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Fly Ash an Alternative for Molding

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Abstract: X-ray diffraction, thermo-gravimetric analysis and scanning electron microscope spectroscopy studies were performed with molding sand and fly ash(received from carbon processing industry and Thermal Power Plant in India) to evaluate and compare their physical properties. It was found that several physical properties of fly ash received form carbon processing industry and Thermal Power Plants are similar. Permeability, green compression strength and dry compression strength of various compositions of fly ash were tested to explore their potential as an alternative to molding sand, thereby reducing the dependency on the latter, as well as to suggest an effective way for disposal of fly ash.
Keywords: Molding sand, permeability, fly ash, casting, X-ray diffraction, thermo-gravimetric analysis and, scanning electron microscope spectroscopy.

I. INTRODUCTION

Natural sand is commonly used in green sand molding for making castings in foundry practice. The quality of casting depends on the permeability, green compression strength, dry compression strength of molding sand.

The supply of molding sand has been reduced due to the scarcity of natural silica sand. In addition, due to the high dependence on natural sand for mold making, the cost of castings in the foundry has also risen, as well as toxic gases are released from the mold and core in the foundry. It has been suggested that carbon industry and coal fly ash could be an excellent alternative to molding sand. Fly ash obtained from thermal power stations and carbon processing industry has been used, as the dustings are thermally stable. Emulsions are suitable binders for making molds[1,2]. Fly ash as well as natural sand may nonstick over the surface of patterns [3]. Scanning electron microscopy (SEM) and XRD study showed that the soil is best suited for the mould clayas it provides coating around the sand grains, which resulted in the filling of voids and reduces the permeability of sand and clay mixtures [4]. Defects produced in the castings are usually related to the properties of the mold. The distribution of thermo-physical properties, bulk density, and thermal expansion or contraction of the mold are important for the formation of several stoichio metric defects [5].Several synthetic and natural resins are used as a binder in mold making. In spite of the benefits in using such mixtures, one crisis is their low flexibility during solidification of the metal [6].

The bulk density and thermal expansion of zircon sand may vary with temperature. As a binder, starch has right viscosity and higher specific binding strength, and the binder bonded core sand will seem to have ample property, and so the use of synthetic resin and natural resin binder can be moderately reduced in foundry sand [8]. The mold properties, including permeability, green and dry compression strengths, were measured subsequently [9]. Permeability is one of the desirable characteristics of the mold, which is usually obtained by high porosity. Moreover, mold strength, durability and mechanical properties can be improved by the addition of local oils and ochadamu clay [10].Previously, steel industry waste mixed with sand was found effective to replace the conventional green sand in foundry molds. Hence, the permeability, dry and green compression strengths of various industrial wastes can be assessed to explore their suitability in mould making [11].

The application of industrial waste materials, such as used foundry sand and fly ash, can help conserve natural resources by decreasing the demand on virgin materials, reduce green house gas emissions through reduced mining actions, as well as decrease the economic and ecological burden [12].

Among the many interesting attributes, thermal power plant and graphite ash has very high melting point, can absorb and transit heat during pouring, and has the ability to allow gases to pass through compacted mass. In thermal power and graphite industries, the carbon and coal ash are burnt in the furnace to produce heat, yielding the fly ash as waste. The storage and disposal of fly ash is a challenging task to industries, potentially causing environmental hazards. The demand for natural silica sand for construction activities, chemical industries, foundries and others is increasing day byday. Therefore, foundry industries expect that alternative materials to replace silica sand be found with desired properties for molding. The purpose of this research is to discuss an approach to utilize fly ash in foundry in making quality castings.

II. MATERIALS AND METHODS

Thermal power plants and graphite industries fly ash are taken as an alternative to the molding sand. Fly ash of carbon processing industry and thermal power plant (Figure 1 (a) & (b)) was collected from HEG Ltd., Bhopal and NTPC Sarni (India) respectively. Green sand for molding (Figure 1 (c)) was collected from Upper lake, Bhopal (India).

