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Liberation Characteristics of Indian Coking Coal Through Washability Investigations

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Abstract

Coking coal is one of the important raw material for iron and steel industry. The study on available indigenous coal has reduced the dependency on imported coal for these industries. Coal may be crushed to optimum top sizes as required by the industry. The top size of coal is washed during beneficiation process. The combustible materials have been separated through simple gravity separation method after the optimum crushing of coal. An attempt has been made through washability study to investigate the impact of comminution on liberation properties of Indian coking coals. The primary objective is to define the Yield- Ash relation of the Indian coking coal by the use of Mayer's washability curves. The coal obtained from run off mines is crushed to two different top sizes i.e. 50 mm and 6 mm. These top sizes coal have been treated with zinc chloride, bromoform and benzene solutions in sink-float test at different specific gravity. The ash yield relationship for both the size fractions reveals that the liberation characteristics of particles of 6mm size are very high as compared with 50mm size of coal. It has been observed that the washability investigations on 50 mm and 6 mm coal fraction reveals that the theoretical yield of clean coal at 10% ash level is around 24.5% and 44.5% respectively on whole coal basis. The washability investigation study shows that the 6 mm size fraction is giving better liberation than 50 mm size fractions.

Keywords: Liberation, Washability curve, Yield-ash relation, Mayer's curve.

Introduction

Coking coal is an essential raw material for an iron and steel industry which is mainly used in the blast furnace. The systematic study of indigenous coal may reduce the dependency on imported coal for these industries. In general, Indian coal contains high ash percent which needs the beneficiation for its utilisation as per requirement by the different industries. An extensive laboratory investigations and washability study of coal is required to understand its quality. The study of liberation of coal helps to determine its purity by progressive crushing. The cleaning tests on commercial scale provide an idea to clean the coal effectively and efficiently. During the formation of Indian coal, the extraneous material is mixed in the coal matrix causing high content of mineral matters as a result the coal has more impurity in the run off mine. Washability characteristics derived from sink-and-float analysis show that coal is intrinsically heterogeneous. Further, this heterogeneity is also evident from the proximate, ultimate, and size analysis. A range of particles from high to low specific gravity is usually seen in the coal run-off-mine (ROM). The Gravity concentration technique utilizes this difference in densities of the particles for coal preparation.

The combustibles can be easily separated by simple gravity separation method after an optimum crushing of coal[1]. The values obtained from sink-float analysis have been used to draw the washability curves to study the coal characteristics under ideal conditions[2-3]. The quantity of material floating in sink-float tests at a particular specific gravity may be considered as two constituents as non-ash and ash forming materials. The easily washable coal has a complete liberation of non-ash material from ash material. Further, it may also be identified from the steepness of "characteristic curves". If the steepness of the characteristic curve is more, it is more difficult to wash the coal.

The coal cleaning process should be chosen on the basis of raw coal properties at hand and coal quality to be achieved at the end. Coal properties may vary from bed to bed even in the same location. Coal from the same bed mined from the different location may not have same response to coal cleaning. As a result, the recovery of clean coal percent varies. The cost estimation accuracy for cleaning of coal is more dependent on the user's knowledge about the coal properties. The utilization of raw coal properties may be the best for its cleaning if the representative float sink analysis includes the characteristics at each specific gravity fraction. The selection of the equipment in a flow chart for coal cleaning depends on the complexities of coal[4]. The coal complexities depends upon the mixing of non-combustible material in the raw coal. The specific gravity of pure coal varies in the range of 1.23 to 1.72 whereas the specific

gravity of ash is more than 2.3. There is mixing of coal and ash across all categories of specific gravity and particle size. The coal cleaning technology and equipments use the specific gravity difference between coal and ash to separate them.

The primary objective of the present study is to define the effect of comminution on liberation characteristics with the Yield- Ash relation for a coking coal of Indian origin through washability studies.

