

Clean fuel-magnesia bonded coal briquetting

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Abstract

Beneficiation from coal fines as solid fuel in Turkey is very much important for economical development. Beneficiation from washed coal fines in the industry using solid fuel at lump size and in the municipal areas as an household solid fuel may be only provided by hot briquetting of the coal fines. The most practical common way of that beneficiation from coal fines in our country have been hot binding by sulfite liquor–sulfite liquor–melas and lime mixtures. Harmful the flue content of sulfite liquor–melas may only be eliminated by lime, a type of solid additive. However, cold bonded briquettes produced from coal fines are environmentally free. Just ash contents of these briquettes increase at a certain degree and heat content of them decrease at a certain extent. By using magnesia binder showed in this study, Tunçbilek lignite fines have been briquetted by cold and hot briquetting techniques. The qualities of briquettes produced by cold binders were compared with to those produced by other hot binding methods. As a result, magnesia binder showed the similar characteristics with those of the briquettes produced by only cold bonded gypsum. Use of magnesite mixture and gypsum just as only cold binder was not suitable for the requirements from the coal briquettes to be used as solid fuels, particularly from household fuels, but just only as cold additive should be used.

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1. Introduction

Fine coals in – 10 mm size extracted from coal mines and coal cleaning plants could be evaluated by briquetting, coarser coal agglomerates to sale various industries or primarily to power plants burning pulverized coals in Turkey. Fines of brown lignites and lower quality coals might not directly be briquetted and could only be marketed as fines due to high briquetting costs. High ash contents and lower calorific values of those lower quality coal fines make costly impossible to use briquetting. Fines of lignites such as Tunçbilek and Soma lignites are much feasible for briquetting [1].

Organic binders softening by heating used in coal briquetting may cause high amount of toxic flue emissions. Coal tar or sulfite liquor of sugar wastes softening at 70–90 °C is used as organic binders in Turkey. Lime addition as binder at certain amounts may decrease that toxic emission.[2]. Thus much more environmentally friendly briquettes could be produced. One of the environmentally beneficial additives is magnesite or

magnesia, commonly used in moisture and sulfur capture. Especially calcined magnesite approximately at 400–500 °C burning temperatures may hold sulfur dioxide emission as sulfate and sulfite components of magnesium in the briquettes. Hence, cold bonded briquetting is much more advantageous in production environmentally friend coal briquettes.

Magnesia and carbon bricks might be used much efficiently as refractory stones resisting at very high temperatures under greater hot metal loads [3]. Magnesia grain size and porosity had greater affect on refractory body qualities [4]. Even bond strength among magnesia ,carbon and other components increased by increased temperature [5].

Coal deposits providing high amount of energy in power plants should be beneficiated at maximum feasible rate in Turkey. Especially high ash and high sulfur type coals are usually evaluated by using various cleaning methods in Turkey [6]. Flue gas descrubbers and desulfurizers may much commonly used in power plants for lower rank coals.

Coals marketing in municipal sites are restricted by coal unfavorable components such as ash, flue and sulfur contents. Especially, ash content and combustible sulfur amount are

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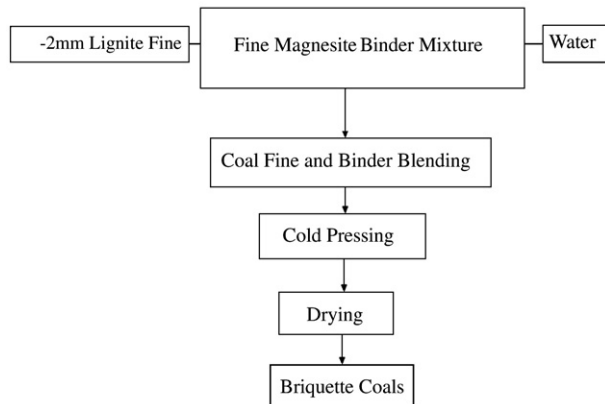


Fig. 1. Briquetting method for magnesia bonded coal agglomeration.

criticized in Turkey. High ash and sulfur content over 20% and 3% are the friendly last limits in municipal regions. While those limits are 10% and 1.5%, respectively in the world [7]. During coal marketing those qualities are the main selection variables, especially for coal briquettes sold in municipal fields. Sulfite liquor and lime mixture used as organic binders in coal briquetting may only eliminates approximately 10% of total sulfur contents of high sulfur coals at ash [8]. The most powerful sulfur capturing alkaline are soda and magnesite [9]. Magnesite and sulfite liquor mixtures are tested in this study and especially cold bonded magnesite briquetting of Turkish lignite are investigated. Test results are compared by those test of organic sulfite liquor bonded briquettes. Optimum cold bonded briquetting process was determined.

