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Efficient use of magnetite in coal beneficiation plants for heavy media separation – A case study

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ABSTRACT

Coal is a major commercial source of energy as a solid fuel for steel plants. The beneficiation of run of mine coal is mostly done by gravity separation using heavy media. Magnetite is the most widely used material for heavy media because of its higher stability in suspension, higher specific gravity, lower viscosity and easy availability. Worldwide, almost 60% of total coal beneficiation is carried out by heavy media process. In India in 80% cases the heavy media used is magnetite. The paper essentially deals with the magnetite stability factors, its preparation and recovery processes, its operational utilization and the existing systems in some Indian coal washing plants. A case study to operating system has been made with a view to identifying the major demerits and difficulties existing therein. Some remedial measures as applicable under Indian conditions have also been suggested.

INTRODUCTION

Coal is a major commercial source of energy. The quality of run of mine coal is upgraded by means of beneficiation processes which are based mainly on gravity–separation principle. The beneficiation processes which are commercially used are jigging, heavy media bath and heavy media cyclone for coarse coal whereas water cyclone, flotation and oil agglomeration are commonly practised for fine coal particles (0–0.5) mm. size.

The specific gravity is built-up by using heavy media. Heavy liquids (mostly organic compounds), heavy particles, sands etc., are commonly used for heavy media. All coal beneficiation plants at present are using magnetite as heavy media. It plays a vital role for maintaining high specific gravity. The magnetite provides stable suspension, moreover it is easy to prepare as well as easy to recover from the process, and can be reutilised.

In this paper, an attempt has been made to discuss the magnetite preparation and recovery process including magnetite stability factors. A mathematical model of magnetite preparation and recovery process has been formulated. A case study of magnetite preparation as well as recovery system has been made for getting acquainted with its difficulties. A better recovery system of magnetite has been suggested under India conditions.

Beneficiation Process

Jigging, Heavy-media bath, Heavy-media cyclone are generally used for coarse coal particles. In Jigging air and water are used for media where as magnetite is a broadly used heavy media to provide stable suspension with stable specific gravity for separating clean coal, middlings and reject.

Flotation, water cyclone and oil agglomeration are used for fine coal particles. The process of coal beneficiation using heavy media has been presented in Table - 1.

Table 1 : Showing coal beneficiation process and media

	Process	:	Media
1.	Jigging	:	Water, Air
2.	Chance Process	:	Sand
3.	Heavy Media Bath	:	Magnetite
4.	Heavy Media Cyclone	:	Magnetite

Heavy Media

In coal beneficiation plants, generally sand or heavy liquids or magnetite is used for building stable specific gravity in the circuit. In India, magnetite is used in all coal beneficiation plants. It is used due to its easy availability better stability, easy preparation and low viscosity properties. Additionally, magnetite is easily recoverable by using magnetic separators, and the recovered magnetite is again used in process cycle, thus reducing the operational cost of beneficiation.

Magnetic Stability Factors

Magnetite should be stable in the process for maintaining the desired specific gravity for separation of clean coal, middlings and reject.

In selecting heavy media, it is essential to study the stability factors. The following points are to be considered for selecting heavy media particles:

i) The particle size should be –300 mesh,

ii) The heavy particles should be easily available,

iii) The viscosity of the media should be low,

iv) The heavy media solid should have high specific gravity (4.0 – 6.5),

v) The stability index of the heavy media should be high,

vi) The heavy media used in the process should be easily recoverable so that it can be reused, and

vi) The heavy media selected should cost as less as possible.

The above properties are found in magnetite that is why, it is used widely as a heavy media in coal preparation plants all over of the world

Magnetite Preparation Process

Run of mine magnetite comes in large lumps (0-75 mm). This magnetite is not pure. Its magnetite content is only 50–65%. This is stored and crushed to 0-15 mm size. Generally Jaw crusher and gyratory crusher are used as size reduction equipment. This is ground to –300 mesh size by wet grinding in ball mills. This ground magnetite is separated by classifier to separate +300 and –300 mesh size particles. The particles below –300 mesh size are passed through magnetic separator for separating the magnetite from non-magnetic particles. In this way, the concentration of magnetite is increased. The process of magnetite preparation has been shown Fig. 1.

Recovery Process of Magnetite

The specific gravity of the suspension is maintained in the range of 1.35–1.37. During process, media is lost by pump leakages and with the process product materials. Generally, the suspension slurry is separated from the process–products by vibrating screens. The attached particles of the heavy media are separated by the action of water-spray on the product. The media becomes diluted to a lower specific gravity. This diluted suspension is stored in the sump. The stored suspension is fed to magnetic separator which separates magnetite. The magnetite concentrate is collected in a tank for building up the specific gravity in the circuit. The recovery system of magnetite has been shown in Fig. 1.

If rate of fresh magnetite concentrate produced = Q_m (T.P.H.), rate of mangetite recovered from process = Q_r (T.P.H.), rate of coal beneficiated = Q_C (T.P.H.), specific consumption of magnetite in process = Q_p (kg/tonne)

