Effect on Isotactic Polypropylene's Mechanical and Morphological Properties Filled with Colour Modified Fly Ash

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Abstract : **Flyash is a wastage of thermal power station and as it is in gray colour and have very low value as a material whereas colour modified flyash is close to the many mineral fillers such as calcium carbonate normally used as filler with Polypropylene to reduce the cost. It has been noticed that the mineral filler though improving tensile strength but reducing the sizable impact strength of filled material. In present investigation the Impact and tensile samples were prepared by injection moulding and tested for charpy impact and tensile strength and found marginal improvement in impact strength as the % of fly ash increases and marginal decreases in tensile properties. SEM scans shows that there is the presence of nano flyash particles and found large variation in particle size. XRD graphs shows that there is the % of ash increases the Crystallinity decreases.**

INTRODUCTION :

Fly ash is a fine powder collected as the residue in the exhaust gases from combustion chambers of pulverized coal fired boilers at thermal power plant stations. Fly ash is usually solid, irregularly spherical in shape. It is a cenosphere [1] that is a hollow spherical shape. Fly ash being a waste material can be utilized in construction of hollow bricks and other building materials which is a low value addition. Therefore still a large quantity of fly ash dispose of as a land filling which causing environmental problems and not many land sights are available . Fly ash has been used in several areas, such as cement and concrete applications, bricks [2], highway pavement, road bases, and backfills. Particulate filled polymer are gaining growing acceptance in the commodity industry because the properties can be adjusted according to the industry's requirements. Fly ash has been used as filler in polymer to produce particulate reinforced polymer composites, saving the other commonly used mineral fillers used in polymers, thereby helping the environment [3].

As particulate filler, fly ash can be a cheaper material as compared to other mineral filler, provided it can match or improve the properties of filled polymers. Although fly ash is a cheap material but the fact that fly ash is grey-black in colour, which limits the application of fly ash only to product where colour is not important (density of calcium carbonate = 2.7 g/cc, density of fly ash = 2.2 g/cc) [4]. One group of researchers has suggested that colour of fly ash is principally controlled by (a) the iron content and (b) the content of unburned carbon [5]. By contrast, another paper indicates that only particle size and its shape determine the colour of fly ash [6]. Fly ash used here is colour modified fly ash as per Patent number 2009200846 . It has colour near white. The mineral fillers used in semi-crystalline polymers are usually talc and calcium carbonate and, to a lesser extent mica and wollastonite[7]. Polypropylene is a commodity plastics used in large area of industrial as well as in house hold, furniture, packaging applications etc. Most of the applications of iPP is filled with some filler like talk, calcium carbonate, mica and wollastonite. Our aim is to use colour modified fly ash as filler.

EXPERIMENTAL:

Materials: The fly ash used in this research is Modified Tarong ZONE 4 (T64) which is collected from the fourth hopper in the Tarong power plant, Australia. The method of modification can be seen in Australian Patent number 2009200846.

Polypropylene used in this research was supplied by Martogg & Company, Australia; with product code 617 OS in form of powder with particle diameter around few micrometers to a few nanometres.

Specimen Preparation:

Powder polypropylene mixed with colour modified fly ash by tumbler mixing. The ratios of iPP and fly ash used to prepare the various samples are given in table-1. The samples were stored in different bags name ASH5, ASH10, ASH15, ASH20, ASH25, ASH30, ASH40, and ASH50.

Table-1

S. No.	Designation	Percentage of PP	Percentage Fly ash
1	PP –fly ash-0	100.00	0
2	PP –fly ash -1	95	5
3	PP –fly ash -2	90	10
4	PP –fly ash -3	80	20
5	PP –fly ash -4	70	30
6	PP –fly ash -5	60	40
7	PP-Fly ash -6	50	50

The dog bone and notched charpy specimens as per ASTM D638-03 & D 256-03(Figure 1,A&B) prepared by using BOY 15 S injection Moulding Machines from Dr BOY KG, Germany. The temperature profile from feed zone to metering zone used form 160oC to 210oC.