(a) (b) (c)

Figure 1: (a) & (b) Fly ash from Carbon processing industry, (c) Green Sand from river bed

X-ray diffraction (XRD), thermo gravimetric analysis (TGA), scanning electron microscopy (SEM) and energy studies were performed on the collected fly ash and molding sand. It was found that Fly ash has similar properties as silica sand.

Fly ash was mixed with molding sand in different proportions. Bentonite was used as a binder, and 4% water was added to the sand mixture. The mixture was introduced into a sand Muller that runs for 5 minutes at150 rpm. Then all tests were performed with each standard mold sample to assess its mechanical behaviors.

Permeability of standard mold samples was measured using permeability meter. Green compression strength of the cylindrical sample extruded from the die (Figure 2) was measured using a universal strength machine (USM). The sample was horizontally placed and standard load applied to measure its strength.

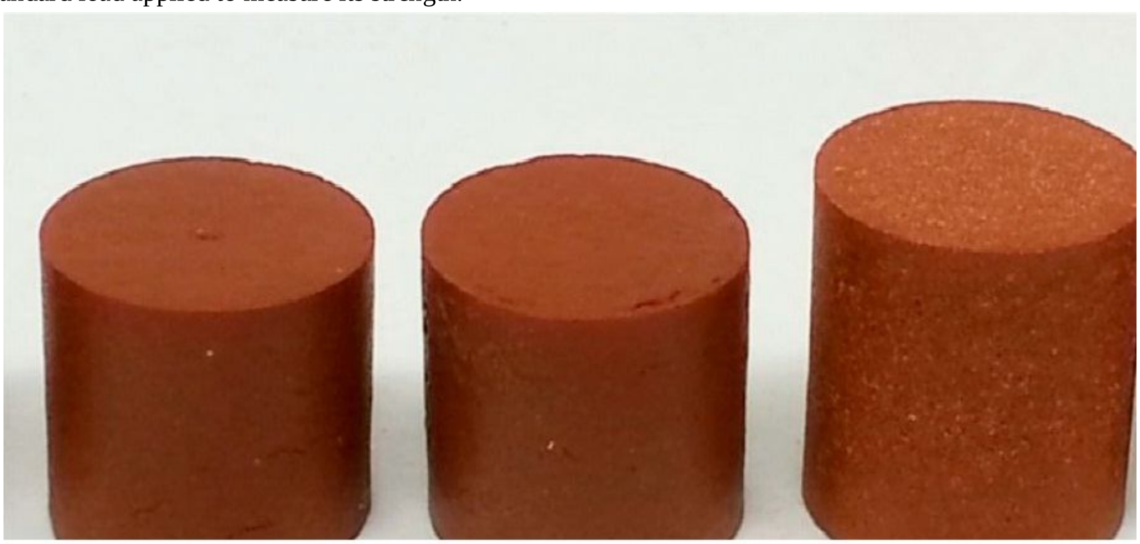

Figure 2: The molding cylindrical material with fly ash of carbon processing industries and clay

Moisture present in the sample was removed by exposing it to sunlight for 8 hours and dry compression strength was measured using the USM. Tests were replicated thrice for each mixture, at different compositions of fly ash(from 0 to 60%) and bentonite (0–5%).Sand molds were made with different compositions of molding sand, fly ash and bentonite.

III. RESULTS AND DISCUSSION

A. *Scanning Electron Microscopy*

Jeol 6404 was used for SEM study. Figure 3and 4show that molding sand is having ariable-sized particle structures and fly ash is having spherical shaped particles (between 3 and 1 micron of diameter) and smooth surface texture. Fly ash particle sizes are finer as compared to molding sand particles. SEM shows both angular and rounded particles. Therefore, fly ash mold could have a slight reduction in compactness, strength and permeability.

