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Low Cost Briquetting of Metallurgical Dust Fines

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Abstract*-Environmental pollution is one of the major problems in plaguing the modern world today. Among the reasons for the prevailing pollution challenges, industrialization and improper waste management are prominent. The generations of certain by-products are unfortunately treated as wastes without adopting any recycling or reuse options and conversion of these by-products or unwanted wastes into utilizable resources. This paper mainly focuses on such conversion of waste into wealth in an integrated steel industry. Metallurgical dust fines are one of the solid waste produce in Blast furnace, Steel Melting Shop (SMS) processing units of integrated steel plants. The present study is based on this produced metallurgical dust fines, consists of considerable amount of iron content, which can be used as raw material in blast furnace for the production of steel. The agglomeration of the metallurgical dust fines in an economical way is the best option for the usage in the Blast furnace. Hence, briquetting process of agglomeration at ambient temperature was studied during the present work. This briquetting process requires small fraction of binders to enhance the binding of inert metallurgical dust fines. CarboxyMethyl Cellulose (CMC), Boric acid and Sawdust with different quantities and combinations were used as 1.1binders for briquetting the fines. Based on the preliminary tests on briquetting molasses a waste from sugar mills was used as admixture and a standard quantity of molasses was added for each fraction of binders or their combinations. The binders, admixtures and metallurgical dust fines are mixed in a mechanical mixer and then compacted in a high pressure compacting equipment to form a briquette. In our work manufactured metallurgical dust fine briquettes were tested in laboratory. Almost all the briquettes met the minimum standards for handling the briquette. The highest compressive strength of 7.56 Mpa was obtained in the combination of CMC & boric acid and CMC & sawdust. The briquette made from dust fines using 3% of sawdust and 25ml of molasses has attained a dry compressive strength of 5.10 Mpa, which was also found to be satisfactory and economically cheapest of all combinations. The present study resulted in arriving at the process flow for briquetting metallurgical dust fines.

Keywords: Briquettes, Metallurgical dust, CMC, Boric acid, Saw dust

1. INTRODUCTION

Environmental protection and conservation of natural resource are important matters today. Material recycling helps in conservation of such natural resources. Among all the wastes, solid waste generation and improper management posing challenge to environment. Therefore, efforts are to be made for controlling pollution arising out of the disposal of wastes through reduction, reuse and recycling aims at either using directly the waste material without any further processing or conversion of these unwanted wastes into utilizable raw materials for various beneficial uses. Steel mills are processing the iron ore and producing significant amount of waste containing reusable or recyclable materials. Hence waste management is becoming an important integral part of steel industrial systems. This paper aims at exploring possible ways and means effective implementation of reuse or recycling options of waste material in a steel industry that uses iron ore as its raw material. The primary objective of this study is to suggest recycling method for metallurgical dust fines generated in steel plant which has multifold uses, and to ensure quality of briquettes made by metallurgical dust fines which can be used along with raw material in blast furnace for processing of ore.

2. PROPOSED METHOD

One should note that even if the methods considered in two problems are same the methodology may be different. It is important for the researcher to know not only the research methods necessary for the research under taken but also the methodology. The present study aims at production of briquettes from the inert metallurgical fine dust particles. It involves agglomeration.

One of the process used for agglomeration iron ore fines is briquetting. Briquetting is the most known and a widely spread technology of materials compacting. The technology uses mechanical and chemical properties of materials to compress them into the compact shape (briquettes) with usage of additives or binders in the high pressure compacting process. Briquetting is executed by briquetting presses. The material is pressed into the pressing chamber with high compacting pressure. For briquette quality control, the physical parameters, such as density, moisture content and compressive strength, were found to be the best indicators.

2.1 Sample Unit

For this purpose the researcher has taken the sample of Visakhapatnam Steel Plant which is one of the biggest steel plants in the world. The researcher with the permission of the authorities in the Steel plant has visited and taken the samples for the study the following.

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2.2 Selection of Binder

The metallurgical dust produced from process of Visakhapatnam steel plant consists of finely divided particles with a specific gravity more than 2.5. It is difficult to convert them as an agglomerate lump at room temperature. Hence, it is necessary to use an appropriate binder that plays an important role in the agglomeration process. But the selected binder should not come in the way while reusing the lump in the blast furnace. Therefore, selection of suitable binder is essential for production briquette, an agglomerate of metallurgical dust. The most popular binder is bentonite. In recent times, some of the researchers (Osman, 2010) used carboxymethyl cellulose. However it is expensive to use such material (Osman, 2010), some of the researchers replaced benotonite with boric acid (Osman, 2010). Therefore present work aims at replacing fraction of carboxymethyl cellulose and pressure impact/compact pressing. Therefore the same method is adopted for the selection of mechanical process in making of metallurgical dust briquettes is Refractory press. It is due to the refectory press machine compacts the inert material such as metallurgical dust into briquettes at ambient temperature which reduces the production cost of briquette making. The impact press (refractory press) is a molding device that provides homogeneous pressure over the entire surface of a mold filled with powder. Impact presses have a higher allowable maximum compacting force. Briquettes formed with impact press are flat uniform and compact boric acid with other low cost cellulose waste material such as sawdust and molasses in different proportions.

