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Beneficiatipon of Chamalang Coal by Froath Floatation

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Abstract. Cleaning of Chamalang coal samples was carried out using froth flotation technique. The kerosene oil was used as a collector. Chamalang coal belongs to lignite to sub bituminous coal category. The constituents of the Chamalang coal sample such as inherent moisture, ash, volatile matter, fixed carbon, sulphur and gross calorific value were estimated on air dry basis and found to be 2.13%, 29.43%, 34.65%, 33.00%, 3.11% and 5482 kcal kg^{-1}, respectively. The froth flotation process was found to be suitable for ash reduction and enhancement of the volatile matter along with fixed carbon. The ash contents of the Chamalang coal samples were observed to be significantly removed (24.5%) whereas the volatile matter was found to be increased up to 25.8%. The effect of slurry ratio and pH was studied. The efficient cleaning of the Chamalang coal was obtained at pH 10 and using a slurry ratio of 25%.

Keywords: Coal cleaning, froth floatation, oleic acid & pine oil

1. Introduction

Pakistan has huge collection of low grader coal. Most of the coal cleaning methods are based on gravity difference such as cyclone separator, shaking tables etc. [1]. Froth flotation can be adapted to a broad range of mineral separations [2].

Froth flotation is used for physical separation of particles based on differences in the ability of air bubbles to selectively adhere to mineral surfaces in mineral/water slurry. The particles with attached air bubbles are then carried to the surface and removed whereas the particles that remain completely wetted stay in the liquid phase. The mineral particles attached with air bubbles have density less than water slurry and therefore remains floating on top surface [3]. Coal is known to be hydrophobic whereas mineral are hydrophilic and said difference in hydrophobicity is exploited which is either exist naturally or induced / enhanced chemically. Although much work has been published in froth floatation however, still it is considered one of the most efficient, difficult and less understood methods of coal cleaning [3]. The process of froth floatation requires careful selection of collector and frother. Amongst collectors, diesel fuel or kerosene oil can be used whereas frothers such as alcohols can be considered in this regard. The objective of the frother is to lower the surface tension of water and thus decrease the size of the bubble with an increase in surface area of air entered in the cell [4].

A number of factors may vary the performance of coal benification such as aeration rate, reagent addition, pulp density and degree of agitation and particle size. The type and dosage of collector and frother were reported to have a great influence on floatation process [5]. A comprehensive review on frother's action, structure and properties has been reported by Hamif and Abbas (2011) [6]. Reaction kinetics for froath floatation was found to be influenced by particle size, rank, type and dosage of frother and collector. It was also reported that floatation rate increases with pulp aeration and significantly decreases in denser pulp [7].

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The present study aims the characterization of Chamalang coal sample through its proximate and ultimate analysis. Further these samples were purified using froth floatation method through optimization of slurry ratio and pH.

2. Materials and Methods

2.1. Characterization of Coal Samples

Characterization of Chamalang coal samples was carried out using ASTM standards. The coal sample was delivered in the particle size range of 1-2 inches. The sample was groaned in end runner mill and particles were sieved using ASTM standard. The proximate analysis for total moisture, volatile matter, ash and fixed carbon was carried out using ASTM standards such as ASTM D-3302, ASTM D-3175, ASTM D-3174 and ASTM D-388 respectively.

In addition, determination of sulfur contents via Eschka method using ASTM D-3177 standard. In order to evaluate the heat value of coal samples, gross calorific value was estimated using ASTM D-5865 standard.

2.2. Froth Floatation

After through washing of container using distilled water, an accurately weighed amount of coal sample with a specific particle size (-150 mesh) was placed in it. Then one liter of water was added. The cell was switched on at fixed rpm of 1000. Five minutes of conditioning time was provided. Seventeen drops of collector (oleic acid) was added with the help of dropper. Only one drop of frother (pine oil) was added and further process remained in operation for next 10 minutes. The air was injected which caused bubble formation. Frother stabilized the bubbles and caused frothing of coal particles by lifting on top surface of the pulp slurry. The froth rich in coal particles was removed with the help of scraper as concentrate. The mineral particles which remained at bottom were removed tailing. The concentrate and tailing were then placed in an oven for drying at around 40 C for 6 hours. The air dried sample was subjected for proximate analysis. The effect of process variables such as slurry ratio and pH was studied against ph range of 9-12 and slurry ratio of 15-35 (% by solid weight). Ph was adjusted using N/10 NaOH solution.

