Effective Utilization of Industrial and Constructional Solid Waste Materials in Foundry Mould Making to Prevent Environment Pollution and Conserve Natural Silica Sand

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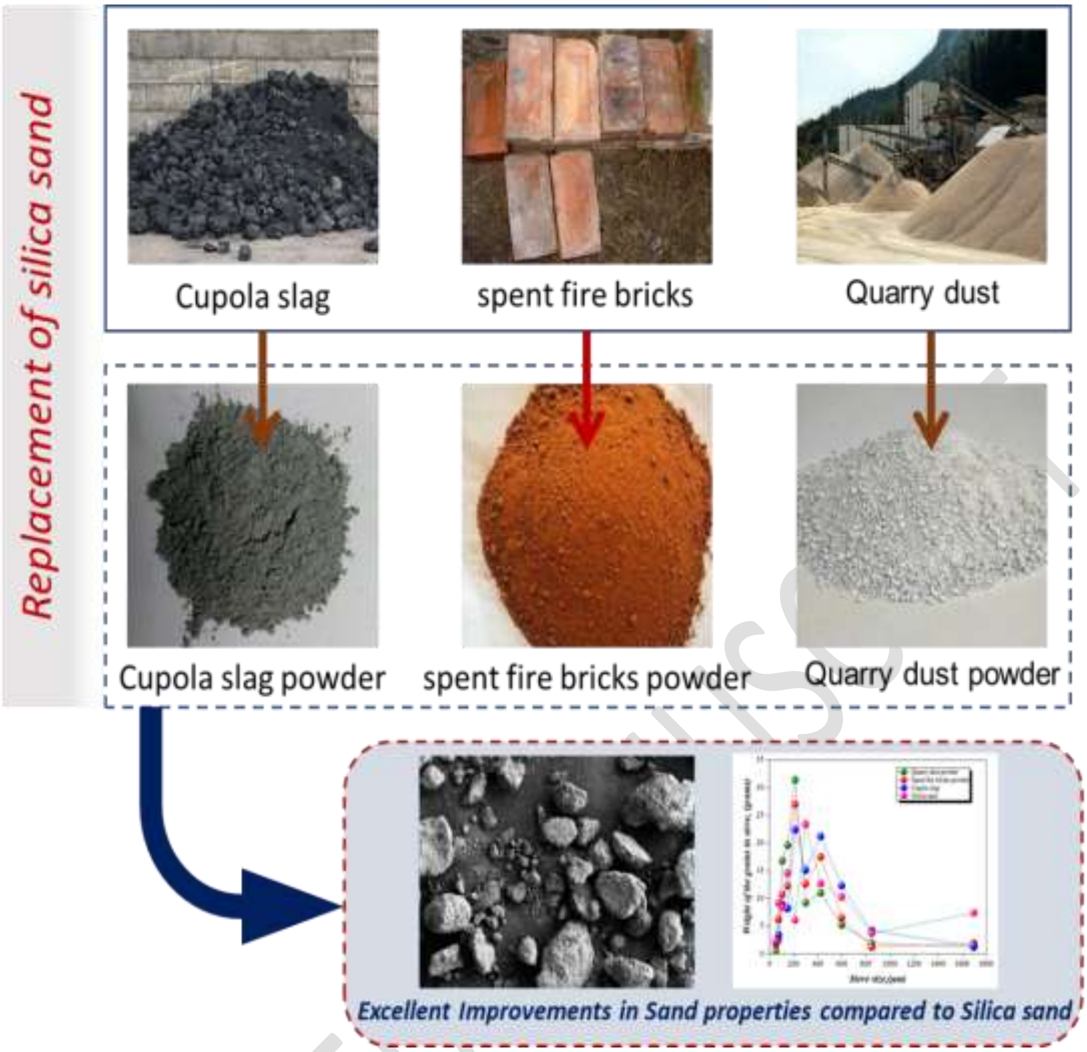
Graphical Abstract



ABSTRACT:

Green sand moulding uses silica sand for metal casting. Silica sand mining and delivery to foundries destroy the ecosystem, making metal casting unsustainable. Due to increased sand-casting output and massive civil buildings in India, the silica sand supply is declining. The depletion and shortage of silica sand necessitate the search for viable replacements. Industrial solid waste from large-scale industrialization pollutes land, air, and water. In order to use industrial waste in large amounts, an attempt is made to use it as a replacement for natural resources. The main objective of this research is to reduce the consumption of silica sand in the foundry mould-making process. Silica sand is replaced with industrial solid waste, cupola slag, and construction solid waste sources like spent fire bricks and quarry dust, up to a considerable amount, to save the natural resources. Utilization of solid waste material in the mould-making process will reduce production costs and environmental pollution, like dumping solid waste materials on land. Sand tests like permeability, green compression strength, dry compression strength, and compactability were conducted to assess the moulding properties of these alternative moulding materials. The process parameters considered for this investigation were the percentage of bentonite binder and the percentage addition of alternative mould materials with silica sand. The various sand tests showed that 40%, 30%, and 20% of quarry dust, spent fire bricks, and cupola slag, respectively, will adequately replace silica sand for mould making. A bentonite binder of 8% is suitable for quarry dust mould, and a 10% bentonite binder is required for spent fire brick particles and cupola slag to yield better results. Aluminium castings were produced at the optimal mixture of these solid waste particles and silica sand. The results of mechanical tests such as hardness, tensile, and impact tests are comparable to those of silica sand castings.

Keywords: Quarry dust, Cupola slag, spent fire bricks, Aluminium castings, Alternative sources, Eco waste reuse.

1. Introduction

In recent years, there has been a steady decline in the quantity of silica sand available to India's foundry sector. Silica sand is mined in large quantities to meet the ever-increasing demand for casting. Such sand mining from beaches damages its ecosystem and the emissions from the transportation of the sand over long distances also emit greenhouse gases, contributing to global warming. Also, the price of getting and transporting silica sand goes up with the price of gasoline. As commercial-grade silica sand is expensive and difficult to transport, it is necessary to investigate less expensive and easily accessible replacement materials for the sand mould casting process. Silicon dioxide (SiO_2), aluminium oxide (Al_2O_3), and iron oxide (Fe_2O_3) are some of the essential elements present in silica sand [1]. The major constituents of industrial and constructional waste like cupola slag, quarry dust and spent fire bricks have SiO_2, Al_2O_3, and Fe_2O_3. However, the main element of silica sand and this construction and industrial waste is SiO_2 which tends to provide refractory properties to the mould. Hence, these industrial and constructional wastes may be utilized in green sand moulding alone or in combination with silica sand at a variable ratio instead of commercial-grade silica sand.

A typical green sand mould comprises mostly of 80% to 95% high-quality silica sand, about 10% bentonite as clay binder, 2% to 5% water, about 5% sea coal and other suitable materials may be added as additives to enhance the specific mould properties. Sand casting is a metal casting process typically using sand as a moulding material for economic casting production. Because sand is the principal component of green sand, significant cost savings in casting production may be accomplished by lowering the procurement and transportation costs of moulding sand.

India's foundries may utilize F-type power plant fly ash instead of silica sand. Fly ash has been found to be a viable option for nonferrous sand casting due to its fusion point being below 1350°C. It has been noted that incorporating fly ash up to 15% in silica sand mould can result in green sand mould castings with appropriate physical and mechanical properties. [2]. Foundries can utilize groundnut shell ash and ant hill powder as binders. A blend of 14% groundnut shell ash and 30% ant hill powder added to the sand met the recommended limits for nonferrous and cast-iron castings in chemical analysis, particle size analysis, moisture content, mouldability and compactability, permeability, green compression and shear strength. [3]. A good sand mould is an essential prerequisite for obtaining a quality metal casting and depends on several factors. The comparative study of six different foundry sands for flowability results revealed that virgin zircon and CB 1450 sands have superior flow properties than other sand types. [4].

