Design of a Low Cost Magnetic Separator for Local Beach Sand Separation

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Abstract: Study had been carried out to identify beach sand minerals available locally. Principles, cost, and design feasibilities of industrially used magnetic separators were reviewed. As the best suit for requirements permanent drum magnetic separator was chosen. Software aided separator design was prepared based on reversed engineering concept, in the purpose of building fully functional prototype. Material selection was carried out. According to basic CAD drawing, prototype was built with necessary design adjustments. Magnetic drum is 20 cm (∅) × 40 cm, which yields a magnetic force field nearly 0.1 T. Prototype proven to separate ferromagnetic minerals in beach sand. Flow rate is nearly 15 kg/hour. Recovery of magnetite in silica-magnetite mixture is about 50-60% in single batch process. Using drum direction of rotation opposite to flow direction, highly magnetic susceptible material was removed with a higher recovery.

Keywords: Ilmenite, Magnetic Drum Separator, Prototype, Sri Lanka

1. Introduction

Beach sand placer deposits bear metallic or industrial ores such as; ilmenite, rutile, garnet, monazite, and hornblende.

Demand for the products from these deposits is very high because of their uniqueness.. Extraction and processing are relatively simple and inexpensive. Hence, the industry is very profitable (Minerals sands demand awaiting supply catch-up, 2011). Price of ilmenite can be varied within $100-1000/mt.ton according to purity (Ilmenite, Alibaba.com).

Local heavy mineral sand deposits include; Pulmoddai, Induruwa and Beruwala (rich in monazite, zircon and garnet) in the South-West coast, near the mouth of the Kelani River in Colombo, Negambo to the North of Colombo and Hambantota (garnet).Further in 1988, "Iluka Resources" had found a reserve around Puttalam estimated at 1.07 billion tons of sand with 7 to 8 percent heavy minerals mainly ilmenite. In 1980 and 1981, "Intersite BV" measured reserves of about 7.2 million tons of heavy minerals around the country (LBO, 2009).

To separate valuable minerals from beach sand typically dredging,

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floating wet plants, cyclones, spirals, magnetic separators, electrostatic, and gravity separations are used.
Common industrial practice is a combination of magnetic separators with high tension separators to separate Ilmenite and other constituents from beach sand. If magnetic separators could be manufactured locally, it will benefit the entrepreneurs by lowering the cost.

2. Literature Review

Local mineral sand constituents were reviewed and ilmenite was recognized as the most economical and abundant mineral. Literature on magnetic separator types result selecting "permanent magnet drum separator" for design and built because of simple design, uncomplicated mechanism, and material availability. Magnet theory and availability were studied, PC hard disc magnets were chosen.

3. Methodology

3.1 Designing Stage

Computer aided design (CAD) of the separator was created using "SolidWorks 2010" CAD software. Design mainly composes of a hopper, vibrating feeder, magnetic drum, framework, and controlling units.

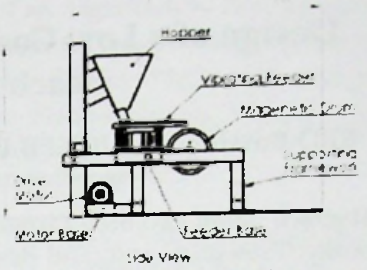

Figure 1-CAD Drawing

3.2 Construction Stage

Hopper - Zinc coated steel sheet made part to store sand. Flow rate is controlled by adjustable door. Hopper height can be adjusted by screw arrangement.

Vibrating feeder - Guide plate made of aluminum to guide sand flow onto drum at uniform thickness and the vibration intensity can be varied for range of flow rates. Dimensions are 17 × 13 cm. For accommodate vibration, feeder is attached to base via springs. Alteration of feeder plate angle is done by screw arrangement and an angle measuring instrument is installed to feeder. Feeder position could also be changed linearly perpendicular to axis of drum by nut and bolt arrangement.

Magnetic drum - Compose of axel, inner shell, magnet assemble, and outer shell. Axel, and inner shell rigidly connected and are stationary, inner shell position can be varied by nut-screw adjustment. Axel and outer shell is connected via bearings, such that outer core rotates independently. Outer core was made by non magnetic C304 stainless steel, with steel lids and

aluminum pulley for driving. Magnet assembly created according to check box array using Neodymium iron boron magnets in PC. Separation zone dimensions of drum are 20∅ ×40 cm.