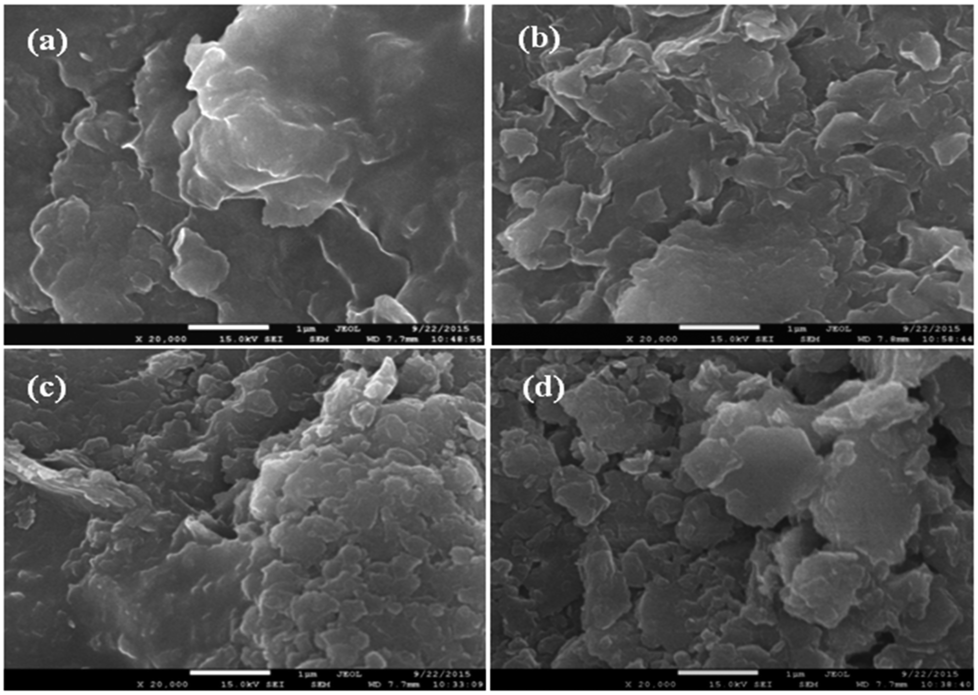

Figure3: Scanning Electron Microscopy(a) Flayash of carbon processing industries
(b) Fly ash of Thermal power plant (c) After mixing of clay material
(d) after the molding of material with coal fly ash

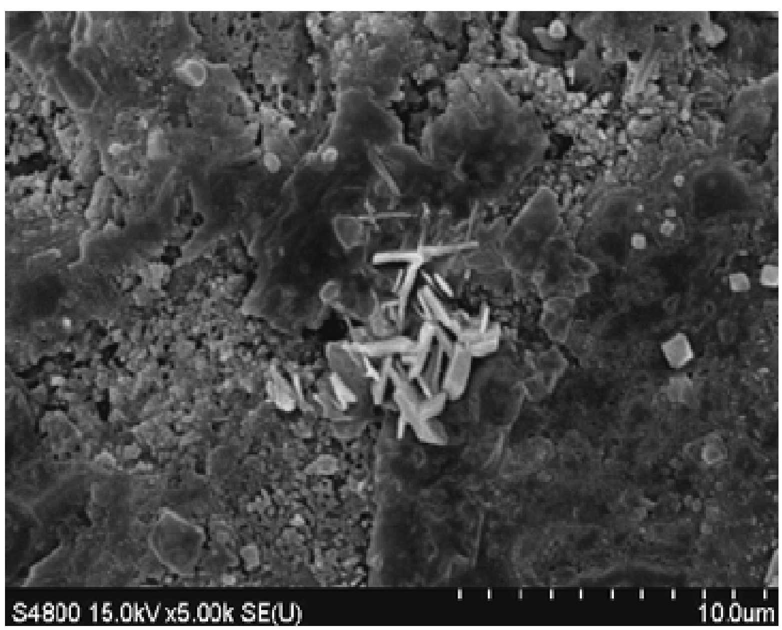

Figure 4:Scanning Electron Microscopy after molding of material with carbon fly ash

B. *X-ray Diffraction*

Diffract ograps of fly ash are shown in Figure5 and 6. The coordinate axis indicates 2θ scale readings and the abscissa indicates counts/intensity. For sand, 1800 was the maximum count and *d* value was 2.50 at 36,2θ, whereas for fly ash, 4500 was the maximum count and *d* value was 2.11 at 36.63 2θ value. Hence, the addition did not reduce the properties of the molding sand, especially its refractoriness.

