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The Effect Of Moisture Content On The Foundry Properties Of Starch-Based Composite Binder

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ABSTRACT: The moisture-dependent characteristics of a starch-based composite binder comprising of silica sand, starch and bond clay was investigated. This study shows that the mechanical properties - gas permeability, compressive strength, compatibility and shatter index were optimum at 12.5% moisture content of the starch based composite binder.

KEYWORDS: starch-based composite binder, silica sand, bond clay, moisture content, gas permeability and shatter index.

1.0 INTRODUCTION

Metal founding is one of the oldest of all industries, both ancient and medieval history offering examples of the manufacture and use of castings. Castings, the products of the foundry industry are manufactured in a single step from molten metal without intermediate operations of mechanical working such as rolling, extrusion or forging. The processes employed in the foundry industry include gravity and pressure die casting, investment casting and centrifugal casting, evaporative pattern casting and many other novel processes, but the general characteristics of founding can be conveniently introduced in relation to a central theme, the production of sound castings by conventional mould. This is clearly understood when one considers the geographical distribution of jobbing and independent foundries in developed, developing and least developed countries of the world. In sand castings, the properties of the moulding clay mixture play an important role in the soundness of the casting produced. Due to the crucial influence on the cast metal product quality, recent years have witnessed intensive search for binders that would meet the quality assurance policy of some of foundries seeking to have competitive edge in the so-called free market economy of the world. In this light, we have delved into composite binders in generally and specifically, the moisture-dependent characteristics of these binders. The main objective is to exploit the salient properties of binders and optimize their use.

2.0 EXPERIMENTAL PROCEDURE

2.1Preparation of Starch:

Cassava is the source of this starch. It is peeled, washed and then milled. As milled, the paste is sieved with plenty of water in a local sieve to remove the chaff. The filtrate is now allowed to sediment and the remainder is now the starch,

2.2 Preparation of Dextrin:

500g of starch is mixed with 100ml HCl and boiled gently to get dextrin. Preparation of moulding mixtures:The mixtures are measured out in different proportions as shown in table 1. There are 3 main proportions in all. The fourth and the fifth serves as the control experiment.The mixtures are:

Sample A

Silica sand	-	4000g
Starch	-	350g
Dextrin	-	50g
Water	-	100ml
Bond Clay	-	150g

The sample is now mixed by a laboratory mixer, then divided into 3 equal parts. The first part (to be referred to as A) is the as-mixed mixture. The second part (to be referred to as A, is A heated to 20°C.

Samples B

Silica sand	-	4000g
Starch	-	500g
Dextrin	-	50g
Water	-	100ml
Bond Clay	-	150g

The mixture is mixed with laboratory mixer and treated as in (A! above to obtain three mixtures B BI and B_2

Sample C

Silica sand	4000g
Starch	600g
Dextrin	50g
H_2O	100ml
Bond Clay	150g

Treated as sample A above to obtain three different mixtures C, C_1 and C_2

Sample D

Silica sand	4000g
Dextrin	50g
Water	100ml
Bond Clay	150g

This has the same composition as in C above but without starch. It will serve as control experiment to check the effect of starch in sample C. The mixture is treated as in A above 3 different mixtures D, $D_1$and D_2 are obtained.

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Sample E

Silica sand	4000g
Starch	600g
Water	100ml

This mixture has starch as the only binder. It serves to check the effect of starch as a single binder as compared to that of starch as composite binder. It is a control experiment. Nevertheless, it is treated as in A above so that 3 different mixtures E, E_1 and E_2 are obtained.

2.3 Test Carried Out

Experiment: To determine the moisture content of moulding mixture.

Apparatus: An electronic scale, a drier, a thermostat.

Method: Weigh out 50g of the sample on the electronic scale. Place sample inside the drier and dry. Connect the thermostat which will put off the drier at 110°C. After drying weigh the specimen, let the weight of the original specimen be G1that of the dried specimen be G_1. Therefore moisture content $=\frac{G-G_1}{G}$x 100%

Experiment: To determine the gas permeability of the moulding mixture.