2.3 Selection of Mechanical Process

The impact press which is widely used in refractory's to agglomerate the inert fines with high pressure impact/compact pressing. Therefore the same method is adopted for the selection of mechanical process in making of metallurgical dust briquettes is Refractory press. It is due to the refectory press machine compacts the inert material such as metallurgical dust into briquettes at ambient temperature which reduces the production cost of briquette making. The impact press is molding device that provides homogenous pressure over entire surface of a mould filled with powder. Impact presses have higher allowable maximum compacting force. Briquettes formed with impact press are flat uniform and compact.

The briquetting procedure

1. 2600 grams of metallurgical dust is taken
2. The binders used in the experiment are Boric acid, carboxymethyl cellulose sodium salt, saw dust and molasses.
3. The saw dust size used in the experiment is 1.18mm sieve passing.
4. Binders are divided into fractions of weight, the classification factor with respect to weight of metallurgical dust the details are shown in the Table 1
5. Predefined quantity of binder was added to the dust.
6. The water content added for each fraction is 200ml, the addition of more water leads to cracks in briquettes.
7. The resulting mixture is placed in an automatic mixing machine for thorough mixing of dust and binder.

Table 1 Description of binder used and its fraction in the mixture used for production of metallurgical briquettes (All fractions in grams)

Binders used	A 3%	B 6%	C 9%
1 Boric acid	78	156	234
2 Carboxymethyl cellulose	78	156	234
3 Sawdust	78	156	234
4 Boric acid & Sawdust	78 (39+39)	156 (78+78)	234(117+ 117)
5 Caboxymethyl cellulose & Boric acid	78 (39+39)	156 (78+78)	234(117+ 117)
6 Carboxymethyl cellulose & Sawdust	78 (39+39)	156 (78+78)	234(117+ 117)

8. 25ml of molasses was added to thus obtain well mixed contents.
9. The resulting material is placed in the mould of size 23*11.5*6 cm
10. The mould is placed in compacting machine for agglomeration.
11. The machine applying an impact of 150 MT.
12. The mould is taken out from machine and placed for drying at room temperature. The drying process helps in gaining strength for the briquette.

3. EXPERIMENTAL RESULTS

The metallurgical dust fines were segregated, through sieve to remove gangue. The sieved metallurgical fines were then separated into fixed quantities of 2600 grams. There which were processed in a mechanical mixer, after adding varying compositions of binders as above described in Table1. The resultant mixture was then subjected to compaction-impaction under a high pressure hybrid briquetting machine to form a briquette in an industry. The briquettes were then dried at room temperature for 3 days as one the functions of this research is to identify the effectiveness and economic feasibility of the briquettes. Upon drying, the briquettes were then transported to laboratory to check whether they can withstand vibrations without any disintegration. The compressive strengths of briquettes made by metallurgical dust fines were also evaluated.

The following figure is the researchers own construct for the process flow of Metallurgical briquettes production

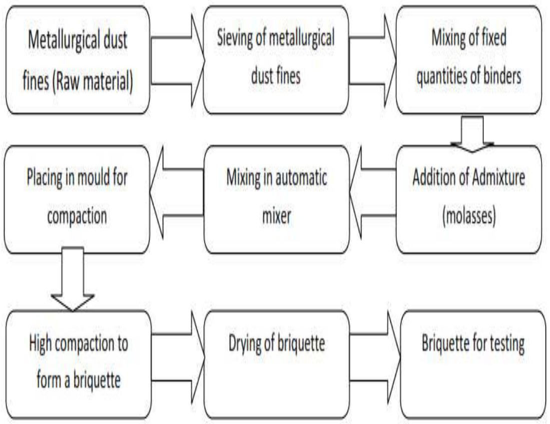

Figure 1 Process flow of the metallurgical briquettes production or manufacturing

Mixing of the Constituents of the Briquettes

The metallurgical dust fines were collected from RINL, Visakhapatnam. Then the metallurgical dust fines were sieved. A mechanical mixer, shown in Figure 2 (a) was employed for proper mixing of the binders and metallurgical fines. After thorough mixing fixed quantities of add mixtures and metallurgical dust fines along with varying quantities of binders and moisture content in a mechanical mixer.