Study of physio-chemical properties such as granulometric analysis, moisture, X-ray fluorescence, etc. of Type C coal combustion fly ash determine its viability as an alternative to silica sand for use in foundries. For chemically bonded sand moulds, a sample with 20% fly ash imparted higher technical qualities and offered better quality steel casting, and the binding capabilities of fly ash significantly decreased the utilisation of silicate oil and CO_2 for binding purposes. [5].

An examination of the A319 alloy's microstructure revealed the presence of an alpha-dendrite, eutectic silicon, Al-Cu phase, and Al-Fe-Si phase. The alloy casted in various moulds like blast furnace slag, ferrochrome slag, red mud, olivine sand, and silica sand have hardness values of as 68HV, 67HV, 67HV, 66HV and 70HV, respectively. The Secondary Dendrite Arm Spacing (SDAS) value for slag mould casting is lower than that of casting using silica sand [6].

The synthetic green sand moulding method's compressive strength with 3% banana peel powder is found to be equal to that of 2% dextrin. When banana peel powder was used as a replacement ingredient mould hardness values are 4.2 % higher than dextrin moulds. 3% banana peel powder moulds showed 18.18% increase in green shear strength than 1% dextrin moulds. [7].

Thermo gravimetric (TGA) and Differential Thermal Analysis (DTA) testing show that Fe-Cr slag is as thermally stable as silica sand. Fe-Cr slag has the suitable characteristics to replace silica sand in moulds and might do so in whole or in part. Fe-Cr Slag moulds may cast both ferrous and nonferrous materials and castings made in slag moulds have a high-quality finish, free of surface flaws and porosity. Improved metallurgical and mechanical qualities may be cast from materials with faster heat transfer in Fe-Cr slag moulds [8].

The locally available sand like the mined silica sand, river sand and beach sands are tested for mechanical and physical property to check its suitability to cast metal. Samples of sand were subjected to mechanical and physical testing. Based on the findings of the foundry tests, the sand from the beach had the maximum grain fineness number (GFN) of 64, while the sand from the mine had the lowest GFN of 44. All the sands had a pH greater than 7, indicating a solid bonding capacity with the binder. Permeability and strength decreased and improved with increasing clay concentration in the mould (from 5% to 30%). The mined silica sand mould showed maximum permeability compared to other sand moulds. The volumetric porosity and surface roughness (SR), measured in terms of the Ra value of cast aluminium alloys from various moulds, were compared. The volumetric porosity (mean value in %) is found to be 3.84, 4.56, 4.12 and surface roughness (R_a in μm) is found to be 3.8, 2.2, 2.7 for mined silica sand, beach sand and river sand respectively [9].

Moulding sand permeability and pouring temperatures affected Cast 6061 aluminium alloy quality. The mixing ratio of moulding sand particles and pouring temperatures affect the hardness, porosity, and microstructure of hydraulic brake master cylinder cast aluminium pistons. The metallurgical properties like microstructure, hardness and porosity are found to be excellent at 80:20 (coarse: fine) sand ratio and 750°C ± 10˚C pouring temperature [10].

Recycling and reutilizing industrial waste's capability will help attain the sustainable waste management vision. Cupola slag an example of industrial waste due to a lack of care, often ends up in landfills or dumping grounds. In construction, cupola slag is mainly used to replace natural fine and coarse aggregates and cement in concrete. Extensive research on cupola slag's microstructure, chemical, and physical aspects, beginning with its inception, has been used to analyse its reusability. SiO_2, Al_2O_3, CaO, MgO, FeO, and other oxides and sulphides were the most abundant in cupola slag, although their relative abundance varied with the cupola's charge. Physical property studies reveal that cupola slag resembles the natural fine and coarse aggregates used in concrete, suggesting that cupola slag might be a substitute for fine and coarse aggregates in manufacturing concrete with adequate strength [11].

Adding carbonaceous additives to the prepared moulding sands in the production of iron castings tends to impart a high-quality surface in iron castings. No negative effects, such as a deterioration of the iron casting surface quality due to the increased gas formation tendency of moulding sand combined significant reduction in permeability, were observed when carbonaceous additives were introduced to the sand composition [12, 13].

1.1 Present work

This work attempts to use industrial waste cupola slag and construction waste like quarry dust and spent fire brick particles in the green sand moulding process effectively by replacing the conventional silica sand. An effort has been made to utilize these alternative mould materials to replace the silica sand up to a suitable percentage without compromising the moulding and casting quality. To initiate this work, alternative materials like cupola slag are collected from iron and steel foundries in Coimbatore (India), quarry dust from the crushing plant in Coimbatore (India), and spent fire bricks from the furnace linings of foundries in Coimbatore (India). The collected solid waste materials are crushed in a ball mill. The waste powders are crushed until the particle size is more or less similar to silica sand. The silica sand, bentonite, and coal dust are procured from the local foundries in Coimbatore, India. The prepared waste powders are first subjected to sand testing to assess the various moulding properties like grain fineness, permeability, green compression strength, dry compression strength, and compactability. After completing the sand tests, the values are tabulated, and graphs are prepared to compare these values with standard silica sand. The optimal combination of these alternative mould materials with silica sand is determined by evaluating the properties of the moulding sand, such as permeability, green compressive strength, dry compressive strength, and compactability. In determining the optimal composition, the green compression and dry compression strength tests are often prioritized due to their sensitivity to moisture and binder weight percentage. The alternative mould material was utilized to produce aluminium castings and subsequently assessed for quality. In order to evaluate the appropriateness of alternative mould materials, mechanical tests such as hardness, tensile, and impact tests on aluminium castings were conducted. An optical microscope was used to examine the surface morphology and microstructure of the aluminium castings produced.

2. Materials and Methods

2.1 Quarry dust, spent fire bricks and cupola slag

Quarry dust powder, a by-product of quarry rocks obtained by the crushing process, is collected from the crushing plant in Tamil Nadu, India. The rock has been crushed into various sizes during the process, and the dust generated is called quarry dust powder; it is formed as waste. It is like fine aggregate mixed with silica sand to find its suitability as a moulding material. Cupola Slag is merely the by-product of the metallurgical process and is the type of iron and steel slag formed by cast-iron production in the cupola furnace. The cupola slag is collected from Coimbatore, India's iron and steel foundries. It is then crushed into fine powder form. A firebrick or refractory bricks are the ceramic material used in furnace linings, kilns, and fireboxes etc., they are replaced with new bricks after usage, and the old bricks are dumped. It is the spent fire bricks (SFB) collected from furnaces in Coimbatore, India. Then it is crushed like fine aggregate to use in sand moulds. The silica sand, coal dust, and bentonite powders were procured from local foundries in Coimbatore, India.

2.2 Sieve analysis

The analysis aims to reveal the grain size distribution of the moulding sands [14]. Initialy100 grams of dry sand were taken for the sieve analysis, and an electric sieve shaker shook the test sands for 15 minutes. After 15 minutes of vibration, the sieve shaker was turned off, and the electronic balance was used to determine the amount of sand still trapped in each sieve [2]. The fineness value was determined using equation (1).

$$Grain\ Fineness\ Number\ (GFN) = \frac{Total\ Product}{Total\ \%\ of\ sand\ retained} \qquad (1)$$

2.3 Standard Sand Specimen Preparation

Figure. 1 Standard sand specimen preparation (Figure 1: a 80:20, silica sand: cupola slag sample; and Figure 1: b 20:80, silica sand: cupola slag sample)

According to the American Foundry Society (AFS) standards [15], the standard sand specimen dimension of 50.08 mm x 50.08 mm was prepared as shown in the Figure.1 (a - b). However, silica sand was mixed with various solid waste particles such as quarry dust, spent fire bricks, and cupola slag at varying compositions. The bentonite percentage is varied as 6,8,10 whereas the moisture 4% [2] and coal dust additive 2% is kept constant throughout the sand specimen. The mechanical mixer was used to mix silica sand with different solid waste, and the sand samples were uniformly rammed with a sand ramming machine. Then prepared sand specimens were tested for mould sand properties of permeability, green compressive strength and dry compressive strength.