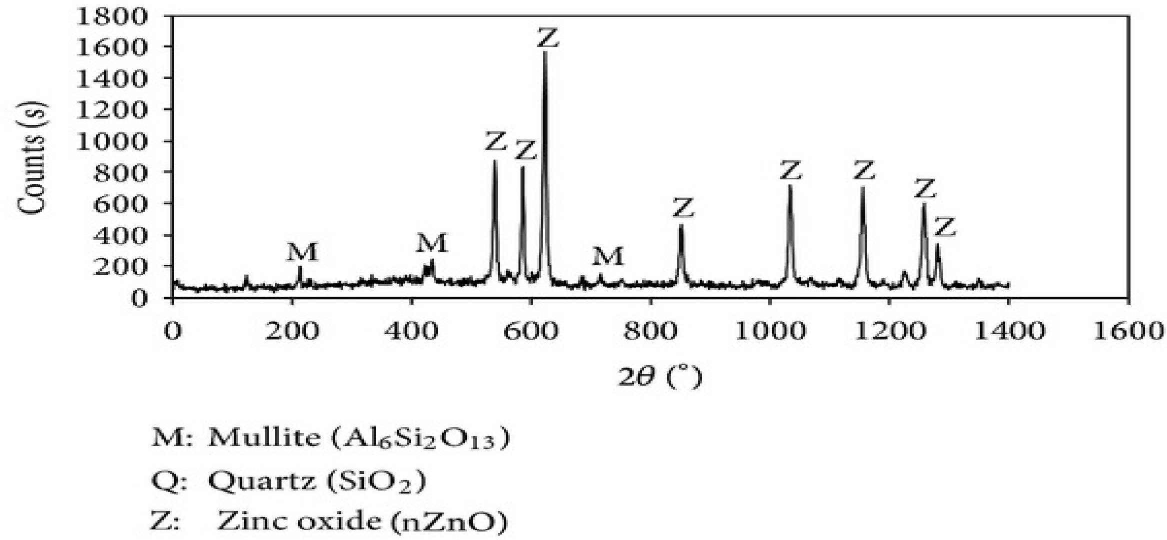

Figure 5: X-ray analysis of flay ash of carbon processing industries

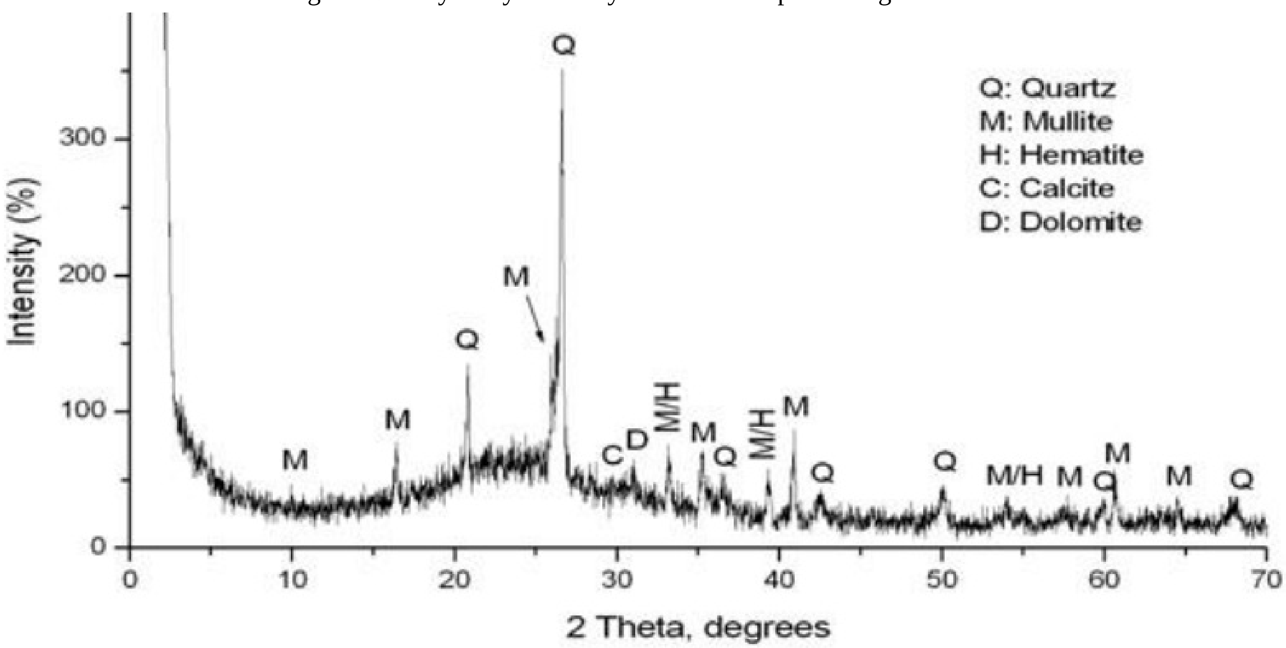

Figure 6: X-ray analysis of flay ash and clay composite materials

C. Thermo-gravimetric Analysis

Thermo-gravimetric Analysis (TGA) of foundry sand shows a gradual weight reduction up to 7.5 and 11.8% for fly ash as temperature increased to 980 from 50°C. The weight reduction in fly ash was 57% more as compared to molding sand. As the molten the temperature of the mold will rise. Hence, the more the temperature, more is the weight reduction of mold.

The Figure: 7 and 8 reveals that the comprehensive strength is increased with the reduction in moisture content and increase in time.

