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Improvement of Mechanical Properties of Recycled Green Sand by Addition of Alumina and Bentonite

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Abstract - *This paper presents the improvement of recycled green sand (RGS) for the use of aluminum alloy casting. Cost of sand and time required for preparation of new green sand are some of the challenges of foundry men. On the other hand, reusing the foundry sand (FS) has good advantage to the foundry-men to make their sand preparation within short period of time at less cost. This paper focus on how to reuse the recycled foundry silica sand by addition of alumina and bentonite with other some compositions of fewer amounts than first time prepared molding sand mixtures. Used foundry silica sand (UFS) depending on the type of compositions, it lacks the original properties due to the burning of organic compositions during molten metal poured in the cavity. It is common to reuse frequently the silica sand by reconditioning the sand using some amount of bentonite and organic compounds such as wood and charcoal dusts. The properties of the sand were similar like that of the original one after reconditioned and a favorable result was obtained as was experimentally proved. The mixture of used sand checked its property in the laboratory and obtained good results of sand hardness, grain fineness (40-68), Permeability test (150-320) and Moisture content (3.5-7.5). The results of mechanical properties of green sand recycled sample were compared with standard values that are using in casting process.*

Key words: recycled foundry sand, reclaiming, mechanical properties, alumina, and bentonite.

1. INTRODUCTION

Casting helps the growth of industrialization by producing intricate shapes from simple to complex structures with no limit of size. Keeping design calculations and pattern making and mold preparation as they are, green sand casting process includes pouring molten metal into sand mold, allowing the molten metal to solidify, and then shaking out the sand mold to remove a casting product. Sand is used to create mold cavity which able to resist the high temperature of steel and aluminum alloys. Preparation was done by recycled sand with addition of alumina, new sand, wood dust and bentonite.

The effect of Alumina (5%) and bentonite on the used foundry sand in various proportions results good mechanical Properties [1].

The sand uses repeatedly to make a mold with minor compositional addition of binders. The color of used sand differs from the new one because of high heat from molten metal during pouring. This can affect the sand chemical and physical properties. Waste foundry sand contains a thin film of burnt carbon, residual binder (Bentonite), sea coal, and resins/chemicals) and dust. "Silica sand is hydrophilic and consequently attracts water to its surface" [2]. The quality of the sand that has good strength, permeability, thermal stability, collapsibility and reusability [3,4] influences the quality of cast product.

Using reused sand is the process of reconditioning of sand in a foundry to get good quality like that of original properties needed for casting application.

The shape of sand grains varies from rounded to medium with spherical shape that gives better flow ability, strength and permeability.

The sand having more angular shape needs more binder which leads lower packing density and low flow ability to create mold cavity [4]. Binders are used to get good surface finish, strength and flow ability due to creation of the binding actions between sand grains which leads to get the required cavity shape. According to American Foundry Society (AFS), the grains size of foundry sands usually, fall in to the range 150-400μm, with 220-250 μm being the most commonly used.

As described by different scholars, in the green sand clay bonded process, the sand is used over and over again after some treatment of the used sand. Bentonite is mostly used as binding agent new sand preparation and used sand to improve sand mechanical properties, [6, 7]. The recycle sand preparation process includes mulling, sieving, removal of coarse sand and iron particles, addition of water and binder, mixing etc.

Different researchers were studied about recycled foundry sand as shown in table 1 and obtained good mechanical properties.

Table1: Mechanical properties of used sand by different scholars.

Sand Property	Lakshman S. (2010)	Sushil K. et al (2010)
Moisture conter	2%	4 -4.7%
Green strength	1200 g/cm3	1750-1900 g/cm3

2. MATERIALS AND METHODS

2.1 Materials

Used foundry sand (UFS) mold prepared with a mixture of sand, water, and a clay or binder (bentonite) with 10- 20% fresh sand [3]. The mixture contained 80-90% sand, 3- 5% water, and 5-10% Bentonite and wood dust were prepared to make the sample mold as shown in table 2. When the sand mixed with Bentonite and alumina, the properties of the sand gets improved. The used sand mulled and sieved mixed with different sand compositions at Federal Technical and Vocational Education and Training Institute (FTVETI); Manufacturing Technology Department in Addis Ababa, Ethiopia as shown in figure 1.

Fig.1: (a) Used sand (b) Alumina

2.2 Methods

2.2.1. Reclaiming of the reused molding sand

The used foundry sand (UFS) was taken for the study. The sand mulled and sieved using different sizes of the sieves to separate coarse sand. The wooden box was made having the dimensions of 30cm x 30cm x 30cm to measure the sand by volume as shown in figure 2. The used sand, binder, new sand, wood dust and water mixed as per their ratios of proportion in the container.