2. Method

Magnesia bonded briquetting is a kind of cold bonded briquetting technique and similar to plaster bound. Magnesite cement mixture used common in refractory industries and refractory structures. However, The magnesite cement mixture used in the experiments was specific and solid bonding and hot bonding processes were practiced in coal briquetting experiments. The method used in solid briquetting of coal fines has shown in Fig. 1.

Magnesite binder was a mixture of burnt magnesite and chlorite containing 55% magnesia and might great capturing ability for sulfur dioxide evolved during coal combustion. Hence magnesia bonded coal briquettes were environmentally friend.

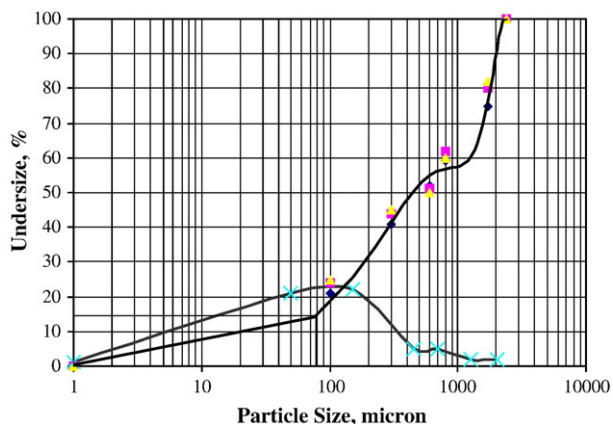


Fig. 2. Sieve analysis of Tunçbilek lignite specimens used in briquetting.

Representative specimens of Tunçbilek lignite were taken following sizing and quartering and specimens are reduced under 2 mm size by controlled comminution in laboratories. Size analysis of specimens used in briquetting tests was seen from Fig. 2. The proximate analysis of Tunçbilek lignite was given in Table 1.

Moisture content of lignite in air dried specimens was lower, however original specimens need to be dried prior to briquetting and dried lignite in briquetting process may be blended with binder mixture and may not loose binder addition under high compressing loads during briquetting. Compression load was hold constant at 2000 kg/cm² in press marked ELE with a max. loading capacity of 15 t in whole briquetting tests due to eliminating loose of binder mixture.

Most common briquetting technique is performed over minus 5–10 mm coal fines. In this study, for determining best cold bonding process minus 2 mm lignite specimens were briquetted and tested for qualities. As seen from Fig. 2 lignite specimens are minus 2 mm size and 80% of specimen as were under 1.2 mm. Minus 300 micron size fraction were 10 and 12%. Rigden Flowmeter apparatus was used in surface area determination. Specific surface area was determined as 700 cm²/g and even particle size distribution coefficient was determined as 0.7 by RRS size distribution. For briquette production specific surface area for lignite fines was not much high due to coarser particles distributed over 300 μ. Size distribution coefficient of lignite specimens was suitable for briquetting fines.

Lignite fines air dried at ambient temperature were mixed with the magnesite binder and water and poured into the cylindrical iron molds at inner diameter of 2.5 cm. Magnesite binder addition of 5, 10, 15, 20% weight ratios were used and water addition ratio was 20% as determined before for Tunçbilek lignite. Wet coal briquettes following produced were hold in chambers in 2 day period at an ambient temperature and than dried at 100 °C, with a precise of ± 5 °C. Compression strengths of dried briquettes are determined in an benchmarked apparatus of soil tension meter. The compression strengths of briquettes produced by only magnesia binding were shown in Fig. 3. Compression strengths of briquettes have reached 800 N value. Water resistance of produced agglomerates were determined by observation of briquette forms, following soaked in water in both a day time and a week time periods. Water resistance were too low due to moisture sensitivity of magnesia in the binding. At low magnesite addition the strength of briquettes were not sufficient and were stayed below 700 N strength values.

