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Fabrication of a Permanent Mould for the Production of Motorcycle Brake Handle

Najeem Adeniyi Yekeen* and Yusha'U Mohammed Mubi

Department of Mechanical Engineering Technology, Federal Polytechnic Kaura Namoda, Zamfara State, Nigeria.
Corresponding Author E-mail: yekeennaj@yahoo.co.uk

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ABSTRACT: The goal is to improve motorcycle brake lever manufacture by developing a permanent metallic mould from the extremely efficient A356 alloy. The cream hardener and filler were used to make a mould pattern, which was subsequently manufactured on a computer numerical control (CNC) machine. The end result is a precise and durable mould that can be used to produce motorcycle brake levers locally, utilizing abundant aluminum resources and reducing the need for costly imports. The gravity die casting process allows us to create motorcycle brake levers at a lesser cost while also utilizing aluminum waste, making this technology both cost-effective and environmentally sustainable. We hope that the Nigerian government recognizes the potential of this manufacturing process and invests in the foundry and automotive sectors to support long-term growth and sustainability.

Keywords: Casting, mould, motorcycle brake handle, pattern, aluminum alloys, hardness, tensile strength.
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INTRODUCTION

Casting is a manufacturing method in which molten metal or liquid material is typically poured into a mould with a hollow chamber of the required shape and allowed to harden (Mahesh et al., 2017). The solidified item, known as a casting, is ejected or broken out of the mould to complete the process. Casting technologies are frequently used to make metal parts in a cost-effective manner and to achieve complex shapes with minimal machining for their intended application.

Castings are high-tech products that combine materials, metallurgy, heat treatment, welding, and measuring. Gravity die casting (GDC) is a method of creating nonferrous metal castings in which molten metal is forced into a steel or permanent mould under pressure (Ankit and Ozal, 2013).

Permanent moulds are often composed of metal and come in a variety of shapes and sizes based on the constructional designs they were designed for. A mould is a blueprint designed to produce the same type of prototype (Chukwudi and Ogunedo, 2017).

Aluminium alloys are widely utilized in the automobile sector for cylinder heads, exhaust manifolds, pumps, and valve bodies, as the current tendency is to attain more performance without adding weight (Ahmad and Ali, 2020). As a result, aluminium alloys are increasingly used in automobile components to reduce weight while maintaining or improving mechanical qualities (Zeelanbasha et al., 2017). Aside from their outstanding casting characteristics and wear and corrosion resistance, aluminum-silicon casting alloys are widely employed due to their diverse mechanical properties and high strength-to-weight ratio (Erzi et al., 2019).

A motorcycle brake lever must have features such as hardness, rigidity, lightness, and resistance because it can withstand an intense hand-push operation without breaking or deforming. Because motorcycle brake levers are such an important component of a motorbike, the lack of a local manufacturing facility has necessitated the importation of these levers, hampered our economic development in the face of a growing foreign exchange rate. As a result, packaging and manufacturing brake levers locally using high-quality gravity die-casting aluminium alloy would benefit the market system by lowering client prices and increasing work opportunities in our country.

There has been limited investigation into the development of a permanent metallic mould for the casting of motorcycle brake levers using A356 alloy. In

this work, a metallic permanent mould casting for the production of motorcycle brake levers was created and then used to cast motorcycle brake handle levers from A356 Aluminium alloy. Finally, the cast of the aluminium alloy motorcycle brake lever made with the mould was submitted to hardness and yield strength tests to assure a smooth surface and high internal quality.