Table 2: Sand compositions

Item	Amount in Vol.%
Used sand	80
New sand	7
Bentonite	4.5
Alumina	3.5
Water	5
Total	100%

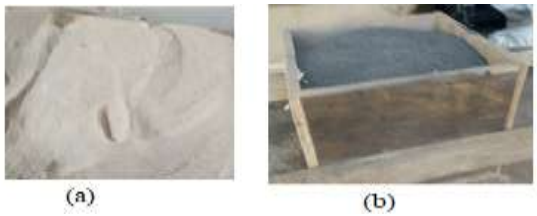

Fig. 2: Sand: (a) Fresh sand; (b) Used sand

To check the quality of sand mixture, uniformity of grains, binders and moisture distribution, the sand lumps broke manually and the result divided into two halves as shown in figure 3. This indicated that the sand can easily be rammed and able to form cavity. The quality of sand influence the quality of cast product.

Fig. 3: Cohesiveness or strength of lump

2.2.2 Conceptual framework of recycled sand preparation.

The conceptual framework of recycled sand preparation as shown in figure 4 indicates the procedures how to make the used sand mold to have similar properties like that of the original sand. Fresh and used foundry sand was mixed by manually and mechanically(vibrator).To separate the different size of sand, used different size of sieve and finally check the sand grain shape. It was mixed with bentonite, wood dust and water using Muller. Sand properties were tested using different mechanical testing equipment. Finally, green sand mold was used for casting as figure 5.

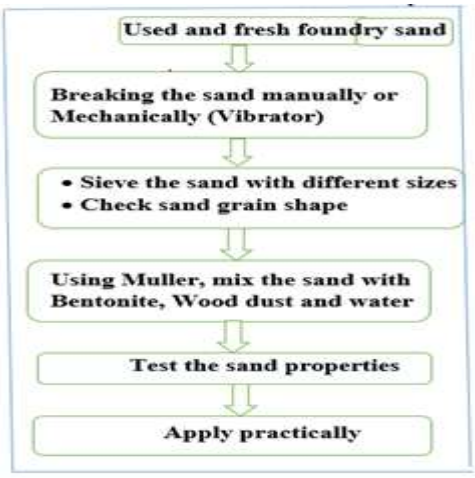

Fig. 4: Conceptual framework of recycled sand preparation

The casting trials were made to check for the effectiveness of the sand using Aluminum alloy after mold preparation. It followed the following procedures:

(i) Design and Calculation: The design included the whole casting processes including the gating system including the amount of metal to be melted, pouring time and others were calculated.
(ii) Pattern making: rectangular solid pattern was prepared with the necessary allowances.
(iii) Sand preparation: the used green sand was prepared with specified ratio.
(iv)Mold preparation: three molds were prepared and rammed manually using cope and drag as shown in figure 5.
(v) Melting and skimming: Aluminum ally was melted in an induction furnace at 715^0C of pouring temperature then poured into the heated steel crucible and skimmed as shown in figure 6.

Fig.5: Prepared molds

Fig.6: Skimming

(vi)Pouring: As shown in the figure 7, three molds were filled with molten metal.

Fig.7: Pouring

(vii) Cooling: the mold allowed cooling at room temperature.
(viii) Shaking out the mold: the mold was easily broke and separated from cast product.
(ix) Finishing: cutting risers, sprue and removed sand particles as shown in figure 8.

Fig.8: Cast products obtained from recycled sand.

The sample size of used foundry sand was determined purposely to be recycled having volume of $0.027m^3$ sand, 1.5 liter of water and 5% of bentonite with wood dust were prepared.

3. RESULT AND DISCUSSIONS

Foundry men can able to save cost and lead time by using recycled/reused sand; for these reasons, sand reclamation is popular in practical application of casting. Using of recycled sand has another advantage of environment safety from being disposing on the land. The preparation of used sand with the addition of bentonite and alumina are convenient for Aluminum alloy casting.

Fresh sand at about 5%, bentonite and other additives added with used sand improved mechanical properties of the recycled sand. When the sand is frequently used, the shape and angle of the sand change to round shape due to high temperature of molten metal. This indicates that there has been a need to improve the required mechanical properties of recycled sand.

4. CONCLUSIONS

The study has been focused on the improvement of mechanical properties of recycled sand by the addition of additives on the major portion of the used sand for the production of Aluminum alloy production. Recycled foundry sand is a time saving and cost effective material when bentonite and silica are added.

In the study additive like bentonite, carbon, and saw dust and to broaden the allowable water content was properly mixed to recycled sand to obtain the standard green sand composition. Moreover, alumina was used as a refractory material which improved mechanical properties of green, dry compression strength and permeability of the recycled sand. The results compared with green sand and recycled green sand and found that addition of alumina in improving the mechanical properties and obtained favorable results. The sand was capable of withstanding the high temperature up to 1600^0C of the molten metal without fusing. It can serve from Aluminum to cast iron foundry applications.

The properties of the recycled sand possessed the mechanical properties of flow ability, green Strength, collapsibility, permeability and refractoriness almost similar with that of new sand properties.

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