RECYCLING OF EAF DUST VIA BRIQUETTING: INFLUENCE OF ORGANIC MATTER ON BRIQUETTE STRENGTH

[1]Christof LANZERSTORFER, [1]Michael PASCHINGER, [2]Christian BRUNNER

[1]*University of Applied Sciences Upper Austria, Wels, Austria, EU, c.lanzerstorfer@fh-wels.at*

[2]*Primetals Technologies Austria GmbH, Linz, Austria, EU, christian.a.brunner@primetals.com*

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Abstract

In EAF steelmaking considerable amounts of dust are generated. Depending on the furnace type and the content of organic material in the scrap EAF dust contains beside iron oxides, slag components and zinc also some organic matter (TC). Recycling of this iron-rich residue is common via briquetting of the EAF dust together with other fine granular steel mill residues and a binder. It is assumed that a higher TC content in EAF is unfavourable for the strength of the briquettes. In this study, EAF dust was refluxed with an organic solvent (n-heptane) in order to reduce the TC content of the EAF dust by approximately 50%. Subsequently, both the solvent-leached EAF dust and the untreated original EAF dust were used in mixtures in the production of briquettes in a stamp press. Bentonite, modified starch and a mixture of molasses and hydrated lime were used as binders. The strength of the agglomerates was tested immediately after pressing, one hour and twenty-four hours after pressing. The results showed in most cases a higher strength of the briquettes containing leached EAF dust.

Keywords: Steel mill, EAF dust, recycling, briquette strength, organic matter

1. INTRODUCTION

Electric Arc Furnace (EAF) dust is a significant by-product of steel production in mini mills, generated during melting and refining of scrap metal and direct reduced iron in electric arc furnaces. This fine particulate matter contains various metal oxides, including iron, zinc, lead, cadmium, and chromium, making it a hazardous material that requires careful handling. According to the "Best Available Techniques (BAT) Reference Document for Iron and Steel Production" the range of dust produced in EAF steelmaking is 10 kg to 30 kg of dust per ton of liquid steel [1,2]. Due to its composition, EAF dust poses environmental and health risks if not properly managed. Regulations worldwide mandate strict disposal and treatment methods to minimize its impact [3].

Numerous routes for environmentally safe utilization of EAF dust have been investigated. EAF dust can be used in vitrification process where it is co-melted with oxides producing glasses [4,5]. EAF dust can be included into mixtures for concrete [6,7] asphalt [8] or in mortar [9,10] and also the use in geopolymers [11,12], as a filler in polymers [13], the use in land fill construction [14] or as an adsorbent [15,16] have been studied.

However, EAF dust contains much iron and, depending of the feed material to the EAF, a large fraction of zinc. Therefore, the recycling of zinc to the zinc industry to close the material cycle of zinc is important. Economical extraction of zinc from EAF dust requires higher zinc concentrations. Therefore, recycling of EAF dust back into the EAF serves two targets: Firstly, the recycling of iron back into the steel production process, and secondly, the up-cycling of zinc for economically recycling of the EAF dust in the secondary zinc industry [17,18]. For recycling of EAF dust the dust is usually integrated into recycling processes of other iron bearing fines used in the steel industry [19,20]. Most of such recycling processes apply an agglomeration step for the fine-grained material like briquetting. The agglomerates need to show sufficient strength to withstand the stress and environmental conditions during storage, transport and charging into the furnace without significant disintegration effects [21,22]. According to [23] a resistance of the agglomerates to crushing higher than 3 MPa should be achieved while in [24] a required strength of briquettes of 10-20 MPa is suggested. Since the binder has to fit also to the subsequent process steps, the selection of a proper binder for the agglomeration process is an important issue [25,26].

In agglomeration of steel mill fine residues it has been noticed that the inclusion of EAF dust into the fines mixture can have a negative effect on briquette quality [27]. In a previous study, the content of leachable organic material (TC content) in the EAF dust showed significant impact on mechanical properties of the EAF dust like flowability and bulk density [28]. The aim of this study was to investigate whether there is an influence of the content of organic material in the EAF on the strength of briquettes produced from iron containing fines.

2. MATERIALS AND METHODS

2.1 Materials

For the basic fines mixture in the agglomeration tests DRI filter dust and DRI screening fines were used collected from a MIDRX® plant. The EAF dust sample was collected from the dust discharge of the combined primary and secondary off-gas dust filter of an EAF. The total carbon (TC) content of the original EAF dust was 7.2%. In order to reduce the TC content of the EAF dust, it was refluxed with n-heptane. After 3 hours of treatment the TC content of the EAF dust was reduced to 4.2%.

Three different binders commonly used in agglomeration of steel mill fines [29-31] were used in the agglomeration process: bentonite, modified starch and a combination of molasses and hydrated lime.

2.2 Methods

For TC reduction 350 g of EAF dust was dispersed in 600 ml n-heptane and refluxed for 180 min. After cooling of the mixture the solvent was removed by vacuum filtration. Subsequently, the filter cake was dried in a laboratory drying cabinet.

