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Multi-gravity separator — An equipment for separation of fines

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ABSTRACT

Multi-gravity seperator, more popularly known as MGS, burst into the mineral dressing scene around the mid eighties. Since then it has found acceptance in a wide variety of applications. It has replaced column cells for fine casseterite recovery in Wheal Jane in the UK and has been found to be the only equipment which could satisfactorily remove graphite from lead concentrate in Hindustan Zinc mines. MGS has found application in Tantalum recovery as also for upgrading Graphite concentrate. The capability of the machine to recover very fine particles (upto 2-3 micron) and produce a clean concentrate has made it a favoured equipment over a wide range of specific gravities.

This paper deals with the details of the constructional features and operational aspects of Multi gravity seperator. Live cases have been discussed.

Key words : Multi-gravity separator, Gravity separation, Lead concentrate, Iron ore fines, Coal fines.

INTRODUCTION

With continuing depletion of high grade ores and the uncertainity over metal prices in the world market, the mining industry is finding itself in an unenviable situation. The options are limited and the way out appears to lower the cost of production by innovation and improvement as also maximise recoveries. Modern high capacity mining equipments and the fine grinding required to liberate highly disseminated ores are generating much higher levels of fines than before. A considerable amount of these fines short circuit the mineral beneficiation equipments and report to the wastes. It has been estimated that [1]

- one third of the Potash mined in Florida,
- one third of the Tin mined in Bolivia,
- one fifth of world's Tungsten.

are lost in the slimes. Near at home, the iron ore mines are dumping million of tonnes of slimes having 50-52% Fe to the tailings ponds. If even 10% of these volumes of wastes could be recovered, the invigourating impact on the economics of operation can easily be imagined.

Research into the methods of recovering these fines has been at the forefront of mineral engineering studies for long. Gravity separation, the work horse of mineral dressing plants in the early twentieth century yielded place to flotation because of its better selectivity and efficient recovery of fines. Yet it has not been that effective in the (-44) micron particle size range and most of the fine we are dealing with right now are in this range. Moreover, the increasing interest that environment is attracting, and rightly so, is exposing the limitation of the flotation technology. Even though its superiority is still undisputed particularly in base metal ore beneficiation, over the years a number of gravity seperation equipments have been developed to handle the fines. These could be used as stand alone equipments or in combination with flotation or other beneficiation equipments. Multi-gravity seperator is one such equipment.

THE MACHINE

The machine consists of two open ended rotating drums operating at an angle to the horizontal plane (4° to 7°). the drums are made of steel and have a polyurethane/steel lining inside. The lining is tapered, thereby providing an angle of about 1° to the inside of the drum. The drums rotate in opposite directions to provide mechanical stability, the speed being in the range of 160 to 300 rpm. A set of scrapers, mounted within each drum on a separate concentric shaft rotating in the same direction as the drum but at a higher speed, pushes the settled material to the outer, narrower end of the drum. A sinusoidal shake is imposed to the drum in the axial direction through a separate drive and eccentric arrangement.

Deslimed feed is introduced into the machine via accelerating rings which help to distribute the material uniformly on the drum surface. Wash water is provided via another similar ring. A schematic diagram of the double drum MGS is given in Fig. 1.

Principles of Operation

The Multi-gravity separator is a continuous thin film separation device used mainly for beneficiating ores with fine particle distribution using an enhanced gravitational field. A schematic diagram of a drum section is given in Fig.2 to indicate the important features of the design.

Feed is introduced into the drum surface in slurry form (25-50% by weight)

