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# Development of the Property of Fly-Ash Filled HDPE Composites -Review

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***Abstract :*** *Fly-ash is fine particles that are extracted from the burning of coal in electric generation power plant in thousands of tons each year. The HDPE material is compounded with different concentration of Fly-ash to form composite material. The TSE (Twin Screw extruder) is used for compounding the material and the test specimen is prepared by injection molding machine to study the physical and other properties. Mechanical property (such as, tensile strength, flexural strength, impact strength, hardness), Electrical property (such as, di-electric strength ,volume & surface resistivity) & Rheological property (such as, melt flow index) is discussed. These results are investigated with different composition of Fly-ash filled with HDPE and other plastics materials. The variation in the physical and other properties is observed.*

***Keywords:*** *Fly-ash, HDPE, Composites, Mechanical Property, MFI, Electrical Property.*

## I. Introduction

High density polyethylene (HDPE) resins are thermoplastics made from the polymerization of ethylene in gas phase, slurry or solution reactors. Polymerization takes place under low-pressure conditions with the support of catalysts. HDPE is commonly recycled which is characterized by a linear polymer chain with few branches. It is Flexible, translucent or waxy, weather-resistant, exhibits good strength at low temperatures (up to -60'C), easy to process by most methods, low cost and good chemical resistance. It is harder, stronger and a little heavier than LDPE, but less ductile.

In the thermal power plants, by the combustion of coal a huge quantity of fly-ash is generated as a by-product. Fly-ash is a heterogeneous material which is made up of various particulates such as inorganic matters and organic matters (minor amount). It is a fine grey coloured powder having spherical glassy particles that rise with the flue gases. FA is considered hazardous since it contains leachable and toxic metals such as Pb, Cd, Zn and Cu which is a waste causing threat to the environment. Exposure to these metals has been associated with lung cancer, heart disease or asthma.

About half of the fly ash is used in cement and brick industries and for landfill purposes. Due to reduce environmental concerns and disposal difficulties, the utilization of fly ash has become of great importance. Therefore, there is a need to find suitable means of utilizing FA in order to address its environmental challenge. Research is in progress to utilize this huge waste as a resource material for making valuable material. In order to reduce the production cost of plastic products, and to improve certain characteristics, Fly-ash is used as filler to the resin matrix. Various mechanical properties, electrical property & rheological property of the composites were investigated. The properties shown by the composites of different composition will help in estimating their suitability for various applications.

## II. Literature survey

**Iftekhar Ahmad and Prakash A. Mahanwar, "Mechanical Properties of Fly Ash Filled High Density Polyethylene",** in this paper the effect of fly ash as filler in mechanical properties of HDPE is described in this study. Three different particle size of fly ash was used. Concentration of fly ash was varied up to 40 % by weight. The composites were prepared using twin screw extruder and then test specimens were prepared by injection molding. Tensile, flexural and impact properties were tested. The microstructure was investigated through scanning electron microscopy (SEM) of the fractured samples. Both tensile and flexural strengths and moduli were found to increase with fly ash addition. Tensile elongation drastically reduced at fly ash concentration greater than 10%. With increasing fly ash concentration impact resistance decreased up to about 15% fly ash concentration and then did not reduce significantly on further addition. Composites with smallest size fly ash particles proved to be better in enhancing strength and relative elongation. Modulus and impact resistance did not seem to depend much on particle size [1].