The TC contents of the original EAF dust sample and the leached samples were measured using an Elementar Vario TOC Select analyzer. For calibration a standard with 4.1% TOC was used.

50 kg of a basic mixture of fines consisting of 70 % DRI filter dust and 30 % DRI screening fines were produced in an intensive mixer (Eirich R09T). For each briquetting experiment, the final dry mixture was produced in a laboratory mixer by mixing of the basic mixture with EAF dust – one mixture with original EAF dust and one with leached EAF dust - in the ratio of 4 : 1. Subsequently, the binder and some water was added to the mixture. Table 1 shows the fractions of added water and binder in the final mixtures.

Table 1 Fractions of added water and binder in the final mixtures.

Type of Binder	Moisture content (wt%)	Binder (wt%)
Bentonite	4	6
Starch	14	3
Molasses + hydrated lime	2	6 + 3

Briquettes were produced in a hydraulic stamp press. Approximately 110 g of the fines mixture were filled into the cylindric die with a diameter of 40 mm. Then, the stamp was put in place and the load was increased at a rate of 5.0 kN s^{-1} up to a maximum load of 100 kN. From each mixture 18 briquettes were produced.

The strength of the briquetts was tested immediately after production (3 pieces), one hour after production (5 pieces) and 24 hours after production (10 pieces). The load was increased at a rate of 0.5 kN s^{-1} and the maximum load before failure was recorded. In the results, the average values of briquette strength are presented.

3. RESULTS AND DISCUSSION

In Table 2 the results for the briquettes made from the basic mixture with different binders are summarized. The briquettes with bentonite as binder show the highest values, while using starch as binder resulted in the lowes values for briquette strength.

Table 2 Strength of briquettes made from the basic mixtures

Type of Binder	Green stength (MPa)	1 h strength (MPa)	24 h strength (MPa)
Bentonite	14.5 ± 0.4	14.7 ± 0.7	20.5 ± 1.5
Starch	7.1 ± 0.1	6.3 ± 0.2	7.2 ± 0.3
Molasses + hydrated lime	13.7 ± 0.8	13.8 ± 1.4	17.4 ± 0.5

In Figure 1 the influence of the addition of EAF dust to the fines mixture is shown. When EAF dust was added to the fines mixture the green strength and the 1 hour strength were reduced for all three binders. The negative effect was greater for the original EAF dust and somewhat less for the leached EAF dust. For the bentonite binder the 24 hour strength was somewhat increased when leached EAF dust was added while it was slightly reduced when untreated EAF dust was added. For the starch binder the results were quite similar. The 24 hour strength was slightly increased when leached EAF dust was added while it was somewhat reduced when untreated EAF dust was added. For the molasses and hydrared lime binder the result were different. For this binder system the 24 hour strength was somewhat increased when untreated EAF dust was added while addition of leached EAF dust resuted in a reduced strength.

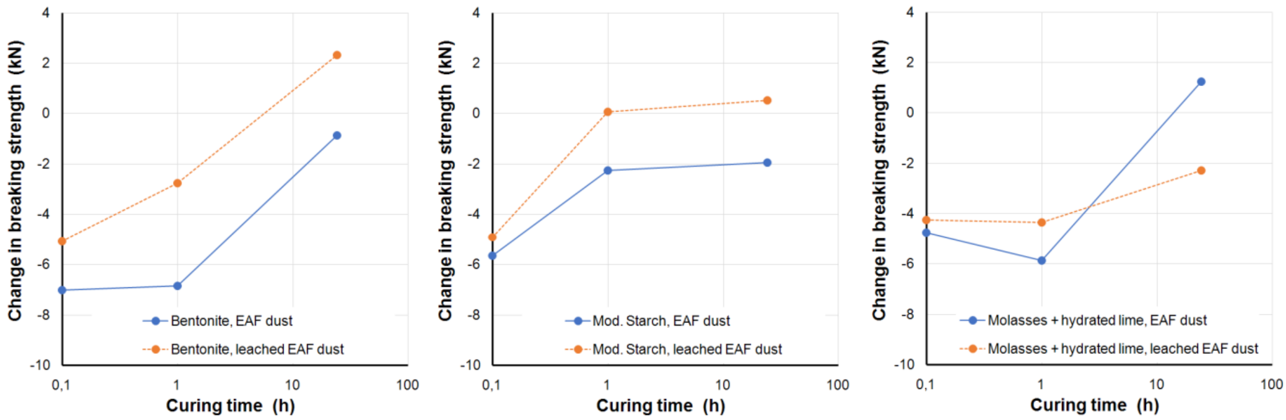

Figure 1 Influence of EAF dust addition on briquette strength

4. CONCLUSION

The results partly confirm the common opinion that the inclusion of EAF dust into steel mill fines mixtures for briquetting has a negative effect on briquette strength. A negative effect mainly exists in the early phase of the curing time of the briquettes. After 24 hours the effect of EAF dust is less negative or even positive. Generally, the negative effect was less for leached EAF dust with a lower TC content. However, for the molasses and hydrated lime binder the original EAF dust performed better than the leached EAF dust. Therefore, the negative effect of EAF dust on briquette strength cannot be assigned generally to organic matter.

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