Methodology

Experimental Method: The Coal collected from run off mine (ROM) has been crushed to two different top sizes namely, 50 mm and 6mm. The crushed coals have been subjected to screening to ascertain the size distribution. The size wise ash analysis of crushed coal of different sizes 50 mm and 6 mm are shown in Table 1 and 2 respectively. The top sizes of coal have been subjected to sink float test by using the chemicals like zinc chloride, bromoform and benzene solution as a heavy media at different specific gravity. The values obtained from the tests have been plotted to study the washability curves on individual size fractions as well as on whole coal.

Table-1
Size distribution of raw coal crushed to 50 mm

Size, mm	Wt%	Ash%
50 - 25	44.9	28.9
25 - 13	20.9	25.2
13 - 6	17.1	22.5
6 - 3	5.5	19.2
3 - 0.5	7.0	23.1
-0.5	4.7	37.7
	100.0	26.5

Table-2
Size distribution of raw coal crushed to 6 mm

Size, mm	Wt%	Ash%
6 – 3	53.4	25.7
3 - 0.5	32.1	23.1
-0.5	14.5	37.7
	100.0	26.6

Results and Discussion

A study has been made on liberation characteristics of Indian coking coal. Coal has been crushed to 50 mm size and screened to study its size distribution. It has been noticed from table 1 that the weight % and ash % of 50 -25 mm size is 44.9 and 28.9 respectively. Similarly, 25 - 13 mm size (wt% 20.9) has 25.2% ash, 13 - 6 mm size (wt % 17.1) has 22.5% ash, 6 - 3 mm size (wt % 5.5) has 19.2% ash, 3 - 0.5 mm size (wt% 7.0) has 23.1% and fines below 0.5 mm size (wt% 4.7) has 37.7 % ash. The screen analysis reveals that the coal is more homogenous in nature and practically there may be little possibility of liberation by further crushing to lower sizes down to 13 mm. Similarly, when coal is crushed to 6 mm size, it has been observed from the table 2 that the wt% and ash content of the size ranging from 6 - 3 mm is 53.4% and 25.7% respectively. Further- 3 - 0.5 mm size (wt% 32.1) has 23.1% ash and fines below 5 mm size (wt% 14.5) has 37.7% ash.

It has been found that the ash content of fines below 5 mm size is same irrespective of the size of coal crushed. The characterisation of raw coal sample i.e. proximate analysis has been shown in the Figure-1.

The ash and yield relationship has been studied and shown in the Figure-2 for both size fractions i.e. 50 mm and 6mm. In case of 50 mm size of coal, the ash% and yield % is high but in case of 6 mm size, the ash% is low and yield% is high. The liberation characteristics of particles of 6mm size are very high as compared with 50mm size of coal.

When coal is crushed to 50 mm size, the individual size fractions, viz., 50–25 mm, 25–13 mm, 13–6 mm, 6–0.5 mm and below 0.5 mm have been subjected to float and sink tests in the range of 1.35 to 1.80 specific gravity and presented in the table 3. Similarly, when the coal is crushed to 6 mm size, the individual fraction has been presented in table 4. It has been observed from the washability results tabulated in table 3 that the coal containing shales and obvious dirts etc. at a specific gravity of >1.80 having ash content more than 75%. The quantity of this high ash content material is in the tune of about 11.61 %. If these materials are discarded, the yield and ash content of coal at a specific gravity < 1.80 would be around 89.39 % and 20.42 % respectively. Similarly, it has been observed from the table 4 that the quantity of ash containing materials at a specific gravity >1.80 is about 12.59%.

The values of washability data generated from the float and sink test for 50 mm coal has been plotted to obtain the curves as shown in Figure-3. The various washability curves has been obtained on individual size fractions as well as whole coal to establish the washability characteristics. Similarly, the washability curve for coal crushed to 6 mm size has been presented in the Figure- 4.

It has been observed from the washability investigations (Figure-3) and from the Mayer's curve (Figure-5), that the theoretical yield of clean coal at about 10% ash level for size fraction 50 mm may be around 24.5 %. However, it may be stressed that the practical yield on industrial scale is likely to be less depending on the efficiencies of the washeries.

