DESIGNING AND CONSTRUCTING A SAND MOULD FOR SHIP PROPELLER CASTING USING DYNAMIC CENTRIFUGAL CASTING METHOD

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ABSTRACT

Propeller manufacturing is an extensive subject, embracing not only many engineering machine shop skills, but also foundry techniques related to the casting of quantities of metal. Furthermore, the skill of propeller manufacturing relies on two factors, i.e. interpreting the hydrodynamic design into physical reality and ensuring that the manufacturing process does not give rise to defects, which could bring about a premature failure of the propeller. This research is based on sand moulding process in producing great and perfect propeller making. The idea is to propose an alternative manufacturing process for ship propeller using centrifugal casting method. The process involves the production of propeller by using sand casting in different ways. In sand casting process, moulding is the most important part that has been applied in order to make the propeller in perfect form. The propeller can be produced using different experimental methods. For the dynamic centrifugal casting method, carbon dioxide sand mould has been chosen because of the hardness of this mould could achieve 97.5 Brinell, which is suitable for this casting method by following the standard set by the American Foundry Society (AFS). Through the experiment conducted, it was found that this sand mould provides great dimensional tolerance and accuracy in the production of propeller, with moisture being completely eliminated from the moulding sand.

Keywords: dynamic centrifugal casting; hardness; premature failure; propeller; sand mould

INTRODUCTION

Propeller manufacturing is an extensive subject, embracing not only many engineering machine shop skills, but also foundry techniques related to the casting of quantities of metal, sometimes of the order of 200 tonnes, into a precise geometric form. Furthermore, the skill of propeller manufacturing relies on two factors, i.e. interpreting the hydrodynamic design into physical reality and ensuring that the manufacturing process does not give rise to defects, which could bring about the premature failure of the propeller (Rawson, 2001). Propeller manufacturing relies on two basic techniques; the use of full pattern for multiple usage or the construction of a unique mould, which will be broken up after casting (Carlton et al., 2009). The technique to be used is a techno-economic question depending on the type of propeller, the numbers to be produced, the finishing technique and the size of the propellers. However, in order to gain an understanding of the manufacturing process in generalized term, the traditional method of manufacturing will be described before outlining the range of variants to this process (Carlton, 2007). Originally, propellers were of simple shape and made in either cast iron or steel. These early propellers were usually cast in the engine builder’s own foundry and were fitted to the vessel in a largely ‘as-cast’ condition, except for some necessary fettling and machining of the bore. Today, the material used has largely changed to bronze that enables propellers to be manufactured to a high standard of surface finish and dimensional accuracy in foundries and workshops devoted solely to the manufacture of propellers. Each propeller is nominally of a different design, and as a consequence it is quite rare for a propeller manufacturer to receive a significant run of propellers to the same design, particularly for large propellers. The traditional method of manufacturing, therefore, reflects this situation and is based on the production of a mould for each propeller, which will be manufactured.

LITERATURE RESEARCH

The requirement of this study is to verify the quality of sand mould for propeller. In this study, the initial stage is to prepare the basic about the existing sand mould that will be the reference of this research. The requirement of this research is also about the sand moulding for the dynamic centrifugal casting process. Based on the requirement, the bonding material of the sand mould will be calculated to find the suitable bonding to make sure the product will achieve the target of product quality and smooth process when dynamic centrifugal casting process is running (Yu, 2001). This study also needs to gather the requirement for the foundry standards according to World Foundry Organization (WFO). Several classification societies are referred such as American Foundry Society, AFS (Rao, 2006).

The existing sand mould is usually constructed for static casting. The bonding between the additive materials is low as compared to mould for dynamics centrifugal casting. The existing sand mould usually uses the green sand method for ship propeller. Besides that, the permanent mould is also used in propeller manufacturing.

The probability of sand mould can be defined in making process and in the casting process. In the mould making process, the probability can be defined when the additive material is not in an exact quantity, it will be affect the bonding between materials used (Jain, 2006). Besides that, the probability of sand mould can also be defined during the casting process, as it may cause sand to drop and will affect the product.

METHODOLOGY

Experiments were conducted by using two methods, which are Carbon Dioxide Sand Mould and Green Sand Mould. Both of these sand moulds have been constructed following the steps required and also by using several measurements of material used. It is because, different percentage of additive material will cause different hardness. This study will use the Copper Aluminium Bronze as the metal for casting process to enable the hardness to be suitable and follow the American Foundry Standard for centrifugal casting method for the metal used (Ramana, 2013).

