

Reuse Of Coal Flyash In Foundry

As the disposal of flyash has attained complex dimensions many researchers have proposed certain uses of coal flyash.

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Coal-flyash is the residue of coal combustion in coal fired power generations. When coal is totally burnt, the constituents of coal viz., principally silica and alumina convert into flyash. About 80% of the ash flies along with flue gases and gets entrapped into bag filters or electrostatic precipitators and is identified as flyash. The estimation of annual flyash generation in India is given in Table - 1.

As the disposal of flyash has attained complex dimension, many researchers have proposed certain uses of coal-flyash. The following are the important utilisations of coal-flyash:

Year	Quantity Million TPA #
1971	12
1981	25
1991	40
1996	65
2000	129

Table - 1: coal flyash estimation in India

- ◆ Land and road fills
- ◆ Heterogeneous catalyst in peroxidative degradation of aqueous dye solutions (eg: dye-effluent from textile, paper and dyeing industries)
- ◆ The preparation of flyash cement concrete
- ◆ The embankment construction
- ◆ The cellular roof blocks
- ◆ Flyash concrete

The author has tried to use the coal-flyash as a refractory filler material in the ceramic shell process.

The Ceramic Shell Process

In the ceramic shell process, the shells are made of applying a series of ceramic coatings to the wax patterns as shown in fig 1. The pattern is first dipped into the dip-coating slurry bath. The dip-coating slurry is a mixture of binder (silox) and refractory filler material (coal-flyash). The pattern drain off excess slurry and to produce a uniform layer. The wet layer is immediately stuccoed with coarse silica sand. Each coating is allowed to dry in the open air. The operations of coating, stuccoing, and drying are repeated several times until the desired thickness to the shell is obtained. The last coat is left

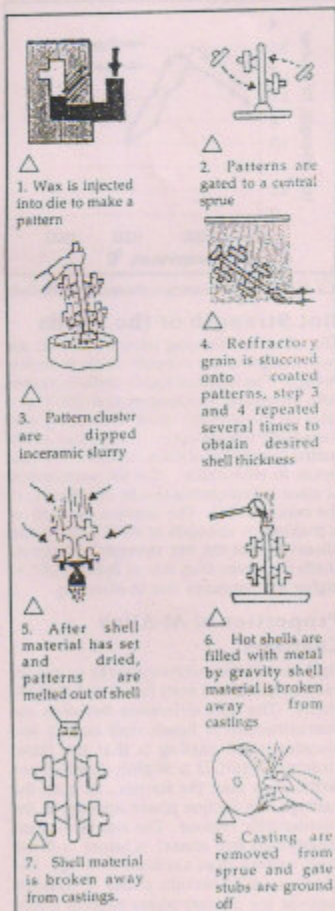


Fig. 1: Sequence of operations in the ceramic shell process

unstuccoed to avoid the occurrence of loose particles on the shell surface. The first two coats are stuccoed with sand of AFS fineness number 120 and the next remaining coats are with sand of AFS fineness number 42. After all coats, the shells are air dried for 24 hours. The shells are dewaxed and poured with liquid metal. In this work Al-Si-Mg alloy is poured. Alumina is employed to compare the results of coal-flyash.

Proximate Analysis of Coal-Flyash

The proximate analysis of coal-flyash fractions is shown in Table - 2. It is observed that fraction of larger particle size (74 mm) have higher fixed carbon content (4.83%) and lower density (2.01 g/cc). A descending order of fixed carbon is followed with increased in density of the fraction. This may be assigned to higher mineral matter content of the fractions with smaller particle size (45 mm). Fractions having larger particle size obviously contain larger agglomerates of carbonaceous matter, thereby increasing the densities.

Particular	% by weight	
	45 μ m	74 μ m
Moisture content	0.94	0.97
Volatile matter	1.00	1.00
Ash	96.02	99.20
Fixed carbon	0.04	4.83
Density, g/cc	2.25	2.01

Table - 2: Proximate analysis of coal-flyash

Whereas fractions having smaller particle sizes contain lower amount of these agglomerates, and accordingly are low in fixed carbon. The carbon content increases the refractoriness of the coal-flyash because of its high melting point.

The physical and chemical properties of coal flyash depend on the composition of the parent coal, conditions during coal combustion, efficiency of emission produced

Particular	% by weight	
	45 μ m	74 μ m
SiO ₂	60.42	58.92
Al ₂ O ₃	33.02	29.20
Fe ₂ O ₃	2.03	3.90
TiO ₂	1.64	1.20
MnO	0.09	0.02
CaO	0.22	0.18
MgO	0.43	0.31
P ₂ O ₅	0.26	0.40
SO ₂	0.05	0.07
Na ₂ O	0.50	0.84
K ₂ O	0.76	1.40
Loss on ignition	0.63	3.86

Table - 3: Chemical analysis of coal-flyash

The physical and chemical properties of coal flyash depend on the composition of the parent coal, conditions during coal combustion, efficiency of emission produced

from anthracite, bituminous and lignite coals vary in their chemical composition. The degree of volatilisation of many minerals is affected by the combustion temperature.