It has also been observed from washability investigations (Figure- 4) and from the Mayer's curve (Figure-6) that the theoretical yield of coal generated for the fraction 6 mm, the

density of cut to achieve 10 % ash level has been noticed. The cleans obtained from the float and sink tests have proportionately been generated which amounts to be 44.5 %. The cleans generated at 10% ash level is suitable for metallurgical industries and it reveals that coal may be used after suitable beneficiation process.

Table-3
Washability data of coal crushed to 50 mm

Sp.Gr	Wt%	Ash%	Cum. Float		Cum.	Sink	Ch. Wt%	Mayer's
			Wt.%	Ash%	Wt.%	Ash%		pt.value
<1.35	10.17	5.43	10.17	5.43	89.83	28.26	5.08	0.55
1.35-1.40	21.88	13.86	32.04	11.18	67.96	32.90	21.11	3.58
140-1.45	24.38	19.24	56.43	14.67	43.57	40.55	44.24	8.28
1.45-1.50	15.74	24.47	72.16	16.80	27.84	49.64	39.91	12.13
1.50-1.60	8.81	31.72	80.97	18.43	19.03	57.93	76.57	14.92
1.60-1.70	3.02	38.03	83.99	19.13	16.01	61.68	82.48	16.07
1.70-1.80	4.40	45.10	88.39	20.42	11.61	67.96	86.19	18.05
>1.80	11.61	67.96	100.00	25.94	0.00	0.00	94.19	25.94

Table-4
Washability data of coal crushed to 6 mm

Sp.Gr	Wt%	Ash%	Cum. Float		Cum.	Sink	Ch. Wt%	Mayer's
			Wt.%	Ash%	Wt.%	Ash%		pt.value
<1.35	19.84	4.58	19.84	4.58	80.16	29.68	9.92	0.91
1.35-1.40	10.71	11.71	30.55	7.08	69.45	32.46	25.20	2.16
140-1.45	13.53	16.19	44.08	9.88	55.92	36.39	37.31	4.35
145-1.50	15.29	20.49	59.37	12.61	40.63	42.37	51.72	7.49
1.50-1.60	20.08	27.74	79.45	16.43	20.55	56.67	54.12	13.06
1.60-1.70	5.11	36.56	84.56	17.65	15.44	63.32	82.00	14.93
1.70-1.80	2.85	43.61	87.41	18.50	12.59	67.79	85.98	16.17
>1.80	12.59	67.79	100.00	24.70	0.00	0.00	93.70	24.70

