Conventional and Advanced Technologies in Coal Preparation

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ABSTRACT
Coal preparation is the removal of mineral matter from the Run-of-Mine (ROM) coal by employing separation processes which are able to differentiate between the physical and surface properties of coal and the mineral matter. Through coal preparation, a uniform product is obtained. Coal is prepared for its utilization in carbonization, combustion, gasification, liquefaction etc. plants. The selection of the logical separation process is based on laboratory studies of the run – of – mine coal known as wash ability studies viz. size distribution, yield curve, cumulative float curve, cumulative sink curve, partition tromp curve. Through coal preparation, extraneous non combustible materials are reduced besides lower emission of particulates and reduction in ash handling problems in thermal power stations. Lower in SOx, NOx and carbon emissions as also reduction in transportation costs per unit and improvement in heat guaranteed. Due to consistent quality of washed coal, the plant efficiency will improve. Also due to lower green house gas emission, reduction in global warming is achieved. The cost of washed coal will enhance. Coarse coal cleaning (particle size > 0.5 mm) was discussed using gravity based and surface properties based methods. Dry separation processes such as electrical and magnetic properties based processes were narrated.

Key words – RoM, Coal Preparation, Granty based cleaning, surface property based cleaning

I INTRODUCTION

In India millions of tonnes of coal and lignite are produced. Daily output of coal production has already reached 3 million tonnes in March 2020 which is enough to run a 660 MW power plant for a year as the state run miners focuses on expansion of projects and increasing production. Now the Coal India Limited (CIL) has focussed on remaining top soil to expose coal, which will rapidly raise output of coal. The CIL has also received environment clearances for a handful of large expansion projects. CIL is currently operating in 15 public sector coal washeries with a total capacity of 36.8 million tonnes per year. Of these 11 are coking coal washeries, while the rest are non coking coal washeries with a capacity of 20.58 million tonnes and 16.22 million tonnes per year respectively, out of 25 coal washeries installed and commissioned in India. But only 19, out of these, are in operation at present with a total washing capacity of 33.17 million tonnes per year. We are getting high to very high mineral matter contents in coal (caking, non coking and coking varieties) on production specially from open cast mines. When this coal is transported from the pit head to any other place in India, either by truck or rail (both using diesel to run their engines), the transportation cost per unit heat becomes more because it is carrying both combustible and non combustible materials. Combustible matter gives heat on burning it in air while non combustible mineral matter takes away part of that heat to raise its own temperature which is a loss. It is therefore imperative to clean the coal to the desired level, as per their utilization needs such as for steel industry or for electricity / power generation in thermal power plants or in any other industry where coal is used as a source of heat.

II DISCUSSION ON VARIOUS METHODS OF COAL PREPARATION

(a) Coal Cleaning - Coal cleaning is a process by which impurities such as mineral matter, sulphur and rocks are removed from coal to upgrade its value. Coal cleaning processes are categorised as physical cleaning, microbial cleaning or chemical cleaning. For the first time in the world, the research work carried out on disposition pattern of sulphur in coal structure by srivastava revealed that the sulphur present in coal is present in different forms such as pyritic sulphur, sulphate sulphur. Thioether sulphur, thiophenic sulphur, aromatic sulphidic and disulphidic sulphur, thioketonic sulphur. This was done using temperature programmed reduction method. A lot of work on chemical desulphurization of coal was done but the total sulphur in coal could not be quantitatively reduced. The reason is one reagent is not effective in reducing all forms of organic sulphur. The reagent effective in removal of pyritic and sulphate sulphur will not at all be effective in reduction of organic sulphur. The iron sulphate may be removed by simple washing the coal with water. Thus the chemical desulphurization process is economically not viable hence no commercial plant came up. Treatment with ferric sulphate could reduce more than 90% of pyritic sulphur. Lot of work on Microbial desulphurization of coal was done resulting in removal of more than 90% pyritic sulphur (using Thio-bascillus Ferro-oxidans as microbe), this is very slow process. Using other different microbes a maximum of about 19% organic sulphur was removed which is uneconomical and hence once again no successful commercial plant came up.

