Figure 4: Crack defect

This defect is caused by several factors, including:

a) Casting planning that does not take into account the solidification process, such as uneven wall thickness of the cast.
b) The surface of the mold and core retain the expansion of the cast.
c) Inadequate size of down sprue and riser.

Efforts to prevent cracking defects are as follows:

a) Filling liquid metal from several places.
b) Pouring time should be as short as possible.
c) Avoiding sharp-angled cast.
d) Avoiding sudden changes in the wall of the cast.

3.2.3 Collapse Defect

Collapse mold defect in metal casting is a defect that occurs when the mold collapses during the casting process can be seen Figure 5.

Figure 5: Collapse mold defect

This can happen due to various reasons such as:

a) Improper mold making: If the mold is not made properly, it can cause the mold to collapse during the casting process.
b) Improper material selection: Using the wrong type of molding material can cause the mold to collapse during the casting process.
c) Improper casting process: If the casting process is not controlled properly, it can cause the mold to collapse.
d) Improperly made gating and risering: If the gating and risering system is not designed properly, it can cause the mold to collapse during the casting process.
e) Improperly designed cope and drag: If cope and drag is not designed properly, it can cause the mold to collapse during the casting process.

Collapse mold defect can cause the final product to not function as intended and also affect the overall appearance of the final product. To prevent collapse mold defect, proper mold design, material selection, and casting process control are important.

IV. CONCLUSION

From this study, several conclusions were obtained regarding the topics have been described, such as:

1) There are several key points to consider in the metal casting process for the B3 x 7 inches pulley, as follows:
   a) The casting process uses the sand casting method.
   b) The molding material planning requires the right composition, especially to keep the mold strong and easy to shape.
   c) The pattern mold uses metal and aluminum materials, so it can be used repeatedly.
2) When pouring molten metal into the mold, it is necessary to ensure that the temperature when entering the mold is at a temperature of 1350 - 1450˚C so that the molten metal does not experience premature freezing.

Some defects were found, including air pocket defects, cracking defects, and mold collapse (kataochi). This is caused by several factors such as lack of regular checks on the mold, the mold is less precise, and the lack of density of the molten metal that is poured into the mold.

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