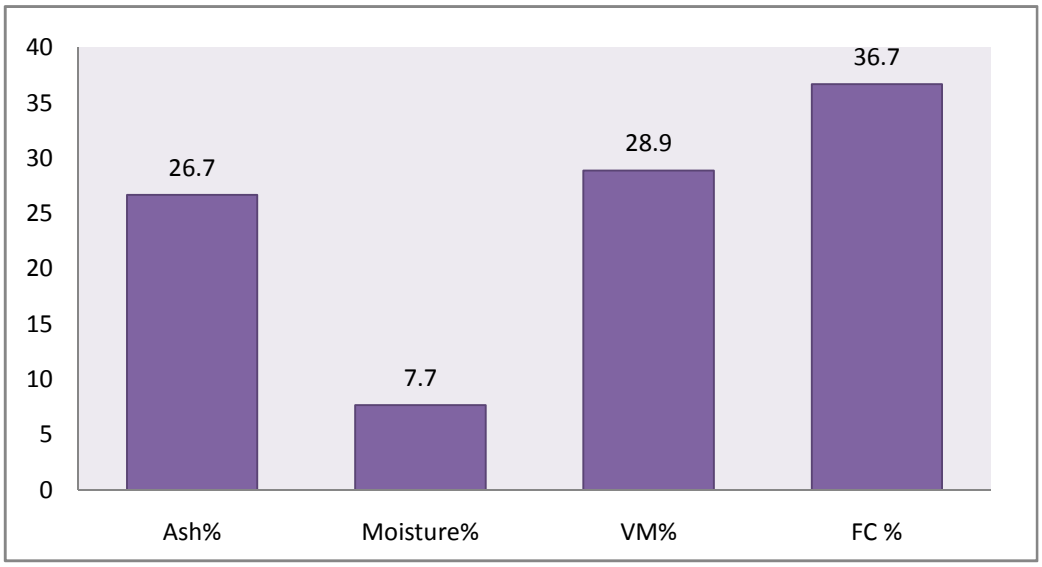

Figure-1
Proximate analysis of raw coal sample

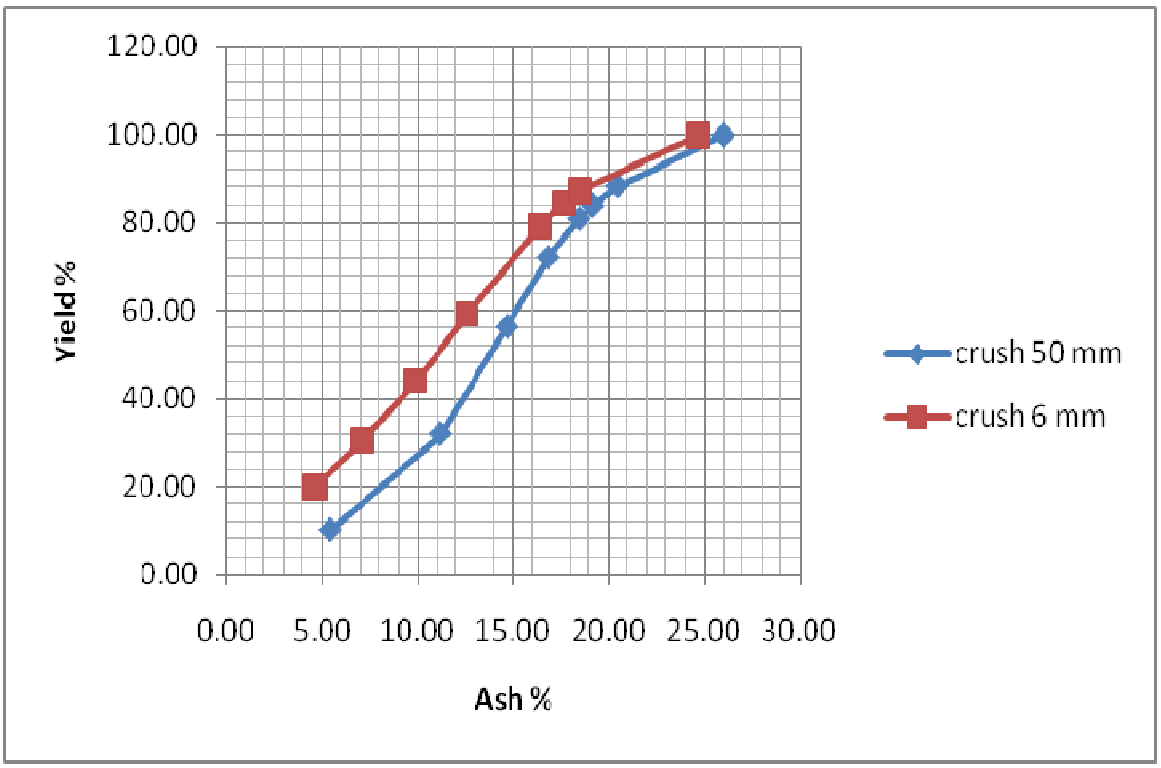

Figure-2
Ash andyield relationship of coal crushed to 50 mm and 6mm

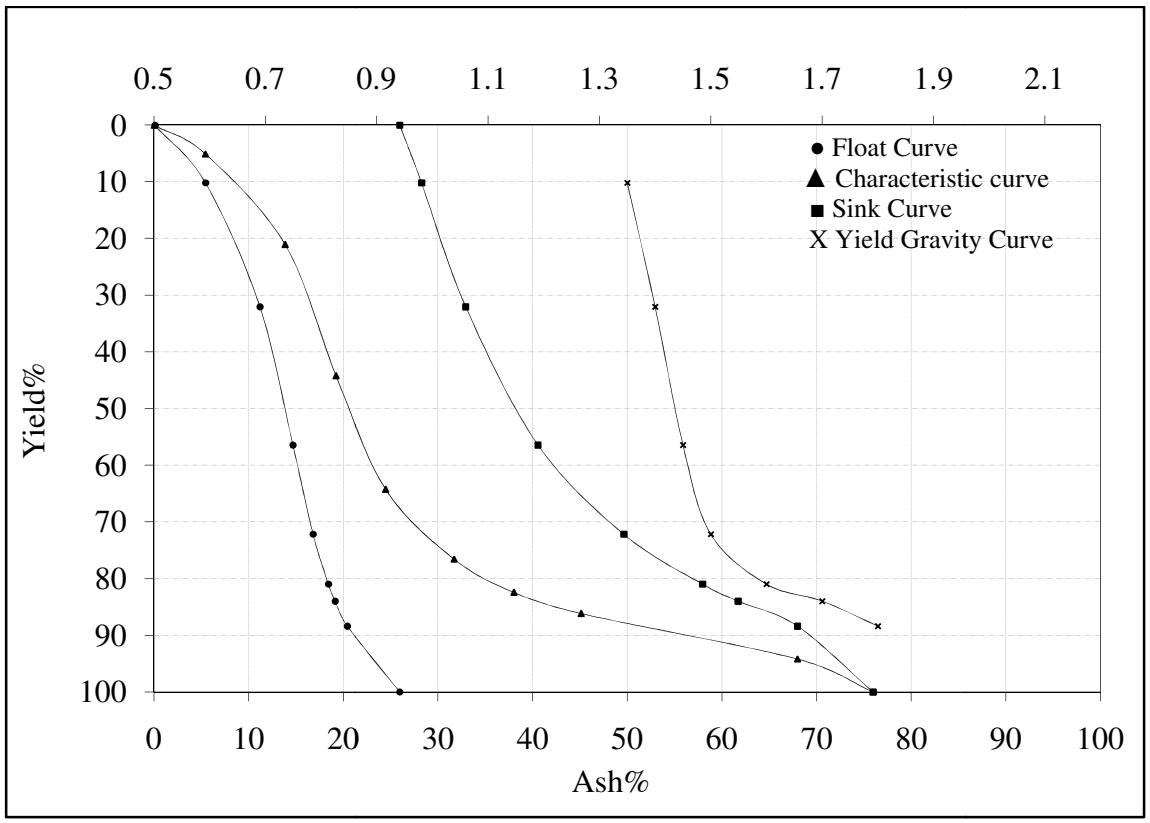

Figure-3
Washability curves of coal crushed to 50 mm

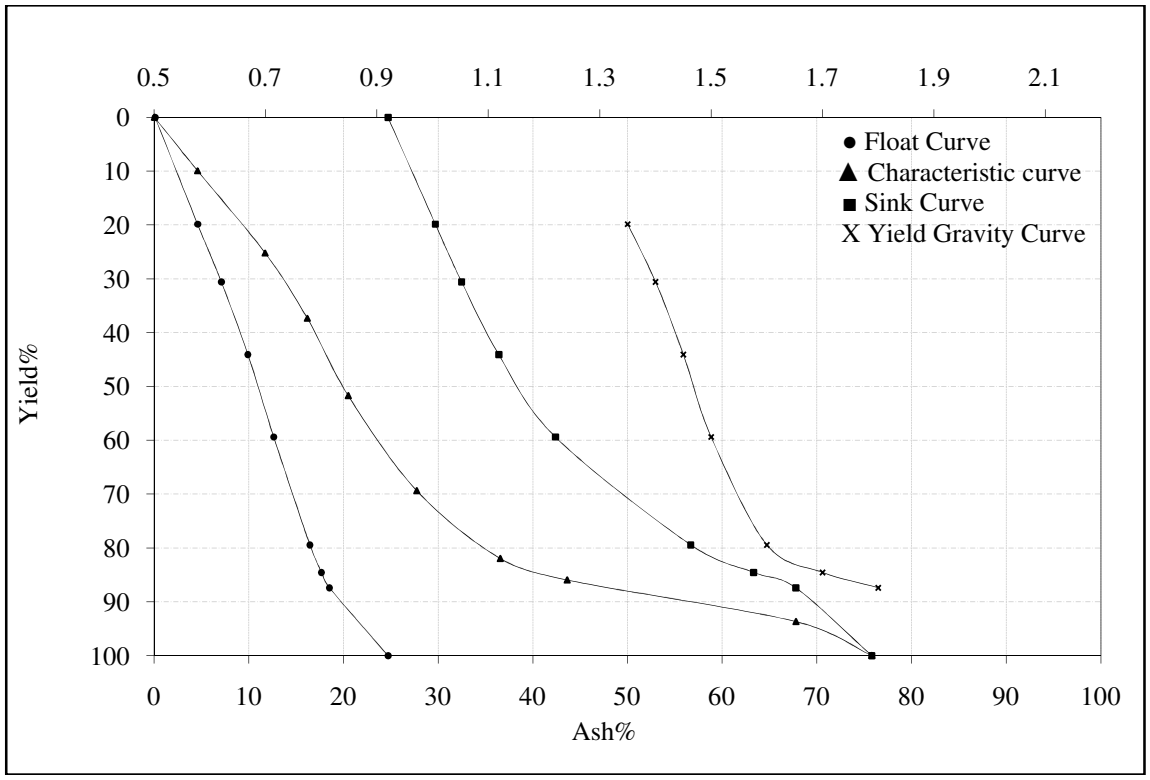