Physical coal cleaning processes includes mechanical separation of coal from its contaminants using differences in their density, magnetic properties etc., are by far the major processes in use today. As already stated chemical coal cleaning processes are currently being developed but their performance and cost are undetermined as on today. Typically density separation is used to clean coarse coal while surface property based methods are preferred for fine coal cleaning. In the density based processes, coal particles are added to a liquid medium and then subjected to gravity or centrifugal forces to separate the organic rich (float) phase from the mineral rich (sink) phase. Gravity based separation is the most common coal cleaning method and is commercially accomplished by the use of jigs, mineral spirals, concentrating tables , hydro cyclones and heavy media separators. The performance of density based cleaning circuits is estimated by using laboratory float and sink (F & S) tests. Organic liquids of varying density as well as inorganic solutions were used as a media for separation of coal from the mineral.

In the surface property based processes, ground coal is mixed with water and a small amount of collector reagent is added to increase the hydrophobicity of coal surfaces. Subsequently, air bubbles are introduced in the presence of a frother to carry the coal particles to the top of the slurry, separating them from the hydrophilic mineral particles. Commercial surface property based cleaning is accomplished through froth or column flotation. To estimate the performance of flotation devices, a laboratory test called release analysis is used.

Theoretically the efficiency of physical cleaning should increase as particle size decreases because of the improved liberation of the mineral matter from the coal matrix. Therefore, recent research on advanced coal cleaning has focussed on improving fine coal cleaning. Column flotation devices developed since 1980's can remove most of the impurities from finely ground coal. Likewise advanced gravity separators, developed mainly for metal mining industries, were shown in recent years to have a good potential for improving the cleaning of finely ground coal. Other physical cleaning methods are selective agglomeration, heavy media cyclonning and dry separation with electrical and magnetic methods. Selective agglomeration and advanced cyclonning have the high probability of commercialization particularly for reducing sulphur content of coal. In selective agglomeration the coal is mixed with oil. The oil wets the surface of the coal particles and thus causes them to stick together to form agglomerates. The agglomerated coal particles are then separated from the mineral particles that stay in suspension because they do not attract oil to their surfaces. A version of selected agglomeration, called the 0tisca T process, was reported to reduce the ash content of some coals, ground to about 2um, below 1% with a high recovery of the heat content. Conventional cyclonning has been used for many years for cleaning relatively coarse coal and considered for fine coal cleaning only in recent years. Coal and heavy media enters the conical shaped cyclone tangentially near the top. As the cyclone spins around its axis, impurities move downwards along the walls and exit through the bottom opening while coal particles move upward near the centre and exit from the top.

Dry methods take advantage of the differences between electrical and magnetic properties of minerals and the coal particles and have not been developed enough for its commercialization. The estimated cost of advanced fine coal cleaning is uneconomical. However, some expenses of advanced coal cleaning can be offset by reduction in transportation cost, elimination of milling cost at power plants, and reduced maintenance cost of power plants. Widespread commercialization of advanced coal cleaning technologies depends upon further improvements in technology, supply and demand for different fuels and future environmental regulations coming up.

(b) Dewatering - Now coming to dewatering of coal fines – water present in clean coal is a contaminant and reduces heat content of the coal. It is estimated that every1% moisture in clean coal is equivalent to 4% ash. Moisture adds to the transportation of coal as well as handling problems. In case of refuge slurry, a significant amount of land and water gets tied up with the slurry disposal and also a significant amount of water is lost due to seepage and evaporation. Breakage of the slurry damns creates a substantial loss of property and sometimes human lives.

Dewatering of fine clean coal and refuse slurry is one of the most important aspects of coal cleaning scenario. It also adds significant cost to the price of the clean coal. For particles larger than 0.5 mm size no particular dewatering problem is encountered, however, particles finer than 0.5 mm are the most difficult to dewater. A typical coal preparation plant produce about 20% of the mined coal as 0.5 mm. Generally, this fine fraction is discarded due to its high cost of processing. However, with the development of advanced coal cleaning technology, such as column flotation, cleaning of fine size coal to low ash and low pyritic sulphur is feasible at high recovery. One of the biggest hurdles in utilization of fine coal cleaning technology by the coal industry is the economic dewatering of fine clean coal product. Until an economical and practical solution to dewatering of fine clean coal is achieved, the efforts devoted to developing fine clean coal technology will be wasted. The hyperbaric filter (HBF), being an expensive technique and refuse being waste material, the coal companies do not want to invested money in dewatering refuge. Deep cone thickener (DPT) was evaluated for dewatering of fine coal refuse. The study showed that using a proper addition of anionic and cationic flocculants to the slurry before it is fed to the deep cone thickener produced a dewatered paste product containing about 50% solids. The process captured more clean water for recycling and produced a material that could be stacked on a slightly slanted surface. The paste eliminates the danger of slurry spillage which had been a serious problem. A couple of coal preparation plants in USA have installed commercial scale deep cone thickeners.

