Designing and Fabrication of a Low Cost Magnetic Separator for Beach Sand Separation

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Abstract: The heavy mineral deposits of Sri Lanka are widely spread over the coastal area. The mining industry is looking forward for an effective method for heavy mineral separation with the low cost equipments, which suit the local environment requirements to reduce the overheads. The major deposit at Pulmoddai, Trincomalee is a well known Illmenite deposit in Sri Lanka. The state company is currently engaged in processing using imported separators, specifically magnetic separators for ore dressing. But they are expensive and also difficult in operating, due to their outdated mechanism. In this context, the research project was launched to design and fabricate a low cost magnetic separator for beach sand separation. Through literature studies, an effort was made to add new features with innovative ideas to suit the purpose of the design. A prototype was fabricated in laboratory scale. The model was fabricated with a low cost in the laboratory is light weight, more portable, easier to assemble & dismantle. Future modifications are also possible with variable parameters. The separator was optimized for beach sand separation.

Keywords: Beach sand, Heavy minerals, Ilmenite, Magnetic separator, Mining industry.

1. Introduction

Currently, there is a large demand for beach mineral sands all over the world. Different methods are used to separate these valuable minerals. Wet and dry magnetic separation methods are the widely used (TiTan Metallurgical Services, 2010).

Sri Lanka is endowed with a variety of beach mineral sands. Spread over the coastal region of Sri Lanka, in many places. These natural concentrates are titanium-bearing mineral sands, with the Pulmoddai deposits on the north-east coast being the major deposit currently exploited (Premaratne and Rowson, 2002). Although local industries are using magnetic separators, there's no such design especially suited for local beach sand separation. It is timely to work on *"Designing and Fabrication of a low cost magnetic separator for beach sand separation"*. A ***laboratory scale dry magnetic separator*** was designed and modified as maimed by the research project. The design mainly consists of three sections, namely feeding silo, magnet and the body and the separating unit. The separator is powered by domestic current supply of 230V, 50 Hz.

The designed models worthy process is a batch process, for converting into a continuous process machine, the silo has to be fed continuously incorporating a

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mechanism for the continuous cleaning of the magnets. The main objective of the project is to design ***an easy to use low cost laboratory scale dry magnetic separator for local beach sand separation.***

2. Literature Review

Table 1: Budget

Expenses (SL Rs.)	Cost Real	Cost University
¼ " steel sheet	6,600	----
Wood ½" sheets	3,000	----
1" Steel bar	7,200	----
Gauge-3 Cu bar wires	2,400	2,400
for silo and stand	4,000	1,000
for two vibrators	2,000	2,000
1/8" Al sheet	4,000	----
4' SH rails	4,000	----
½" thread bar	2,100	2,100
4 wheels	2,000	2,000
Other services	10,000	----
Other material	4,000	----
3 Amp controllers	2,400	2,400
3 Switches	300	300
Total	**54,000**	**12,200**

Literature review was carried out on minerals, methods of sand separation, magnetic separators and silos. Depending on a survey, budget of the laboratory scale separator was proposed (Table 1).

3. Methodology

Selection of the magnetic separator by using literature (FERRO FILTER, n.d.) was followed by the fabrication of the prototype. Metal/wood parts cut in according to the dimensions and fabrication finalised.

3.1 Designing Stage

Optimum parameters following the literature survey (Wills and Napier, 2006) for the *silo, induced magnets* and *separating unit* were selected. A proto type of the separator was made prior to the fabrication.

3.2 Production Stage

Prototype was followed, but due to lack of materials and problems encountered in fundamentals of the magnets, mechanism of the separator and economical feasibility, variations introduced resulted in better solutions. Design and fabrication of the separator was carried out enabling easy dismantling which made much easier handling. A silo with a sliding door was made to control the feed. 45^0 pointed magnets were made out of mild steel (Wills and Napier, 2006). 3.6 kg of gauge 21 Copper wires was used with 1545 turns made in one core for the 230V (DC) supply. The frame members were made of wood (Figure 1). The separating unit was made of perspex with a separating plate, vibrator, hopper and the exhaustion tubes. It could be rotated horizontally enabling the downward flow of sand by gravity and vertically to enhance segregation. The structure was made of steel and wheel-mounted for easy transportation (Figure 2).

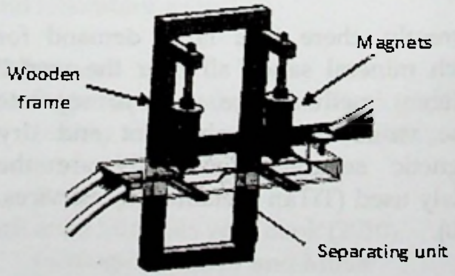

Figure 1: Magnets and the frame

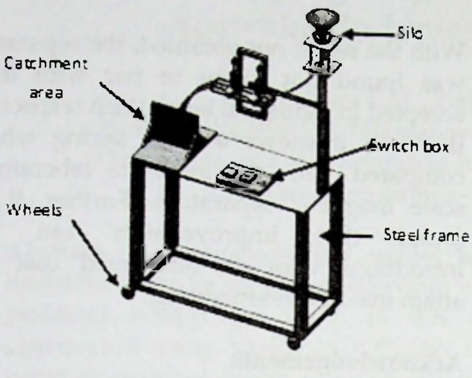

Figure 2: Designed separator

3.3 Post Production Stage

Experiments were conducted with dried samples (moisture $4^0/_0$) by varying the horizontal angle, vertical angle and the voltage of the magnets. Finally a cost analysis was done.