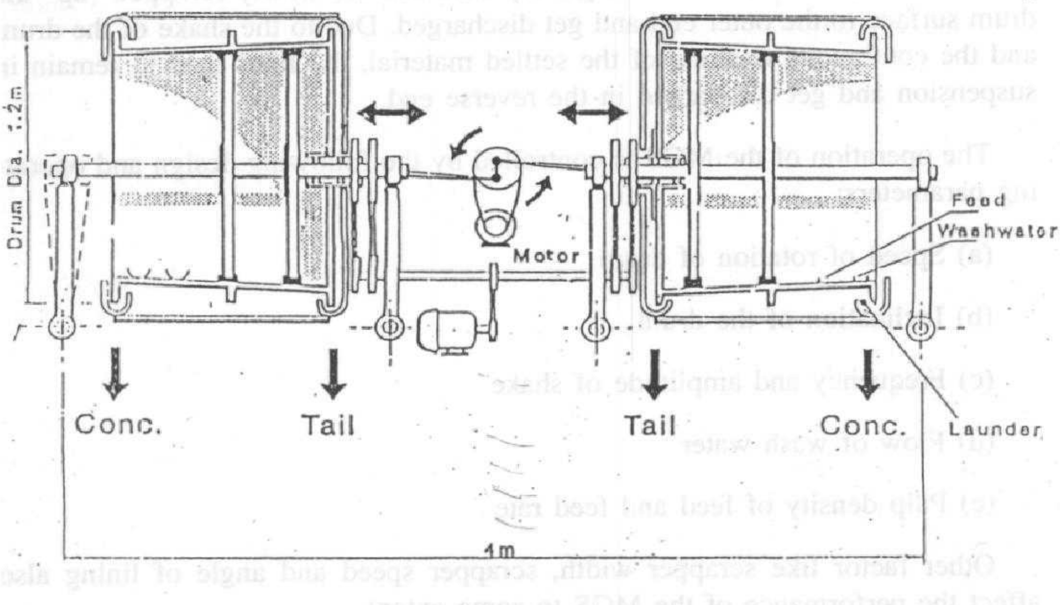


Fig. 1 : Schematic diagram of MGS

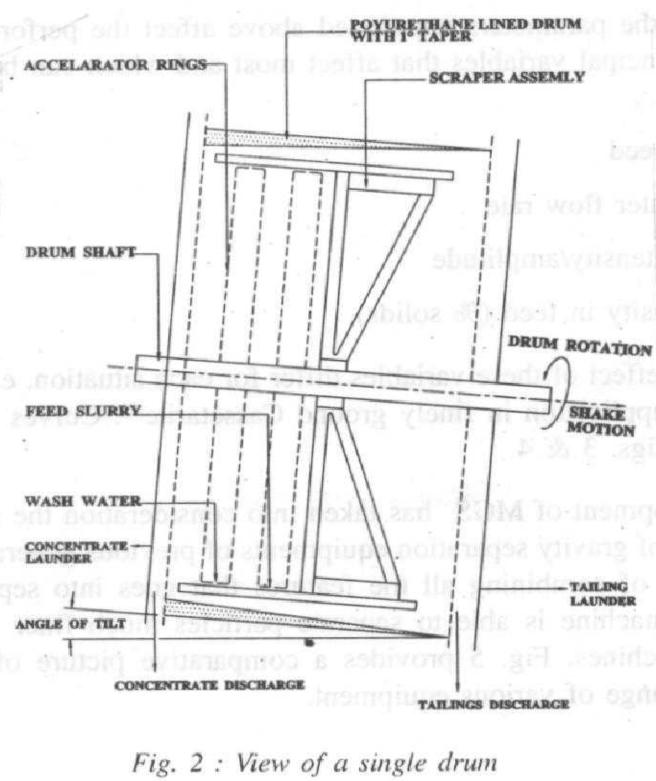


Fig. 2 : View of a single drum

via an accelerator ring which allows uniform distribution of solids and also reduces the velocity. The heavy particles (larger or more dense) settle quickly to the drum surface under enhanced gravity field and are slowly scrapped "up" the drum surface to the outer end and get discharged. Due to the shake of the drum and the continuous washing of the settled material, the fines tend to remain in suspension and get discharged in the reverse end.

The operation of the MGS is controlled by the following design and operating parameters:

(a) Speed of rotation of drum

(b) Inclination of the drum

(c) Frequency and amplitude of shake

(d) Flow of wash water

(e) Pulp density of feed and feed rate

Other factor like scrapper width, scrapper speed and angle of lining also affect the performance of the MGS to some extent.

While all the parameters mentioned above affect the performance to some extent, the principal variables that affect most and which can be easily/quickly controlled are

* Drum speed
* Wash water flow rate
* Shake intensity/amplitude
* Pulp density in feed (% solids)

While the effect of these variables differ for each situation, extensive data is available for application in finely ground Cassetarite[2]. Curves depicting these are given in Figs. 3 & 4.

The development of MGS has taken into consideration the advantages and shortcomings of gravity separation equipments of previous generations. Through a unique way of combining all the features that goes into separation of fine particles the machine is able to separate particles much finer than preceding generation machines. Fig. 5 provides a comparative picture of the operating particle size range of various equipment.

