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Investigation of Washability of Seyitömer B3 Coal Seam, Turkey

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Abstract: In this study, the evaluability of lower calorific B3 coal seam belonging to Seyitömer lignite operations which is about 25 km away from Kütahya was researched. The coals pertaining to the B1 and B2 seams in the region are used as fuel in thermal power plant after the washing process. However, B3 seam cannot be evaluated which contains 28.7% humidity, 44.69% ash, 13.81% volatile matter, 12.8% fixed carbon and 1543 kcal/kg lower calorific value. For this purpose, sink-float tests were carried out on representative samples taken for evaluation of B3 coal seam. As a result of float-sink tests on different particle sizes, the optimum results were obtained at particle size intervals of -31.5 + 16 mm (72% yield, 25% ash, 1425 kcal / kg calorific values) and -63 + 31.5 mm (76% yield, 22% ash, 1751 kcal / kg calorific value). Also, optimum density was measured to be 1.5 gr/cm^3. It has been decided that while coarse particle size scan be enriched with the jig method, the fine particle size scan be enriched with the shaking table according to the results of the sink-float. As a result of enrichment experiments with jig, the lower calorific value of clean coal was obtained as 2903 kcal/kg, while the schist was obtained as 687 kcal/kg at particle size of -63 + 31.5 mm. Also, ash contents were 15.14% and 75.16% respectively. On the other hand, as a result of enrichment experiments with shaking table, the calorific value of clean coal was obtained as 2403 kcal/kg while the schist was obtained as 385 kcal/kg at particle size of -16 + 12, 5 mm. Ash content were also obtained as 16.96% and 68.85% respectively. According to these results, the calorific value of B3 coal seam has been made suitable for being used at thermal power plants.

Keywords: Heavy medium separation, coal seam, washability.

Introduction

Seyitömer lignite (Kütahya-Turkey) is Pliocene formation. There are serpentinized ultrabasic rocks (gabbro and diorite) on the base of the basin. The bottom of the sediments is conglomerate and the upper parts are of blue-green clay. In this structure, there is a main seam having 15-20 m thickness which is called seam B. This seam also called as B1, B2 or B3, based on the percentage of their ash and calorific values (Öteyaka et al, 2008). There are approximately 150,000,000 tons of visible reserves in Seyitömer lignite operations and it is estimated that 35,000,000 tons of this amount is composed of B3 coal seam which has low calorific value. General chemical features on the stamp basis of the B1, B2, and B3 seams, which constitute an important part of Seyitömer lignite and have different calorific, ash and moisture values. When the ash, moisture and lower calorific value (LCV) of samples from these seams are analyzed, it seems that they cannot be used as fuel in general. So, it is necessary to eliminate the existing impurities in coal, in the case of public health being taken into consideration. It is seen that they have low calorific value and high ash values (Öteyaka et al, 2008). Generally, the lignite in Turkey have high ash content (almost 25% of the reserves contain more than 30% ash) and low calorific value (Kemal,1991). Their consumption areas are restricted for this reason. Today, they are generally used in power plants, causing environmental problems. The quality of lignite must be increased using physical and chemical methods for them to be used without any problems (Öteyaka et al., 2004).

There are different ways of conducting sink and float analysis by using heavy liquids. Simple sink and float analysis is a method wherein samples are subjected to a single sink and float separation and the two products are weighed and analysed. Four different kinds of standard washability curves are given in below along with this purpose (Subba Rao, 2016).

1- The characteristic curve, also known as elementary ash curve, or fractional yield ash curve.

2- Total floats-ash curve or cumulative floats curve.

3- Total sinks-ash curve or cumulative sinks curve.

4- The yield gravity curve.

Of these families of curves, the characteristic curve is rightly regarded as the parent curve from which the other two curves (total floats-ash curve and total sinks-ash curve) may be derived either by direct calculation or by graphical plotting. As a result the graphical representation of float and sink results help to understand the washing or cleaning possibilities of coal at any desired ash level of floats or at any desired specific gravity of cut and is therefore more suitable for studying the implications of these results for practical use (Subba Rao, 2016).

