Physicochemical Problems of Mineral Processing, 35 (2001), 153-160
Fizykochemiczne Problemy Mineralurgii, 35 (2001) 153–160

A. M. RAMADAN*, A.M. SALEH*, T.A. TAHA* and M.R. MOHARAM*

AN ATTEMPT TO IMPROVE MECHANICAL PROPERTIES OF BRICK PRODUCED FROM EL-MAGHARA COAL WASHING PLANT WASTE

Received March 5, 2001; reviewed and accepted May 15, 2001

Treatment of wastes became a vital demand to maintain the environment as clean as possible . The treatment of wastes and reuse of their constituents in industry will be helpful for this trend as well as for economy. Flotation technique is one of the important separation techniques that can be applied for treatment of wastes efficiently. The filter cake of El-Maghara coal washing plant was one of these wastes which contains a considerable amount of clay. This filter cake was treated in a previous work by flotation in order to clean it from the contained fine coal. The residual clay was tested as a raw material to produce brick models with acceptable mechanical properties. Improvement of the mechanical properties of such brick models by mixing such clay with sand is exactly the main objective of this work. The effect of different factors such as, weight percent of sand and its particle size on the mechanical properties of the brick models was investigated. It was found that 20 % and 60 % of sand sample characterized by size distribution of - 1500 + 0 μm and - 500 + 0 μm respectively are enough to achieve a considerable extent of improvement in the mechanical properties of the clay brick produced.

Key words: fine coal, clay, sand, brick, mechanical properties

INTRODUCTION

A serious consequence of coal mining and preparation is the significant amount of waste products which may lead to pollution of all three components of environment, namely, air, water and soil. Also, wet methods of coal beneficiation have contributed much to surface water pollution. Hence, treatment of plant process water and / or wastes and reuse of these wastes become necessary for preferable environment (Shan et.al 1990, Cellier,1990). Recently, a new strategy called wastless technology has been developed to prevent further environmental degradation (Cellier 1990). This approach

* Al-Azhar University, Fac. of Eng., Min. & Pet. Dept., Nasr City, Cairo, Egypt

aims to obtain the complete utilization of raw materials in order to decrease the amount of tailings and processing of these tailings to make the majority of its waste products acceptable for utilization in a manner both economically feasible and environmentally inoffensive. The coal fines of wastes were utilized by applying the technique that agglomerates it into a coarser more handleable size product which called coal brequitting technology. There are different technologies and attempts through the mineral processing literature concerned with the treatment of fine coal wastes and reuse of their constituents which can be helpful for both environment and economy (Lukc 1994, Tucker et.al1994). In earlier work (Ebied 1984), Fayoum clay powder was mixed with different amounts of sand and with sufficient amount of water and extruded into perforated briquettes. The results showed that a mixture of 70 % clay and 30 % sand (wt. %) was found to have a suitable ceramic properties. Another works (Elwan et. Al. 1999, Elwan et.al. 2001) dealing with mixing the by-pass cement dust as nonplasic material with clay for preparation of clay for brick industry. The results obtained showed that the substitution of 10 wt. % clay by cement dust increases the gas permeability of the fired bricks, which prevents the brick to bloat and also increases the crushing strength. Filter cake produced from El-Maghara coal washing plant, northern Sinai-Egypt, represents about 112,000 ton/year. Along the mine age which is about 35 years, a huge amount of filter cake will accumulate in the storage area near the mine. This kind of waste was found to contain more than 45 % of coal fines. It was suggested to recover this amount of fine coal by flotation technique. In a previous study (Ramadan et.al. 2000), an attempt was done to recover such high amount of coal fines by flotation technique. Promising results were obtained using kerosene as a collector with about 50 % yield. The residual clay was also tested as a raw material for producing brick models and acceptable results were recorded. Hence, a considerable amount of clay ,i.e, about 56,000 ton/year will be collected. The main objective of this work is to improve the mechanical properties of such brick models by mixing the residual clay after flotation process with different amounts of sand of different particle sizes.

MATERIAL AND METHODS

Filter cake produced from El-Maghara coal washing plant as tailing was used as a raw material for clay after its treatment by flotation to separate the involved coal fines. X ray analysis was done for such filter cake sample and the results are tabulated in table 1. The flotation tests were carried out in 8 liter Denver flotation cell. The applied optimum flotation conditions are shown in table 2.

The experimental procedure includes, 5 min conditioning, 5 min collector contact, 1 min frother contact and the flotation was continued until the bubbles got barren. Then, clay tailings were collected and kept for making brick models. The sand used was obtained from Sinai region and supplied by Manganese Sinai Co.. The chemical and sieve analyses of the sand sample are shown in tables 3 and 4.