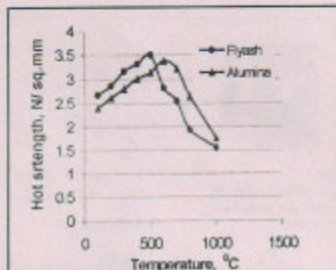


△ Fig. 2: SEM photomicrographs of the ceramic shells sintered at 700°C. a) Flyash shell b) Alumina shell. Dark areas represent organic matter. Light areas are mineral matter. Round particles are SiO_2 .

The chemical composition of coal-flyash is given in Table-3. It is clear that the chemical composition of coal-flyash is size dependent. The silica, alumina, magnesia and calcium oxide contents are increased with decrease in particle size. The loss on ignition values indicate that the coarser flyash have high carbonaceous matter and lower mineral content. Up to 74 mm particle diameter sized fractions of coal flyash has densities ranging from 2.0 to 2.8 g/cm^3 . The silica and alumina contents of 45mm particle diameter sized fractions of flyash are 60.43% and 33.025% respectively and those of 74mm particle diameter sized fractions are respectively 58.62% and 29.20%. The ratio of crystalline material to glassy, amorphous material increases with particle size. Flyash can be separated into three major matrices: glass, multi-quartz and magnetic spinel. The major constituents of the magnetic matrix are magnetic, hematite, ferrite, sulphates and carbonates.

SEM Analysis of Coal - Flyash

The modes of particle association and surface irregularities of coal - flyash are observed by scanning electron microscope (SEM). The photomicrograph (fig.2) for coal-flyash (45mm) indicates that it consists of mostly of solid and few of hollow spherical particles of variable size. There are small bulgings of siliceous and aluminous glass with appearance of cracking at the tip of bulges. The photomicrographs also indicate that dark areas are organic material, light areas are mineral matter. Gray sheets are mixtures of coal and flyash. Large grains are quartz. Solid and porous part indicates the presence of mineral matter probably quartz and hematite. Irregular black parts of micrographs, which are porous, indicate the presence of partially burnt coal particles.



△ Fig. 3: Effect of sintering on the strength of the shells

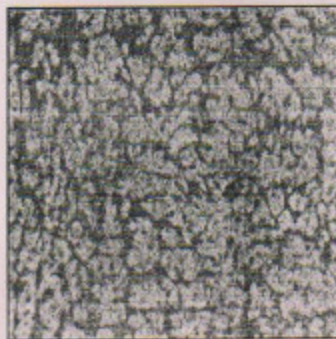
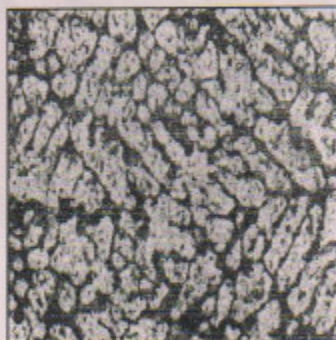
Hot Strength of the Shells

The effect of sintering temperature on the hot strength of the ceramic shells is shown in Fig.3. The length of flyash shells increases with increasing temperature upto 500°C and later on the strength starts decreasing with increasing temperature. This is due to the partial conversion of silica content in the coal flyash to cristobalite. The recrystallization of silica to cristobalite results in softening of the ceramic shell. The alumina shells show a maximum strength at 600°C. It is also observed that the hot strength of alumina shells is greater than that of flyash shells at higher temperatures due to sintering.

Properties of Al-Alloy Castings

Fig.4 reveals the microstructures of al-alloy castings produced from flyash and alumina shells. The only difference between the microstructure of flyash shell casting and alumina shell casting is that the latter structure exhibits a slightly finer phase distribution than the former. In both the castings, the section phase appears at the interdendritic regions. The size of a-phase (aluminium rich phase) is larger in flyash shell casting than alumina casting. The appearance of section phase is possible because the primary phase to form during

the earlier stages of solidification is a. Thus the liquid gets depleted with aluminium and will be enriched with section. During the progress of solidification, the liquid melt



△ Fig. 4: Micrographs of Al-Si-Mg alloys castings. a) casting from the alumina shell b) casting from the flyash shell.

present in the interdendritic zone attains eutectic. Thereafter while solidifying two phase mixture of a + Si is formed. The sizes of phases in flyash shell casting are larger than alumina shell casting due to longer solidification time. Prolonged solidification retards nucleation and promotes growth.

The tensile strengths of castings produced from the flyash and alumina shells are 149.25 and 154.62 N/mm^2 respectively.

Conclusions

The coal flyash can be used as a refractory filler material in the ceramic shell process to cast metals/alloys like non-ferrous metals or alloys which develop shell temperature upto 500°C. □

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