Literature review

Motorcycle brake lever

The brake lever on a motorbike activates the braking system, allowing riders to slow down or stop (Chukwudi and Ogunedo, 2017). There are two types of mechanisms: mechanical and hydraulic, each with its own particular function and efficacy. Furthermore, there are disparities between different models of bikes, independent of whether they utilize hydraulic or mechanical brakes, as well as differences in material quality (Santolaya et al., 2013). A mechanical brake lever works simply by pulling a metallic cable, causing the two brake pads to exert pressure to one of the bike's rims (Figure 1). Hydraulic brakes, on the other hand, function a little differently: when the brake lever is squeezed, it pushes particular oil, causing pressure and slowing or stopping the bike. Given the critical role that brake levers play, they must possess specific properties: they must be robust and stiff enough to endure extreme hand pressure without breaking or bending, while also being lightweight and resistant (Chukwudi and Ogunedo, 2017). It is crucial to note that the positioning of the brake levers for the rear and forward brakes must comply with the laws and customs of the nation in where the bike is being sold. The manufacturer should include instructions for activating the rear and forward brakes (Chukwudi and Ogunedo, 2017).

Properties of A356 Alloy

The motorbike brake handles will be made of A356 aluminium, a hypoeutectic Al-Si-Cu alloy created specifically for GDC. Iron, a common impurity in Al-alloys, is added to prevent die-soldering (MikkoKarkkainen, 2019). Al-Si alloys have several advantages, including lightweight, good ductility, high thermal conductivity, corrosion resistance, and wear resistance (Yao, 2011). The melt composition of A356 is shown in (Table 1). Gravity die casting of a certain material, known as A356, presents significant complications. One of these issues is connected to eutectic silicon, which can take on a brittle acicular (needle-like) structure that is easily fractured. Typically, these silicon particles are faceted and develop on contaminants like aluminum phosphate. To solve this issue, chemicals such as Sr can be employed to change the Si-growth mechanism and make it more isotropic. Furthermore, faster cooling rates can cause the creation of more circular and tiny Si particles (MikkoKarkkainen, 2019). Another issue in gravity die casting of A356 is the development of brittle intermetallic precipitates rich in iron. These intermetallics can be divided into two kinds based on their formation temperature. The intermetallic phase that forms above the alloy liquidus temperature is known as sludge, and its nominal composition is Al15 $(Fe,Mn,Cr)_3Si_2$ or Al12$(Fe,Mn,Cr)_3Si_2$ (Mikko Karkkainen, 2019).

MATERIALS AND METHODS

Materials and equipment

Aluminium alloy was utilized to create a metallic permanent mould for the cast motorcycle brake handle levers, while cream hardener and filler were employed to create the design, which was then cast. A356 alloy was chosen for its cost, stability, ductility, strength, availability, good mach inability, and corrosion resistance, all of which favour aluminium in-mould fabrication. Other materials and equipment used include ethanol, emery cloth, an electrical crucible furnace with automatic temperature control, crucible pots, a ladle, an electronic weighting balance, a digital thermocouple, an infrared thermometer, a digital vernier calliper, a metallurgical light microscope, a hardness machine, a testometric universal testing machine, and a surface roughness tester.

METHODS

The methodology employed in this work is presented in this section in order to achieve the objectives of the work.

Development of pattern for motorcycle brake handle Levers

The pattern required to prepare the mould cavity for casting was constructed from cream hardener and filler. The cream hardener and filler were blended in equal parts to allow it to solidify and adopt the shape of a rectangle (Figures 2a and b). A computer numerically controlled (CNC) machine was used to build the shape of a motorcycle brake lever in the pattern based on the lever's dimensions and design utilizing G & M codes generated by CARTIA V5R20 software. Gates and risers were designed to flow molten metal into the die. The necessary components were provided during the design and manufacturing of the brake lever die mould. Following this, the pattern's surface was smoothed with emery paper.

