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Research Article

The Effect of Addition Slag of Cast Iron and Cement to Unsaturated Polyester on Impact and Bending Properties

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Abstract

Slag is a partially vitreous by-product of the process of smelting ore, which separates the desired metal fraction from the unwanted fraction. Slag is usually a mixture of metal oxides and silicon dioxide. This research deals with formation a new composite materials have good properties and cheap from unsaturated polyester and waste materials usually unusual alone and harm to environment. In this research, the effect of three slags powder (cast iron slag, cement dust) on some mechanical and physical properties of unsaturated polyester were studied. The results showed that the Bending strength increased with increasing of the powder. The impact strength decreases with increasing of slags.

Keywords: *Unsaturated Polyester; Slag; Impact; Bending; Mechanical; Properties.*

Introduction

Slag is a partially vitreous by-product of the process of smelting ore, which separates the desired metal fraction from the unwanted fraction. Slag is usually a mixture of metal oxides and silicon dioxide. However, slags can contain metal sulfides and metal atoms in the elemental form. While slags are generally used to remove waste in metal smelting, they can also serve other purposes, such as assisting in the temperature control of the smelting, and minimizing any re-oxidation of the final liquid metal product before the molten metal is removed from the furnace and used to make solid metal.

Basic slag is a byproduct of steelmaking using the basic version of the Bessemer process or the Linz-Donawitz process. It is largely limestone or dolomite which has absorbed phosphate from the iron ore being smelted. Because of the slowly released phosphate content, and because of its liming effect, it is valued as fertilizer in gardens and farms in steelmaking areas (Wikipedia The free Encyclopedia , Slag, 2013). The term slag cement is a very general one that can include many types of materials and combinations.

Slag cement is also used at times to refer to a very specific material, as it is in ASTM Standards C2191 and C5952. In C219, slag cement is defined as a blend of granulated blast-furnace slag and hydrated lime in which the slag constituent is more than a specified minimum percentage. C595 gives the minimum percentage applicable in that particular specification.

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In recent years, slag cement has been commonly used to refer to either combinations of Portland cement and ground slag or to the ground slag alone. It is possible at times to find varying opinions as to the proper classification for the latter - cement or mineral admixture.
Blast-furnace slag is the non-metallic product produced simultaneously with iron in the blast furnace and consists primarily of silica and alumina from the iron ore combined with calcium and magnesium oxides from the flux materials. It is tapped from the furnace at a temperature near 1500^{o}C, and, dependent upon the cooling method used, is converted into one of three basic types of product. All are defined in ASTM CI253.

Air-cooled slag is a predominantly crystalline material resulting from solidification in a pit under atmospheric conditions. After cooling, it is dug, crushed, and screened to the desired size. The air-cooled slag has little; or no cementitious properties and is primarily utilized as a mineral aggregate used in all types of construction.

Granulated slag is a glassy, granular product resulting from rapid quenching of the molten slag. Quenching with water is the most common process, but air or combinations of air and water may be used. Dependent upon the slag composition and temperature and the speed of quenching, the granulated slag may vary from a friable, popcorn-like structure to small, sand-size grains resembling a dense glass. The slag glass consists of the same major oxides as does Portland cement (but relative proportions differ considerably), has excellent hydraulic properties, and with a suitable activator sets in a manner similar to Portland cement.

Expanded slag is produced by treating the molten blast-furnace slag with controlled quantities of water, usually less than that used for granulation. The product is more vesicular and lighter in weight than the air-cooled slags. Various pit and machine processes may be used to combine the slag and water. The process used and variations in the amount of water control the cooling rate and can result in products varying from highly crystalline materials resembling an extremely vesicular air-cooled slag to very glassy materials similar to those from granulating processes. A palletizing process4, now growing in popularity, produces spherical particles of highly glassy slag.

Physical properties and the cementitious characteristics of the expanded slags vary with extent of crystallization, as does the appearance, from those of air-cooled slags to those of granulated slags.

Blast-furnace slag is used in the production of cement or cementitious materials in two basic ways: (a) as a raw material for the manufacture of Portland cement, and (b) glassy slag ground and combined with hydrated lime, gypsum or anhydrite, Portland cement, etc., where the slag is utilized for its inherent cementitious properties (Donald W. LewIs P.E, 1981).

2. Experimental Procedure

2.1. Materials

2.1.1. Matrix Polymer

Unsaturated Polyester (UPE) was used in this research. The mixing ratio used was 100g of UPE resin with 0.5g accelerator (Cobalt napthenate) and 2g hardener (Methyl Ethyl Ketone peroxide).