Notched Charpy Impact Test

The mould for injection moulding contains 2 shapes of die, one to produce dog bone specimens and the other to produce charpy impact specimens with a V-notch in the middle of the specimen. The dimension of the specimen is according to ASTM D256 (see Figure 2).

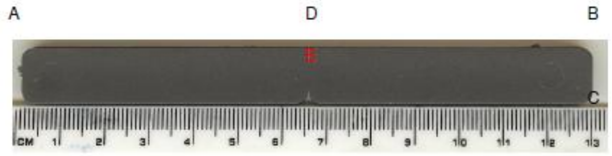

Figure-1. The specimen for notched charpy impact testing (notch in the lower side of point E)

Length (AB) : 128 mm
Width (BC) : 13 mm
Thickness : 4 mm
Notch Width (DE) : 11 mm
Notch root radius : 0.25 mm

Charpy Impact Testing:

The principle of this testing is a swinging pendulum with a striker on top of it with certain length and mass was subjected to a specimen. Both ends of the specimen were fixed behind the supports. When the specimen is impacted by the striker, it absorbs energy and when the energy is too high the specimen fracture occurs. Initially, the pendulum which has a length of R and a mass m, was held with an angle in raised position of 135o (I). The pendulum support was then loosened so that the pendulum fell down and impacted the specimen (H). The specimen was broken and the pendulum finally rose into a certain degree (S). The test was also carried out testing without specimen, and the position of pendulum after hitting the air also noticed (A).
The details are given in Figure 2. The impact result depends on Energy, Fracture appearance and Notch root concentration.

The 5 samples for each composition were tested at room temperature on Toyoseiki charpy impact tester .

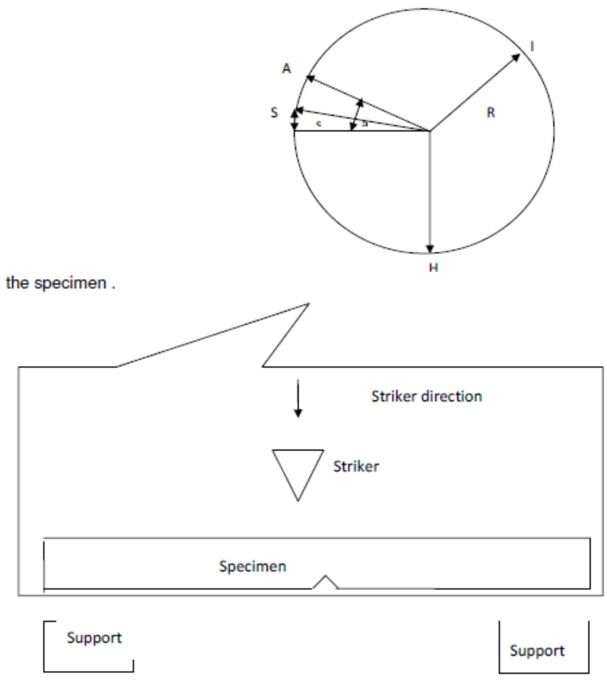

Figure 2. Schematic notched charpy impact testing

In this research, the notched impact results are expressed based on energy only. The impact energy was calculated by assuming that it was influenced only by potential and friction energy. Based on the differences in height of pendulum position between before (HI) and after impacting the specimen (HS), the potential energy was calculated. Based on the differences in height of pendulum position between before (HI) and after impacting the air without specimen (HA), the friction energy was calculated. Finally by dividing the impact energy by thickness and width of the specimen, impact strengths then were calculated. The impact energy, friction energy and the potential energy were calculated by using following formula.