Sand moulding process

Green sand is widely used in sand casting. The sand used for moulding preparation is natural and green. To make the mould, a box measuring 800mm long and 400mm wide was used. This box was large enough to fit

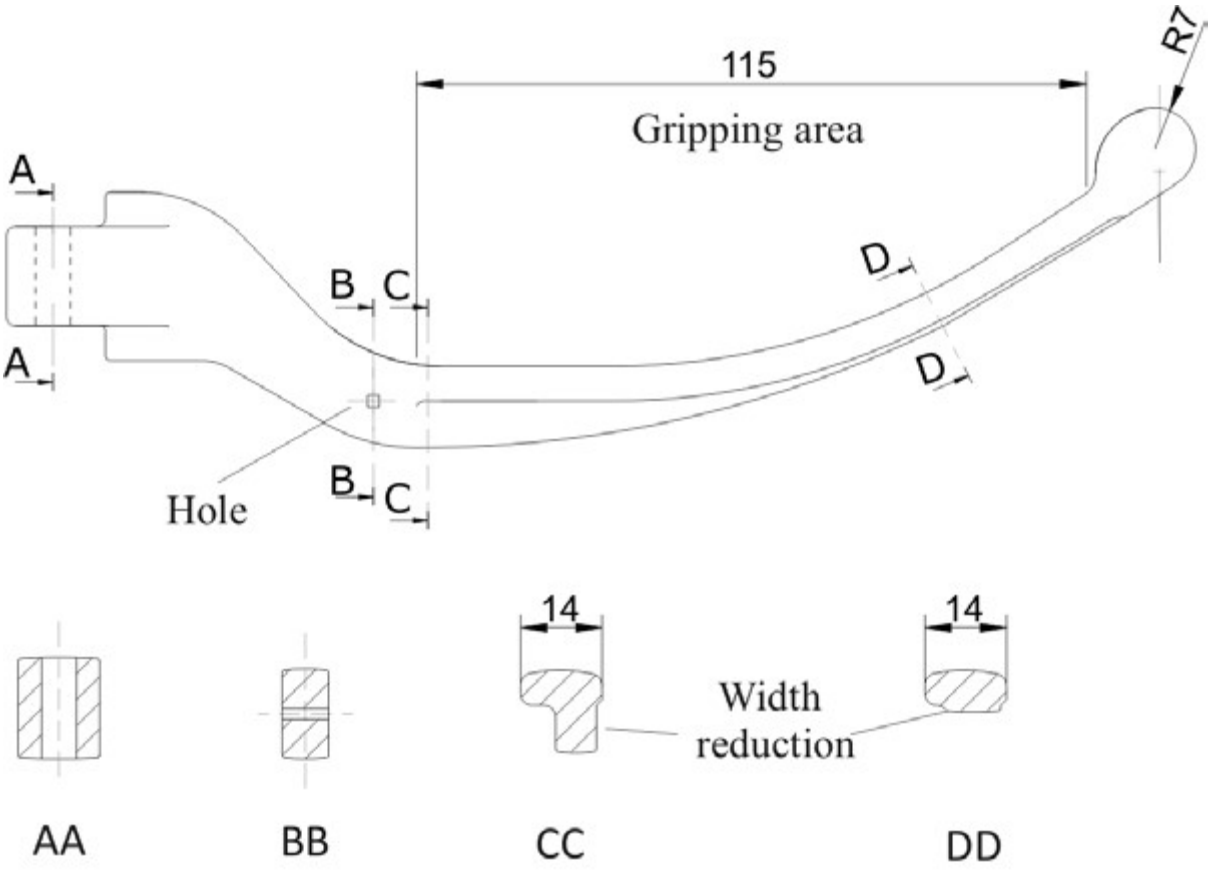

Figure 1: Motorcycle Brake Lever

Table 1: Chemical composition (in wt. %) of the A356 alloy used in this study.