The most important criterion in defining the washability characteristics of coals for the purpose of comparing and correlating the results is the Washability Index proposed for the first time by CIMFR at the Fourth International Coal Preparation Congress held at Harrogate (UK) in 1962. This index is expressed by a number ranging between zero and 100 and is independent of the overall ash content of the raw coal or the level of clean coal ash. When this index is low, the coal is difficult to wash and when the index is high the coal becomes easy to wash (Subba Rao, 2016).It is well known that the size of a coal generally influences its washability characteristics. Therefore,it is expected that the various parameters that are used to define the washability characteristics of any coal should vary with the size of screening and size of crushing the coal and then, each size fraction of coal is subjected to float and sink tests.

These test results give an opinionon washability characteristics in terms of Washability Index (WI), Optimum Degree of Washability (ODW), Optimum Recovery % (OR), Optimum Specific Gravity (OSG), Optimum Ash % (OA), Near Gravity Material (NGM) at optimum cut point and Washability Number (WN) (Subba Rao, 2016).

The aim of this research is to investigate the washability and removing possibilities of impurites existing in B3 coal seams. Hence, it will be understood that whether B3 coal seam will be used as household fuel and as thermal power plant fuel.

Experimental Studies

B3 coal seam constitute an important part of Seyitomer lignites which have different calorific values, ash and moisture values. Specifications of this seam are shown in Table 1.

Table 1 The chemical characteristics of B3 coal seams.

Contents	**B3 Seam**
Moisture	28.7
Ash %	44.69
V %	13.81
Fixed carbon %	12.8
Lower calorific value, kcal/kg	1543

Desired characteristics of Seyitömer lignites are shown in Table 2. It is seen that the lignites of B1 and B2 seams can only be used by the Electricity Production Incorporated Company (EPIC) to produce electricity, but B3 seam cannot be used due to its low calorific value.

Table 2 The areas of usage for SLC lignites and desired characteristics.

Areas of use	Ash%	Moisture%	LCVkcal/kg
1st and 2nd unit of EPIC	35±10	40±10	1750±100
3rd unit of EPIC	35±10	40±10	1850±100
Heating	—	—	2800(minimum)

Table 3The analysis results along with the size distribution of B3 coal seam.

Size (mm)	Weight (%)	Ash (%)	Moisture (%)	LCV(kcal\kg)	Sulphure (%)
-63+31.5	25.25	33.58	30.42	2088	1.72
-31.5+16	17.89	38.25	28.10	1775	1.83
-16+12.5	10.48	43.41	27.71	1579	1.71
-12.5+4	12.47	40.65	28.48	1324	1.82
-4+2	10.15	50.60	28.43	1275	1.84
-2+1	8.63	53.40	28.92	1284	1.88
-1	15.13	66.12	27.48	845	1.71

Ash ratios change due to particle size distribution in the sieve analysis, it was seen that the amount of ash which was 33.58% in the coarse size -63 + 31.5 mm, rose to the fine sizes and reached 66.12% in the size of -1 mm.

Float Sink Tests

The wash ability curves of the sink-float tests in different sizes are given below.

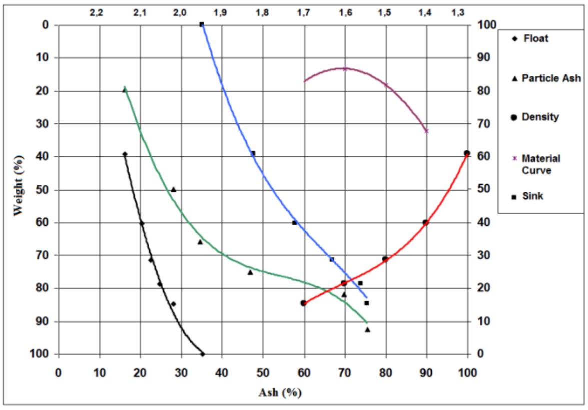

Fig. 1 Washability curve of -63 + 4 mm particle size.