3. Results and Discussions

3.1. Proximate Analysis of Raw Coal Sample

Total moisture, volatile matter, ash contents and fixed carbon were evaluated using ASTM standards as described in section 2.1. The results are presented in Table I below.

Table I: Proximate analysis of raw coal sample

Test	**Value**
Inherent Moisture	2.13 %
Volatile Matter	34.65 %
Ash	29.43 %
Fixed Carbon	33.00 %

Pakistani coal reserves are considered not to be of good grade due to high proportion of sulfur and ash contents. Therefore, in order to characterize the Chamalang coal, sulfur contents and gross calorific value were evaluated using Eschka mixture methods and bomb calorimeter respectively. The results are presented in Table II as given below,

Table II: Evaluation of sulfur and gross calorific value

Test	Value
Sulfur	3.11%
Calorific Value	5482 kcal/kg

3.2. Proximate Analysis of Raw Coal Sample

In order to enrich organic matter and reduce mineral contents of coal samples, it was purified using froth floatation method. The effect of slurry ratio and pH on volatile matter, ash contents and fixed carbon was investigated. The results are presented in the following Fig. 1 & 2. The experiments were carried out using particle size range of -150 mesh, impeller speed of 1000 rpm, conditioning time of 5 min and floatation time of 10 min, amount of oleic acid as collector was 2 g / kg of coal, addition of pine oil as frother was one drop and mass of coal used per analysis was 150, 200, 250, 300 and 350 g respectively. These conditions remained constant for coming series of experiments.

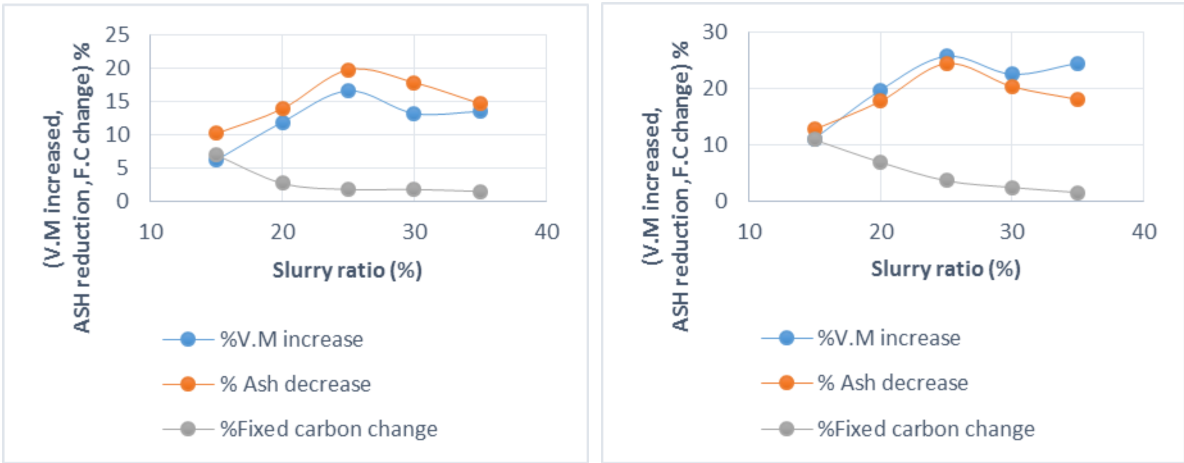

Fig. 1: Effect of solid loading (slurry ratio) on volatile matter, ash contents and fixed carbon at pH 9(L) & 10(R)