Apparatus: Specimen tub e with cap electronic scale, ramming machine and a dietert electronic permmeter which uses the orifice principle and is calibrated so that direct reading could be obtained.

Method: Measure out 150g of the sample, fill the capped specimen lube with sample, place inside a ramming machine and ram 3 times (Standard). Then lighten the specimen tub on the permmeter. Put the machine on, the pointer runs down and goes to zero. Now push the handle, the pointer goes up and stops, then the g as permeability of the machine is read off directly. It is calibrated in percentage/

Experiment: To determine the compressive strength of the moulding mixture.

Apparatus: The specimen used during permeability testing, Ridstatedietert pendulum or dead weight apparatus.

Method: Use a plunger to push the specimen out of the metal tube. The test piece is placed between the compression heads. The magnetic rider is put in place in position on scale in front of pendulum weight. The pendulum weight id raised by turning the hand wheel when the test piece breaks, the green strength in KN/m^2 is indicated at the left trailing edge of the magnetic ridder

Experiment: To determine the shatter index of the moulding mixture

Apparatus: Measuring scale, specimen tube, ramming machine, a shattering machine which comprises stripping post, pan, sieve, anvil and a falling height of 188cm.

Method: Weigh out 150g of the sample put the weighted sample into a capped specimen tube. Take the tube to ramming machine and ram three times (Standard). The specimen is pushed upwards into a stripping post so that the specimen is ejected and falls squarely unto he anvil of the equipment. The specimen shatters.

Method: Weigh out 150 g of the sample put the weighed sample into a capped specimen tube. Take the tube to the ramming machine and ram three times (Standard). The specimen is pushed upwards unto a stripping post so that the specimen is ejected and falls squarely unto the anvil of the equipment. The specimen shatters some go into the pan under, through the sieve while others remain on the sieve and anvil. Discard those parts of the specimen that fall into the pan. Weight the part of the specimen that remains on top of the sieve and anvil. Let the initial weight of specimen be Y. Let the weight of specimen on top of sieve and anvil be Y_1

i.e. Shatter index = $\frac{Y-Y_1}{Y}x100$

Experiment: To determine the compatibility of the moulding mixture.

Apparatus: Tester consisting of a linear scale graduated from 0-65%, attached to the standard rammer. Tube filler accessory comprising a 6.7mm aperture sieve and funnel mounted on a heavy metal base. A location hole at the base of the machine ensures the specimen tube is accurately positioned. A striking blade to remove excess sand alter the specimen tube has been filled.

Method: Place the specimen tube under the funnei of the sieve. Ensure it is fitted on the location hole. Pour part of the specimen on top of the sieve and now sieve. The sieved specimen now falls into the specimen tube until the tube gets filled and over flows. The striking blade is used to remove the excess mixture. The specimen tube is now taken to the ramming machine where it is given a standard ramming (three times). The compatibility is read directly from the depth of the rammer on the vertical scale. It is calibrated in percentages from 0 to 65%.

Experiment: To determine the effects of degree of ramming on:

1. The compressive strength
2. Shatter index
3. Gas permeability of moulding mixtures

Apparatus: Weighing scale, metallic specimen tube with cork, ramming machine and compressive strength, shatter index and gas permeability testing machines, Method: Weigh out 150g of each sample, transfer into the specimen tube. Ram at different rates e.g. 3, 5, 7 and 9. Then test their gas permeability, compressive strength and shatter index at each degree of ramming. Complete the process to all test samples.

Experiment: To determine the effect of increased temperature on the shatter index,compressive strength and permeability of the moulding mixture.

Apparatus: Measuring scale, specimen tube, ramming machine, furnace, stopwatch and shatter index, gas permeability and compressive strength testingmachines.

Method: Weigh out 150g of each sample (A, B, C, D) Raise the furnacetemperature to 240, 400, 600 and 800°C and soak each sample for 30 minutes. Measure their gas permeabilities, compressive strengths and shatter indices of eachmixture.