Element	Si	Mn	Ti	Fe	Sr	Cu	Ni	Al
% Composition	7.1	0.31	0.23	0.17	0.05	0.01	0.0013	Balance

Source: (Rheinfelden, 2018)

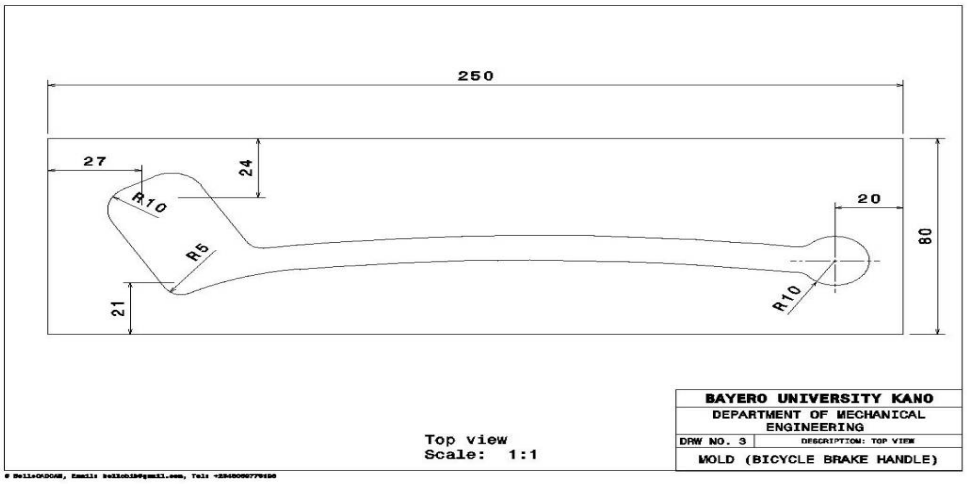

Figure 2a: Geometry of motorcycle brake handle.

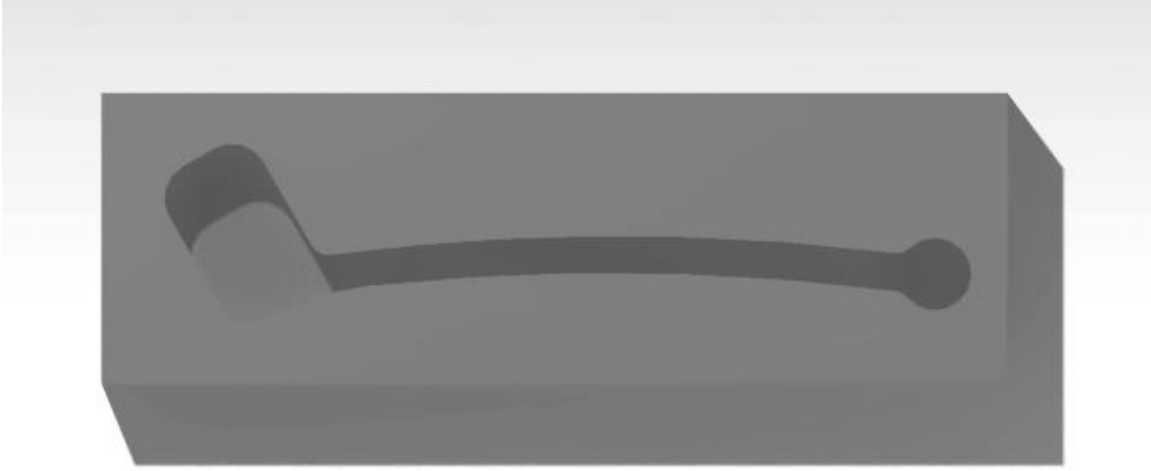

Plate 2b: Die mold of motorcycle brake handle

Table 2: The elemental composition for the a356 aluminum alloy produced (Rheinfelden, 2018).

Element	Composition (%)	Weight of element to be used (g)
Aluminum (Al)	92.14	4607
Iron (Fe)	0.17	8.5
Manganese (Mn)	0.31	15.5
Silicon (Si)	7.1	355
Strontium (Sr)	0.05	2.5
Titanium (Ti)	0.23	11.5
Total	100	5000

the pattern, as well as the riser and gating system, with some room for sand ramming. After the moulding process was complete, the cope was fastened with the drag, and the mould was ready to pour the molten metal.