$$E_p = mg(HI - HS) \quad (1.0)$$

$$E_f = mg(HI - HA) \quad (1.1)$$

$$E_i = E_p - E_f \quad (1.2)$$

Substitution equation 1.0 and 1.1 to 1.2, it becomes

$$E_i = mg(HI - HS) - mg(HI - HA)$$

$$E_i = mg(HA - HS) \quad (1.3)$$

$$HA = R(1 + \sin a) \quad (1.4)$$

$$HS = R(1 + \sin s) \quad (1.5)$$

Substitution equation 1.4 and 1.5 to 1.3, it becomes

$$E_i = mgR(\sin a - \sin s) \quad (1.6)$$

The impact strength is then calculated by using following equation.

$$\sigma_i = \frac{E_i}{w * t} \quad (1.7)$$

Where in :
Ei is Impact Energy (J)
Ep is Potential energy (J)
Ef is Friction energy (J)
g is gravitation (9.8 m/s2)
R is Length of Pendulum (10.09 cm)
m is Mass of Pendulum (1.165 kg)
σi is impact strength (J/m2)
w is sample width (m)
HI is height of pendulum before hitting
t is sample thickness (m)
HA is height of pendulum after hitting air
HS is height of pendulum after hitting specimen.

Results and discussion:

Values obtained from tensile and charpy impact strength are given in Table No2
Samples were tested as per ASTM standard the results are given below.

Table -2

S. No.	Designation	Tensile strength Kgf/cm^2	Tensile modulus Kgf/cm^2	Charpy Impact $Kg\text{-}cm/cm^2$
1	PP –fly ash-0	361.15	10152	6.9
2	PP –fly ash -5	353.30	12957	7.3
3	PP –fly ash -10	333.00	13437	7.64
4	PP –fly ash -15	312.00	13942	7.76
5	PP –fly ash -20	290.60	14231	7.87
6	PP –fly ash -25	276.00	16108	7.95
7	PP –fly ash -30	272.06	17092	8.33
8	PP –fly ash -40	228.10	16980	8.66
9	PP –fly ash -50	198.50	16152	9.92

Tensile Strength:

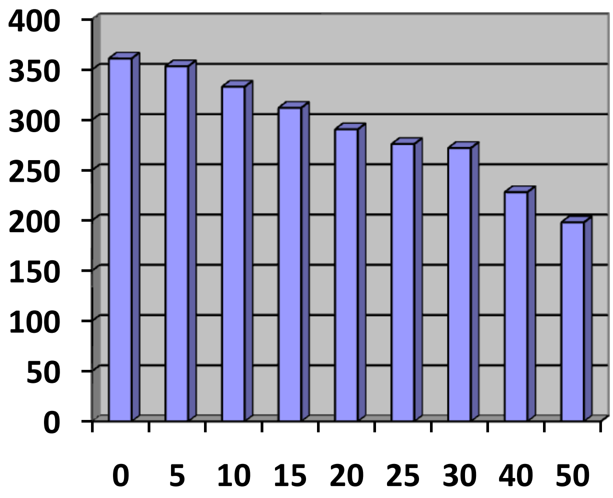

Figure 3 - Tensile strength of PP and different % flyash in Kgf/cm2

As shown in Fig-3, the tensile strength of the compound decreases as the %age of the flyash increases . It is observed that there is marginal change in tensile strength as we added flyash 5,10,15% but there is significant reduce in tensile strength up to 54% at 50 % addition of flyash at 20,25,30% fly ash show marginal change in tensile strength with respect to each other.

Tensile Modulus:

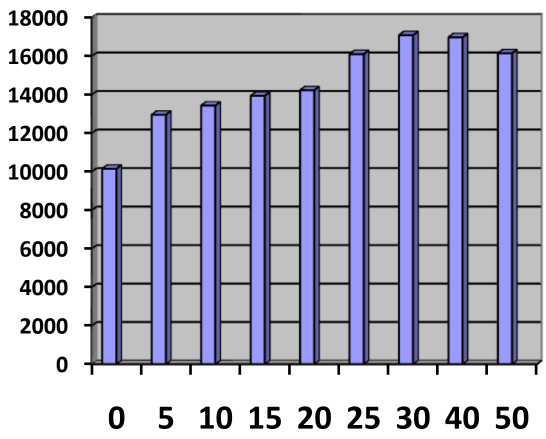

Figure-4 Tensile modulus of PP and different % fly ash in Kgf /cm^2

As shown in Fig-4, the tensile modulus depicts the haphazard results in the compound. As it can be seen that there is approximately more than 30% increase in tensile modulus when 5% flyash was added in the PP. when the flysah is added again then it started to increase by approximately 50%. It is observed that after reaching its zenith point it again started to decrease. In nutshell it can be said that it has 17092kgf/cm^2 peak value .

