

# Studies on the Effect of some Cereal Binders on the Hardness Values of Cast Aluminium Alloys (Al – 12%Si)

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## ABSTRACT

The effect of some cereal binders on the hardness values on casts Al - 12% Si was investigated. Sand casting technique was employed in the cast of the Aluminum Alloys. Cereal binders (Maize, Guinea corn, Rice) at different compositions were introduced into the moulding sands and tempered to form the Sand moulds. The cast specimens were subjected to series of experimental processes in standard Foundry/Metallurgical laboratories. The result of the tests show that percentage increases of the additives resulted to decreases in the hardness values of the cast Aluminum alloys. It was also revealed from the study that, the Aluminium alloy at 1% composition of the Guinea corn binder is preferable for engineering applications in which the metal may be scratched, abraded, indented, or machined.

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## Introduction

Materials are the very foundations of technology, since without suitable materials nothing can be constructed. There are thousands of different materials available today. Therefore it is impossible for the engineer to have detailed knowledge of them all, but it is important that he has a good understanding of the fundamental principles that control the properties of materials. In addition, he will also have to consider many factors including the metallurgical properties of a material before selecting the most suitable material for some specific engineering applications.

In sand casting processes, efficient control of sand is an important consideration in quality casting. Good quality casting demands that the mould possess high strength, low friability, thermal stability and high gas permeability [1]. The moulding sand may contain additives which together impact firmness on being rammed. The function of the binder or additive is to produce cohesion between the refractory grains in the green or dried state. Since bonding materials are not highly refractory the required strength must be obtained with the minimum possible addition [2].

A variety of organic oils and resins, cereals and silicates may be used singularly or in combination as binders [3]. Clay bonded sands are distinguished by the fact that they can be recycled in closed systems and the bond regenerated by the addition of water but, the action of most other binder is irreversible and the moulding material has to be discarded after

a single production cycle [4]. Two main divisions of binders are known: inorganic and organic binders [3].

Cereal binders are organic binders derived from the common cereal grains such as guinea corn, maize, wheat etc. They are frequently produced as flour like dry materials and occasionally as fluid materials such as molasses, [5]. The cereals binders are burnt out during the casting operating thus increasing the permeability and allowing for the expansion of the hot sand. These additives also improve the surface finish of the casting [6].

Investigation of the characteristics properties and uses of sand binders have been widely reported. Result of the tests in which additives like wood flour, coal dust, cereals were added to the binder's shows that there was substantial improvements on foundry properties of the sand [7]. Quality sand improves or adds to the properties of the metal to make it more suitable for its properties [3]. However, most of these studies did not investigate the effect, the cereal binders would have on the hardness of Aluminum casts. It is therefore the aim of this study to assess the hardness properties of these alloys, so as to determine their suitability as engineering materials.

Production/casting of quality materials is of great concern to manufacturers, to ensure that the products do not suffer failure in service. It is therefore necessary to access the properties of the specimens to be cast, so as to determine their suitability for engineering applications. The objective of the study is to examine the effects of the cereal binders on the hardness values of the cast specimens and also to ascertain the



alloys suitability for specific engineering applications. The study shall be of immense use to researchers/stakeholders in foundry industry in the production and selection of Aluminum alloys for engineering applications. Data from this study would aid the Government and Policy makers identify suitable materials for construction/fabrication needs of homes and industries.

**Materials and Methods**

The materials used in the study included the followings: Scrap from the top cylinder of the engine block of a Volkswagen of standard composition (Al-12% Si), Natural sand from North Bank of River Benue in Makurdi, Carbolite electric furnace (Model GPC 1281) of maximum rating 1200°C, Mild steel crucible of diameter 160 mm, Tongs, Hacksaw, Petrol plus detergent solution, Analog weighing balance of maximum rating 160.0 g and sensitivity 0.1 g., Cylindrical pattern, Metal flask of uniform thickness, Measuring cylinder (100 ml), Sand paper of different grits, Metalserv polisher machine, Vickers hardness machine, Cereals (maize, guinea corn and rice), Stop watch, Center lathe Machine.

The experimental procedure involved sand preparation, mould preparation, metal melting and casting, machining operations after casting and carrying out the hardness tests. During sand preparation, impurities such as hard lumps, metallic objects, and stones were removed from the sand. The estimated particle size of the foundry sand was 600 µm. Various compositions of the binders (maize, guinea corn, rice) were introduced separately into the foundry sand. The sand was mixed and properly tempered in order to ensure uniform distribution of the ingredients. The moulds were produced with the foundry sand and the three additives (maize, guinea corn and rice), of same particle size and cylindrical metal flask was produced

Aluminium scraps were cut into sizeable bits and carefully washed with petrol and detergent solution to remove oil and other non-metallic inclusions and dried. A crucible made from mild steel was cleaned and pre-heated to remove moisture. Then aluminium scraps was loaded into the crucible placed in the furnace and heated to about 750°C. Aluminium chloride was added to degas the melt and the crucible was then removed from the furnace by means of tongs and the metal poured into the mould for complete solidification. The center lathe machine was used to turn the specimens to cylindrical sizes of diameter 23 mm and length 20 mm under steady low temperature.