2.4 Scanning Electron Microscopy (SEM)

The surface morphology and shape of silica sand, quarry dust, cupola slag, and spent fire bricks particles were examined with Scanning electron microscopy (SEM). Figure. 2, Figure. 3 and Figure. 4 represent the quarry dust, cupola slag, and spent fire bricks particles observed with different magnifications [16, 17]. The test sand samples were mounted on a sample holder with a working distance (WD) of 6.9 mm to 10.3 mm, and a 10 kV voltage was applied.

2.5 Compressive Strength

The compressive property of the sand mould will determine the size and quality of castings that can be produced with that mould. The compressive strength of sand specimens was evaluated with the universal strength machine (USM). The prepared sand samples were held between the compression grips. On both sides, a compressive force is applied until the specimen fractures. During the dry compression strength test, the sand specimen is dried in an oven at 80°C for three hours and then chilled for about 60 minutes in a desiccator [18]. Individually, specimens are removed from the desiccator as soon as they are sufficiently cooled and loaded in the machine to complete the test [7].

2.6 Permeability Test

The permeability of the sand specimen is tested by an apparatus called a permeability meter. The sand of proper permeability must be used to ensure sound castings [19]. Low permeability leads to casting defects of blow holes and scabs and difficulty shaking out the casting from the sand. The prepared sand specimen was subjected to 2000 cm^3 of air, and flow duration was recorded [2]. The permeability number was calculated using equation (2).

$$Permeability\ (P) = \frac{V \times \mathrm{H}}{P \times a \times t} \qquad (2)$$

Where V = Volume of air passing through the sand specimen in cm^3, H = Height of the specimen in cm, P = Pressure of air in g/cm^2, a = Area of the specimen's cross-section in cm^2, t = Time for the flow of air in minutes.

2.7 Compactability test

The compactability indicates the water-tempering degree of the green sand moulding. The compactability of sand samples was analysed by a compactability scale accessory mounted on a sand rammer. The prepared sand samples are filled into specimen tubes with a height of 115 mm and 50 mm wide opening [2]. Samples were rammed three times using a sand rammer, and the extra sand was removed [20]. The height difference between the top of the tube and the surface of the sand calculates the compactability and it is denoted as compactability percentage. The percentage decreases in the height of a loose sand mass under controlled compaction influences the moulding sand properties.

3. Result and discussion

3.1 SEM morphology of quarry dust, spent fire bricks powder and cupola slag

SEM analysis revealed surface morphology, size and shape distribution of quarry dust cupola slag and spent fire bricks particles [21]. Quarry dust particles are more or less irregular in size and sharp in shape(angular), which is supposed to have more strength and better interlocking between neighbouring sands and binders. These quarry dust particles are obtained by crushing and milling operation sequence for 8 hours from initial raw quarry rocks. The size and shape distribution of quarry dust was represented in the SEM micrograph of the Figure. 2 (a – d). The shape contour of the spent fire bricks particles and cupola slag are sub-angular, as observed in the SEM micrograph of Figures. 3&4 (a – d). The cupola slag has more mould permeability than spent fire bricks powder.