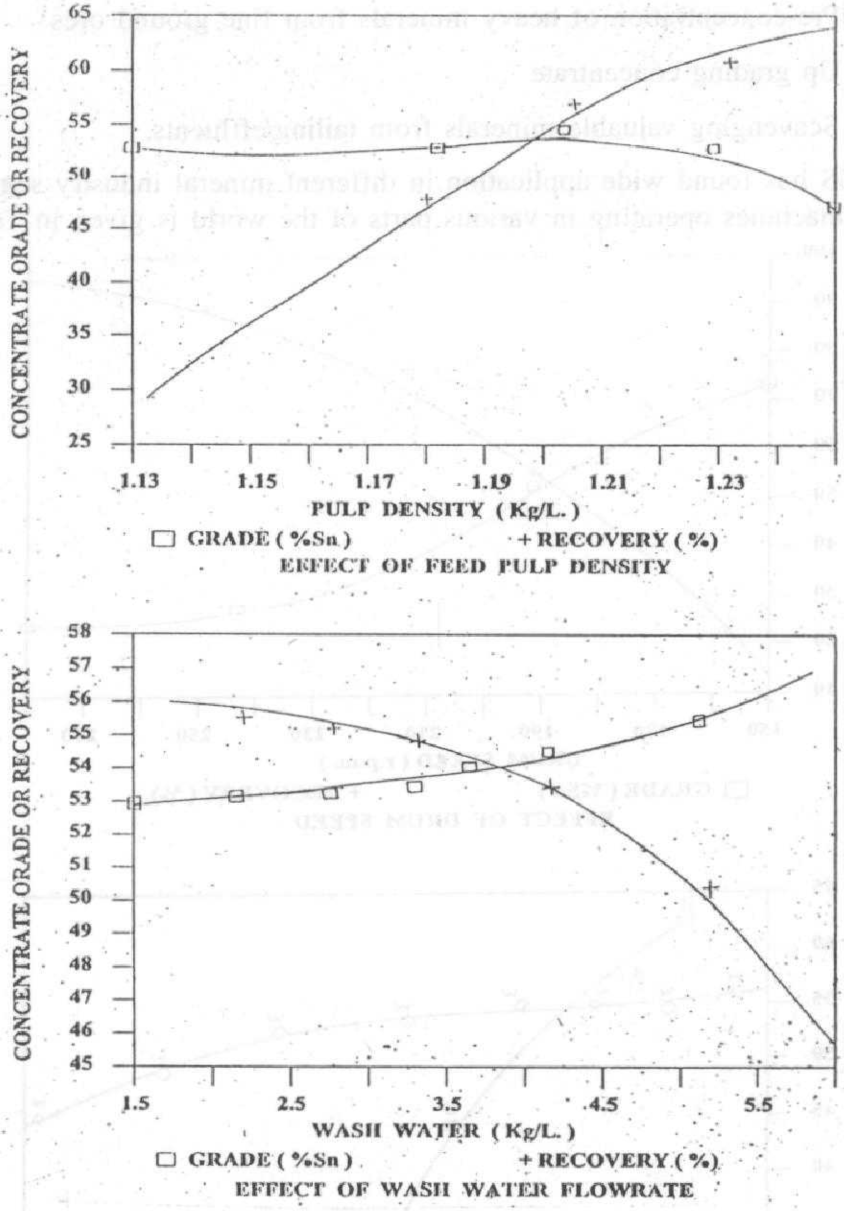


Fig. 3 : Effect of pulp density and wash water

APPLICATION OF MGS

There is scope of application of MGS in various locations in mineral processing plants e.g.

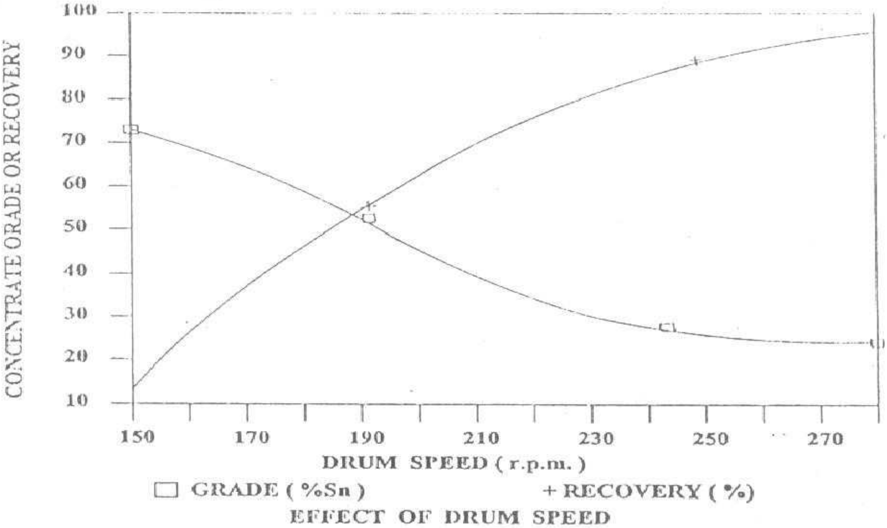
(a) Recovering precious metals from fine alluvial ground ores