When the experiments were carried out in the size of -63 + 4 mm, the ash content increased from 16.26% to 75.51% as the ambient density increased from 1.3 g / $cm^3$to 1.7 g/cm^3. At the same time the caloric value decreased from 2624 kcal/ kg to 289 kcal / kg . At the density of 1.5 gr/cm^3, it was determined that the amount of floating was 71% by weight, the content of ash was 23% and the calorific value was 1765 kcal/ kg (Fig.1).

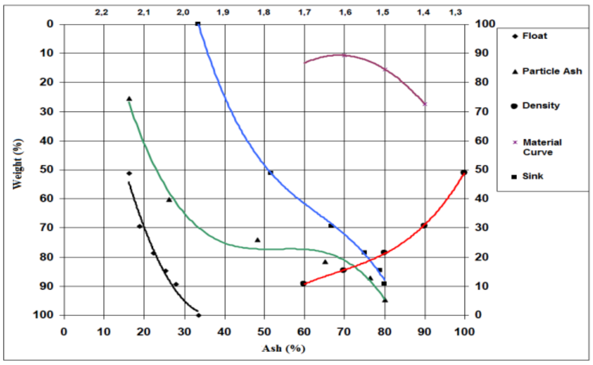

Fig. 2 Washability curve of -63 + 31.5 mm particle size.

When the experiments were carried out in the size of -63 + 31.5 mm, the ash content increased from 16.2% to 80.12% as the ambient density increased from 1.3 g/cm^3 to 1.7 g/cm^3. At the same time, the caloric value decreased from 2796 kcal/kg to 459 kcal/kg.

At the density of 1.5 gr/cm^3, it was determined that the amount of floating was 76% by weight, the content of ash was 22% and the calorific value was 1751 kcal/kg (Fig.2).

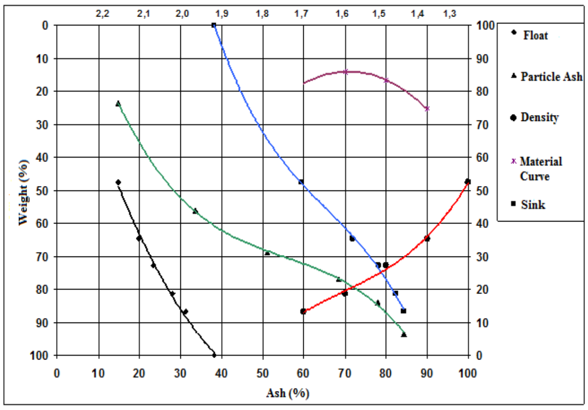

Fig. 3 Washability curve of -31,5+16 mm particle size.

It has seen that in Figure 3, when the experiments were carried out in the size of -31.5+16 mm, the ash content increased from 14.9% to 84.26% as the ambient density increased from 1.3 g/cm^3 to 1.7 g/cm^3. At the same time, the caloric value decreased from 2678 kcal/kg to 479 kcal/kg . At the density of 1.5 gr/cm^3, it was determined that the amount of floating was 72% by weight, the content of ash was 25% and the calorific value was 1425 kcal/kg.

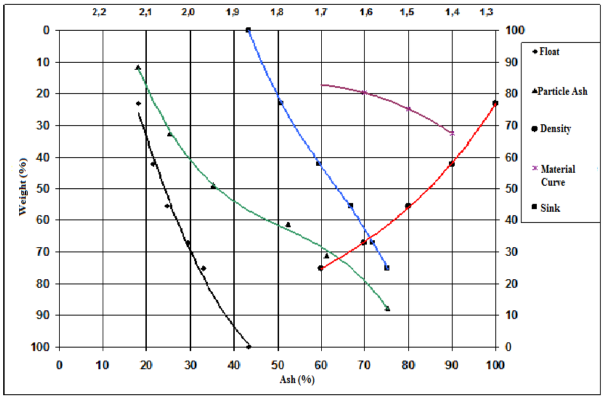

Fig. 4 Washability curve of -16+12.5 mm particle size.

