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Mould Preparation Practices in Metal Casting Operations for the Production of an Optical Alignment Gauge

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Abstract
This project investigated Mould Preparation Practices in Metal Casting Operations for the production of an Optical Alignment Gauge in Kano State, Nigeria. Silicate Sand and Resin formation were used to create the mould, which is usually rigid vessel around the completely knocked down parts of an optical alignment gauge which are the patterns. The material used are resins, catalyst, releasing agent, sodium silicate sand that was prepared to hold the process of filling the hole with molten aluminium. Four lecturers, one Industrial Personnel, four Foundry artisans, one Instructor, two technicians respectively carried out the production process in Federal College of Education (Technical) Bichi Kano State, Nigeria. Among others, the techniques for mould preparation for the production of an optical alignment gauge was a success, adhering strictly to safety operation procedures during mould preparation activity, regularly inspecting foundry activities at each stage of mould preparation as well as using the appropriate mould preparation tool for specific task. There is no significant difference in the accuracy of the produced optical alignment gauge and the original. It was recommended that the production will further exposed the NCE II students to the fundamentals on the aspect of mould making for the production of parts. Provide an avenue for NCE III students in line with TEM 325 (Maintenance and repairs of mechanical equipments) to be able to dismantle, couple and calibrate the produce parts. More so, to produce a replica functional optical alignment gauge purely with metal, thereby stimulating the lecturers and students to be engaged in the aspect of mould making skills for production purposes. Also, this research has trigger critical thinking towards creativity and innovation on production in fulfillment of the National Commission for Colleges of Education minimum standards (2012). It also gives room for the lecturers and student to know how it is made from scratch to finishing and also the practical use to individual as well as enhancing the needed skills required by the lecturers and students in metalwork technology and also the adjustment of vehicles tyres alignment in the automobile workshop.

Keywords: Metal Casting, Mould Preparation, Optical Alignment Gauge, Practices,

Introduction

Mould production involves a lot of preparations and stages in the manufacturing process of metalwork. The replicate shape of the mould which is prepared in sizes open up to the pouring of molten metal into the mould where it solidifies as a casting cavity. Metal production has serves as a means of sustaining the nation economy over the years. A nation that produces metal will definitely have a buoyant economy because the production of metals will attract the development of manufacturing industries that will make use of the metals as raw materials for further production. Virtually all manufacturing companies make use of metals as their primary raw materials. The presence of manufacturing and construction industries will aid the rate at which the metal products are consumed and also help to create Jobs (Edwin, 2017).

A careful look at the developed countries in the world, it will be observed that china produced 57% of the world steelin 2020 and becoming the first to produce over one billion tons of steel in 2008, 2009, 2016 and 2016 as a result of global recession. Thus, the presence of functioning metal industries boosts the nation economy. In 2010, the sector of ferrous metal smelting and rolling of China employed an annual average of 3.4563 million employees, making the sector among the biggest employers in China (Metal Injection Molding, 2017).

Mould preparation and metal handling processes are Casting process which are categorized (Ohnaka,2015). The mould creation process in its simplest form involves the designing of the pattern of a given shape; creation of refractory mould containing the designed pattern; as well as core making. Ohnaka added that the metal handling process is concerned with heating of the metal (Melting process), filling the mold cavity with molten metal (Pouring process), allowing it to solidify (Solidification process) removal of casting from the mold and cleaning, finishing and inspection of the metal cast component. Obviously, each step depends on the one proceeding it as well as one succeeding it as casting process becomes complex requiring the use of techniques due to rapid technological advancement in metal foundry with Metal Handling Process being governed by such complex laws of physical chemistry. One of the most critical aspects of Metal Handling Process is the solidification techniques especially in traditional casting.

Casting is a process of forming metal objects by melting metal and pouring it into moulds. It is the use of liquid metal to cast the shape of the object directly, producing cast metal. Castings obtain their shape principally when molten metal solidifies in the desired form. According to Tukura and Paiko (2008), casting remains one of the world basic industries and has been considered one of the most important activities. This is because all other methods of forming or shaping objects, cast products remains the cheapest, the simplest in the production of not only automobile components, but other general parts. Casting is essentially a simple, inexpensive and versatile way of forming, so it is not surprising that, it was historically the first method used as certain advantages are inherent in the metal casting process.

The casting working environment present dangerous condition, particularly around furnace and other equipment used in Mould Creation and Metal Handling Practices in casting operations. Typical foundry process involving molten metal are carried out at high temperatures, may emit toxic fumes, produce noise and present other hazardous conditions (Anshika, 2017). This condition makes metal casting a dangerous line of work for foundry professionals as improvements in the Mould Creation and Metal Handling Practices come with safety measures to be observed which poses the need to find out for safety practices in casting operations. Therefore, most of the major components of machine tools, power plants, industrial machinery and equipment, automotive, agricultural products of the foundry. Hardly can you think of any major machine or equipment which has no components that have been cast in a foundry. One can therefore rightly say that metal casting is basic to economic development and self-reliance in developing countries like Nigeria where little attention has been paid to the development of the casting industry for too long (Edwin, 2017).