**Ikhlas Kitta, Salama Manjang, Wihardi Tjaronge, Rita Irmawaty**, **"Effect Of Fly Ash Filler To Dielectric Properties Of The Insulator Material Of Silicone Rubber And Epoxy Resin",** in this paper Currently, many operated the coal fired power plant to meet the energy needs of the world's electricity. But the coal fired power plant produces waste that can pollute the environment, such as fly ash and bottom ash, so requires management to not cause environmental problems, because coal fly ash classified as a hazardous waste. Fly ash has a particle size that is very smooth, and of some literature research done previously, fly ash coal containing silica (SiO2), alumina (Al2O3), titanium dioxide (TiO2), magnesium oxide (MgO) and zinc oxide (ZnO) are potentially as filler that are likely to be used as a mixture of silicone rubber and epoxy resin for electrical insulators. So this research theme was engineering insulation materials by utilizing waste coal fly ash. The purpose of this study was to obtain performance characteristics of waste coal fly ash as filler in silicon rubber and epoxy resin. To achieve these objectives, the activities that have been done is examined the effects of the use of fly ash as filler in silicone rubber material and epoxy resin. Parameters measured were dielectric strength and relative permittivity. The result of this research is the dielectric strength of silicone rubber rose with increasing quantity of fly ash. Conversely in epoxy resin, dielectric strength decreases with increasing quantity of Fly-ash. Furthermore, the measurement results relative permittivity, where the value of the relative permittivity of silicon rubber swell if it is filled with fly ash, as well as epoxy resin which has a value of permittivity relative to the concentration of fly ash filler material is linear[2].

**S Mishra and N G Shimpi, "Comparison of nano $CaCO_3$ and Fly-ash filled with styrene butadiene rubber on mechanical and thermal properties",** in this paper Different particle sizes (21, 15, 9 nm) of $CaCO_3$ were synthesized by *in-situ* deposition technique and confirmed by X-ray diffraction method. The nano $CaCO_3$ was added from 0.1 wt % to 0.5 wt % in the styrene butadiene rubber (SBR). Rubber nano composites were compounded on two-roll mill and molded in compression molding machine. Mechanical properties such as tensile strength, elongation at break, modulus at 300 % elongation, hardness, specific gravity, swelling index, and flame retardancy and abrasion resistance were studied. These results were compared with Fly-ash filled SBR. There was an improvement in properties of rubber nano-composites because of uniform dispersion of nano $CaCO_3$ particles in the matrix that intercalates the rubber chains. Hence degree of cross linking increases multifold in comparison to commercial $CaCO_3$ and Fly-ash[3].

**Samson Oluropo Adeosun, Mohammed Awwalu Usman, Emmanuel Isaac Akpan,Winifred Ifeoma Dibie, "Characterization of LDPE Reinforced with Calcium Carbonate—Fly Ash Hybrid Filler**", in this paper The synergetic effect of calcium carbonate (CC)-fly ash (FA) hybrid filler particles on the mechanical and physical properties of low density polyethylene (LDPE) has been investigated. Low density polyethylene is filled with varying weight percentages of FA and CC using melt casting. Composites are characterized for mechanical, thermal, micro-structural and physical properties. Results show that the flexural strength increases with increases in FA content of the hybrid filler. It is evident from the study that to achieve optimum density a certain combination of both fillers need to be used. The optimum combination of CC and FA for a higher density (1.78 g/cm3) is found to be at 20wt% FA and 30 wt% CC. An increase of 7.27% in micro-hardness over virgin polyethylene is obtained in composites with 10 wt% FA and 40 wt% CC. The presence of higher amount of CC is seen to be detrimental to the crystallinity of composites. X-ray, FTIR and DSC results show that composite with 45 wt% CC and 5 wt% FA exhibits a typical triclinic polyethylene structure indicating that the composite is amorphous in nature. There was the synergy between FA and CC fillers on flexural strength and crystallinity of composite. However, the fillers show the antagonistic effect on energy at peak and micro-hardness [4].

**RSN Sahai, and Neha Pawar , "Studies on Mechanical Properties of Fly Ash Filled PPO Composite with Coupling Agent",** in this paper In this study, the effect of the coupling agent on fly ash filled polyphenylene oxide composites with different filler concentration (5 to 25% by weight) on the mechanical and rheological properties of the polyphenylene oxide composites (PPO) was investigated. The PPO Composites of fly ash were prepared by Haake Rheocord 9000 twin screw extruder machine. The standard test specimens were molded on compression moulding machine. Mechanical and rheological properties were determined using these test specimens. It was found that with the addition of fly ash as filler in PPO showed improvement in flexural strength and modulus with the increase in fly ash concentration, whereas tensile strength, melt flow index and impact strength are found to decrease with increase in fly ash concentration [5].