It is seen that in Figure 4, when the experiments carried out in the size of -16+12.5 mm, the ash content increased from 18.11 % to 75.23 % as the ambient density increased from 1.3 g/cm^3 to 1.7 g/cm^3. At the same time, the caloric value decreased from 2435 kcal/kg to 835 kcal/kg.

At the density of 1.5 gr/cm^3, it was determined that the amount of floating was 53% by weight, the content of ash was 25% and the calorific value was 1990 kcal/kg.

When the experiments were carried out in the size of -12.5+4 mm, the ash content increased from 14 % to 70.68% as the ambient density increased from 1.3 g/cm^3 to 1.7 g/cm^3. At the same time, the calorfic value decreased from 2526 kcal/kg to 341 kcal/kg (Fig. 5).

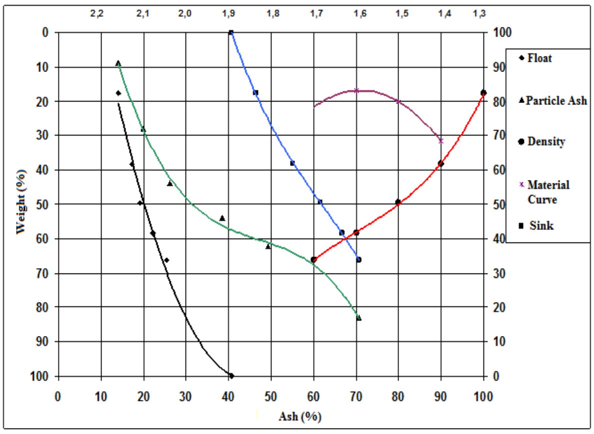

Fig. 5 Washability curve of -12.5+4 mm particle size.

At the density of 1.5 gr/cm^3, it was determined that the amount of floating was 50% by weight, the content of ash was 20% and the calorific value was 1919 kcal/kg.

From all of these sink-float experiments, at the density of 1.5 gr/cm^3; 76% efficiency, 22% ash content, 1751 kcal/kg calorific value wasobtainedat particle size -63+31.5 mm.On the other hand, 72% efficiency, 25% ash content, 1425 kcal/kg calorific value wasobtainedat particle size -31,5+16 mm.

Enrichment Tests

The jig machine is used to beneficiate for coarse size ores, whereas the shaking table is more suitable to enrich for fine size ores in mineral processing(Meenan, 1999; Guney et al., 1996). For that reason, it was determined that it would be appropriate to enrich the coal with jigging in coarse sizes (-63+31.5 mm, -31.5+16 mm, -16+12.5 mm, -12.5+4 mm) and the shaking table would be appropriate in fine sizes (-16+12.5 mm, -12.5+4 mm, -4+2 mm).Ash content and calorific values of different particle sizes were examined and each fraction was subjected to enrichment separately.

Results and Discussion

The best wash ability process was obtained from the result of float-sink experiments. When those tests interpreted particle size of -63 + 31.5 mm (76% yield, 22% ash, 1751 kcal / kg) and particle size of -31.5 + 16 mm (72% yield 25% ash, 1425 kcal / kg) had best results at the 1.5 g/cm^3 ambient density. The beneficiation procedure was designed thanks to result of float-sink experiments and sieve analysis. The enrichment results of jig and shaking table are given in Table 4 and 5.

Table 4 Jig test results on different particle sizes.