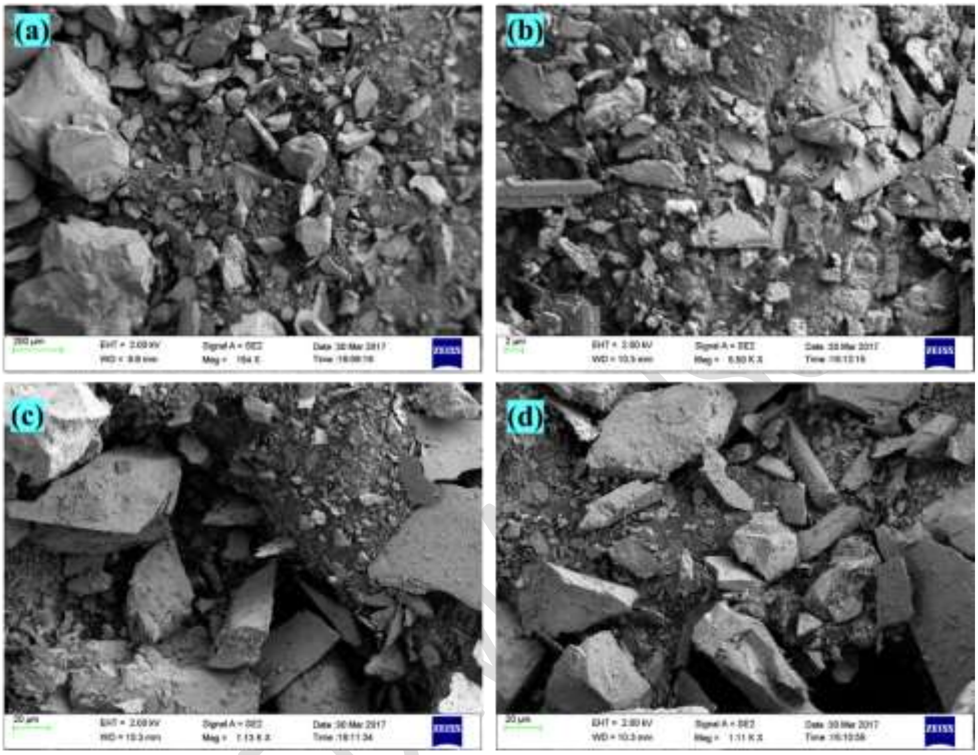


Figure. 2 SEM micrograph of Quarry dust

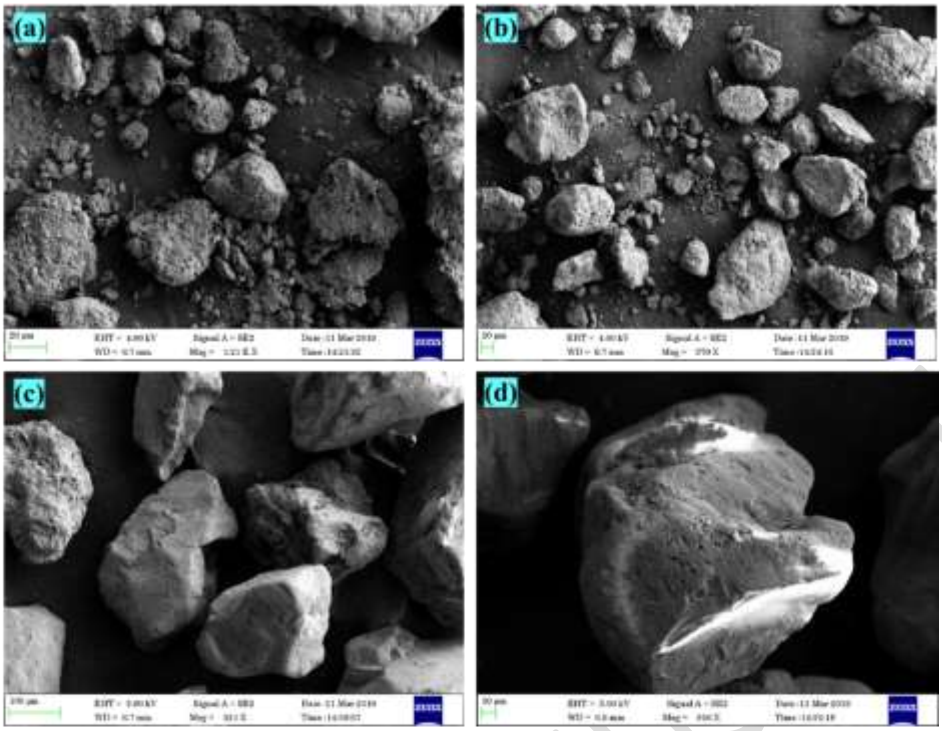


Figure. 3 SEM micrograph of Spent Fire Bricks

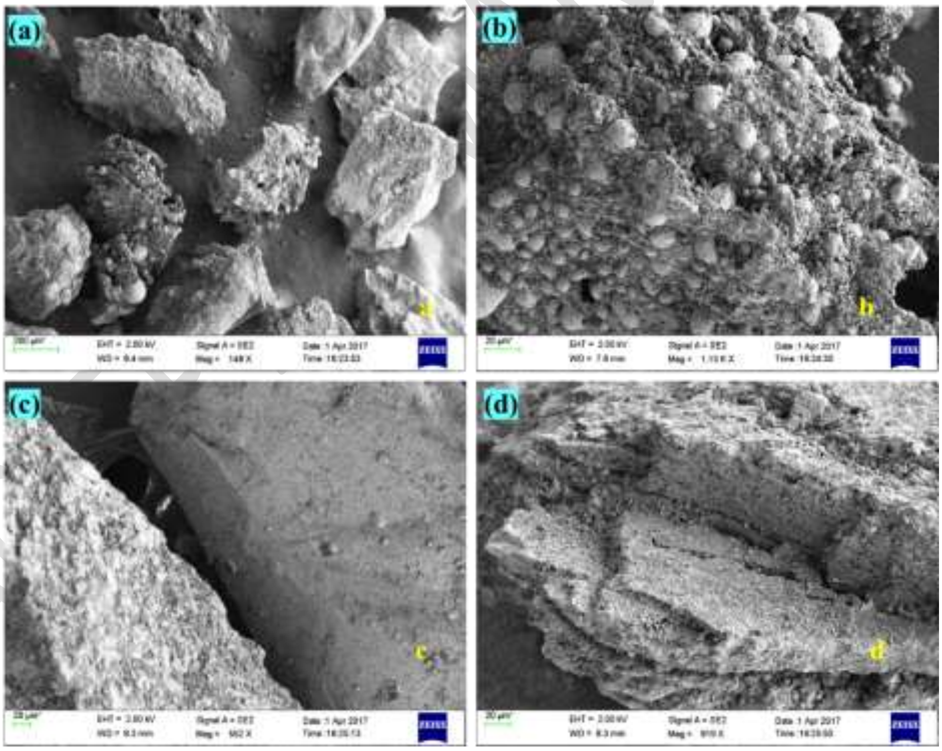


Figure. 4 SEM micrograph of the Cupola Slag

3.2 Sieve analysis

The particle size and distribution of silica sand, quarry dust, spent fire bricks particles, and cupola slag was found using sieve analysis. The series sieve size of 1700 μm, 850 μm, 600 μm, 425 μm, 300 μm, 212 μm, 150 μm, 106 μm, 75 μm, and 53 μm sieves size was used to sort 100 g of silica sand, quarry dust, fire brick particles, and cupola slag. Silica sand, quarry dust, spent fire brick particles, and cupola slag has different particle size distributions, shown in Figure. 5, representing the grain fineness number (GFN) defined by the American Foundry Society (AFS). In contrast to the spent fire brick particles, which has a particle size distribution of 425 μm to 212 μm, the majority of silica sand particles fall within the 212 μm to 106 μm in range. The particle size distribution for cupola slag is mainly in the 425 μm to 150 μm range, whereas quarry dust is predominantly in the 425 μm, 300 μm and150 μm range. The average grain fineness number of silica sand, spent fire brick particles, quarry dust and cupola slag are 83 μm, 81 μm, 79 μm, and 71 μm. The GFN of waste spent fire bricks particles and quarry dust is more similar to that of silica sand. Cupola slag has a coarser particle size distribution and has lower GFN than competing mould materials. This result suggests that these mixtures may work well in foundry settings. Sand moulds made with this mixture of sand may provide sound castings.

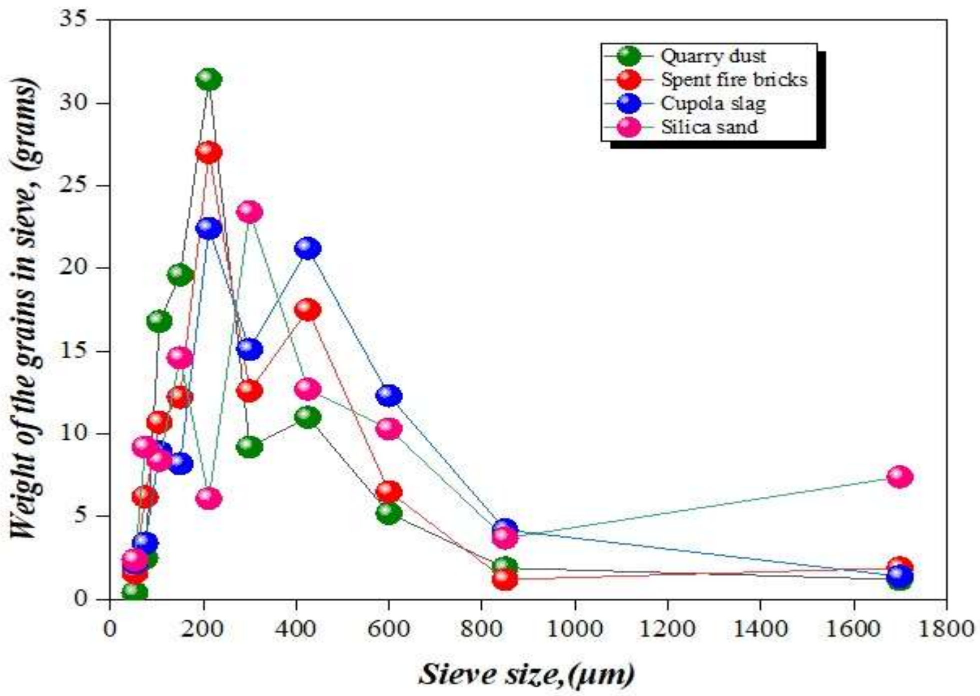


Figure. 5 Particle size distribution of silica sand, quarry dust, spent fire bricks particles and cupola slag

3.3 Green Compression strength

The green compression strength is conducted for the sand samples of quarry dust, spent fire bricks particles and cupola slag at varying compositions with silica sand. The bentonite binder percentage varies from 6% to 8% and 10%. The Green compression results revealed that the moulding sand's green strength increases when bentonite clay [22] is added to the mixture, as shown in Figure. 6. The moisture content of 4% and additive coal dust of 2% are constant for all the samples. As the bentonite percentage increases, the green compression strength for 100% silica sand samples, the values of 280 gm/cm^2, 350 gm/cm^2 and 350 gm/cm^2 at 6%, 8% and 10% binder, respectively. For the quarry dust samples, the green compression strength increased from 6% to 8% binder content, but after increasing further to 10% binder, the green compression strength decreased. The maximum green compression strength is 570 gm/cm^2 at 8% binder of 40% composition with silica sand. As the bentonite binder percentage increases, the green compression strength increases for spent fire brick and cupola slag samples. The maximum green strength values were 530 gm/cm^2 for spent fire brick particles at 30% and 520 gm/cm^2 for cupola slag at 20% composition with 10% bentonite binder.