(b) Pre-concentration of heavy minerals from fine ground ores.

(c) Up grading concentrate

(d) Scavenging valuable minerals from tailing/effluents.

MGS has found wide application in different mineral industry segments. A list of machines operating in various parts of the world is given in Table 1.



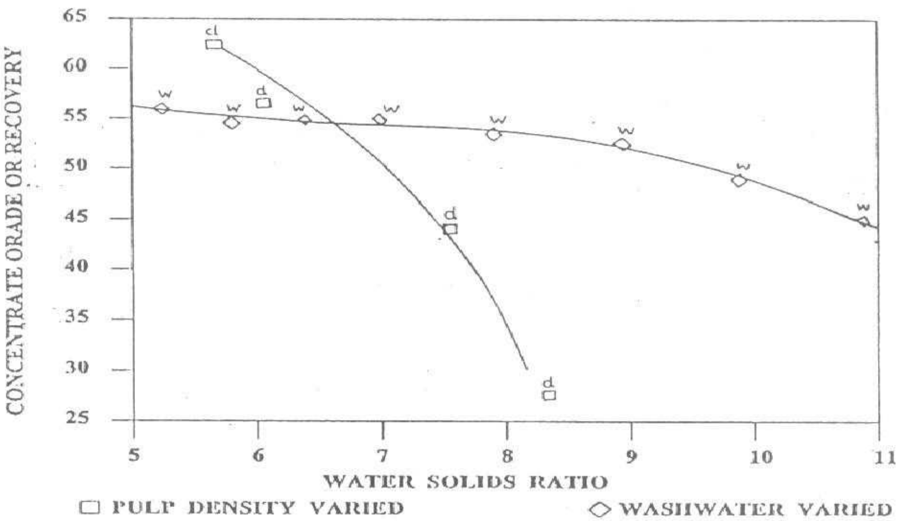


Fig. 4 : Effect of drum speed and percentage of solid

Table 1 : Mozley C902 Multi-gravity separation reference list

Client	*Location*	*Qty.*	*Application*
Jesenik (Hire now returned)	CFSR	1	Gold Zinc
Uley Graphite	Austria	1	Graphite upgrading
TSUMEB	Namibia	3	Iron Ore Fines
Pittston Minerals	Australia	1	Graphite
South Crofty PLC	UK	1	Tin Flotation upgrading
Waller Metal Limited (Mineral Regina)	Peru upgrading	1	Wolfram recovery/
Noranda	Canada	1	Heavy Metals
Solnechney upgrading	Russia	15	Tin Recovery/
Hindustan Zinc Limited	India	1	Zinc concentrate Upgrading (Ph 1)
Hindustan Zinc Limited	India	1	Zinc concentrate Upgrading (Ph 2)
Tantalum Mining	Canada	1	Fine Tantalum recovery
Renison	Australia	2	Tin Flotation upgrading
Barit Maden	Turkey	2	Celestite Tailing Recovery & upgrading
Yichun Tantalum Mining	China	1	Tantalum Recovery
Minsur SA	Peru	1	Tin Flotation upgrading (Ph 1)
Minsur SA	Peru	2	Tin Flotation upgrading (Ph 2)
Carpo	Mexico	1	Barytes Recovery
Qwalia-Wodgina Tantalum	Australia	1	Tantalum Recovery
Minerals Girona	Spain	1	Recovery & upgrading of fine barytes
ONA	Morroco	2	Cobalt & Copper Recovery

The machine was originally developed for recovery of very fine Casseterite ore which were getting lost in the tailings from the processing plants in Cornwall. A significant milestone in the progress of this machine lies in its replacing column flotation cells at Wheal Jane. This development is well documented and Table 2 gives a comprehensive picture of the comparative performance of two equipments[2]. It indicates clearly that MGS could provide a better grade recovery relationship than column flotation in this application. Apart from better metallurgy the operating costs are substantially less due to much lower power consumption, non-requirement of reagents and easier controls.

