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Blast Furnace Slagas a Filler Material A Review

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Abstract – Blast Furnace Slag, (BFS) is a secondary byproduct of Iron industry,which has a combination of acidic and basic oxides and show a complex, multiphase structure.They are much less dense that of iron hence they float above the metal and are easily extracted. Compared to other conventional fillers BFS are "Manufactured" byproduct rather than natural resources .Due to its composition and structure BFS is suggested as a promising functional filler that can potentially improve the property profile of composites. The byproduct of iron industries are disposed in landfills, this disposing slag impose serious environment concerns as it is noneconomic and unsustainable solution. Industrial wastes majorly BFS can be used as filler material in composites and thus cleaner environment can be obtained.
Keywords – Blast furnace slag, composites, filler material.

I. INTRODUCTION

Blast furnace slag (BFS) is a secondary byproduct of blast furnace operations.The investigation of the capability of BFS as a functional filler in polymers was found to be quite scarce in literature, where few studies have been found so far. To extract iron from ore, it is necessary to purify the ore from foreign substances it holds and remove the oxygen inside the iron oxide by resolving it. In order to carry out these processes, iron ore is heated and melted at hightemperatures in blast furnaces. With high temperature in the furnace, residualmolten iron, molten lime, silica,alumina, a slag composed of coking coal ash, and other foreign matters are
Generated while the carbon in the Cokingcoal combines with the oxygen in the iron oxide and
Leavesthe furnace as CO and CO_2Gases. Molten slag, which is cooled down and granulated,is referred to as "ground granulated blast furnace slag". Consuming a great amount of energy and emitting destructive greenhouse gases to the atmosphere during the production process, most of the binder materials have a significant role in environmental pollution. Therefore, binder users utilize various mineral additives to reduce the CO_2 emission and to increase the production rate, by reducing the energy consumption. Granulated blast slag, which is one of those mineral additives, is formed during the production of pig iron in iron and steel factories and major part of it is ready to be used as an alternative binding material. BFS are composed of four main oxides: calcium oxide (CaO), silicon oxide (SiO2), aluminum oxide, (Al_2O_3) and magnesium oxide (MgO) beside other secondary oxides and elements such as manganese oxide (MnO) and sulfur (S).

II. IMPLEMENTATION OF BLAST FURNACE SLAG AS A FILLER MATERIAL

Abdelhamid Mostafa, Stephan Laske, Gernot Pacher, Clemens Holzer, Helmut Flachberger, Elke Krischey, Bertram Fritz,(Ref 1) Their study was focused that BFS could be an effective functional filler, improving the property profile of thermoplastics such as polypropylene (PP) and polystyrene (PS) and investigating the effect of incorporating BFS as a micro-sized filler on the rheological, thermal, and mechanical behavior of PP and PS.It was observed that both types are ground into 71, 40, and 20micrometer batches and introduced in 10, 20, and 30 weight fractions via melt kneading. Mixtures are then formed into 4-mm and 2-mm thick plates via compression molding. Slight increase in rheological factors is observed with increasing filler loading. BFShinders the crystallization of PP, resulting in slight increase of crystallization temperatures (Tc) and lowering of crystallizationenthalpy, No significant effect of filler on transition temperatures (Tg) is reported. Mechanically, BFS increases the tensile modulus OfPP, but decreases its strength. For PS formulations, a modest toughening effect is observed by slag filler.
A.Mostafa,T.Lucyshyn,C.Holzer,H.Flachberger,W. Oefner, G. Riess, B. Fritz (Ref 2) They analyzed that due to its composition and structure, BFS issuggested as a promising functional filler that can potentially improve the property profile of polypropylene. To overcome the lack of compatibility between BFS and polypropylene (PP), two coupling agents, vinylethoxysiloxane homopolymer silicon methacryloxypropyltrimethoxysilane, are utilized for treating the BFS surface. The influence of each coupling agent on the BFS–PP compound properties is investigated in this work. It is observed that both coupling agents equally increase the complex shear viscosity and thermal conductivity of the modified BFS compounds by 10% and 12%, respectively, compared to their unmodified counterparts..
MeralAkkoyun and SerifeAkkoyun (Ref 3) In this study, a comprehensive investigation of the effect of BFS and Fly Ash on morphology, electrical and thermal conductivity, and rheological and mechanical properties ofwater-blown rigid polyurethane foams was performed. It was observed that an important effect of the electrical percolation threshold on the final properties of the foams, and an improvement in the filled foam propertiescompared to the unfilled one. For both fillers, an increase in electrical conductivity, tensile strength, and cell diameter of the foams was observed up to the electrical percolation threshold. A decrease in the tensile strength and a stabilization of the electrical conductivity of the foams were obtained, with a decrease in the cell diameter occurring at the same time.
I. Gunes, T. Uygunoglu, A. Evcin,and B. Ersoy (Ref 4). The