**Dr. R.S.N. Sahai, and Dr. P.A. Mahanwar, "Effect of Particle Size and Concentration of Fly Ash on Mechanical Properties of Polyphenylene Oxide Composites",** in this paper In this study, the effect of the fly ash with different particle size and different filler concentration (5 to 20% by weight) on the mechanical and rheological properties of the polyphenylene oxide (PPO) composites were studied. The PPO Composites of fly ash were prepared by Haake Rheocord 9000 twin screw extruder machine. The standard test specimens were molded on Injection moulding machine. Mechanical and rheological properties were determined using these test specimens. It was found that with the addition of fly ash as filler in polyphenylene oxide, showed improvement

in flexural strength and modulus with the increase in fly ash concentration whereas tensile strength, melt flow index and impact strength are found to decrease with increase in fly ash concentration [6].

**Ikhlas Kitta,Salama Manjang, Wihardi Tjaronge, Rita Irmawaty, "Performance Study of Silicone Rubber Polymer was Filled Fly Ash as Insulator Material on High Voltage Transmission Tower",** in this paper Silicone rubber has emerged as an alternative material for porcelain insulators and glass insulators on a high voltage transmission because it is lightweight, so it helps in planning the structure of the transmission tower however, due to the cost of production of silicone rubber insulators are expensive and it is less resistant to climate change, it has not been used extensively as in Indonesia. One method to get silicone rubber insulator that is cheap is to mix it with other materials in the form filler that is inexpensive and easy to obtain as fly ash of coal because this material has a particle size that is very fine and its contents are materials that have been and are being investigated as filler of silicone rubber. This paper describe about the research that has proven the feasibility of fly ash as filler for silicone rubber. The results of this study is the tensile strength of silicone rubber increased proportional to the increase of fly ash content on silicone rubber, but lowers elongation-to-break of the silicone rubber. Furthermore, the electrical properties, namely the dielectric strength of silicone rubber will increase with the addition of filler (fly ash),where the greatest dielectric strength on the composition of the filler (fly ash) 40%. As for the relative permittivity is increased with the addition of filler (fly ash) to silicone rubber by 50%. And the silicone rubber surface resistance will increase with the addition of filler (fly ash) [7].

## III. Preparation Methods For Composites

The preparation methods for Fly-ash filled HDPE composites. Injection grade HDPE (m5520) was supplied by ONGC having density 0.952g/cm$^3$ & MFI of 21g/10min. fly ash was supplied by pyramid chemicals Vadodara, Gujarat, India.

**Table-1** Physical property of Fly-ash used

| Sr. No | Property | Unit |
|---|---|---|
| 1 | Density (g/cm$^3$ ) | 2.17 |
| 2 | Bulk density (g/cm$^3$ ) | 1.26 |
| 3 | Moisture content (%) | 2 |
| 4 | Particle size | Spherical/irregular |
| 5 | Color | Grey |

**Table-2** General Chemical Composition of Fly Ash

| Sr. No | Chemical composition | Percentage |
|---|---|---|
| 1 | $SiO_2$ | 30 – 60% |
| 2 | $Al_2O_3$ | 11 – 19% |
| 3 | $Fe_2O_3$ | 4 – 11% |
| 4 | MgO | 5 – 6% |
| 5 | CaO | 2 – 45% |

Fly-ash was dried in oven for 4 hrs at 100℃ to reduce its moisture content. Fly-ash filled HDPE composites were prepared with varying concentration of Fly-ash viz, 10%, 15%, 20%, 25% (*by wt*) using co-rotating twin screw extruder. The temperature set points were 160℃, 170℃, 180℃, 190℃ & 200℃ respectively from feed zone to the temperature of the die. The RPM of the twin screw extruder was set around 50-55. RPM was kept constant for all the four batches. The extrudates were cooled by water and then granulated with the help of pelletizer.