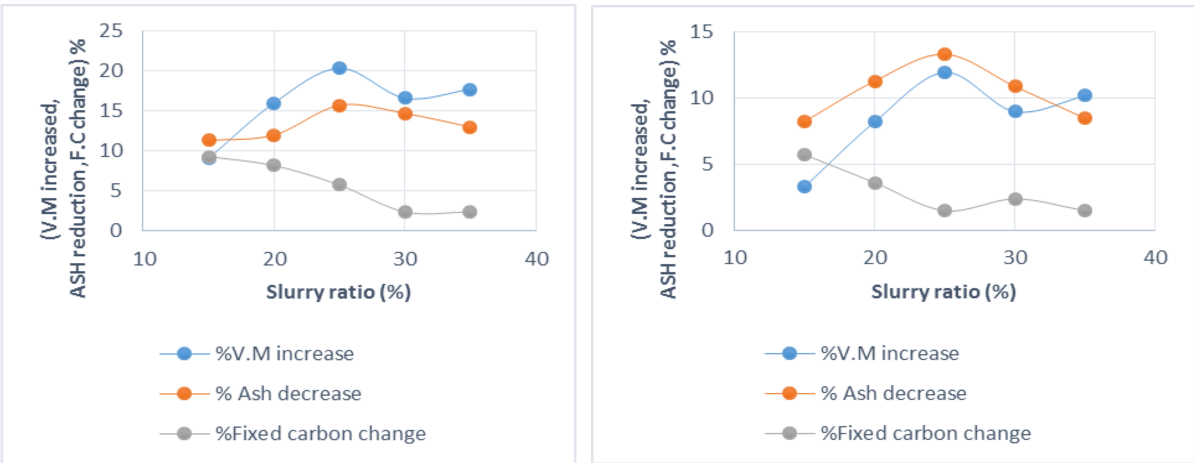

Fig. 2: Effect of solid loading (slurry ratio) on volatile matter, ash contents and fixed carbon at pH 11(L) & 12(R)

Fig. 1 & 2 presents the effect of slurry ratio on % increase in volatile matter, reduction in ash contents and % change in fixed carbon. As evident in Fig. 1 & 2, maximum increase in volatile matter was observed at pH 10 with slurry ratio of 25. It is noticeable in these figures that other slurry ratios at pH 10 showed high percentage of volatile increase. The maximum ash reduction in concentrates was obtained at pH 10 and slurry ratio 25% as shown in Fig. 1. The percentage of fixed carbon change was found to be maximum using slurry ration of 25 at pH 10 (F.C = 36.6% by wt. at 15% slurry ratio), (F.C = 35.3% by wt. at 20% slurry ratio) and (F.C = 34.2% by wt. at 25% slurry ratio).

Based on these findings, results may be summarized as; ash contents reduced from 25.7% by wt. to 22.2% at pH 10. Volatile matter increased from 38.5% to 43.6% by wt. at pH 10. Consequently, under optimum experimental conditions (pH 10 and slurry ratio of 25%), the maximum reduction in ash contents and maximum increase in volatile matter was obtained.

In order to investigate the effect of pH on volatile matter, ash contents and fixed carbon, a series of experiments were conducted using particle size range of -150 mesh, impeller speed of 1000 rpm, conditioning time of 5 min and floatation time of 10 min, amount of oleic acid as collector was 2 g / kg of coal, addition of pine oil as frother was one drop. These conditions remained constant for next series of experiments. Results are shown in the following Fig. 3, 4 & 5.

Fig. 3 to 5 presents the effect of pH on % increase in volatile matter, % reduction in ash contents and % change in fixed carbon. It was observed that no significant change in results was obtained when compared with results as shown in Fig. 1 & 2. A maximum % increase in volatile matter along with maximum % decrease in ash contents was observed using a slurry ratio of 25% by wt. at pH 10. As a result of these findings as presented in Fig. 1 to 5, Chamalang coal cleaning is recommended using froth floatation method. The coal sample was not found suitable for its cleaning using froth floatation over pH values of 11 which may be speculated due to the low affinity of collector in the strong basic media.