Gypsum cold binder as plaster similar to magnesite binder are added into the briquettes at a determined weight ratios of respectively 5%, 10%, 15%, 20% weight ratios and by using 20% water rate. Specimens were mixed and briquetted in standard cylindrical iron molds. Briquettes dried in 2 days at ambient temperature and dried at 100 °C, with a precise of ± 5 °C and compression tests were carried out and results of only gypsum binder use are illustrated in Fig. 4.

The compression strengths of gypsum bonded lignite briquettes were very low and styled 300 N at 10% gypsum addition and water resistance were not sufficient for requirements. Even high amount of gypsum addition increased compression strength, however those values such as 500 N were still very lower than other type of cold bonded briquettes. Water resistance were too low due to moisture capturing of briquettes. Gypsum as plaster bond was strong, but coal was capturing high amount of water into the particles.

According to the results obtained above it is determined at only magnesite and gypsum bonding needed so much amount of binder addition and increased ash content of briquettes, showed even at so much low water resistance at cold binding.

Due to insufficient strength of magnesite binder, a mixture of a type of organic binder, sulfite liquors, sugar waste liquors, and magnesia and another

Table 1

Proximate analysis of Tunçbilek lignite fines (DB: dried base, ADB: air dried base, CB: carbon base)

Ash, % (DB)	25.4
Moisture, % (ADB)	5.8
Total S, % (DB)	3.9
Volatile matter, % (CB)	39.8
Fixed carbon, % (CB)	60.2

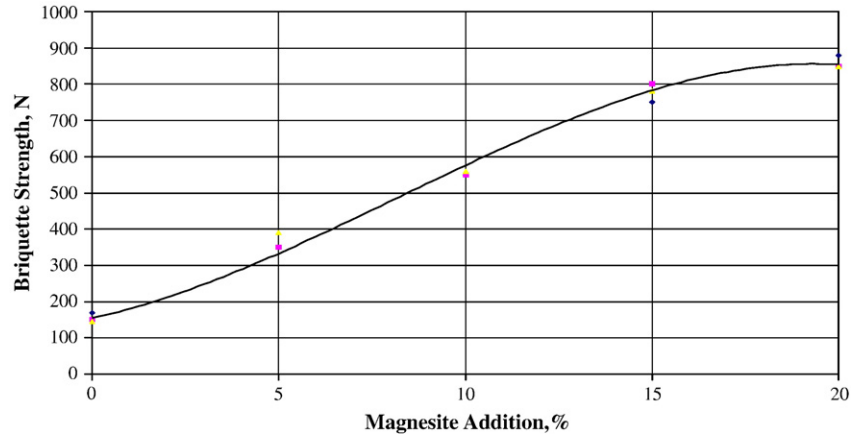


Fig. 3. Effect of magnesite binder addition on briquette strength.

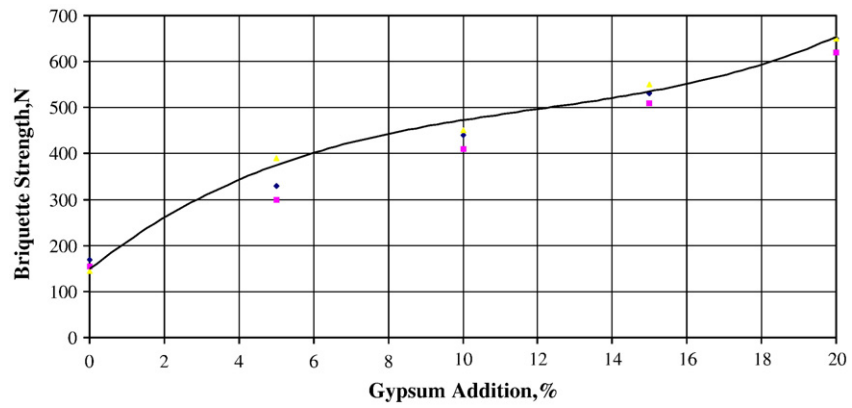


Fig. 4. Effect of gypsum addition on briquette strength.