Table 1. X ray analysis of filter cake sample

Constituent	Content %
SiO_2	26.10
TiO_2	1.5
Al_2O_3	13.36
Fe_2O_3	3.97
MnO	0.03
MgO	0.55
CaO	1.37
Na_2O	0.14
K_2O	0.92
P_2O_5	0.05
LOI	52.01
Total	100 %

Table 2. The optimum flotation conditions

Parameter	Dosage/value
Frother (pine oil)	60 mg/l
pH	6
Solid/liquid ratio	10 %
Gas flow rate	6 l/min.
Impeller speed	1000 rpm.

Table 3. Particle size distribution of sand sample

Particle size, µm	Wt., %
+ 1500	03.2
- 1500 + 1200	41.3
- 1200 + 750	30.2
- 750 + 500	13.1
- 500	12.2
Total	100

Table 4. Chemical analysis of sand sample

Constituent	Content, %
SiO_2	94.86
CaO	1.28
MgO	0.68
Fe_2O_3	0.33
TiO_2	0.73
Al_2O_3	2.12

The residual clay tailings were found to have about 78 % ash content. This means that a considerable amount of coal fines are still unrecovered. Also, it was found that the water reservation of such type of clay was about 33 %, which means that the porosity of such clay is very small. During the ignition of the native clay brick model the briquette bursts. This burst was attributed to the pressure exerted by the produced gases from the ignition of coal included in the clay. The amount of coal contained in the clay and the low porosity provided good support for such interpretation. To avoid the burst of briquette during the ignition as well as to improve its physical and mechanical properties, it is suggested to mix such clay with sand. This suggestion mainly aims to increase the porosity of clay to give a chance for the introduced gases during the ignition to escape. In this regard, a mixture of clay and sand were prepared at different weight percent, 20, 40, and 60 % of sand. First, the sand sample was used in the mixture as it is, i.e, - 1500 + 0 μm and second, the clay was mixed with the individual size fractions of sand, namely, - 1500 + 1200, - 1200 + 750, - 750 + 500, and - 500 + 0 μm at constant weight percent. Each mixture was mixed well with a suitable amount of water and the paste was hand formed in a wood briquette of 12.5 x 6 x 3 cm. The formed bricks were left to dry at room temperature in the laboratory atmosphere for one week and overnight at 100^{o}C in a drier then, fired in a muffle furnace for 4 hours at 950^{o}C. The physical properties (water absorption) and mechanical properties (Compressive strength) of the fired briquettes were measured to make sure that their specifications are compatible with the Egyptian standard specifications for brick industry (9).

RESULTS AND DISCUSSION

EFFECT OF APPLYING OPTIMUM CONDITIONS ON THE REMOVAL OF COAL FINES FROM THE FILTER CAKE

The optimum conditions indicated by Ramadan (Ramadan et. al. 2000) for the removal of coal fines from the filter cake were applied at different collector dosage in order to determine the optimum collector dosage for the separation process. These optimum conditions are shown in table 2 and the results obtained by applying them in flotation process are shown in figure 1. As can be seen from this figure the coal recovery increases by increasing the kerosene dosage. The increase of kerosene dosage more than 3 kg/t did not cause a considerable changes in coal recovery. On the other hand, the ash content changed in the range of 17 to 21 %. The best flotation recovery of fine coal is obtained at 3 kg/t of kerosene. This may be due to the best adsorption of kerosene on the coal surfaces which makes the coal surfaces more hydrophobic. This, in turn, may lead to strong attachment between coal surfaces and air bubbles. Under these conditions the removal of coal fines from the filter cake was found to increase. Hence, the main frame for the best operating conditions is completed by determining the suitable collector dosage.

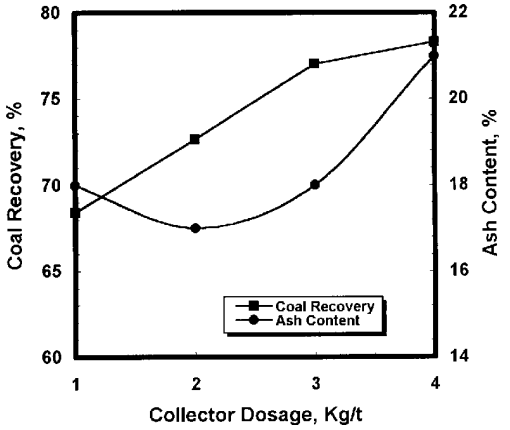

Fig. 1. Effect of collector dosage on the removal of coal fines from filter cake

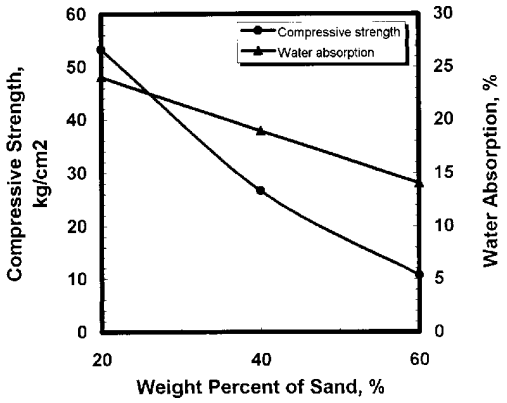

Figure 2. Effect of weight percent of sand (-1500 + 0 μm) on physical and mechanical properties of produced bricks

From the results obtained, it was found that the residual clay tailing have about 78 % ash content. This means that it still has about 20 % of coal fines. The water reservation of such clay was found to be about 33 % , i.e, it has very low porosity.

