Effect of the Variation of Moisture Content on the Properties of Nigerian Gum Arabic Bonded Foundry Sand Moulds

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Abstract: Each of four commercial grades of Nigerian acacia species (gum Arabic) had been investigated in previous researches for binding foundry moulding sands with gum arabic as binder added to sand in two phase schedules of bonding with acacia exudates added to mix in powdered form before mould compaction and acacia exudates in pre-solutionized form before mould compaction. Each showed that sand bonded with powdered gum Arabic gave stronger bonds than that with pre-solutionized gum arabic pointing out that the amount of moisture in gum arabic moulds could have significant effects on bonding performance of material. This effect was investigated in this study by varying the water added to moulding sand specimens bonded with each of Nigerian grade of gum arabic and then subjecting specimens to mechanical property analyses like moisture content, green/dry compressive strength, permeability, hardness and shatter index using standard foundry laboratory equipment of Ajaokuta Steel Company limited to ascertain degree of excess moisture effects on gum arabic moulds. It was found that Nigerian acacia has high moisture/volatile matter and addition of undesired water caused weakening of bond strength. Optimum moisture was found to be 2-3%/3-4% for grades 1, 2 and 3/grade 4, respectively. The significant lies in fact that foundries that use gum arabic as binder for moulding sand would be guided on optimum water to be added to mix thereby avoiding wastes through defective casting caused by poor quality moulds the benefit of which is better production economics.

Key words: Moisture • Sand • Mould • Foundry properties • Gum Arabic

INTRODUCTION

Foundry sand for metal casting is usually sourced from natural deposit or from synthetic mix of refractory sand grain, binder agent and moisture that provides the right bonding reaction environment [1]. Each constituent is importance in determining characteristics of sand [2]. With natural sand there is limitation to extent of control on bonding material and moisture; with synthetic sand the three constituents are well selected to give desired properties within limits [3]. Amount of moisture is directly related to type and nature of binder used for the production of synthetic sand [4]. This makes it mandatory that optimum/effect of moisture be investigated for binder to ascertain best compositional mix.

Ademoh and Abdullahi [5] researched with the grade 1 Nigerian acacia species exudates as foundry sand binders and found out that the material in powdered form with 2-3% moisture is suitable for non-ferrous, malleable and grey iron, but unsuitable for steel casting. Grade 2 acacia was studied and found suitable for non-ferrous castings at compositional range of 4.5-13% acacia exudates and 3% water [6]. The Nigerian gum Arabic grade 3 was experimented with to bond moulding sand and found suitable for non-ferrous and grey iron castings at 6-9% composition [7]. 11.5-13% grade 4 acacia was found suitable for binding light steel casting moulds [8]. Each study used two schedules to bond mould specimen; first schedule bonded specimens with powdered gum Arabic while second schedule bonded specimens with pre-solutionized gum Arabic.

The findings showed that specimens bonded with powdered gum Arabic gave better properties than those bonded with pre-solutionized gum Arabic which
contained higher moisture. This prompted the study aimed at determining the effect of varying moisture content of gum Arabic bonded mould. The objectives of the study is to vary the water added to specimen bonded with each Nigerian acacia species; subject the specimen to properties tests like moisture content, green/dry compressive strength, shatter index and permeability and analyze result to ascertain optimum moisture for gum Arabic bonded moulds.

**MATERIALS AND METHODS**

The research used experimental techniques to measure the empirical values of mechanical properties of moulded sand specimen bonded separately with each of grades 1, 2, 3 and 4 Nigerian acacia exudates. The added water content to group of specimen bonded with each grade of acacia was varied from 2-8%. Properties measured are moisture content; green/dry compressive strength; hardness, green permeability and shatter index. Silica sand of known source with 0.03% clay of BS sieve size 40-72 was used to produce specimens. Sand was oven dried at 110°C to remove free water and sieved with BS mesh to obtain required grain sizes [9]. Each gum Arabic grade was milled to smallest possible grain size to enable even distribution. The sand grains gum Arabic binder and added water were thoroughly mixed in roller for about 10 minutes and then moulded into specimens. Each measured 2 inches diameter by 2 inches height with weight of 130 g after ramming in three blows with 6.5 Kg from 2 inches height [10]. Specimens were then subjected to the above listed tests which are the most tested of all mechanical properties of moulding sand as verified by Dietert [11].