The utilization of super absorbent polymer (SAP) in the nappy application is well known. The concept of utilizing these polymers was investigated for the purpose of dewatering coal and other fines generated by preparation processes such as flotation. SAP's are granular, highly cross linked synthetic polymers with excellent water absorbing properties. The dewatering process is characterized by three main stages (a) contact of SAP with high moisture fine coal, (b) separation of dewatered fine coal from SAP, and (c) regeneration of used SAP, by exploiting its response to changes in conditions such as pH or temperature. Preliminary tests showed the separation step to be very difficult. The novel idea of encasing a given amount of polymer in a water permeable cloth solved this problem of separating the swollen polymer from the dewatered coal. Preliminary tests investigating the effectiveness of the sachets of polymer showed a drastic decrease in the moisture contents of slurries.

Furthermore, it was shown that it was possible to regenerate the polymer (still within the sachets) through thermal drying. A full scale experimental program was then followed to accurately determine the feasibility of using the sachets of SAP. The experimental variables were initial slurry moisture content and polymer dose. It was observed that the sachets seemed to work fastest and most effectively at high moisture and also at high doses of SAP. Regeneration of polymer was also investigated using two methods (a) thermal regeneration, and (b) pH induced regeneration. The experimental variables for investigating the regeneration processes were - method of regeneration and grade of water used. Thermal regeneration at 70 C seemed to work successfully. Although the cost of using thermal energy is still a problem, the safety aspect (fine hazards) has been addressed since the polymer does not ignite when heated, unlike fine coal particles that may do so. The alternative method of regeneration, which exploits the pH sensitivity of the polymer, was less successful. The laboratory experiments conducted over a period of 76 hours on slurry mixtures, with phases of mixing showed that it is possible to decrease moisture content by 70% (on an average) using SAP's. A final moisture content of 13% (on an average) was obtained. It was observed that the sachets seemed to work fastest and most effectively at high moisture contents and also at 2% dosage of SAP. The fact that higher polymer dosage is more effective has financial implications in terms of the amount of SAP needed to dewater a given amount of coal as well as time constraints. However, more vigorous experimentation could prove the dewatering of fine coal by SAP to be economically feasible. It is important to mention here that Virginia Tech developed new chemicals which were added to the fine coal slurry that increased the efficiency of mechanical dewatering of coal fine using Vacuum filtration, and centrifugation.

III CONCLUSION

Coal preparation is the removal of mineral matter from the Run-of-Mine (ROM) coal through separation processes which differentiate between the physical and surface properties of the coal and the mineral matter. Through coal preparation, a uniform product is obtained. Coal is prepared for its utilization in carbonization, combustion, gasification, liquefaction etc. plants. The selection of the logical separation process is based on laboratory studies of the run – of – mine coal known as wash ability studies viz. size distribution, yield curve, cumulative float curve, cumulative sink curve, partition tromp curve. Through coal preparation methods, extraneous mineral matter was reduced resulting in lower emission of particulates and reduction in ash handling problems in thermal power stations. Coarse coal cleaning (particle size > 0.5 mm) was discussed using gravity based and surface properties based methods. Dry separation processes such as electrical and magnetic properties based processes were narrated.

Lowering in SOx, NOx and carbon emissions, as also, reduction in transportation costs per unit heat can be easily achieved. Due to consistent quality of washed coal, the plant efficiency will improve. Also due to lower green house gas emission, reduction in global warming is achieved. The cost of washed coal will enhance. Dewatering of washed fine coal and that of slurry refuge were discussed using SAP. Processes for regeneration of SAP have also been discussed.