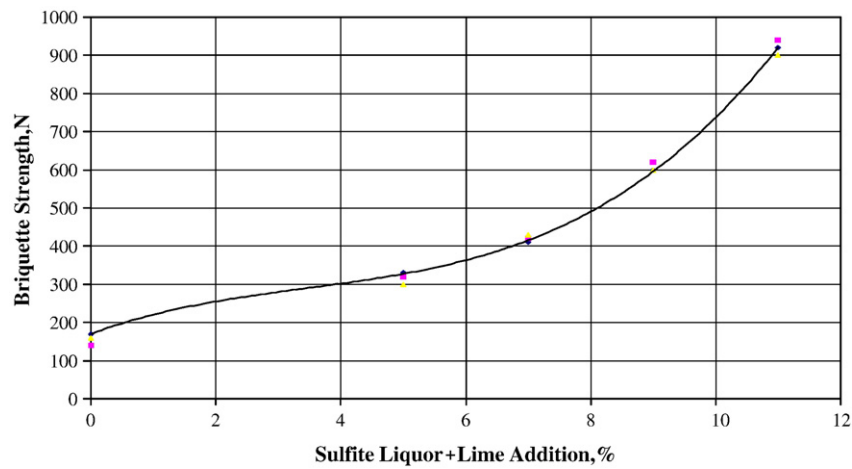


Fig. 5. Effect of lime addition on sulfite liquor bonded briquette qualities.

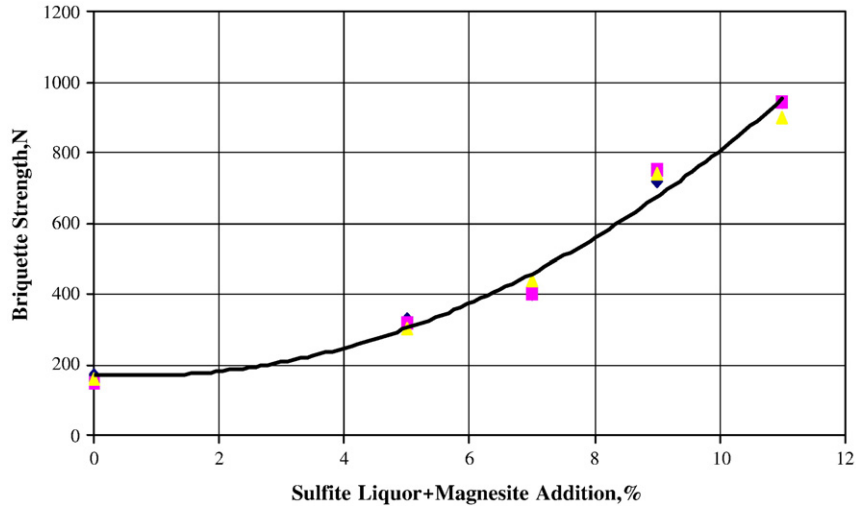


Fig. 6. Effect of magnesite binder addition on sulfite bonded briquette strength.

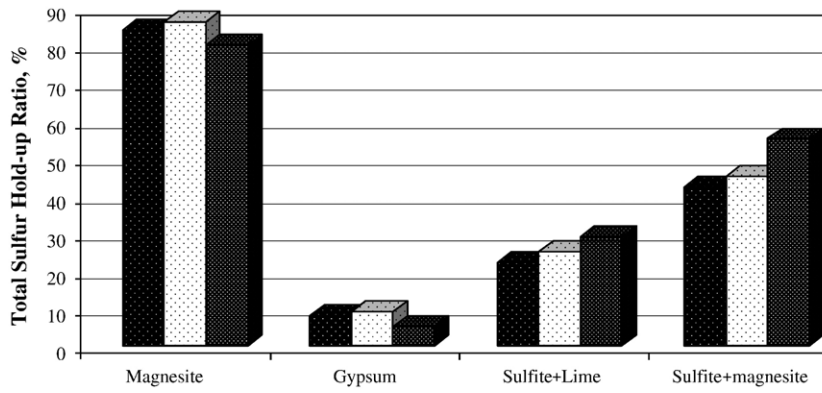


Fig. 7. Effect of binder on sulfur hold-up in combustion.