Development of A356 type Al-Si-Mg Alloy used for the experiment

A356 aluminium alloy is one of the materials used in the automotive sector to cast motorcycle brake levers. The A356 aluminium alloy utilized in this fabrication was designed and manufactured at the Foundry Laboratory, Federal Polytechnic, Kaura Namoda, Zamfara State, as it could not be bought directly from the Nigerian market or industry (Tables 2 and 3). The method for making A356 Alloy was developed by (HelderPuga, 2020). It was developed using the elemental composition of the alloy shown in (Table 3), as taken from the literature for the A356 alloy (Rheinfelden, 2018). A pure aluminium cable of known weight was inserted into the crucible and melted to a temperature of 6500 degrees Celsius inside an electrical furnace.

Silicon, manganese, iron filler, strontium, and titanium particles were fully mixed with the molten pure aluminium.

Melting of A356 Alloy

The formed aluminium A356 alloy was remelted in an electric crucible furnace with a capacity of 100kg at the Foundry Workshop, Federal Polytechnic, Kaura Namoda, Zamfara, Nigeria, at temperatures ranging from 680 to 720^{o}C.

Pouring of melting metal

Using gravity die-casting, molten aluminium A356 alloy was poured into the mould's cavity. Motorcycle brake grip levers composed of aluminium alloy are generated when the molten metal solidifies.

Solidification and knock out of permanent metallic mould

The sand mould was broken after solidification to remove permanent mould for motorcycle brake levers.

Fettling and cleaning process

The permanent metallic mould was fettled and cleaned using emery paper and a hand-grinding machine.

Table 3: Various tests conducted on the cast motorcycle brake lever.

Hardness (BHN)	Tensile Strength (N/mm²)	Material Composition					
		Aluminum (Al)	Manganese (Mn)	Iron (Fe)	Silicon (Si)	Strontium (Sr)	Titanium (Ti)
68	130	Balance	0.31	0.17	7.1	0.05	0.23
62	132						
69	131						

Plate 3: Cast component of motorcycle brake handle

Testing

The permanent metallic mould was tested by melting aluminium at 680°C and putting it into the mould after preheating to prevent sputtering of the molten metal. The molten metal solidified in the permanent mould, resulting in high-quality motorcycle brake levers. Quality evaluation tests were performed on the brake levers to determine their mechanical properties, such as hardness and tensile strength, and the results were obtained.

RESULTS

The cast sample of motorcycle brake handle using permanent metallic mould was given (Plate 3).

DISCUSSION

The fabrication of a permanent mould for the production of motorcycle brake handle was successful designed and fabricated taking into consideration the entire safety requirements for its safe operation. The permanent metallic mold was constructed according to the specification of the motorcycle brake lever drawing as indicated in figure 2(a). The mould pattern was made with cream hardener and filler, after which the mould was cast.

The permanent metallic mould was tested by melting aluminium at 680°C and putting it into the mould after preheating to prevent sputtering of the molten metal. The molten metal solidified in the permanent mould, resulting in high-quality motorcycle brake levers. Quality evaluation tests were performed on the brake levers to determine their mechanical properties, such as hardness and tensile strength, and the results were obtained. The hardness results obtained from the tests range between 62 to 69HRB while tensile strength ranges between 130 to 132N/mm^2 which showed that the cast specimens were having good mechanical properties and the results are in agreed with Zhichao et al. (2022). The motorcycle brake handle casts were having good macrostructure due to preheating of the mould as indicated in the work of Alexopoulos (2015).

Conclusion

Using cream hardener and filler, the pattern might be created prior of casting the mould. The A356 alloy proved to be an excellent choice for mould material, and because silicon was added during the alloying process, the aluminum mould is anticipated to have an extremely long service life and be able to handle high operating temperatures. The CARTIA software created a drawing that was used to design and fabricate the motorcycle brake levers. The cast components of the drawing had good mechanical qualities.

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