2.1.2. Reinforcing Filler

Three types of filler were used in this research. These types were Cast Iron slag, dust of Kufa cement and dust of Najaf cement p**o**wder. The Chemical compositions of Slags showed in table 1. The chemical analysis result of dusts of Kufa and Najaf Cement and cast iron slag carried out in chemical lab of Najaf cement factory (Iraq) and was as following:

Table 1 Chemical compositions of dusts of Kufa and Najaf Cement and cast iron slag

Component	Weight content % (Kufa) dust cement	Weight content % (Najaf) dust cement	Weight content % cast Iron
SiO2	13.38	6.14	77.44
Al2O3	5.87	1.74	0.06
Fe2O3	1.61	0.86	12.78
Cao	40.35	18.94	2.71
Mgo	3.08	1.17	0.76
So3	8.83	25.25	0.61
L.O.I	21.8	18.07	2.3

2.2. Samples Preparation

The samples were prepared by mixing unsaturated polyester with Slag powder using different filler content. The three powders were added to polyester and hardener and then they were homogeneously mixed. The mixed of composites was poured into the mold according to test.

2.3. Mechanical Tests

2.3.1 Charpy Impact Test

The unnotched Charpy impact strength tests were conducted according to ASTM D-256 at room temperature. The impact strength was concluded from this test. Impact strength (I.S.) is calculated by applying the relationship:

$$I.S. = UC / A \qquad (1)$$

Where: UC is the fracture energy (Joule) which is determined from Charpy impact test instrument. A is the cross – sectional area of the specimen.

2.3.2 Bending Test

The three point bending test was conducted according to ASTM D790. The support span was set at 90mm.
This test gives information about load-deflection and then elastic modulus was extracted by using the following equation:
The flexural strength was calculated by following equation:

$$F.S = 3PL / 2\, bd^2 \qquad (2)$$

Where: F.S: flexural strength (MPa), P: applied force until the failure of specimen occurs. L: span, b: width of specimen, d: thickness of specimen.

Flexural Properties

It is observed in Fig (1) that the increase in volume fraction of slag leads to increase in flexural strength for all particle size, these results can be explained as the total area available to deformation stress and played an important role in flexural properties (Singh P *et al*, 2005).The effect of filler on flexural strength may be due to the increase in the filler content in a polymer composite there is increase in effective surface fracture energy, size of voids and agglomeration of filler particles. The dispersed particles make the crack propagation path longer, absorb a portion of energy and enhance the plastic deformation. Therefore, the surface fracture energy increase and the strength of composites increase with volume percentage of filler (Parvais M.R *et al*,2010).

3. Impact Properties

Figure (2) illustrates that the impact strength decreases with increasing filler loading. This is mainly due to the reduction of elasticity of material due to filler addition and thereby reducing the deformability of matrix. An increase in concentration of filler reduces the ability of matrix to absorb energy and thereby reducing the toughness, so impact strength decreases (Bose,S. *et al*,2004). These results agree with results obtained by Najat and Petr

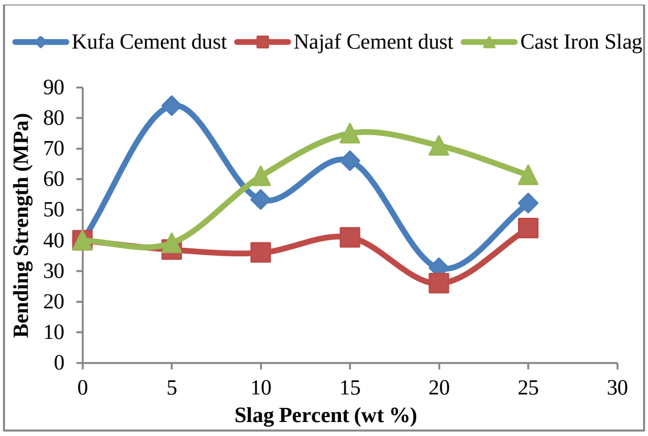

Fig 1 Variation of the Bending strength of polyester with filler loading of slags

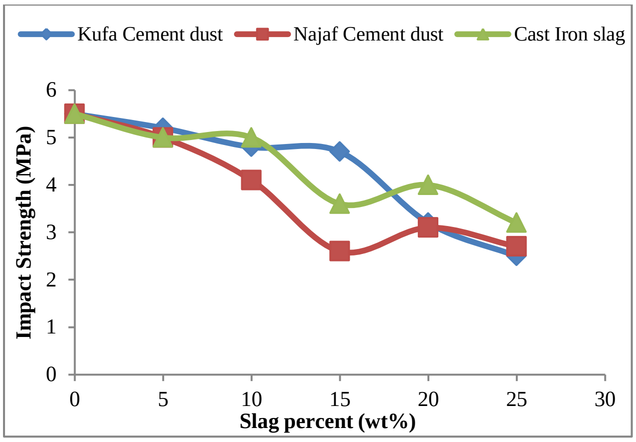

Fig 2 Variation of the impact strength of polyester with filler loading of slags

Conclusions

In this paper, effects of three types of slags on impact and bending strength of unsaturated polyester were investigated. Based on the analysis in the present experimental work, the following conclusions can be deduced:-

- Creation new composite materials have good properties and cheap from unsaturated polyester and waste materials usually unusual alone and harm to environment.
- The flexural strength went up with increasing of filler addition. The impact strength declines with increasing of filler loading.

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