Table 2 : Summary of MGS performance

	Tin Float Feed %Sn	Tin Float Tail %Sn	Tin Float Conc %Sn	Tin Float Stage Rec%
Column Flotation	0.757	0.227	50.16	60.79
MGS 16.07.92-18.11.93	0.558	0.187	55.45	66.71
MGS 0.9.08.93-18.11.93	0.480	0.140	55.83	71.01

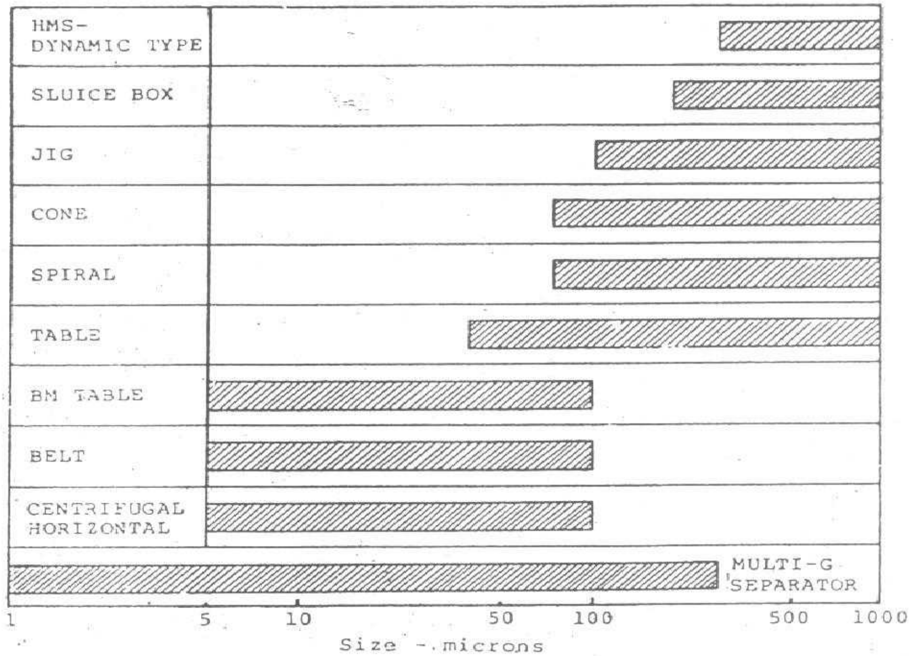


Fig. 5 : Operating size ranges of wet gravity separators

In India the MGS has been installed by Hindustan Zinc Ltd. (HZL) in their Rajpura-Dariba mines for separation of graphitic carbon from lead concentrate. In fact, MGS was the only technology which could reduce the graphite content from 7% to around 3%. This application is also well documented[3], Table 3 provides data on the performance of MGS in lead circuit at Hindustan Zinc Ltd.

Table 3 : Plant trials on MGS on lead concentrate[3]

Shake Frequency	RPM	Wash Water	Feed %Pb	Feed % GL	Conc Lead	Grade GL
245	130	20	47.8	16.1	64.3	3.62
245	130	40	48.3	12.2	64.6	1.98
296	130	20	46.1	15.3	61.90	4.0
296	130	40	50.2	12.7	64.90	1.42
296	110	20	47.1	15.4	68.80	1.44

SCOPE OF APPLICATION IN INDIA

There is enormous scope of application of MGS in India particularly in iron ore washing and fine coal beneficiation circuits. Needless to mention these two mineral segments form the backbone of the recent thrust for improvement of industrial infrastructure in the country.

Iron Ore Beneficiation

As mentioned earlier about 7 million tons of iron ore slimes having 50-52% Fe are pumped annually to the tailings dam as waste. These slimes have been well characterised and have been found to be liberated from gangue minerals like Silica and alumina. There is ample scope of beneficiating these fines and recover 30-50% of the materials as a fines product.