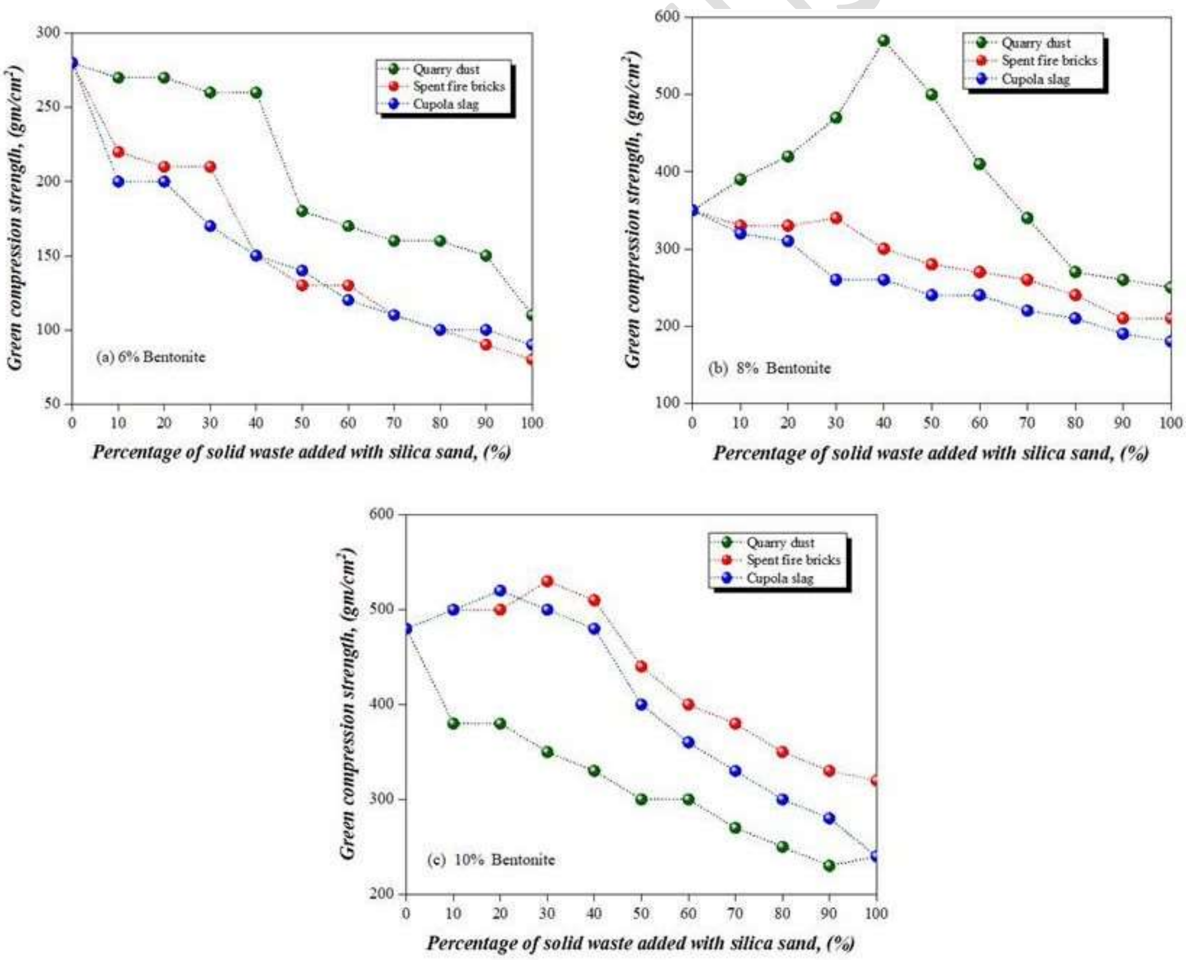


Figure. 6 Green compression strength of silica sand with alternative mould materials

3.4 Dry Compression strength

The dry compression strength for the sand samples is conducted similarly to the green compression strength. Still, the different sand samples are heated in the oven at 80°C for three hours and then cooled in a desiccator for about 60 minutes. This test reveals the strength of the sand mould in the dry state. As the bentonite percentage increases, the dry compression strength for 100% silica sand samples is 2070 gm/cm^2, 2090 gm/cm^{2}and 2570 gm/cm^2 at 6%, 8% and 10% binder, respectively. The quarry dust has maximum dry compression strength of 2270 gm/cm^2 for 40% composition at 8% binder, which is shown in Figure. 7. The spent fire bricks particles and cupola slag have maximum dry compression strength of 2120 gm/cm^2 and 2050 gm/cm^2 for 30% composition and 20% composition at 10 % binder, respectively.