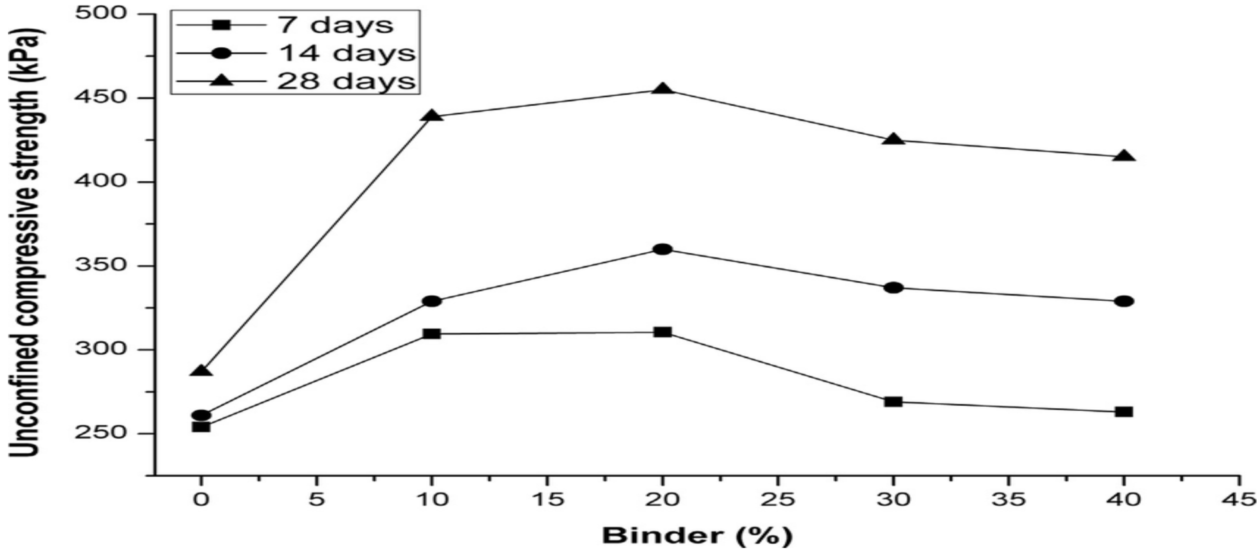

Figure7 :Binding strength of fly ash of Carbon industry

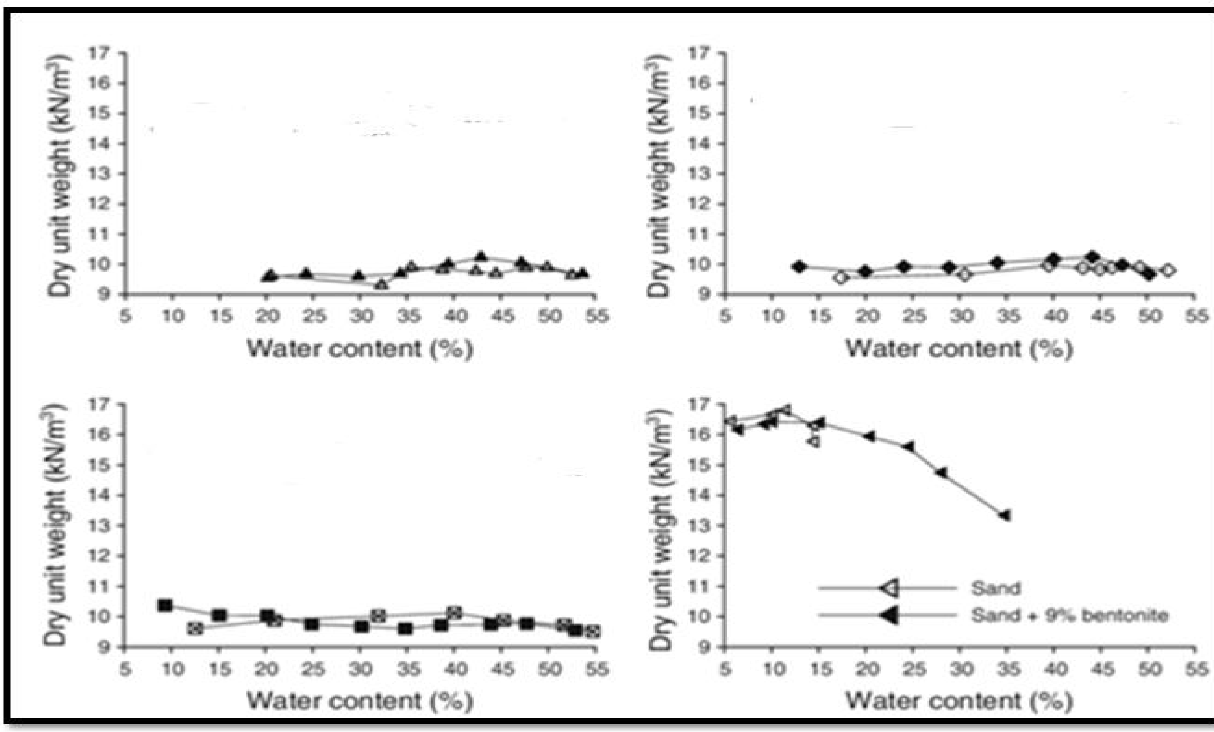

Figure 8:Dry unit weight Vs. water content

D. Permeability

The fly ash was added gradually to the molding sand(between 0 and 60wt %). Similarly, bentonite(between 0 and 5%) was added to the sand mixture. Composition of collected fly ash is shown in table 1. It is found that permeability of the sand mixture decreased with constant addition of fly ash. Details are given in Table 2 and, Graphs 1. Due to the round and smooth texture as well as small size of flyash particles, they could easily get into the gaps in molding sand particles, thereby lowering permeability.

Greater reduction is seen at lesser quantities of bentonite as compared to higher quantities. The decrease in permeability after the addition of 2.1% bentonite to sand mixture was 30%. It was 32% for 3% bentonite addition to sand mixture. Bentonite added at 2.1% to the sand mixture gave the optimum permeability. Moreover, the addition of fly ash to sand mixture was also found to reduce permeability, but the influence was much less as compared to bentonite. The decrease in permeability due to fly ash addition could be compensated by lowering bentonite addition.