Charpy impact strength

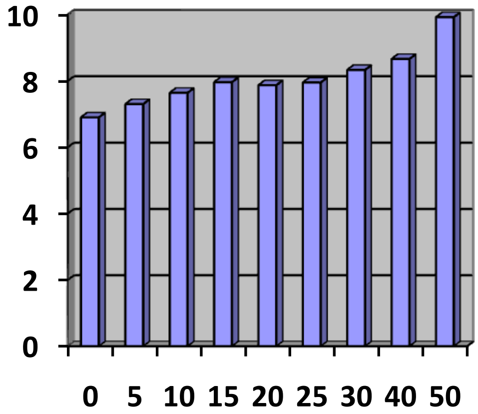

Figure-5 Charpy impact strength of PP and different % flyash in Kg-cm/cm^2

As shown in Fig-5 Charpy impact strength there is significant change in the impact strength by approximately more than 30%. But results shows that the impact strength increases with the increased %age of fly ash there is an increase in the impact strength. Hence it has been observed that in all cases the impact strength is higher than the virgin PP.

Morphology properties by SEM:

The hitachi make S-4500 SEM (Scanning Electron Microscope) was used for morphological properties. The test was conducted at UNSW Australia. The SEM graph shows that the even dispersion of the fly ash and also shows the variation in the particle size as shown in figure -6.

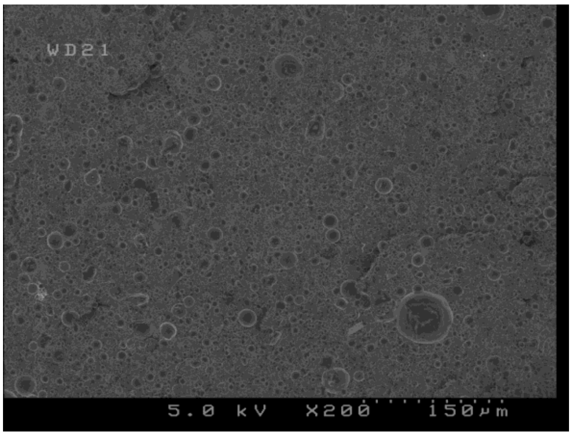

Figure-6 SEM image of 50 % flyash filled sample.

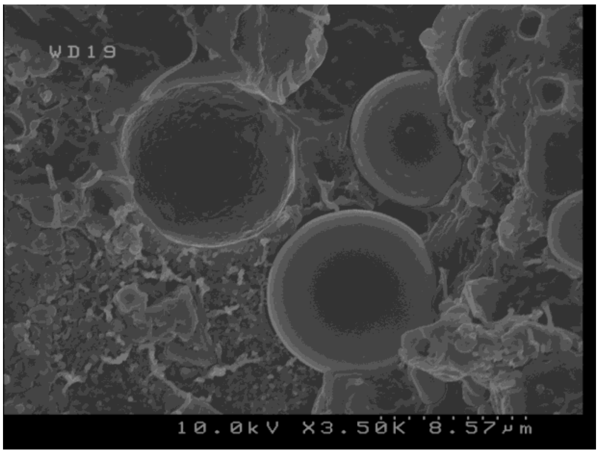

Figure-7 SEM results at 20% fly ash filler.