Statement of the Problem

The COVID-19 has really exposed the global supply chain to be vulnerable to the consumers and businesses around the world. Pandemic related lockdown was at first that grounded manufacturing sector to a halt. This has necessitated the need for production as the world continue to feel the effect of the disruption that is getting more worse before they get better,(Foresight, 2022).Today, nearly every mechanical device that is used, from automobiles, farm implements, machine parts are manufactured using metal parts that were created in the casting process. The difference between today's cast metal products and those that were manufactured even 200 years ago is the precision and tolerances that could be achieved through the modern techniques in metal casting processes. Throughout the centuries, various combinations of raw materials have been developed to produce various metal types. The assembling of industrial metal cast by products such as machine parts, farm implements and automobile parts for industries in the country generated so much wealth in the past, but the actual industrial production within the country now is going at a slow pace(Kano State Government, 2016).

The growing concern about having increasing metal casting products such as cooking utensils motorcycle brake handles, and so on that are made locally. Literature review shows that the markets for this products are depreciating by the day as metal casting products made locally are not produce in mass to compete with similar goods produced abroad (Liman & Adamu 2015). Locally produced goods will eventually lead to creation of more market thereby discouraging the purchase of similar goods produced abroad and also enhance the students with skills required on graduation from the college. In casting, the part being produced and the tooling used to produce the part interact in complex ways, which affect the safety of casting professionals, quality and cost of the casting. Hence, the need to produce an optical alignment gauge replacing the plastic parts with a more durable aluminum locally through casting practices.

Aim and objectives of the Project

The aim and objective of this project is to produce moulds of different parts of an optical alignment gauge and also to couple the parts as a functional unit of an optical alignment gauge accordingly, this project tends to:

1. Expose the NCE II students to the fundamentals on the aspect of mould making for the production of parts.
2. Provide an avenue for NCE III students in line with TEM 325 (Maintenance and repairs of mechanical equipments) to be able to dismantle, couple and calibrate the produce parts.
3. Provide a replica functional optical alignment gauge, thereby stimulating the teachers and students to be engaged in the aspect of mould making skills for production purposes.

Safety Operation Procedures

The very nature of foundry work is hazardous if things are not done properly or if equipment is neglected and not checked for malfunctions. Clutter on the floor increases the chances for accidents, so it should be kept clean and the aisles clear as possible. The large copes are to be secured always to avoid possibility of falling while a careful check is made on the cables; chains hook links hoist and lifts. Before using crucibles, bring them up to heat gradually. Rapid increase or decrease in temperature is dangerous, because even a small amount of moisture can cause steam and an explosion (NIOSH, 2015).

The crucibles should be kept where moisture cannot be attracted and shouldn't be filled to the brim. Metal expands when heated and can crack a crucible. Therefore, crucibles should be handled with care to avoid spills and on no condition should cold metal be directly put in to hot molten metal. During operations in the foundry eye protection, aprons, leggings and gloves is a necessity for safety of the personnel to be dressed in. Where respiratory are required, be sure you are using the proper and approved type for the atmosphere in which you are working. It is the responsibility of the institution to provide the respirator, but it is your responsibility to wear it.

Mould Preparation Practices

Mould preparation practice in local metal casting operations is highly used in countless applications, and testing its purity is critical in several manufacturing processes in metal sorting, quality control and the final product (Parks & Kuhn, 2022). No quantity of metal is completely pure; therefore any bulk material is likely to have some contaminations. Optical emission Spectrometry can be used to analyze the purity of the aluminum alloys. This can result in the detection of contaminants in sub parts per million (PPM) range sample preparation. To make two pieces mould of Resin mixed with sodium silicate powder. The two part mould should be split along the horizontal axis following steps by step procedure. In this particular work the original pattern is plastic shaped coupled with some aluminum parts.

The mould box has to be built, using seams with hot glue secure with a mould strap. The pattern must first be embedded in the clay. Following the building of the clay bed inside the box, press the pattern in to the clay bed until only the top half is exposed. Used more clay to fill in any open spaces and level the clay surface to the pattern midpoint and flatten and

smooth the clay surface. Meanwhile, embed small round crystal balls in the clay to create registration keys between the moulds half. The mixing of the resin and the silicate powder is done and dispensing it slowly over the pattern on height point of 1.25cm in to one Conner of the mould box to have an even flow, then allow curing.