**Table-3** Specification of Twin-Screw Extruder & Pelletizer

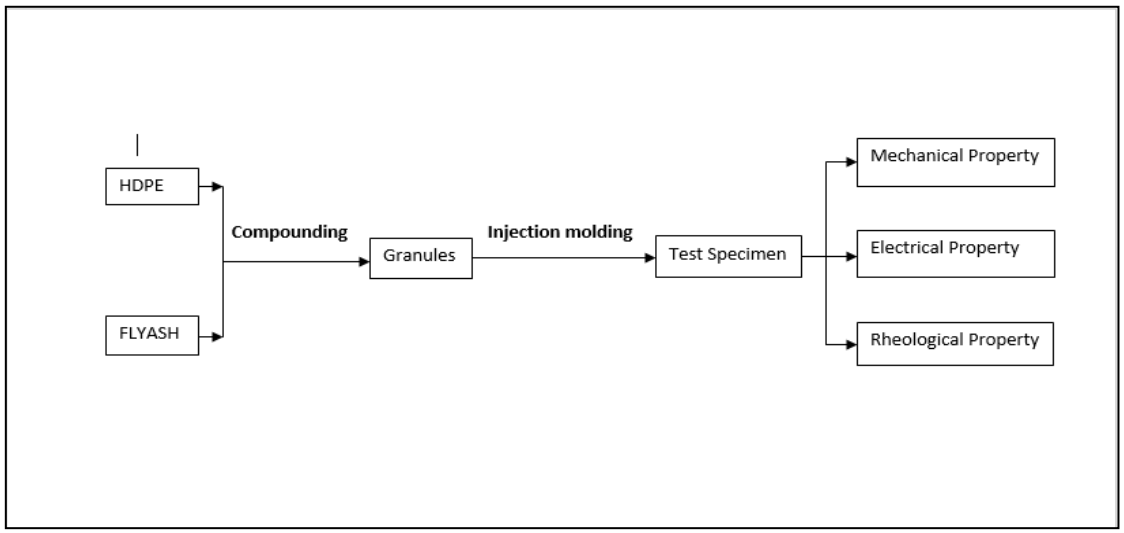
| Sr. No | Extruder Type | Co-rotating |
|---|---|---|
| 1 | Driving motor | 5.5 *Kw* |
| 2 | Torque/Shaft | 45 N |
| 3 | Screw Die | ϕ21m |
| 4 | Torque | 90 Nm |
| 5 | Machine Serial No. | SP 244CP 5 |
| 6 | Output RPM | 600 |
| 7 | L/D Ratio | 40:1 |
| Pelletizer | | |
| 1 | Output | 26 kg/hr |
| 2 | No of strips to be cut into dicers | 1-2 |
| 3 | Standard granules to be cut | ϕ3×3 mm |
| 4 | Cutting tool dimensions | ϕ90×50 mm |
| 5 | Cutting tool rotation speed | 0-1000 r/min |

JSW Injection molding machine of 180 tons used for manufacturing plastic specimen. The specimens were cast for tensile strength, flexural strength, dielectric strength, surface and volume resistivity, hardness, impact strength through injection molding. The granules were then fed to injection moulding machine. The mould was designed as per ASTM standards to produce specimens for tensile, flexural and impact tests. The molding machine heats the plastic to assist in melting. The nozzle of the injection molding machine then injects the melted plastic into the mold (injection pressure). The cavity of the mold is now filled with the plastic liquid. This will then cool down to form a solid product. Injection PEAK pressure was kept around 810kgf/cm$^2$. Finally, ejectors push the cooled product out of the machine as a finished part. These specimens were kept at room temperature to cool it down and relieve the stress before the test.