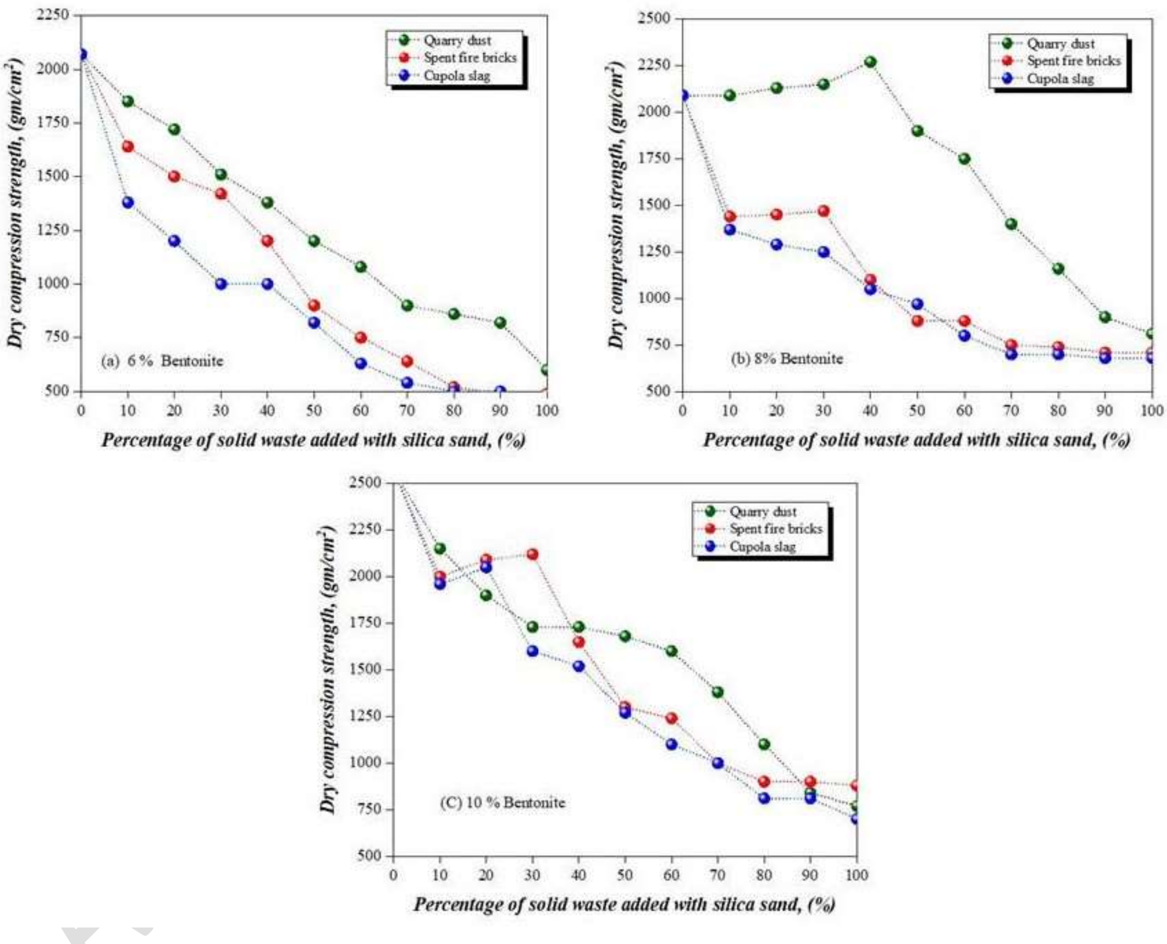


Figure. 7 Dry compression strength for different moulding materials

3.5 Compactability

The compactability test is conducted for sand samples of different solid waste at varying compositions with silica sand separately at the interval of 10 % and up to 100%. The moisture content of 4% and additive coal dust of 2% are kept constant for all the samples. It was observed that the mould compactability decreased as the bentonite percentage increased, which is shown in Figure. 8. The 100% silica sand sample has the compactability value of 51%, 50% and 48% at 6%, 8% and 10% bentonite binder, respectively and the maximum compactability is found to be 51% at 6% bentonite binder. The maximum compactability is 52% for 30% spent fire brick particles composition at 6 % bentonite binder. The quarry dust showed a maximum compactability of 50% for 40% composition, and cupola slag showed a maximum compactability of 44% for 10% composition at 6% bentonite binder. There is no specification that has been set for minimum and maximum values of compactability in the available literature [23,24]. However, compactability decreases as the particle size of green sand mould ingredients gets smaller and as the percentage of binder in those components rises.

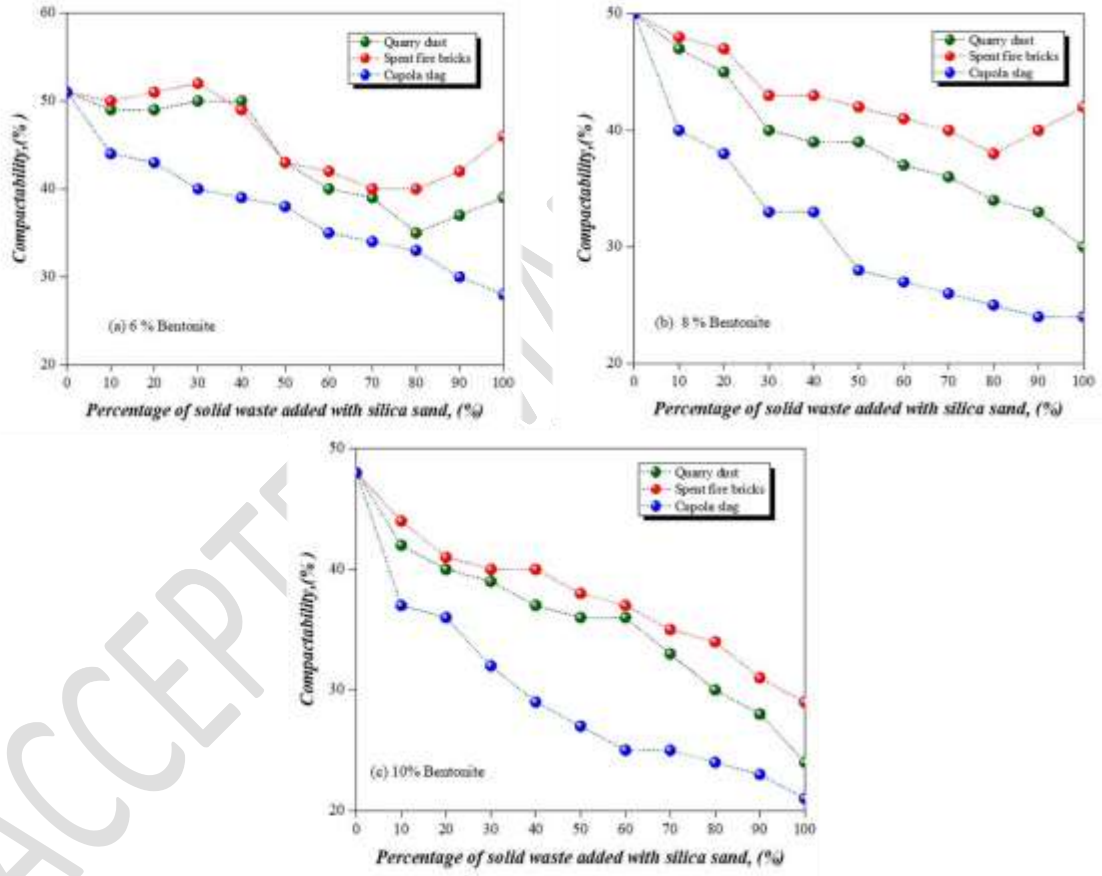


Figure. 8 Compactability of silica sand with alternative mould materials

3.6 Permeability

The permeability test results are shown in Figure. 9. Adding more bentonite binder to the sand mixture steadily reduces its permeability. Increased permeability was seen for pure silica sand, while decreased permeability was observed for all other compositions. Because the solid waste particles tend to lock with the silica sand particles, the bulk density of the mould is increased while the porosity is decreased. Cupola slag had high permeability values of 123, 124, and 99 at 6, 8, and 10% bentonite binder when replaced 100% with silica sand. The mould made from the mix will enable gases to escape readily from the casting, decreasing the likelihood of gas inclusions, but only within the specified permissible limit for nonferrous and cast-iron castings. Nevertheless, the permeability of the mould may be enhanced by adjusting the particle size of the moulding sand, the quantity of binder, the additives, the moisture content, the vent holes, etc.