Figure-4
Washability curves of coal crushed to 6 mm

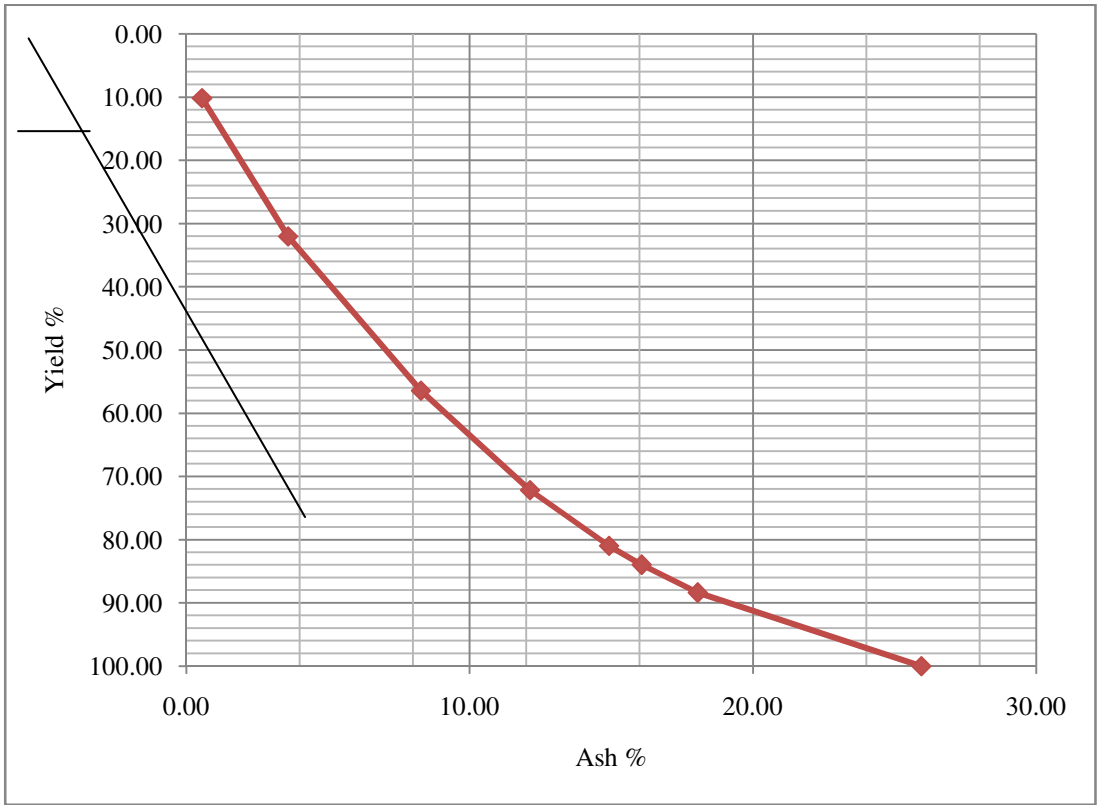

Figure-5
Mayer's curve of coal crushed to 50 mm

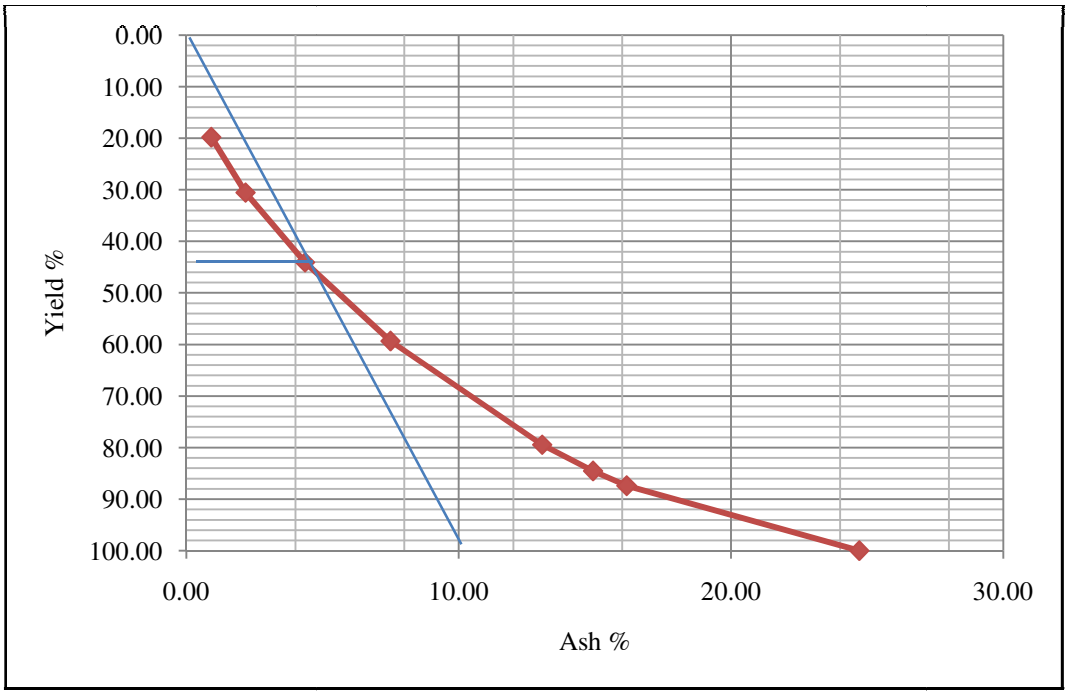

Figure-6
Mayer's curve of coal crushed to 6 mm

Conclusion

The washability study on coal sample shows good characteristics after its processing. The washability investigations on 50 mm and 6 mm coal fraction reveals that the theoretical yield of clean coal at 10% ash level is around 24.5% and 44.5% respectively on whole coal basis. The washability investigation study shows that the 6 mm size fraction is giving better liberation than 50 mm size fractions. However, it may be stressed that the practical yield on industrial scale is likely to be less depending on the efficiencies of the washeries. The cleans were further characterized for finding its suitability in metallurgical purpose.

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