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objective of this report has been to describe the wear and friction characteristics of epoxy-based polymer composites, as well as the mechanism of how the blast furnace slag can enhance the properties of polymer composites. It was observed that the use of blast furnace slag, as
an additive material in epoxy based polymer composites, has leaded to a notable improvement in the wear resistance, friction coefficient and surface quality compared to the pure epoxy samples.

Azmi Erdo Gan,Mustafa Sabri, VahdettinKoç, Ali Günen (Ref 5) In this study, dry sliding wear behaviors of epoxy matrix composites reinforced with Al_2O_3, BFS, FeCrS and COS under different loads were investigated. It was observed that the slag fillers showed higher wear resistance than the Al_2O_3reinforced composites. Among the slag fillers, the blast furnace exhibited superior tribological performance. While $Al_2O_3$and blast furnace slag reinforced composites showed plastic deformation due to fatigue, transverse cracks and displaced reinforcement particles were observed in ferrochromium slag and converter slag reinforced composites. Increasing the applied loadwill cause acceleration in wear rate.

Zhanhong Wang Guihua Hou Zirun Yang Qiong Jiang Feng Zhang MinghuaXieZhengJun Yao(Ref 6)This study was to investigate the properties of friction materials doped with varying amounts of high specific heat capacity blast furnace slag. Braking performances were evaluated in terms of stability of friction coefficients and wear resistances. It was observed that the hardness decreases from63.6HRL to 57.0 HRLwith increasing slagcontent from0 to 43wt.%. The impact strength gradually increases from 3.59 kJ/m2 to 3.70 kJ/m2 when the content of slag increases from 0 to 43 wt.%. Doping was also found to increase the friction coefficients but decrease wear rates, mass-loss and heat release.

PrasantaKumarPadhi and Alok SatapathyRef 7) in this work, composite samples are prepared by reinforcing micro sized blast furnace slag as the particulate filler in epoxy resin reinforced with bi-directional glass fiber. They are subjected to solid particle erosion using an air jet type erosion test rig. Erosion tests are carried out by Taguchi's orthogonal arrays.Factors like BFS content, impact velocity, erodent temperature, impingement angle in declining sequence are significant to minimize the erosion rate.Thisstudy reveals that BFS possesses good filler characteristics as it improves the erosion wearresistance of the composite.

Prasanta Kumar Padhi, Alok Satapathy and Anand Mohan Nakka(Ref 8) there work explores the possibility of fabricating a new class of thermoplastic composites using PP as the matrix base and BFS as the particulate filler and analyses the dry sliding wear response of these PP-based composites filled with micro sized BFS.It was observed that BFS, an industrial waste, can be used as a potential filler material in PP matrix composites.It modifies the tensile, flexural, and impact strength of these thermoplastic composites. Composite microhardness is also greatly affected by the presence of hard BFS particles in the matrix body.Factors like sliding velocity and filler content (wt% of BFS) are found to be significant to minimize the specific wear rate.

Prasanta Kumar Padhi and Alok Satapathy (Ref 9) In this work, an attempt was made to improve the wear resistance of short glass fiber (SGF)-reinforced epoxy composites by incorporation of micro sized blast furnace slag (BFS) particles. It was observed that the presence of BFS particles enhanced the sliding wear resistance of epoxy resin, but the composites with SGF reinforcement suffered greater wear loss than the composites without SGF.