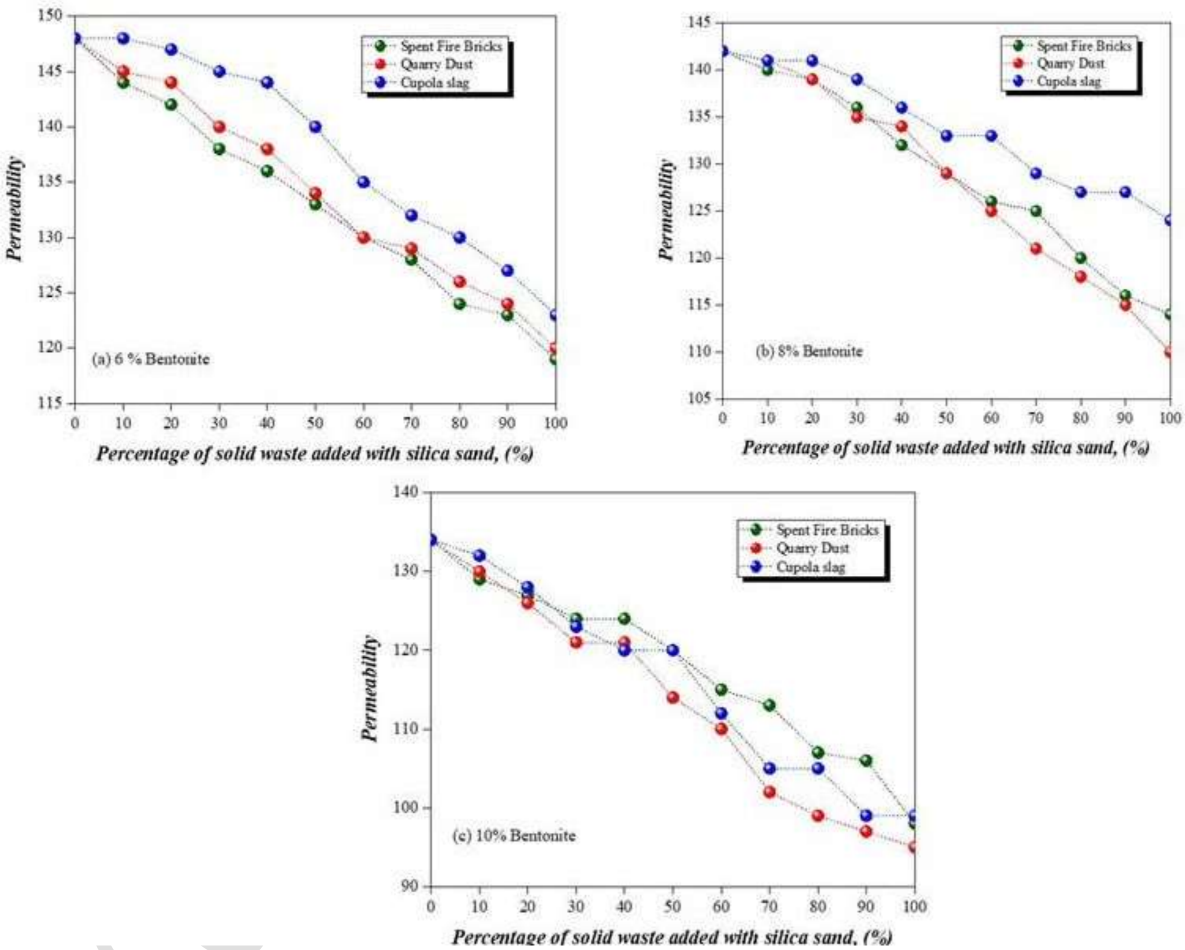


Figure. 9 Permeability of silica sand with alternative mould materials

3.7 Optical microscope

Optical microscope images of LM6 aluminium alloy described the surface morphology and microstructure observed at magnification range 100X in sand casting of LM6 aluminium alloy with different sand materials of quarry dust, spent fire bricks and cupola slag, which is shown in Figure. 10 (a-d). Generally, in sand casting, nucleation occurs at the mould/metal interface portion. Sand-cast LM6 aluminium alloy has a microstructure that is composed of white - Al dendrites, dark grey silicon particles, iron-rich Fe intermetallic

- phases, and Cu intermetallic phases. It also has some course, fine structure, dendritic and columnar structures. The main structure of white α- Al dendrites is observed in microscopic investigation. LM6 aluminium alloy that was cast in a different mould sand was discovered to have a microstructure that contained a change in the size of the secondary dendritic arm spacing (SDAS) between - Al dendrites [25]. The decrease in SDAS value results in improvements to the alloy's mechanical properties, such as increased strength and hardness, and a reduction in the inter-dendritic shrinkage porosity of the material [6].

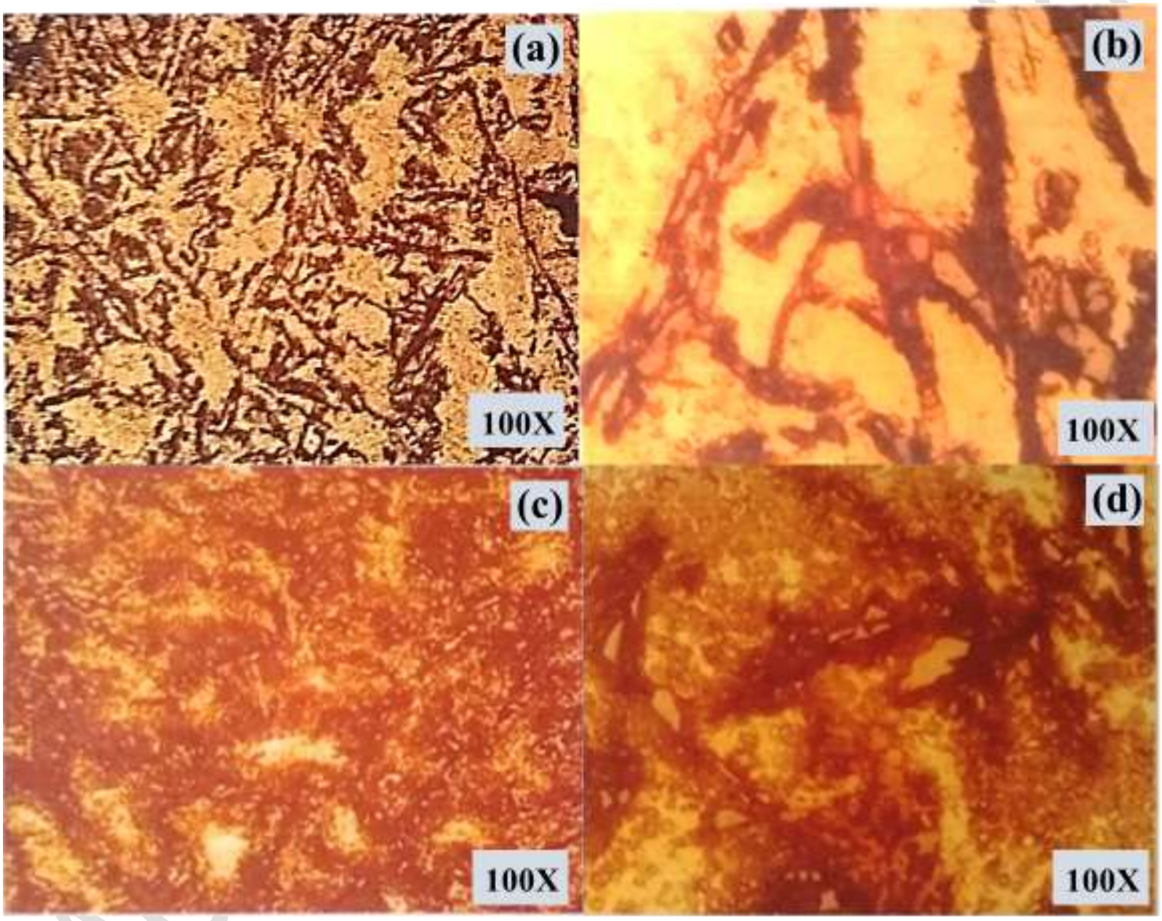


Figure.10 Microscopic analysis of a)100 % silica sand casting, b) Quarry dust casting, c) Cupola slag casting, d) Spent fire brick casting

3.8 Mechanical strength

3.8.1 Hardness property

The Vickers hardness value of LM6 aluminium alloy cast with 100% silica sand and various alternative sand materials, such as quarry dust, spent fire bricks, and cupola slag, is shown in Figure. 11. It showed a slight variation in hardness results when the alloy was cast in different moulding sands. By comparing the hardness value of LM6 aluminium alloy formed in silica sand moulds to those cast in other alternative material moulds, it is clear that there is a significant overlap between the materials. The maximum Vickers hardness of 69 HV was observed for 100% silica sand casted aluminium, and the minimum hardness was found to be 46 HV for spent fire brick particles casted aluminium, respectively. Quarry dust and cupola slag castings have hardness values of 63 HV and 56 HV, respectively.