A few plants are already using hydrocyclones to recover a product having 63-64% Fe from these slimes. In some operations additional recovery from primary cyclone overflow slimes is being practised through further cycloning and magnetic separation from cyclone underflow. It is felt that MGS could be a very effective equipment for upgrading the cyclone underflow product to as high as 66-67% Fe. Since the MGS operates utilising the sp. gr. difference between the ore and the gangue minerals the performance is expected to be much more steady as the sp.gr. difference does not vary significantly within the same or adjacent deposits. Extensive test work has been conducted on MGS on iron ore slimes at various laboratories. Table 4 presents results of test work conducted in a national laboratory showing that MGS can be used to generate an iron ore product having 66-67% Fe.

Table 4 : MGS test results on iron ore slimes

	% Fe	% Al_2O_3	SiO_2
Feed	54.89	7.17	4.33
Concentrate	66.90	1.86	1.19

Fine Coal Beneficiation

In the beneficiation of fine coal (<0.5 mm) MGS holds great promise as an economic alternative to the present system of spiral concentration and flotation. Extensive test work has been conducted in the laboratory on coal fines and typical results are given in Table 5.

The significant reduction in the level of ash % and sulphur % is noteworthy. Test work has also been carried out at site for an extended period of time and the same results as obtained in the laboratory has been reproduced. An extract from the report on test work is given below.

Trials conducted at RJB Mining, Prince of Wales Colliery, UK indicate that plant washing effluent of 20% w/w pulp density containing 52% ash (dry basis), when deslimed using Mozley cyclones, could feed the MeGaSep with 50 mt/h solids of 40% ash suspended in a stream of 62% w/w pulp density. The product from this after dewatering in a sugar bowl centrifuge produced approximately 25 mt/h coal solids of 18% ash. This tonnage reflects reliable set of process conditions and does not necessarily reflect the maximum tonnage capability of the machine.

This has an enormous impact not only in terms of generating revenue from otherwise waste coal but also considerably increasing lifespan of the tailings lagoons and providing clear water from the centrifuge which can be recycled back to the process circuit.

Not only can effluent water be used but existing material from tailing lagoons can be incorporated in the feed to the circuit thus using the "stockpiled" coal which has been discarded in past years.

Table 5 : MGS test result on coal fines

(a) FEED	125mm Hydrocyclone Underflow 100% - 1mm 40% Ash	
MGS TYPE	C900 Laboratory / Pilot Plant unit	
REQUIRED	To reduce ash content to less than 20%	
SETTINGS	Rotational Speed	278 rpm
	Shake Speed	5.0 cps
	Amplitude	12 mm
	Tilt Angle	3.0°
	Washwater	2.01/min.
	Feedrate	40 kg/h
	Feed density	28% w/w
Results	Product %Ash	1.7
	Reject %Ash	74.1
	Solids Rec. to Product %	57.9
Comments	Desliming the product in a 50 mm hydrocyclone further reduced ash content to only 7.5% with 88.4% solids recovery	

(b) FEED	Froth flotation product	1.33# Sulphur	16.3% Ash
MGS TYPE	C900 Laboratory / Pilot Plant unit		
REQUIRED	To reduce Sulphur content		
SETTINGS	Rotational Speed		308 rpm
	Shake Speed		5.0 cps
	Amplitude		12 mm
	Tilt Angle		4.0°
	Washwater		1.51/min.
	Feedrate		40 kg/h
	Feed density		30% w/w
Results	Product %Sulphur		0.87
	Reject %Sulphur		7.82
	Product % Ash		12.9
	Reject % Ash		63.5
	Solids Rec. to Product %		93.3
Comments	Approximately half the sulphur present is considered to be non pyritic or 'organic' and not recoverable by gravity processes.		

It is established beyond fact that this is a viable alternative to flotation and has additional important advantages like

* Much lower power consumption
* Elimination of reagent costs

* Much smaller foot print
* Better control on operation

Of course, each coal type has to be tested to determine the operating parameters and the extent of washing possible. In combination with hydrocyclones this is an alternative to consider. This is particularly true for small scale washing/ mobile washing plants being put up in different parts of the country.

CONCLUSION

Multi-gravity separator is an efficient piece of equipment for separation of fine particles even upto 3 micron. It has a number of design and operating variables which can be utilised to obtain optimum performance in recovering valuable minerals from waste streams as also for upgradation of concentrate. This equipment holds particular promise in India in recovering iron values from slimes and also for washing of coal fines. In both these areas, which are of great importance to Indian minerals sector, MGS could be cost effective technology.

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