EFFECT OF WEIGHT PERCENT OF SAND (THE WHOLE SAMPLE)

To illustrate the effect of sand on physical and mechanical properties of clay bricks, different mixes were made by substituting clay by sand (20 %, 40 %, and 60 % by wt.) of - 1500 + 0 μm size range and the produced bricks were tested for compressive strength and water absorption determination. The results obtained are presented in figure 2. From this figure, it is clear that the compressive strength decreases by increasing the wt. % of sand in brick model. This may be attributed to the particle size distribution of sand sample. By increasing the wt. % of sand in brick model more than 20 % by wt., the voids between the coarse particles, which represent the highest content among the fractions indicated in table 3, will increase. The decrease of water absorption trend as shown in Fig. 2, may be taken as an evidence for such conclusion. These voids which created between the coarse particles may lead to the reduction in the compaction of the fired briquette. Also, these voids may promote the extensive cracking which results from the variation of thermal expansion between phases which, in turn, reduces the compressive strength of such brick models.

EFFECT OF SIZE FRACTION OF SAND

To indicate the effect of particle size of sand on the physical and mechanical properties of bricks produced from the clay tailings, each size fraction of sand was tested as nonplastic material with clay and mixed well at a typical value of 60 % sand

by weight. The results obtained are shown in Fig. 3. As shown from this figure, the decrease of particle size from 1350 μm to 975 μm did not cause any considerable changes in the compressive strength of the brick models. This may be attributed to the presence of coarse size fractions of sand which may lead to producing unsuitable brick models with regard to physical and mechanical properties. This result is mainly due to the reasons mentioned above about the worse side effect of the voids created between the coarse particles of sand. However, by decreasing the particle size fraction of sand less than 975 μm, the compressive strength of brick models was found to increase gradually until it reaches about 60 kg/cm^2 at 250 μm particle size. This may be attributed to the reduction of voids between particles as a result of presence of fine and unique size fraction of sand as nonplastic material with clay tailings. So, homogeneous and compacted brick models are produced with reasonable physical and mechanical properties. As a result of the homogeneity and compactness of the brick models, their porosity was found to be suitable for escaping the produced gases during ignition. The obtained results from the plotted data of water absorption may be a strong evidence for the mentioned interpretation.

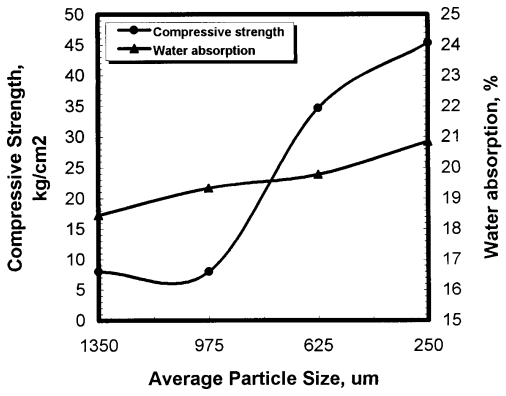

Fig. 3. Effect of particle size of sand on physical and mechanical properties of bricks

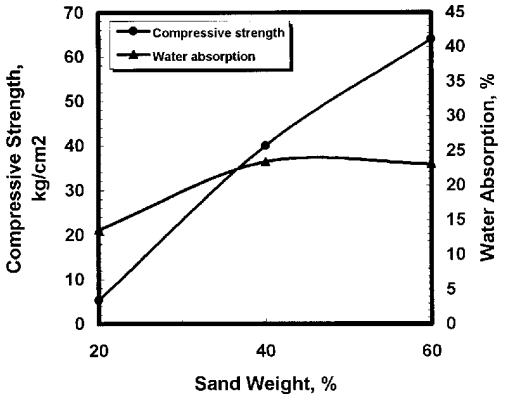

Fig. 4. Effect of weight percent of sand (for - 500 + 0 μm size fraction) on physical and mechanical properties of bricks

EFFECT OF WEIGHT % OF SAND FOR - 500 + 0 μm SIZE FRACTION

To illustrate the effect of wt. % of sand for - 500 + 0 μm size fraction, the data were plotted and indicated in figure 4. As shown from this figure, the compressive strength increases by increasing the wt. % of sand. On the other hand, the water absorption was also found to increase by increasing the wt. % of sand from 20 % to 40 %. However, by increasing the wt. % of sand higher than 40 % the water absorption was found to be nearly constant. This may be attributed to the large homogeneity between sand and clay which lead to severe cohesion between the particles of sand as

a result of the presence of clay which behaves as cementing material on the large surface area of sand particles. This cohesion may decrease the voids between sand particles to a great extent which, in turn, increases the compaction of fired brick models.