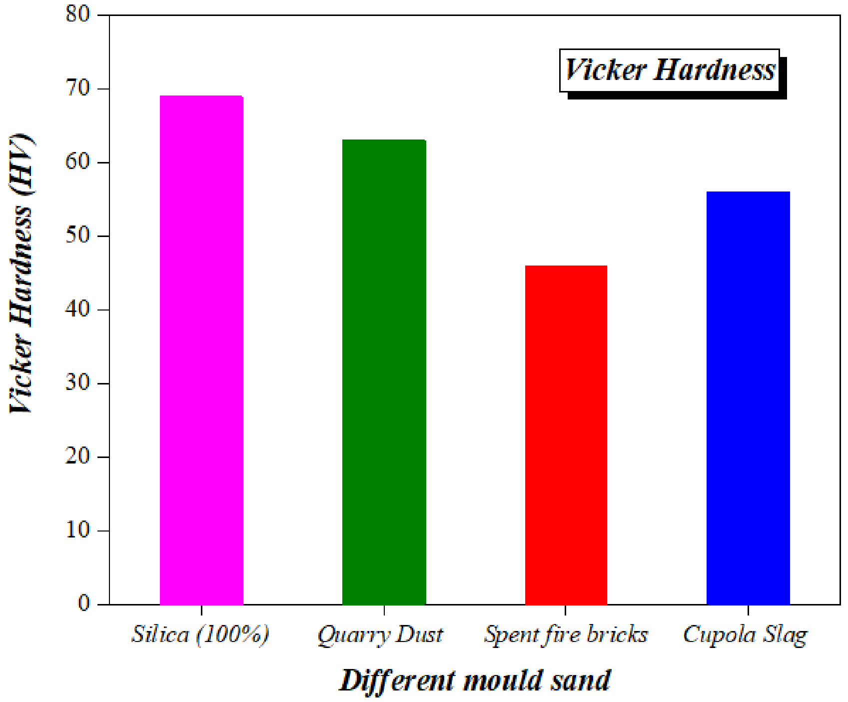


Figure. 11 Hardness of aluminium casting with different moulding sand

3.8.2 Tensile Strength

Figure.12 shows the tensile strength of LM6 aluminium alloy cast in different moulding sands, and it was observed that alloy cast in quarry dust mould has a higher tensile strength of 155 N/mm^2 than silica sand mould tensile strength of 135 N/mm^2. The spent fire brick particles and cupola slag mould castings have a lower tensile strength of 108 N/mm^2 and 119 N/mm2, respectively. The durability of these solid waste particles as a mould material in the foundry application is demonstrated by an improvement in the mechanical properties of an LM6 aluminium alloy that was cast in a solid waste particle mould.

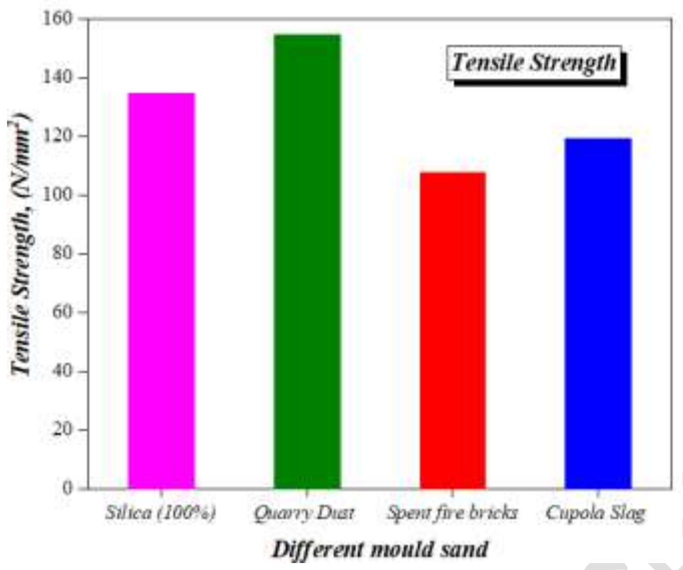


Figure. 12 Tensile strength of aluminium casting with different moulding sand

3.8.3 Impact strength

The aluminium LM6 aluminium alloy cast on different moulds of quarry dust, spent fire brick particles, cupola slag, and silica was subjected to a Charpy test and examined for impact strength. Figure. 13 represents the impact strength variation with different mould materials. The silica sand casting has the highest impact strength of 2 joules. Quarry dust casting has impact strength of 1.8 joules, and cupola slag has impact strength of 1.6 joules. Compared to other mould castings, the impact strength is low for spent fire brick castings at 1.5 joules.

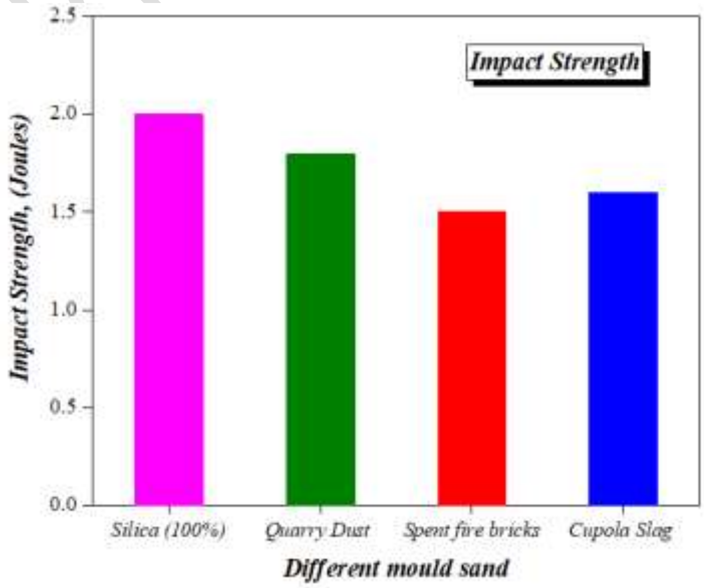


Figure. 13 Impact strength of aluminium casting moulding with different moulding sand

4. Conclusion

In this proposed work, a deliberate attempt has been made to replace the conventional silica sand in mould making with an alternative source like quarry dust, spent fire bricks particles and cupola slag in suitable proportion to produce aluminium castings. The moulding materials were subjected to a grain fineness test to find the average grain size of the particles. The average grain fineness number (GFN) are found to be 83, 81, 79 and 71 for silica sand, spent fire bricks particles, quarry dust and cupola slag, respectively. The highest number represents the fine sand that can produce castings with good surface finish and dimensional accuracy. The SEM analysis is conducted to find the particles' morphology. Quarry dust powder was observed to have more angular shape particles, whereas the cupola slag and spent fire brick particles are sub-angular in shape. The angular and sub-angular sand particles while enough ramming, gives a stronger bond and higher mould strength but low permeability. The alternative mould materials were mixed with silica sand at varying compositions in the interval of 10% (10%, 20%, up to 100%) and sand tests like permeability, green compression strength, dry compression and compactability were conducted to find the moulding properties. The process parameter considered for this investigation was the percentage of bentonite binder and the % addition of alternative mould materials with silica sand. The various sand tests showed that 40 %, 30% and 20% of quarry dust powder, spent fire bricks powder, and cupola slag powder will adequately replace silica sand for mould making. The bentonite binder of 8% is suitable for quarry dust mould, and 10 % bentonite binder is required for spent fire bricks powder and cupola slag powder to yield better results. The aluminium castings are produced by making moulds with these alternative materials at the best composition and binder percentage. The castings are inspected for defects, and mechanical tests like hardness, tensile and impact tests are conducted and then compared with standard silica sand (100%) casting to assess the properties. The test results are in a comparable range with silica sand castings. This research shows that these solid waste particles can replace the widely mined silica sand up to a considerable volume, offset the damages done to the environment, and reduce the production cost of castings in the green sand moulding process.

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