**Table – 4** Standardization of Various Properties for Plastics Material

| Sr. No | Test | Test Method |
|---|---|---|
| 01 | Tensile Strength | ASTMD 638 |
| 02 | Flexural Strength | ASTMD 790 |
| 03 | Impact Strength | ASTMD 256 |
| 04 | Hardness | ASTMD 2240 |
| 05 | Di-Electric Strength | ASTMD 149 |
| 06 | Surface Resistivity | ASTMD 257 |
| 07 | Volume Resistivity | ASTMD 257 |
| 08 | MFI | ASTMD 1238 |

## IV. Methodology




## V. Conclusion

1) The study on development of the property of Fly-ash filled HDPE composites has been done.
2) Tensile strength and Elongation at break of the composite may be decreases with increase in concentration of Fly Ash for Fly-ash filled HDPE composites. This is primarily because of formation of voids at Fly-ash-matrix interface. When elongated, these voids coalesce & lead to fracture or break. This happens also because of weak filler matrix adhesion.
3) Flexural strength may be found to increase with fly ash concentration. Finest particles showed best flexural strength at all concentrations.
4) Composites may be found to possess lower melt flow index at higher amount of Fly ash.
5) Dielectric strength of the composite may decrease with increase in concentration of Fly Ash for Fly-ash filled HDPE compositesSurface & volume resistivity may be increase with fly ash concentration.
6) Impact strength & hardness may be increase with fly ash concentration.

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## References

[1]. **Iftekhar Ahmad and Prakash A. Mahanwar, "Mechanical Properties of Fly Ash Filled High Density Polyyleethne** *of* **",** *Journal Minerals & Materials Characterization & Engineering*, Vol. 9, No.3, pp.183-198, 2010jmmce.org Printed in the USA. All rights reserved

[2]. **Ikhlas Kitta, Salama Manjang, Wihardi Tjaronge, Rita Irmawaty**, **"Effect Of Fly Ash Filler To Dielectric Properties Of The Insulator Material Of Silicone Rubber And Epoxy Resin",** INTERNATIONAL JOURNAL OF SCIENTIFIC & TECHNOLOGY RESEARCH VOLUME 5, ISSUE 03, MARCH 2016 ISSN 2277-8616

[3]. **RSN Sahai, and Neha Pawar , "Studies on Mechanical Properties of Fly Ash Filled PPO Composite with Coupling Agent",** International Journal of Chemical, Environmental & Biological Sciences (IJCEBS) Volume 2, Issue 4 (2014) ISSN 2320–4087 (Online)

[4]. **Samson Oluropo Adeosun, Mohammed Awwalu Usman, Emmanuel Isaac Akpan,Winifred Ifeoma Dibie, "Characterization of LDPE Reinforced with Calcium Carbonate—Fly Ash Hybrid Filler**", **Journal of Minerals and Materials Characterization and Engineering, 2014, 2, 334-345** Published Online July 2014 in SciRes.http://www.scirp.org/journal/jmmcehttp://dx.doi.org/10.4236/jmmce.2014.24038

[5]. **Dr. R.S.N. Sahai, and Dr. P.A. Mahanwar, "Effect of Particle Size and Concentration of Fly Ash on Mechanical Properties of Polyphenylene Oxide Composites",** International Journal of Chemical, Environmental & Biological Sciences (IJCEBS) Volume 3, Issue 2 (2015) ISSN 2320–4087 (Online)

[6]. **Ikhlas Kitta,Salama Manjang, Wihardi Tjaronge, Rita Irmawaty, "Performance Study of Silicone Rubber Polymer was Filled Fly Ash as Insulator Material on High Voltage Transmission Tower", International Journal of Innovative Research in Advanced Engineering (IJIRAE) ISSN: 2349-2763 Issue 01, Volume 3 (January 2016) www.ijirae.com**