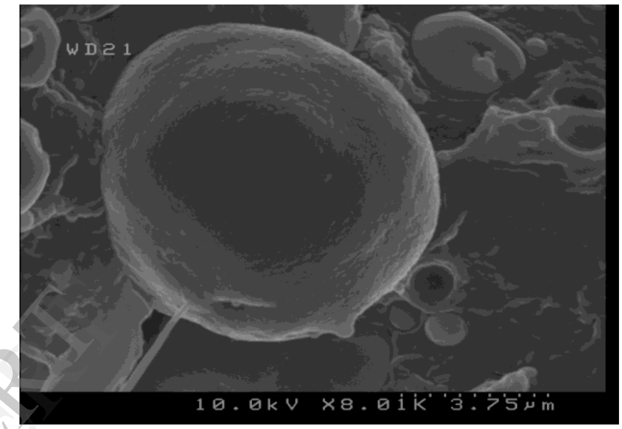

Figure-8 SEM Results at 50% fly ash.

As shown in micrograph Fig-7 the flyash has round particles and depicts that there is poor adhesion on interface. It is also showing that particles pulled out from the surface of the material. Micrograph shown in Fig-8 the there is large difference between the particles some particles are 3 to 4 microns and other are few hundred nanometre scale.

Crystallography: XRD diffraction has been done on Philips make X'pert model at UNSW Sydney Australia . The diffraction angle was set from 2 to 60 degree. It is observed that as the % of flyash increases the Crystallinity decreases. The unburnt carbon peaks also cannot be detected by XRD. It is possible that the carbon content is too small or carbon is present as different carbon allotropes such as amorphous carbon and graphite, or the carbon peaks overlapped with other peaks. The components in the fly ashes were determined using XRD based on at least 3 peaks matching with the library data for accuracy. The major content of the fly ashes were quartz (SiO_2) and mullite ($3Al_2O_3$ and $2Si_2O$)

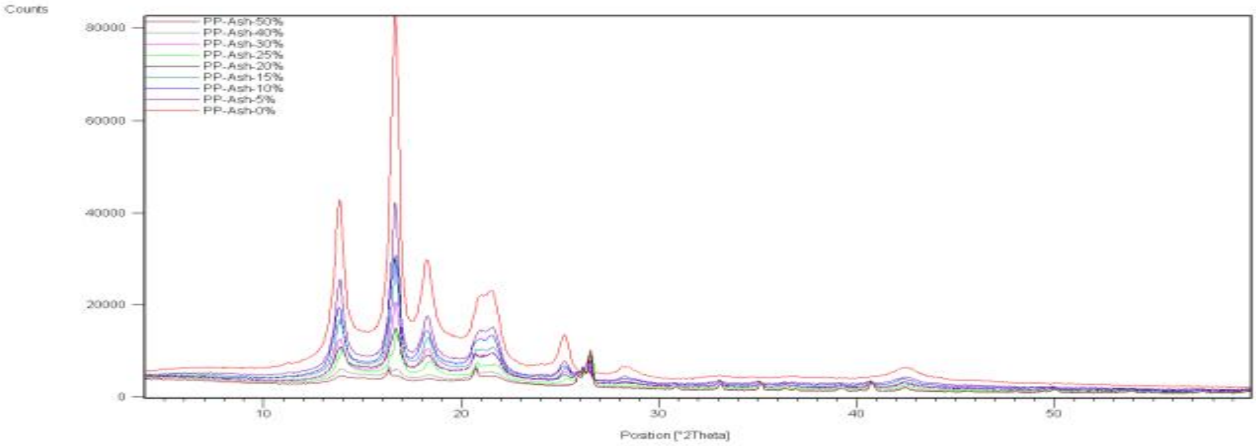

Figure-9 XRD graph of all the composition of pp and flyash

CONCLUSION:

Sample was prepared at different compositions 0, 5, 10, 15, 20, 25, 30, 40and 50% of flyash. Compound was melt mix directly mixed in injection moulding machine.

As the % of flyash increased the tensile strength decreases meanwhile the tensile modulus in general increased.

SEM graph shows that there is variation in the particle size and it varies from 3-4 micron to few hundred nanometers.

The XRD graph shows that the Crystallinity decreases as the % of flyash increases.

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