Figure 1. Carbon Dioxide Sand Mould

Figure 2. Green Sand Mould

RESULTS AND DISCUSSION

A comparison between Carbon Dioxide Sand Mould and Green Sand Mould has shown their own hardness for every trial using the Hardness manual Tester B-Scale as shown in Fig. 3. The results obtained from the experiment are presented in Table 1 and 2.

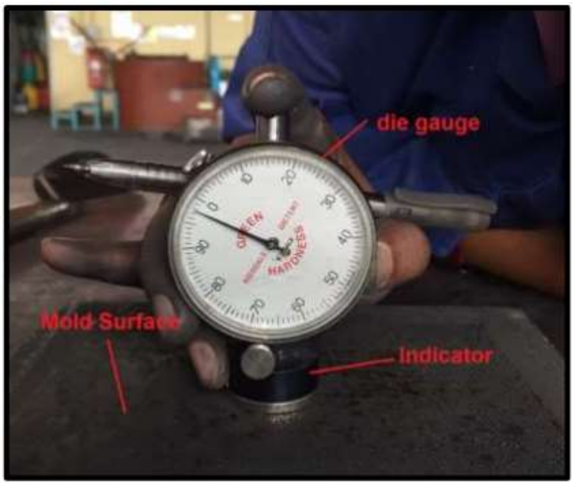

Figure3. B-scale hardness Tester

Table 1. Hardness Test of Carbon Dioxide process

Trial No.	Sodium Silicate , %	Gassing Time,s	Mixing Time,min	Mould Hardness,Brinell
1	4	15	5	53.1
2	5	30	5	66
3	5	35	7	65
4	6	45	5	78
5	6	48	8	70
6	6	55	7	82
7	6	60	10	97.5

Table 2. Hardness Test of Green Sand Mould

Trial No.	Bentonite , %	Coal Dust, %	Water, %	Mixing Time,s	Mould Hardness,Brinell
1	10	5	10	45	54
2	15	10	10	55	59
3	20	15	10	60	61
4	25	20	10	70	65
5	30	25	10	80	69.5
6	35	30	10	85	70.5
7	40	35	10	90	75

From Table 1, it can be observed that the mould hardness value increases as the percentage of sodium silicate increases. At lower percentage of sodium silicate, higher gassing time leads to decrease in mould hardness. The reason could be the over gassing of the sand specimen. Besides that, the time taken for mixing also can affect the mould hardness in the Carbon Dioxide Sand Mould process. Table 1 demonstrates accurate results for every trial. Table 2 shows the characteristic of Green Sand Mould hardness of experiment value are lower compare to Carbon Dioxide Sand Mould. These results show that the Green Sand is not suitable for casting mould materials. This is because the melting point of the Copper Aluminium Bronze metal used for casting needs to be given serious concern since low mould hardness can affect the final product. The metals used for casting have their own characteristics. From the data gathered after that experiment, the Carbon Dioxide sand mould is chosen, where the hardness value is 97.5 Brinell (Altan, 2007). This value is usually stated in American Foundry Society (AFS) as a suitable hardness of mould that can be used for high melting point casting and involved with medium vibrations.

The centrifugal casting method has been the reason for this process to be chosen. This casting method has been tried with several rotation speeds to find out the best speed to produce a good product. Finally, a good product can be defined by mechanical testing.

CONCLUSION

Based on the data gathered, it can be concluded that the hardness of sand mould for both processes, which are Carbon Dioxide Sand Mould process and Green Sand Mould process have their own special bonding. The Carbon Dioxide Sand Mould process has been chosen for this project that involved the sand mould centrifugal casting for Copper Aluminium Bronze (Cu3) metal. Besides that, for the Carbon Dioxide Sand mould, the materials for the sodium silicate process tend to be low cost. Therefore, sands can be used as the base aggregate for the silicate sand mixture. These include silica sands, bank sands, lake sands as well as zircon, chromite and olivine sands. Compared to other casting methods cores and moulds are strong. It can reduce fuel cost since gas is used instead of other costly heat generating elements. It also reduces the requirement for a large number of mould boxes and core dryers. This sand mould provides great dimensional tolerance and accuracy in production and moisture is completely eliminated from the moulding sand.

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