COMPARISON BETWEEN SPECIFICATIONS OF PRODUCED BRICK MODELS WITH THE EGYPTIAN STANDARD SPECIFICATIONS OF BRICK INDUSTRY

To make sure that the specifications of such brick models are suitable for brick industry the obtained optimum conditions were applied to produce brick models which have been tested for determining the water absorption and compressive strength in order to compare their specifications with the Egyptian standard specifications. The results obtained are tabulated in table 5. From these results, it is clear that the brick models produced in this work are compatible well with the Egyptian standard specifications for brick industry (Barakat 1984).

Table 5. Specifications of brick model

Test	Egyptian standard	Brick model specifications
Water absorption % Compression resistance	not more than 30 not less than 20 kg/cm^2	23 % by wt. 62 kg/cm^2

CONCLUSIONS

An adequate physical and mechanical properties could be produced by substituting clay by sand. The weight percentage of sand depends on the particle size of sand sample. Throughout this study, it was found that 20 % and 60 % of sand sample which is characterized by size distribution of - 1500 + 0 and - 500 + 0 μm respectively is enough to give a considerable improvement of clay brick produced. The results of the study may be applied for exploiting the clay of northern Sinai whether from the filter cake of El-Maghara coal washing plant or from natural clays which are found in the same area for brick making. This, no doubt, will take part in the development of this area.

REFERENCES

BARAKAT M. A.(1984) *Building materials and standard measuring tests,* Dar El-Ratib Co. Publishers, Cairo, Red-lay bricks, Chapt. 9, pp 262-283.

CELLIER F., (1990), Improvement in the quality of water at the freyming washery by means of a rapid clarifier, *Proceeding of the 11th Inter. Coal prep. Congress*, Tokyo, Japan, pp. 212 - 215.

EBIED E. A., (1984), Evaluation and Studies of some local raw materials and its capability for production of some building materials, M.sc. thesis, Faculty of science, Cairo University.

ELWAN M., ABDEL- AZIZ D., and EL-DIDAMONY H., (1999), Effect of by - pass cement dust on the properties of clay bricks", *Ceramic Silikaty*, 43 (3), p. 109 – 114.

ELWAN, VI. NI., El- ALFI E.A. and EL - DIDAMONY H.,(2001) Effect of by-pass cement dust as nonplastic material on clay bricks, *7th Inter. Conference in Min., Pet., and Metall., Eng.* (MPM), Min., and Metall. Eng. Dept., Faculty of Eng., Assuit University, Assuit, Egypt, pp. 333 - 342.

LUKAC J.(1994), Briquitting of hard brown coal without binding agent, *Proceeding of 12th Inter. Coal Prep. Congress*, Cracow, Poland, pp. 581 - 586.

RAMADANA.M., SALEH A.M., and MOHARAM M.R.,(2000) Waste treatment of El-Maghara coal washing plant by flotation for beneficial reuse of its constituents in industry, *8th International Mineral Processing Symposium*, Antalya, Turkey, Oct. 16 - 18.

SHAN Z., YAN X., ZHANG C., PI P., XE X., (1990), New approach to clean - coal dewatering and waste water purification, *Proceeding of the 11th Inter. Coal Prep. Congress*, Tokyo, Japan, pp. 199 – 204.

TUCKER P.V., BOSWORTH G.B. and KALB G.W., (1994), New developments in coal briquitting Technology, *Proceeding of 12th Inter. Coal Prep. Congress*, Cracow, Poland, pp. 587 – 598.

Ramadan M.A., Saleh M.A. Taha A.T. Moharam M.R., *Uwagi nad poprawą mechanicznych właściwości cegieł produkowanych z odpadów węlowych z zakładu El-Maghara*, Fizykochemiczne Problemy Mineralurgii, 35, 2001, 153-160 (w jęz. ang.).

Poprawa mechanicznych właściwości cegieł wykonanych z mułu węglowego przez dodanie piasku, stanowiła główny cel badań. Wpływ takich parametrów jak zawartość piasku, skład ziarnowy na właściwości mechaniczne produkowanych cegieł był badany. Zostało ustalone, że obecność 20% piasku o uziarnieniu –1500 μm oraz 60% piasku o uziarnieniu –500 μm pozwala na wyraźną poprawę mechanicznych właściwości produkowanych cegieł.