The second half of the mould is done by removing the mould box, turn the mould over and the clay. Do not remove the pattern from the first half of the mould. Then carefully remove the crystal balls and leave the pattern in its position. Remove excess clay with brush and mind the pattern, then the mould box is reassembled. Spray the releasing agent on the exposed pattern and create a funnel shape object with the clay. Secure the clay funnel to the top part of the pattern and mix the resin and the silicate powder, dispense slowly over the pattern on height point of 1.25 cm in to one Conner of the mould box to have an even flow. Carefully remove the mold box and trim flashing slowly disengage the cured half into two and removing the pattern. The cavity is the two parts of the mould that is the replica of the pattern that is ready for casting when the molting aluminum is poured in to the mould. Again with a quick 5 steps recap of the process.

1) One half is embedded in clay.
2) The first half of the mould is poured and allowed to fully cure.
3) The mould is turned over and clay is removed.
4) Releasing agent is sprayed to prevent bonding.
5) The second mould is poured and the mould is allowed to cure prior to demoulding.

Fig: 1 Telescope Cap mould

Produce with Resin and sodium silicate powder.

(Owolabi, 2022)

Materials and Methods

The material used in this project just to mention but few are Mould natural sand, Dried silica sand, Synthetic fiber, on viscosity oil/releasing agent, Calibrator Metal round pipe 5mmx6 fits, Resin/Gel coat/resin/formulation/catalyst/Accelerator/pigment Cutting/grinding stone electric lower, Nonferrous metals (Aluminum 100kg, zinc 50kg and lead 50kg).The

production of composite mould takes a step by step process as safety is very important in the production of the mould which is as follows:

1) Composite making should be done in a well-ventilated workshop.
2) Safety hand gloves should be put on while handling materials like: resin, catalyst, and accelerator and glass fibers.
3) Barrier cream should be use especially, before touching glass fibre because of its inching sensation.

The production of mould and fabrication of an optical alignment gauge starts from the conception of the researcher that equipment can be produced locally. Teaching the following courses TEM 211 which is foundry and forging, TEM 327 Advance fabrication and welding and TEA 325 which is maintenance and repairs of mechanical equipment respectively. It is expected for every metalwork student to offer these courses and on graduation to be equipped with the skills required to do such in the metal work department.

In view of these, steps where taking to produce the optical alignment which is as follows:

Step 1; Material were sourced within and outside the state.
Step 2; Mould preparation was made with different techniques that gives in to desired shape, or replica of the Completely Knocked Down (CKD) alignment gauge.
Step3; Melting the aluminium scraps in to a molting state.
Step4; Testing the molting aluminium Based on the degree of heat in the furnace.
Step5; Pouring the molten aluminium in to the mould for solidification of the Parts.
Step6; Retrieving the solidify parts from the mold and checking for defect.
Step7; Cutting, grinding and filling off excess parts to shape and for the purpose of drilling, tapping and die operations.
Step8; Cutting out printed calculator board on the plastic in a circular form.
- Cutting out 2.5 metal plates for angle IN and OUT.
- Cutting out mirror parts for target plate and the mirror side.

Step9; Assembling of parts to form a unit of the telescope, target plates, pipes, torch bars handles e.t.c.
Step9; Finishing operations using sanding machine and painting for a good aesthetic appearance.

Findings of the Project

With respect to this project, findings among others are given below:

1. This project has given an insight that parts can be reproduced in its shape and size.
2. That students and staff now discovered that it is possible to produce a functioning quality product locally.
3. That aluminum scrapes can be through process turned into wealth.
4. That mass production is possible.

5. That the knowledge obtained can be used in the production of other mechanical products.
6. That the precision degree given by the locally made optical alignment gauge gives the same degree on the original imported optical alignment gauge.

Discussion of Findings

The project of mould production and fabrication of an optical alignment gauge model was quite tasking and challenging, using all reliable and available resource to mitigate all problems for the replica of this gauge to be produced. Meanwhile, against all odds the research assistance and all that were engaged during the period of sourcing for materials, production and finishing was a booster to the success achieved in this regard. Bye and large an optical alignment gauge have been produced with the same accuracy reading to that of the original anywhere in the world as it is in this project.

Conclusion

From the findings of this project, it can be concluded that local metal casting practices were established increasing awareness and productivity in our country. The process are in the area of mould preparation, safety precautions in mould preparation, metal handling and safety precautions in metal handling practices.The project has provided an additional literature to the existing body of knowledge in the mould preparation and metal handling practices in metal casting operations in Federal college of Education (Technical) Bichi kano State Nigeria. This provides a practical evidence for the use of mould preparation and metal handling practices as well as in enhancing safety precaution in mould preparation.

Recommendations

Based on the findings from this project, the following recommendations were made:

1. Quality training and periodic retraining programmes should be organized by the metalwork department for foundry practices to expose students to use foundry equipment to enhance their skills in mould preparation.
2. Industries, government, non-governmental agencies, private enterprises and communities should provide consumable materials necessary for practical activities in teaching and learning process in metal casting for the production of parts of any equipment that might be difficult to access easily.
3. The industries and the colleges should have linkage in real exchange of ideas that will keep the colleges updated with the recent technology and techniques in the foundry.

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