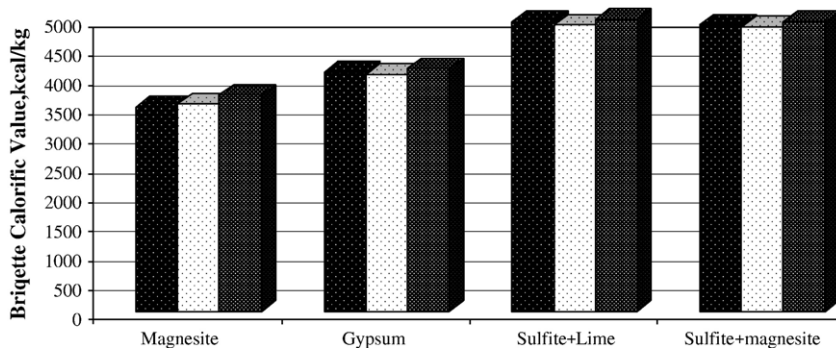


Fig. 8. Effect binder type on briquette calorific value.

alkaline type, lime addition were tested as hot briquetting technique in this study. Lime were mixed at a weight ratio of 25% with sulfite liquor and softened at 90 °C. Binder mixtures are mixed by dried coal samples in a benchmarked chamber working at 100 °C with a temperature precision of ± 5 °C. The compression tests and water resistance tests were carried out. Compression strengths of dried briquettes are determined in an benchmarked apparatus of soil tension meter. Test results are shown in Fig. 5. Water resistance of produced agglomerates were determined by observation of briquette forms, following soaked in water in both a day time and a week time periods. The all briquettes produced by hot briquetting showed no change in the briquette form.

Sulfite liquor and lime mixture were added at a weight ratio of 5%, 7%, 9%, 11% with lignite and briquetted under a compression load of 2000 kg and briquettes were tested for strengths and results of compression tests were seen from Fig. 6. Water resistance of briquettes were so high that all briquettes produced by hot briquetting with lime showed no change in the briquette form. Compression strengths were reached 900 N values and even 11% binder addition could be sufficient.

Instead of lime, magnesite were added with sulfite liquor in the briquetting process. Same rate of binder mixture were used and the briquettes were tested. Test results were illustrated in Fig. 6 The compression strength of lignite briquettes reached similar higher values over 900 N and even at a addition rate of binder of 9% strength values reached 750 N and coal quality was much preferable for calorific values and ash contents.

3. Results and discussion

Produced coal briquettes were analyzed for sulfur hold-up occurred alkaline capturing of evolution amount of sulfur after combustion. Sulfur analysis are carried out according to the ISO standards and results of analysis are shown in Fig. 7. Magnesite binder addition providing 9% magnesia in briquettes showed highest sulfur capture ability and over 83% rate sulfur holdup performance were obtained from lignite briquettes with magnesite bonded. At the same rate of gypsum addition sulfur holdup were approximately stayed at a very low 11% value. Sulfite liquor–magnesite binder mixture additions were provided 4.5% magnesia as alkaline in briquettes and sulfite liquor–lime binder mixture additions were provided 3.5% lime as alkaline in briquettes. Sulfur holdups of hot briquetting by magnesia and lime stayed just only much lower values of 42% and 24%, respectively.

The calorific values produced briquettes were analyzed in a benchmarked calorimeter bomb using 30 bar oxygen in combustion chamber and results were seen from Fig. 8. As shown in Fig. 8, Magnesite and gypsum additions at lower rates decreased calorific values of lignite briquettes to under 4000–3700 kcal/kg from originally heat content of 4900 kcal/kg. Sulfite liquor–magnesite and lime mixture bonded briquettes showed similar heat contents similar to the heat values of

original coal. The heat values were even higher due to drying effect of softening binder in mixtures.

4. Conclusions

Magnesia bonded briquetting may be used effectively and friendly in environmentally critical areas, especially in municipal regions specified in the country. Cold bonding of magnesia make possible to use of high sulfur coal and lignite in municipal regions and also in power stations without harming neighborhood.

Magnesia bonded lignite briquettes may hold up 86% of total sulfur content of lignite at an binder addition rate of 20% or similar sulfur holdup rates might be obtained at lower 15% addition amount. Water resistance of those briquetting techniques were high. However, hot briquetting technique gave better results in water resistance due to surface covering of briquettes improved by softening organic binder.

Magnesia bonded briquettes were better than gypsum bonded briquettes and stronger at lower mixing addition amounts with lignite.

Magnesia-sulfite liquor binding mixture were more advantageous in sulfur capture at highest calorific values, especially in briquetting lower rank coals and high sulfur lignite.

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