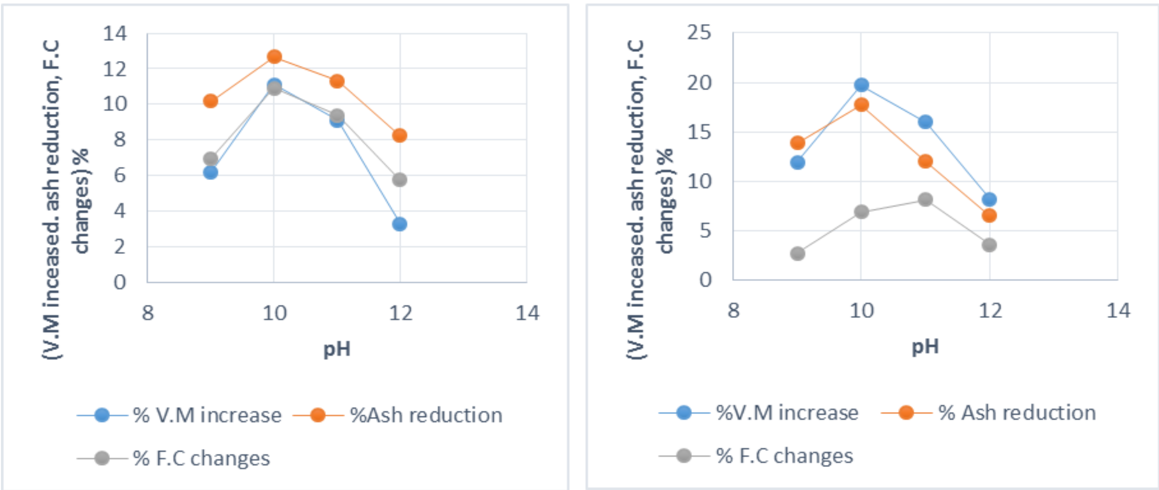

Fig. 3: Effect of pH on volatile matter, ash contents and fixed carbon at solid loading of 15% by wt (L) & 20% by wt (R)

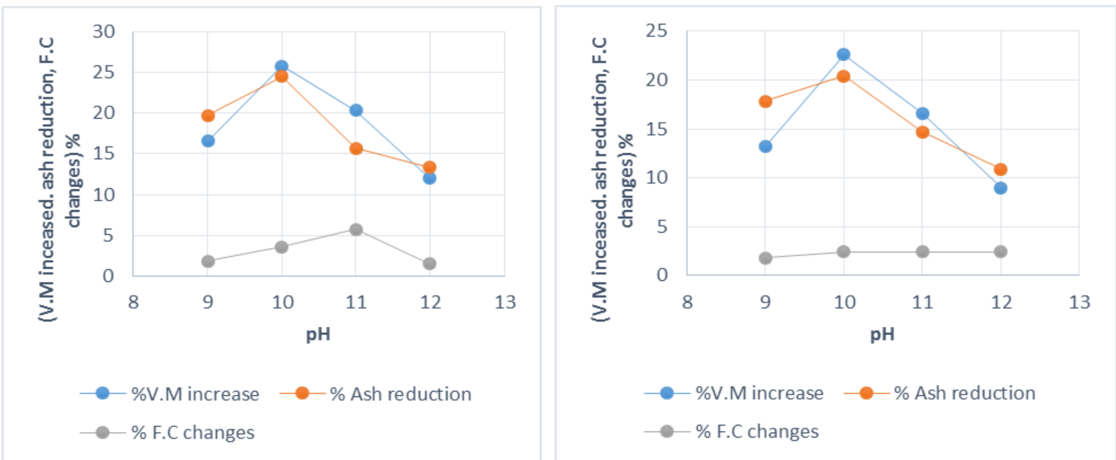

Fig. 4: Effect of pH on volatile matter, ash contents and fixed carbon at solid loading of 25% by weight (L) 30% by wt (R)

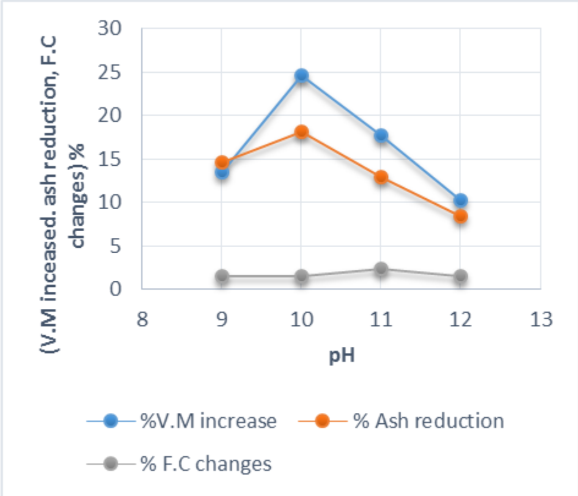

Fig. 5: Effect of pH on volatile matter, ash contents and fixed carbon at solid loading of 35% by weight

4. Conclusion

The presented study revealed that froth floatation method is suitable for reducing ash contents, increasing volatile matter and a considerable change in fixed carbon. The ash contents of the Chamalang coal samples were observed to be significantly removed (24.5%) whereas the volatile matter was found to be increased up to 25.8%. The effect of slurry ratio and pH was studied. The efficient cleaning of the Chamalang coal was obtained at pH 10 and using a slurry ratio of 25%.

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