Results
Effects of moisture content in the gas permeability, compressive strength compatibility and shatter index of moulding mixtures.

Sample A

	Gas Permeability (%)	Moisture Content (%)	Compressive Strength (KN/M^2)	Compatibility (%)	Shatter Index (%)
A	60	7.2	35	44	53.3
Al	55	20.0	33	35	52.0
A3	50	3.3	25	30	20.0

Sample B

	Gas Permeability (%)	Moisture Content {%)	Compressive Strength (KN/M^2)	Compatibility (%)	Shatter Index (%)
B	56	11.6	30	47.1	47.3
BI	50	25.6	26	40.5	39.9
B2	47	8.4	21	28.2	18.7

Sample C

	Gas Permeability (%)	Moisture Content (%)	Compressive Strength (KN/M^2)	Compatibiiity (%)	Shatter Index (%)
C	54	13.8	31	48	49.30
CI	51	24.4	24	28	34.70
C2	46	10.5	25	30	13.30

Sample D

	Gas Permeability (%)	Moisture Content (%)	Compressive Strength (KN/M^2)	Compatibility (%)	Shatter Index (%)
D	62	6.4	50	35	40.4
DI	58	17.5	35	29	33.0
D2	52	3.1	30	18	18.6

Sample E

	Gas Permeability (%)	Moisture Content (%)	Compressive Strength (KN/M^2)	Compatibility (%)	Shatter Index (%)
E	70	7.6	20	50	26.5
El	66	18.3	15	45	17.6
E2	62	4.5	18	55	21.5

3.0 RESULTS AND ANALYSIS

From the foregoing samples, the effect of moisture content on the gas permeability, compressive strength, compatibility and shatter index was conducted and the following observations were made:

a. Gas permeability - 61%
b. Compatibility - 44.5%
c. Compressive strength- 3 5.5 KN/M^2
d. Shatter Index - 54.5%

2. For sample B, the optimum moisture content was 12.5%. The corresponding values of tested properties are:

a. Gas permeability - 58.8%
b. Compatibility - 48%
c. Compressive strength- 48.5KN/M^2
d. Shatter Index - 43.5%

3. For sample C, the optimum moisture content was 13.5% (Fig 3). The corresponding values of tested properties are:

a. Gas permeability - 45%
b. Compatibility - 47.5%
c. Compressive strength - 30.5KN/M^2
d. Shatter index - **48.8%**

4. For sample D, the optimum moisture content was 6.5%. The corresponding values of tested properties are:

a. Gas permeability - 62%
b. Compatibility - 29.5%
c. Compressive strength - 49.5KN/M^2
d. Shatter Index - 40%

5. For sample E (Fig. 5) the optimum moisture content was 7%. The corresponding values of the tested properties are:

a. Gas Permeability - 68.6%
b. Compatibility - 50%
c. Compressive strength - 25.5KN/M
d. Shatter Index - 20%

With the results above, sample A has high permeability, average compressive strength and high compatibility and shatter index. It will make a good moulding mixture. For sample B, it has high gas permeability, compressive strength, and compatibility and shatter index. It will make an excellent moulding mixture. Sample C, has a low compressive strength and might not hold mould. Sample D, has low compatibility

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and shatter index which makes it difficult to form and when set, it will be very difficult to shatter hence low compressive neither hold mould nor shatter when casting. Therefore, it is never an advisable moulding mixture.

4.0 RECOMMENDATION AND CONCLUSION

Due to its poor qualities when used singularly binding mould sand starch is best used in a composite binding medium which enables to develop properties akin to those obtained using synthetic binders for high temperature castings. It is advised that high retractory materials be included in the moulding mixture due to high temperature instability of starch.

5.0 CONCLUSION

Optimum foundry moulding properties of starch-based composite binders are obtained at 8 and 12.5% moisture content of sample A and B respectively depending on which sample is being selected for use.

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