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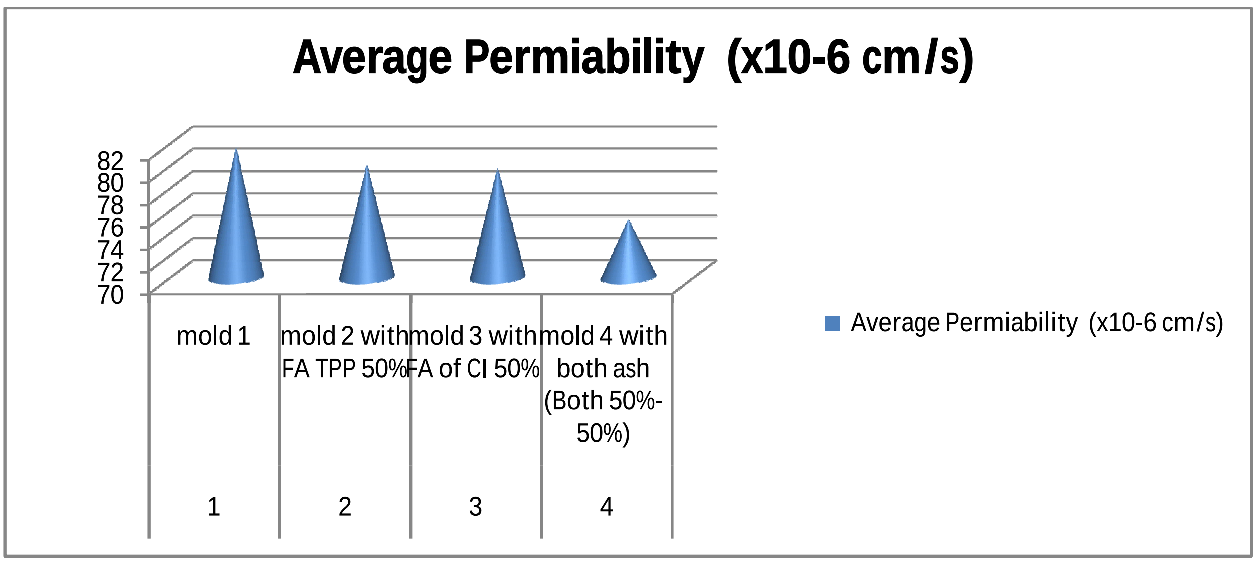
Table 1: The % composition of collected fly ash and when used as mold material

S. No.	INGREDIENT	% COMPOSITION OF FLY ASH COLECTED FROM CARBON INDUSTRY	% COMPOSITION OF FLY ASH COLLECTED FROM THERMAL POWER PLANT	% COMPOSITION FLY ASH MOLD MATERIAL
1	SiO_2	64.16	62.19	62.8
2	Al_2O_3	19.50	18.08	16.25
3	Fe_2O_3	3.03	3.66	3.18
4.	Mullite	2.32	1.80	1.45
5.	ZnO	1.21	1.45	1.23
6.	other	12.81	12.82	15

Table 2: The Permeability of fly ashAs mold material

S. No.	Cylinder	Dimensions of cylinder	Average Permeability ($x10^{-6}$ cm/s)
1	mold 1	1 x 1 x1 cm^3	81.7
2	mold 2 with FA TPP 50%	1 x 1 x1 cm^3	80.1
3	mold 3 with FA of CI 50%	1 x 1 x1 cm^3	79.8
4	mold 4 with both ash (Both 50%-50%)	1x 1 x1 cm^3	75.2



Graph 1: Permeability of deferent mold with the different composition of Fly ash

IV. CONCLUSIONS

Fly ash collected from Thermal power plant and graphite industries is an excellent alternative to molding sand for use in dry sand molds. Various analyses were done with fly ash mixed with molding sand. The permeability, and dry compression strength results showed flyash to be a suitable candidate for partial replacement of molding sand. Although the green and dry compression strengths of pure sand mold decreased gradually with the addition of fly ash, the addition of bentonite restored the above technological properties to the sand mixture. Our investigations revealed that 26% fly ash addition to molding sand produced satisfactory surface finish of castings. The mechanical properties and refractoriness of this material is increased by the addition of natural resins, for the quality of casting.