4. Results and Discussions

The separator was tested with beach mineral sand samples, by varying above mentioned parameters to find out the maximum operating values of those parameters. Sundried samples were used to reduce moisture (moisture $4^0/_0$), which influences cohesion. Efficiency of the machine was checked with materials with known values.

4.1 Silo

To find out the silo efficiency, a 500g sample of dried beach mineral sand was tested with time measurements for emptying the silo with and without vibration.

Without the vibration = 36.3s
With the Vibration = 48.4s

$$\text{Vibration Efficiency} = \frac{(48.4 - 36.3)}{36.3} \times 100 \qquad (1)$$

$$= 33.3\ {}^0/_0$$

Without vibration the sand flows under gravity and may be subjected to cohesion, but with vibration, the sand moves with a general speed after being sorted and preventing cohesion.

4.2 Horizontal Angle

It is directly related to the flow of sand inside the separating unit by gravity. Experiments were carried out to find the minimum horizontal angle keeping the vertical angle zero and using dried samples that would start to move downwards inside the separating unit in both cases with and without vibration. The Coefficient of Friction (μ), the effective Coefficient of Friction (μ_e) and the increase in anti- cohesion (E) due to the vibration was calculated (Wills and Napier, 2006).

Table 2: Horizontal angle readings

Mineral	Without Vibration		With Vibration		E (%)
	A	μ	A	μ_e	
Garnet	22	0.40	4	0.07	82.7
Silica	25	0.47	6	0.10	77.4
Sand	**27**	**0.51**	**8**	**0.14**	**72.4**
Ilmenite	27	0.52	10	0.18	66.1
Zircon	30	0.58	10	0.18	69.5
Rutile	32	0.62	12	0.21	65.9

$$\mu = \tan \alpha \qquad (2)$$

$$E = \frac{(\mu - \mu_e)}{\mu} \times 100 \qquad (3)$$

The above table (Table 2) shows that the minimum horizontal angle for **beach sand is 8°** and the increase in anti- cohesion (E) by the vibration for down flow is **72.42%**.

4.3 Vertical Angle

The optimum vertical angle tested for the segregation was at **horizontal angle of 8°**, without magnetism. The vibration can separate heavy particles in to the upper flow by means of segregation.

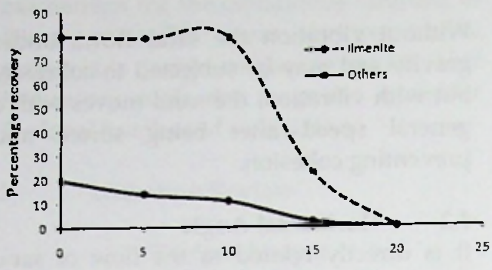

Figure 3: Vertical angle vs mineral recovery in upper flow

The optimum vertical angle was fond to be 5^0 - 10^0 (Figure 3). So the magnetic separation can be enhanced using the segregated products, when separating.

4.4 Magnets

The performance of the magnets with the varying voltage was tested.

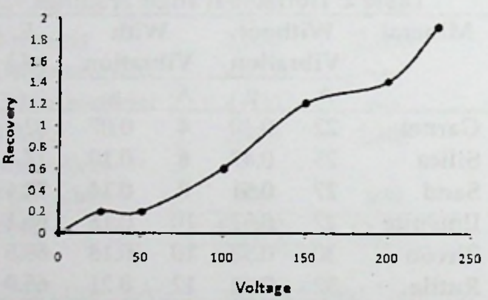

Figure 4: Voltage vs Ilmenite recovery

Both point magnets could collect 2g of Ilmenite per run with a voltage of 230V (Figure 4). A batch run is about 5 minutes, which gives a separation of 24g per hour. The efficiency is controlled by the feed rate.

4.5 Cost Analysis

Using materials from the University premises gave a cost of Rs. 13,000. In industrial environment the cost will be around Rs.25,000, due to high material cost, fabricating cost, labour fee, etc.

5. Conclusions

With the result not obtained, the separator was found not to be in par with that accepted in industrial level. With respect to the cost, it shows a clear saving when compared with the available laboratory scale magnetic separators. Further, it is found that improvements can be introduced with an additional cost to attain maximum separation.

Acknowledgements

The authors are thankful to Dr (Mrs.). S. Karunarathne, Head, Department of Earth Resources Engineering for facilitating the research project and Dr. A.K.M.B. Abeysinghe, Coordinator - Research Project for coordinating the research project and Mr. Sarath Perera, technical officer and Mr. S. D. Sumith, laboratory attendant of mineral processing laboratory, Department of Earth Resources Engineering for assisting in the laboratory work. Without which the success achieved would have been impossible.

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