Prabina Kumar Patnaik,Priyadarshi Tapas Ranjan Swain, Sandhyarani Biswas (Ref 10)in this work, a new class of hybrid composites consisting of needle-punched nonwoven viscose fabric reinforced epoxy filled with different weight proportions (0, 5, 10, and 15 wt%) of blast furnace slag (BFS) are prepared. It was observed maximum micro-hardness of 37.43 Hv and impact strength of 2.192 J is obtained with the incorporation of 15 wt% of BFS loading in the composite. However, the maximum value of tensile, flexural and inter-laminar shear strength of composites is 44.53, 58.67 and 60.87 MPa respectively at 10 wt% of filler loading. Steady-state result shows that specific wear rate is increased with the increase in sliding velocity and declined with increase in normal load. The resistance against slurry abrasion has been improved with the incorporation of fillers and BFS emerged as a potential filler material for polymer composites.

P.K.Padhi and A.Satapathy(Ref 11) They analyzed on processing and solid particleerosion wear response of a new class of hybrid
Composites prepared by reinforcement of short glass fibers (SGF) in blast furnace slag (BFS) filled polypropylene (PP) matrix. In this investigation, composites with different BFS content(0, 10, 20 and 30 wt. %) in a polypropylene matrix base, with and without 20 wt. % SGF reinforcement, are prepared by injection molding route. It was observed that during the erosion process, the BFS particles absorb a good part of the kinetic and thermal energy associated with the erodent. These composites suitable for applications in highly erosiveenvironments can be prepared by reinforcement ofshort glass fibers and filling of micro-sized blast furnaceslag particles in polypropylene resin. The experimental resultssupport the conclusion that blastfurnace slag can be used as a potential filler material in thermoplastic polymers for producing wear-resistant composites. The peak erosion rate is found to occur at 60^o impingement angle for all BFS filled composite.

Prasanta Kumar Padhi& Alok Satapathy (Ref 12) They investigated thesolid particle erosion behavior of a new composite material formed by adding blast furnace slag (BFS) particles at different amounts of 0, 10, 20, 30 wt% to short glass fiber (SGF)-reinforced epoxy resin. The resulting hybrid composites are subjected to solid particle erosion using an air jet–type erosion test rig. It was observed that the study of the influence of impingement angle on the erosion rate of the composites filled with different weight percentages of BFS reveals their semi-brittle nature with respect to erosion wear. The peak erosion rate is found to occur at a75 ◦ impingement angle for all of the composite samples. Factors such as impact velocity and filler content (wt% ofBFS) are found to be significant to minimize the erosive wear rate.

Gaurav Singh, Souvik Das, Abdulaziz Abdullahi Ahmeda, Showmen Saha, Somnath Karmakar (Ref 13)This research aims to investigate the possibility of using GBFS in place of natural sand in concrete. In this study the sand is replaced from 10% to 100% by GBFS and its effect on compressive strength of concrete is studied. It was observed that the long term strength development of GBFS concrete is almost double of normal concrete in both normal and marine conditions.It is one of the promising solutions towards sustainable infrastructure without compromising strength and economy.

Namrata Verma, Neha Singh, Himanshu Kumar Malviya Saurabh Jain(Ref 14) The use of the BFS as a filling material in rural road construction and replace the quantity of aggregate in Rural Road Construction.It was observed that slag fails in abrasion test it can't be used in the surface course. Hence it can be used in the base course and sub-base course in road construction.It is found in large chunks that mean we can use it for both coarse aggregate and fine aggregate BFS as a low cost material used in rural road construction.Water absorption capacity is best as compared to other filler material.

III. CONCLUSION

It is therefore concluded that utilization of industrial mineral wastes, majorly Blast Furnace Slag as a filler material is an important alternative to reduce disposal cost, potential environment pollution problems, decrement of natural resources and production cost.As a raw material, the proposed filler may introduce both economic and ecological advantage as considered as inexpensive secondary product rather than a natural resources. The addition of fillers in polymeric compounds not only yield higher mechanical strength but also ensures cost reduction in terms of consumption of conventional materials. There are no systematic studies to investigate such application of BFS. Therefore, one of the modest attempt is incorporation of BFS in polymeric system in improving the Rheological, Thermal, and mechanical behavior.Hence much more literature work should be done.

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