then we get $(Q_c \cdot Q_p).1000 = Q_r + Q_m$

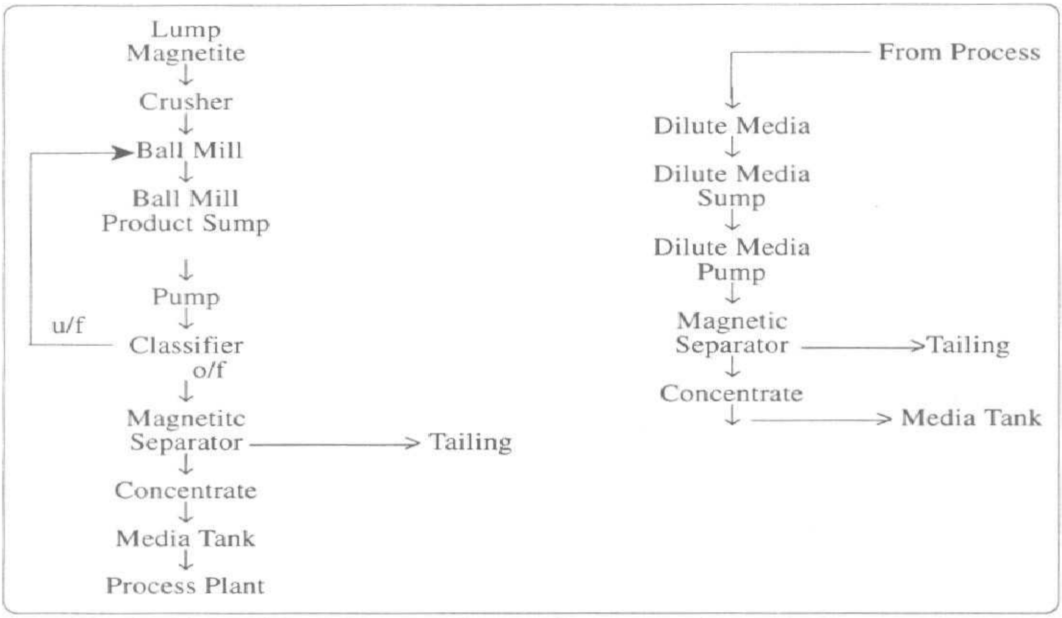

Fig. 1 : General flow diagram of magnetite preparation and recovery system.

or, $$Q_p = \frac{Q_r + Q_m}{1000.Q_c}$$

The above equation gives an idea that in order to keep specific consumption Q_p low, Q_r should be as high as possible so as to make the fresh addition of magnetite in each cycle as low as possible. This calls for an efficient system of media recovery for providing a stable specific gravity in the process circuit. A specific consumption of 1.5–2.5 kg/tonne indicates an excellent operation. Magnetite consumption rates at different coal washeries in India are shown in Table 2.

A CASE STUDY OF MAGNETITE PREPARATION AND RECOVERY SYSTEM

Sudamdih coal preparation plant has been designed to beneficiate coal using heavy media cyclone for coarse coal whereas flotation cell is installed for fine coal upgradation. In this coal preparation, magnetite preparation and recovery circuits have been provided for stable specific gravity.

In the magnetite preparation system, ball mill is used for wet grinding the ore. The ball mill product is pumped to classifier cyclone for size separation. The

Table 2: Media consumption in different coal beneficiation plant in India

Name of the Coal preparation plant		:	Consumption rate of magnetite (kg/tonne raw coal)
1.	Dugda I	:	3–4
2.	Dugda II	:	3–4
3.	Bhojudih	:	3–4
4.	Patherdih	:	4–5
5.	Moonidih	:	4
6.	Barora	:	3–4
7.	Mahuda	:	4
8.	Chasnala	:	2–3
9.	Jamadoba	:	2–3
10.	Sudamdih	:	5–6

underflow is returned to the ball mill, the overflow is used as heavy medium. At the same time, diluted media obtained from process is fed to another classifier along with all the washing and leakages fallen on floor. The underflow of this classifier is fed to a double-drum magnetic separator. The magnetite concentrate is resused as medium. The tailing from the double drum separator is used as wash water for coarse coal washing circuit.

Cost

The cost of magentite preparation and recovery system is associated with electricity, maintenance and wage costs. The operation and media costs should be 8 to 10 Rupees per tonne of raw coal feed, but this cost is higher due to design defects as well as leakage of magnetite from pumps, pipes and screens. The cost may be reduced by improving the magnetite circuit.

Suggestions for Improvement of Media Circuit

It is essential to improve the media circuit in such a way that magnetite concentrate can be obtained continuously for maintaining the desired specific gravity of cut for separation of clean coal, middlings and rejects. Following points are to be considered:

i) Lump magnetite should contain, more than 60% magnetics.

ii) Ground media size should be 90% –300 mesh

iii) Ball mill with classifier circuit to be operated continuously. Percentage utilisation of ball mill operation should be in excess of 50%

iv) Classifier overflow must be passed through efficient magnetic separator

v) Magnetic separator level must be maintained at the optimum.

vi) A scrapper blade to be provided over the magnetic separator so that only concentrate is recirculated

vii) The heavy media pump and the delivery pipes should be leakage free.

viii) Media preparation and recovery system need to be independent of the process plant so that the concentrate of magnetite can be accumulated for quick building of the gravity of the suspension.

ix) For recovery of the attached heavy media the process product should be water sprayed on separate screen.

x) For increasing the stability of magnetite suspension, a stabilizer is required to be added in the suspension.

xi) Ball mill grinding incurs high power cost hence, the operator should be skilled and trained for optimal use of the machine.

xii) A proper maintenance management is essential for smooth operation.

CONCLUSIONS

Clean coal is essential for efficient steel making processes both in terms of quality and quantity. Indian run of mine coal containing high ash is not suitable for direct use in coke making and pulverization. The techno economics of coal beneficiation suggests that it should be cleaned nearest mine-site. There should be an optimal resource utilization with efficient recycling procedure. Magnetite a widely used heavy media should be recovered in the process cycle to the maximum extent possible. This is essential for keeping the cost of coal beneficiation and hence the cost of washed coal low. The problem deserves a special attention in India Coal industry particularly in view of the opening up of global mineral markets including coal in recent years.

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