Production of Wet Briquette

The resultant mixture is then subjected to high pressure input loading and compaction (Machinery used for briquetting through compaction process is shown in Figure 2 (b)). After compaction the wet briquette is formed, the wet briquette thus produced is as shown in Figure 2(c). It needs to be handled with care and precaution should be taken as mishandling can lead to partial disintegration of briquette.

Dry Briquettes

In addition to the compressive strength the metallurgical briquettes should be test for stresses arises during transportation. Hence the metallurgical briquettes can withstand handling and transport stress. The laboratory facility doesn’t support such tests. Hence, the briquettes were subjected to transport stresses by transporting them from the factory where they were produced to the testing laboratory in the university. The total length of travel is more than 30kilometers there is no damage or disintegration of the briquettes. The metallurgical briquettes were tested for compression only after subjecting them to transport stresses.

The wet briquettes produced are dried for 3 days, at room temperature. The binders upon reacting to the moisture content in the brick now form a strong bonding between the metallurgical dust fines, which helps in keeping the briquette compact and strong and these briquettes are called dry briquettes. The dried briquettes produced are shown in Figure 2 (d).

Compressive Strength of Briquettes

The compressive strengths of briquettes made by metallurgical dust fines were then evaluated in laboratory as shown in Figure 3 and the values as given in Tables 2 and 3

All the following figures are the researcher’s own construct

Figure 2 Process Flow in the Production of Metallurgical Dust Briquette (a) Mechanical mixer (b) Impact press equipment used for briquette production (c) Wet briquette (d) Dry briquettes

Figure 3 Compression Tests of Metallurgical Dust Briquettes

Laboratory investigations on metallurgical dust fines

The compressive strength results of the metallurgical dust briquettes with individual and combination of above

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mentioned binders are incorporated in the below Tables 2 and 3 respectively The highest compressive strength of 7.56 Mpa is obtained for the briquette produced using the binder combination of CMC & boric acid and CMC & sawdust. As cost is a decisive factor in determining the effectiveness of the production cycle, the combination of CMC & Boric Acid turns out to be an expensive alternative when compared to the combination of CMC & Saw dust, which is considerably cheaper and easily available. As per I.S 2185 the minimum average compressive strength of construction bricks shall be 3.5 to7 Mpa. In the Figure 5 the briquette made of only with 3% of sawdust and 25ml of molasses has attained a dry compressive strength of 5.10 Mpa which is also found to be satisfactory and economically cheapest of all combinations. Further increase in the percentage of saw dust there is decrease in the dry compressive strength of briquettes.

Moreover, According to Osman Sivrikaya (2010), the maximum recorded wet, dry and fired compressive strengths of pellet is 0.07 MPa, 0.17 MPa and 19.98 MPa respectively. The CMC used for making of pellets is 2 kg/ton and the fired compressive strength obtained is 14.7 Mpa as shown in Figure 4.

Table 2 Compressive Strengths of Briquettes Prepared from Individual Binder

Binders are divided into fractions of weight, the classification factor with respect to weight of metallurgical dust				
Nomenclature	Boric acid	CMC	Sawdust	Compressive strength, Mpa
1A	3% (78gms)	-	-	5.67
1B	6% (156gms)	-	-	2.45
1C	9% (234gms)	-	-	1.89
2A	-	3% (78gms)	-	4.53
2B	-	6% (156gms)	-	2.64
2C	-	9% (234gms)	-	2.45
3A	-	-	3% (78gms)	5.10
3B	-	-	6% (156gms)	3.66
3C	-	-	9% (234gms)	2.07

Table 3 Compressive Strength of Briquettes Prepared from Combinations of Binders

Binders are divided into fractions of weight, the classification factor with respect to weight of metallurgical dust				
Nomenclature	CMC	Boric acid	Sawdust	Compressive strength, Mpa
4A	-	1.5% (39gms)	1.5% (39gms)	6.04
4B	-	3% (78gms)	3% (78gms)	4.34
4C	-	4.5% (117gms)	4.5% (117gms)	3.96
5A	1.5% (39gms)	1.5% (39gms)	-	7.56
5B	3% (78gms)	3% (78gms)	-	5.67
5C	4.5% (117gms)	4.5% (117gms)	-	4.34
6A	1.5% (39gms)	-	1.5% (39gms)	7.56
6B	3% (78gms)	-	3% (78gms)	3.78
6C	4.5% (117gms)	-	4.5% (117gms)	3.16

Comparatively with increase in the addition of CMC from 2kg/ton to 15kg/ton we attained a compressive strength of briquette 7.56 Mpa with a combination of saw dust, which is almost half the fired compressive strength of pellet made with CMC by Osman (2010). Further increase in the quantity of binders leads to decrease in dry compressive strength of briquettes as shown in Figure 5 and Figure 6. The compressive strength obtained for 3% quantities is more when compared to 6 and 9 percent. Form the analysis of Figures 5 and Figure 6 there should be addition of optimum amount of binders to be used to attain excellent compressive strengths of briquettes, as further addition of binders lead to degradation of compressive strength of briquette.