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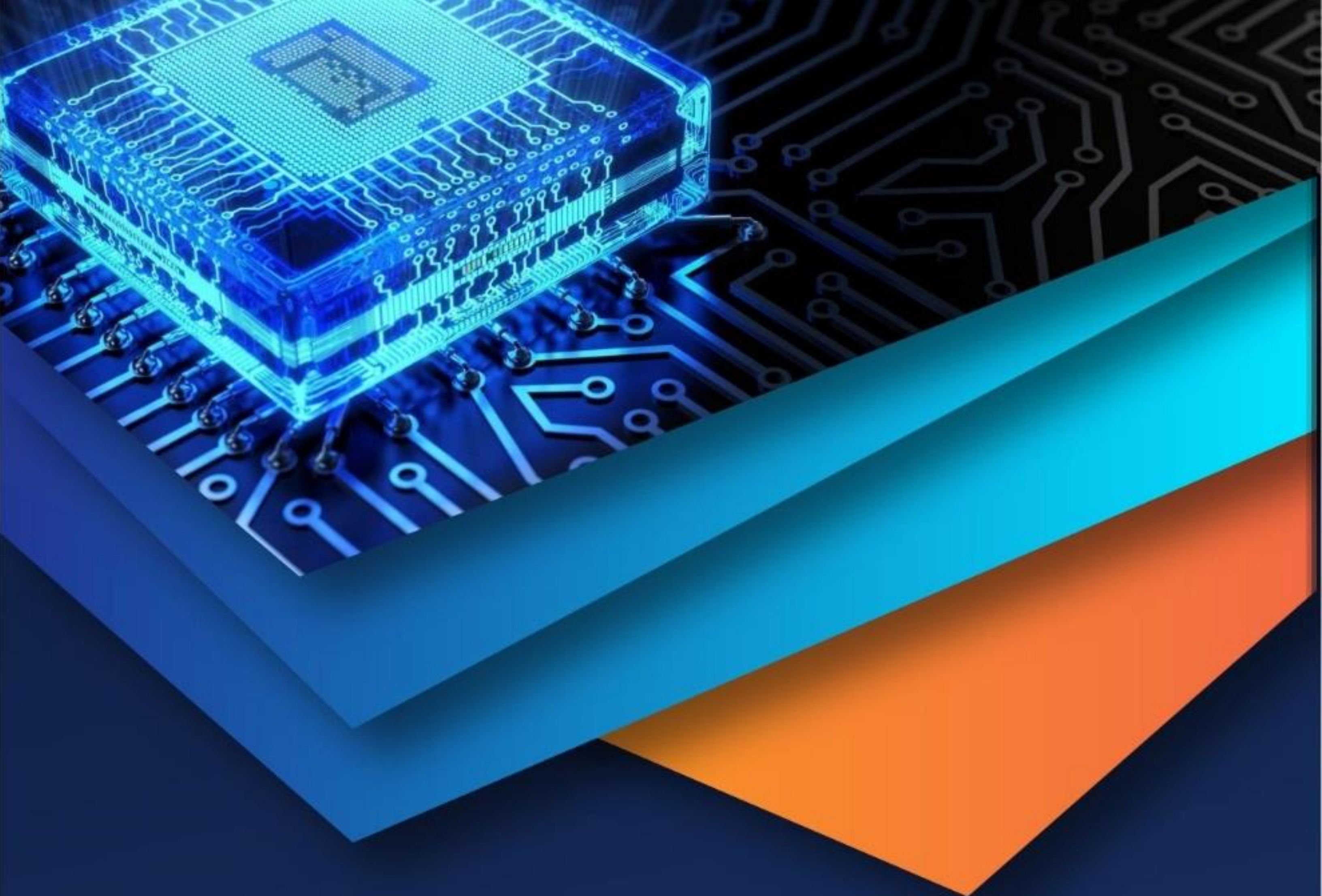

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