For the hardness tests, the surfaces of all the samples were polished and indentations were made on the specimens using Vickers Micro-hardness testing machine. The two diagonals were measured and their mean determined. The Vickers

hardness numbers were then read from the Vickers hardness table using the Mean of the diagonals (Dm).

**Results and Discussion**

Tables 1 to 3 show the respective diagonal dimensions and the corresponding hardness values obtained for maize, guinea corn and rice binder compositions used for the study, while Table 4 presents the summary of the binder composition and the hardness values.

**Table 1: Hardness values for cast Al -12% Si and Composition of Maize binder**

% Composition (A)	D1	D2	Dm	Hv kg/mm <sup>2</sup>
0.0	65.00	65.50	65.25	87.80
1.0	66.80	66.80	66.80	83.10
2.0	67.50	67.25	67.25	81.90
3.0	68.00	68.10	68.10	80.00
4.0	69.50	69.75	69.75	75.90
5.0	71.00	71.25	71.25	73.00

**Table 2: Hardness Values for Cast Al-12% Si and Compositions of Guinea corn Binders.**

% Composition (B)	D1	D2	Dm	Hv kg/mm <sup>2</sup>
0.0	65.00	65.00	65.00	87.80
1.0	66.50	66.00	66.25	84.40
2.0	67.00	66.90	66.95	82.60
3.0	68.00	68.00	68.00	80.20
4.0	69.50	69.50	69.50	76.80
5.0	71.50	71.00	71.25	73.00

**Table 3: Hardness Values for Cast Al -12% Si and Compositions of Rice binders**

% Composition (C)	D1	D2	Dm	Hv kg/mm <sup>2</sup>
0.0	65.00	65.00	65.00	87.80
1.0	73.50	73.00	73.25	69.00
2.0	74.00	74.00	74.00	67.70
3.0	74.50	74.50	74.50	66.80
4.0	75.00	75.50	75.25	65.40
5.0	76.00	76.00	76.00	64.20

The results of the effect of the binders on the hardness of Al-12% Si presented in Table 4 show that, when no additives were present in the mould, the hardness values of the cast were 87.80 kg/mm<sup>2</sup>. On introduction of 1.0% composition of the maize binders, the hardness of the cast decreased to a value of 83.10 kg/mm<sup>2</sup>. The decrease in hardness of the cast was as a result of the effect of percentage composition of the maize binder in the mould. It was also observed that the hardness



values of the cast decreased with further increase in the binder composition. The decrease could be attributed to the quantity of gases that diffused through the melt during pouring.

**Table 4: Percentage Composition of the Binders and Hardness values of Al -12% Si**

% Composition	Hv (Maize binder)	Hv (Guinea corn binder)	Hv (Rice binder)
0.0	87.80	87.80	87.80
1.0	83.10	84.40	69.00
2.0	81.90	82.60	67.00
3.0	80.00	80.20	66.80
4.0	75.90	76.80	75.40
5.0	73.00	73.00	64.20

The effect of the guinea corn binder on the hardness values of the cast is also observed in Table 4. On the introduction of 1.0% composition of guinea corn binder into the mould, the hardness value of the cast decreased from 87.80 kg/mm<sup>2</sup> to 84.40 kg/mm<sup>2</sup>. The decrease in hardness of the cast was also as a result of the effect of % composition of the guinea corn binder in the mould. The guinea corn at 1% composition in the mould has the highest hardness value of 84.40 kg/mm<sup>2</sup> on the cast out of the three additives introduced into the mould. Therefore, 1% composition of guinea corn binder is most suitable in improving the hardness of the cast. Table 4 also show that rice binder impart the least hardness value of 64.20 kg/mm<sup>2</sup> at 5% composition, out of the three additives.

During pouring, it was observed that the higher the composition of the binders in the mould, the greater was the gases that evolved out of the moulds. The decrease in hardness values of the cast at high composition of the binders in the mould could be attributed to the quantity of gases that diffused through the melt.

Hardness is a mechanical property of metal which is useful in consideration for engineering applications. A hard material is usually brittle and is difficult to shape by cutting, forming etc. It can therefore be deduced from Table 4 that the cast is most brittle at 1% composition of the guinea corn binder and least brittle at 5% composition of rice binder.

## Conclusion

From the study conducted using maize, guinea corn and rice as binders in foundry sand, to cast the aluminum alloy, the following positions have been established. Guinea corn binders at 1% composition is most suitable for improving the hardness value of the cast Aluminum alloy (Al 12% Si), of the three additives used. Rice binders at 5.0% composition imparted the least hardness values of 64.20 kg/mm<sup>2</sup>. Based on the results obtained from this study, the Aluminium alloy at 1% composition of the Guinea corn binder is preferable for engineering applications in which the metal may be scratched, abraded, indented, or machined.

In this research, only three additives or binders (maize, guinea corn and rice) were considered, but other consumable and starch products, such as: cassava, yams etc. in this country should be studied, to assess their suitability especially in casting non-ferrous alloys.

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