Sizes (mm)	Products	Weight (%)	Ash (%)	LCV (Kcal/k)	Humidity (%)	Unburned part (%)	Content	Combustin recovery (%)
63+31.5	Lave	38.25	15.14	2903	39.25	84.86	3245.78	48.87
31.5+16	Lave	35.67	16.29	2665	38.15	83.71	2985.97	47.84
-16+12.5	Lave	31.18	17.56	2312	37.09	82.44	2570.48	41.47
-12.5+4	Lave	31.12	21.95	1796	36.74	78.05	2428.92	39.60

It was seen that the highest combustion yield and calorific value was obtained in coarse sizes.When the experiments were carried out in the size of -63+31.5 mm, the calorific value of the lava was obtained 2903 kcal/kg while the schist was obtained687 kcal/kg and the ash ratio was 15.14% in the lave, whereas the schist was 75.16%. The combustion yield was obtained as 48.87%.

The enrichment results of shaking table in different sizes are given below.

Table 5. Shaking table test results on different particle sizes.

Sizes (mm)	Products	Weight (%)	Ash (%)	LCV (Kcal/kg)	Humidity (%)	Unburned part(%)	Content	Combustion recovery(%)
-16+12.5	Lave	35.87	16.96	2403	37.45	83.04	2978.64	46.74
-12.5+4	Lave	36.11	18.86	1995	36.98	81.14	2929.97	47.53
-4+2	Lave	34.03	24.26	1856	34.65	75.74	2577.43	46.63

It was seen that the highest combustion yield and calorific value was obtained at-16+12.5 mm particle size.When the experiments were carried out in the size of -16+12.5 mm by using shaking table, the calorific value of the lave was obtained 2403 kcal/kg while the schist was obtained 385 kcal/kg and the ash ratio was 16, 96% in the lave, whereas the schist was 68.85%. Furthermore, the combustion yield was obtained as 46.74%.

The results of enrichment tests belonging to jig and shaking table which are carried out at the same particle sizes (-16+12.5 mm and-12.5+4);

-The ash value was obtained 16.96% and 17.56% for shaking table's lave and jig's lave at the size of -16+12.5 mm respectively. The combustion yield (46.74%) with the shaking table was higher than Jig (41.47%). At the same time, in experiments with shaking table (2403 kcal / kg) calorific values turned out to be higher than jig (2312 kcal / kg). For that reason,-16 + 12.5 mm is more suitable to be enriched with a shaking table.

-Similarly, at the size of -12.5+4 mm in lave, ash value was 18.86% for the experiment with shaking table and was21.95% for the experiment with jig. The combustion yield (47.53%) with the shaking table is higher than the jig (39.6%). Experiments with shaking table have given higher calorific values than jig. So, it is more suitable to enrich with shaking table at 12.5+4 mm.

Conclusion

There are approximately 150,000,000 tons of visible reserves of Seyitömer lignite in operation area. It is estimated that 35,000,000 tons of this amount is composed of B3 coal seam. The ash content of Seyitömer B3 was found to be 44.69%, 28.70%, volatile matter 13.81%, fixed carbon 12.80%. The lower calorific value was 1543 kcal/kg as well. It means B3 seam cannot be used by the thermal power plant (Table 2). In order to evaluate B3 coal seam in thermal power plant, the samples taken from the B3 coal seam were subjected to beneficiation by using jig and shaking table.

According to the test results belonging to jig and shaking table.

- The highest combustion yield and calorific value was obtained in coarse sizes (-63+31.5 mm and -16+12.5 mm) for jig and shaking table.

- At the experiments with jig, when the experiments were carried out in the size of -63+31.5 mm, the calorific value, combustion and ash content yield of the clean coal was obtained 2903 kcal/kg, 48.87 % and 15.14% respectively.

- When the experiments were carried out in the size of -16+12.5 mm by using shaking table, the calorific value, combustion yield and ash content of the clean coal was obtained 2403 kcal /kg, 46.74% and 16.96 % respectively.

- Considering the desired characteristics of Seyitömer lignites in Table 2, as a result of jig tests and shaking table tests in all particle size fractions, the calorific value and ash content of B3 coal seam has been made suitable for being used at thermal power plants after the beneficiation with jig and shaking table (Table 4 and Table 5).

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