Supporting framework– Framework is mainly L iron and bracket assembly which hold main design components and provide means of position adjustments.

Controlling units – speed controls vary Amperage/Voltage to the motors which run the magnetic drum and the vibrating feeders. Position controls change position of hopper, feeder, and drive motor. Angle controls change the angle of feeder and inner core. This enables optimizing of the equipment.

Drive motor – A 12V heavy duty DC motor was chosen to drive magnetic drum. It draws current of 15 A. Aluminum pulley which is smaller than pulley in magnetic drum was created and fixed to the axel of motor. M-31 belt run on the pulley.

Power source – for drive motor PC power supply (current up to 20 A) is arranged, 10 V and 0 V output lines are used.

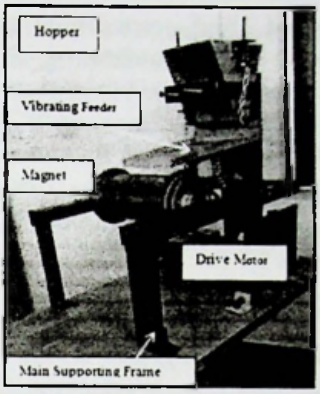

Figure 2-Fully Assembled Prototype

3.3 Testing

3.3 Intensity of Magnetic Drum

Freely suspended paper clip was used and the maximum distance from drum surface, where the paper clip was moved, considered as indicator of intensity.

3.4 RPM of Magnetic Drum

RPM of the magnetic drum was determined by measuring time taken to wind 15 m string, along the drum.

3.5 Effect of sample compositions

Known sample mixtures of magnetite and silica sand were run through the separator. With the use of hand magnet, magnetite in the concentrate and tailing was separated for recovery calculations.

3.6 Recovery of batch process

200 gram of each mixture of magnetite and silica sand were

prepared and concentrate was recycled in three batches.

4. Results

4.1 Intensity of Magnetic Drum

Maximum distance to attract the clip was 1.5 cm.

Table 1-Determination of RPM

4.2 RPM of Magnetic Drum

Average seconds per 15 m =16.67 s
Perimeter of drum = 0.393 m.

Average RPM of magnetic drum = (15×60)/ (16.67×0.393) = 137.38 rev/min

4.3 Flow rate

It was observed that to separate 500g of sample it took two minutes, hence flow rate of 15kg per hour

4.4 Effect of sample compositions

Table 2-Effect of Sample Composition

Sample No	Sample Ingredients (grams)		Magnetite output (grams)		Recovery %
	Magnetite	Silica	Concentrate	Tailing	
01	375	125	240.93	83.38	64.25
02	250	250	154.44	62.88	61.78
03	125	375	60.86	32.76	48.69
04	60	440	31.64	13.87	52.73

$$Recovery = \frac{magnetite\ in\ concentrate}{total\ magnetite\ in\ sample} \times 100$$

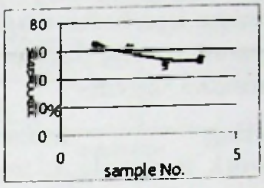

Figure 3-Recovery Variations with Composition

Trial	1	2	3
Time (seconds/15 m)	16	19	15

4.5 Recovery of batch process

Table 3-Batch Process Test Results

Trial	Magnetite Recovery grams	Recovery Percentage	Cumulative Recovery Percentage
1	110	55	55
2	38	42.2	74
3	19	38.8	83.5

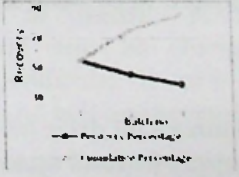

Figure 4-Recovery in Batch Process

4. Discussion

Objective of recovery calculation is to check whether the design is capable of separating ferromagnetic material, and it is successful.

But in economical point of view literature suggest primary concern

should be separating ilmenite because of value and abundance.

5. Conclusions

Design is successful in separating ferromagnetic material such as magnetite.

Design should be enhanced to separate paramagnetic material (Ilmenite).

Design enhancement could be achieved by using a design with larger number of magnet pieces, using magnets with larger strength, maximizing the induced field by arranging magnet pieces in arrangements designed with the use of software such as "Mag Net", combining permanent magnets with electro magnet, and using magnet poles arranged near the material flow.But similar design can be used in magnetite impurity removal in ilmenite separation plants.

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