**RESULTS**

The result of is presented in graphical plots in Fig. 1-4. Figure 1 presented result for the specimens bonded with grade 1 gum Arabic, Fig. 2 for that bonded with grade 2, Fig. 3 for that with grade 3 and Fig. 4 for specimen bonded with grade 4 Nigerian acacia exudates. The moisture content test determined dampness of mould specimen; the green and dry compressive strength measured ability of sand mould to withstand pressure of molten metal during casting. Green hardness measured the resistance of sand mould against abrasion. Green permeability measured ease of escape of evolved gas from mould to forestall defects. Shatter index measured collapsibility of mould after casting. According to Dietert [11] these are most essential and measured as their values give adequate information on other physical/mechanical properties of a good sand and active binder.

**DISCUSSION**

The result in Fig. 1 is for specimen bonded with grade 1 gum Arabic. Fig. 1a showed moisture content measured with varying percentage added water. Moisture increased from 1.5 at 2% added water to 7.0 at 8% added water. This is explained by fact that initial water added to mix was absorbed by the dry powdered grain of sand and gum Arabic for solution formation. After water saturation level of mix any more added water is held up as free water thereby accounting for the continuous increase in moisture. The green/dry strength rose from 5.4/140KN/m² at 2% added water to maximum of 6.5/154KN/m² at 3% added water; thereafter it decreased continuously to 3.6/122KN/m² at 8% added water. The result showed that 2-3%/3-4% added water is the optimum range for grades 1, 2, 3/grade 4 respectively for best performance of material.

Permeability increased from 107No at 2% water to 188No at 8% added water; green hardness continuously decreased from 28No at 2% water to 17No at 8% added water; while shatter index increased from 58 No at 2% water to 85No at 8% added water. These trends are due to fact that as moisture increased with increased added water the bonded particles of the sand mould become loose resulting to easier escape of gasses, weakening of bond strength and resistant against abrasion and higher collapsibility; leading to rising permeability/shatter index and lowering green hardness.

The result in Fig. 2, 3 and 4 for grades 2, 3 and 4 Nigerian gum Arabic bonded mould specimen all follow the same trend of behavior with only slight variations in the figures obtained due to intrinsic properties of different species as dictated by their varied chemical compositions. The trend is therefore also adduceable to the same reason as explained above. The result when compared to result of previous work where just sufficient water was added to moulding sand mix [5-8] showed that the excess moisture brought by high amount of added water must be responsible for the poor binding properties. Comparatively, the adverse effect is worst with grade 1
RESEARCH RESULT PRESENTED IN GRAPHICAL FORMS

Fig. 1a: Moisture content (%) of Foundry sand moulds bonded with 3% Grade 1 Gum Arabic mixed with varying percentages of added Water.

Fig. 1b: Green and Dry Compressive strengths (KN/m²) of Foundry sand moulds bonded with 3% Grade 1 Gum Arabic mixed with varying percentages of added Water.

Fig. 1c: Green Permeability No, Green Hardness No and Shatter index No of Foundry sand moulds bonded with 3% of Grade 3 Gum Arabic mixed with varying percentages of added Water.
Fig. 2a: Moisture content (%) of Foundry sand moulds bonded with 3% Grade 2 Gum Arabic mixed with varying percentages of added Water

Fig. 2b: Green and Dry Compressive strengths (KN/m²) of Foundry sand moulds bonded with 3% Grade 2 Gum Arabic mixed with varying percentages of added Water

Fig. 2c: Green Permeability No, Green Hardness No and Shatter index No of Foundry sand moulds bonded with 3% of Grade 2 Gum Arabic mixed with varying percentages of added Water
Fig. 3a: Moisture content (%) of Foundry sand moulds bonded with 3% Grade 3 Gum Arabic mixed with varying percentages of added Water

Fig. 3b: Green and Dry Compressive strengths (KN/m²) of Foundry sand moulds bonded with 3% Grade 3 Gum Arabic mixed with varying percentages of added Water

Fig. 3c: Green Permeability No, Green Hardness No and Shatter index No of Foundry sand moulds bonded with 3% of Grade 3 Gum Arabic mixed with varying percentages of added Water
Fig. 4a: Moisture content (%) of Foundry sand moulds bonded with 3% Grade 4 Gum Arabic mixed with varying percentages of added Water.

Fig. 4b: Green and Dry Compressive strengths (KN/m²) of Foundry sand moulds bonded with 3% Grade 4 Gum Arabic mixed with varying percentages of added Water.

Fig. 4c: Green Permeability No, Green Hardness No and Shatter index No of Foundry sand moulds bonded with 3% of Grade 4 Gum Arabic mixed with varying percentages of added Water.
followed by grade 2, then grade 3 and grade 4 the least affected.

**CONCLUSION**

The research showed that high amounts of added water to gum Arabic bonded moulding sand caused high moisture content in moulds that caused weakening of bond strength and adversely affect other mechanical properties of moulds. Optimum moisture range for best performance of the material is 2-3%/3-4%.

**REFERENCES**