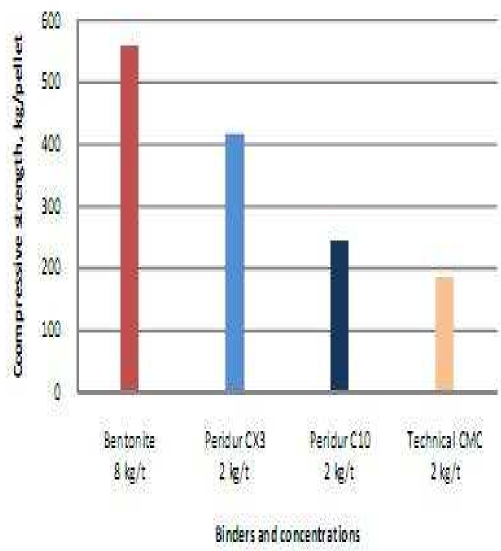

Figure 4 Compressive Strength of Fired Pellets (1200^0C, 120 Min) Produced With Selected Organic Binders (Osman Sivrikaya, 2010)

The following graphs are researcher's own construct

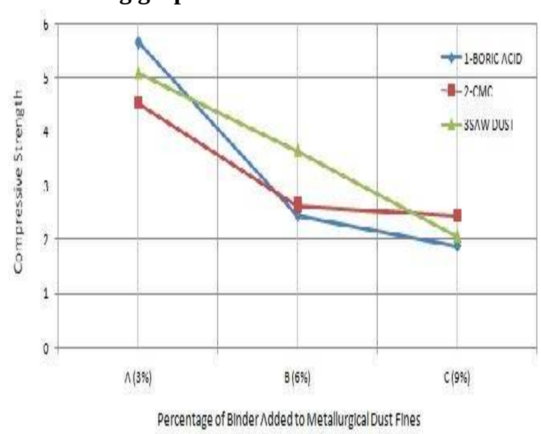

Figure 5 Compressive Strengths of Briquettes Prepared from Individual Binder

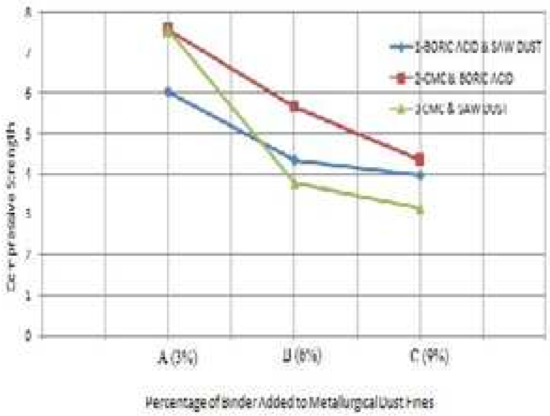

Figure 6 Compressive Strength of Briquettes Prepared from Combinations of Binders

4. CONCLUSIONS AND FUTURE SCOPE

The combination of an organic binder CMC and a Boron compound as an alternative to bentonite are used in the metallurgical dust briquetting production. These binders are beneficial and successful in reducing the acidic impurity constituents which are induced by bentonite. The combination of CMC & Boric Acid turns out to be an expensive alternative when compared to the combination of CMC & Saw dust, which is considerably cheaper and easily available. The cost of CMC is approx. 1200 Rupees/Kg.The briquette made of only with 3% of sawdust and 25ml of molasses has attained a compressive strength of 5.10 Mpa which is also found to be satisfactory and economically cheapest of all combinations.The briquettes are resistant to vibrations without any disintegration even though the briquettes are dried at ambient temperature for a period of 3 days and transported over a distance of 30 kilometers. **There is a scope for further study with different binders adopting the same methodology to get the metallurgical dust briquettes much more cheaper**. As the briquettes consists of more than 40% of Fe content this metallurgical dust briquettes can be used as substitute for high grade iron ore lumps which are used as raw material in blast furnace.

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