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Recovery of Heavy Minerals from Hydrocyclone Underflow Discharge of the Boralesgamuwa Kaolin Refinery

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Abstract

This paper presents the process of recovering heavy minerals from the hydrocyclone underflow discard at the Boralesgamuwa Kaolin Refinery. Heavy minerals such as ilmenite, rutile and monazite are among the materials present in the hydrocyclone underflow.

Introduction

China Clay or Kaolin (chemical formula $Al_2O_3.2SiO_2.2H_2O$) is the chief raw material used in the manufacture of high quality domestic pottery. Kaolin deposits are found as a sedimentary formation at varying depths in Boralesgamuwa area. These sedimentary deposits are associated with quartz, mica, feldspar and also with heavy minerals such as ilmenite, rutile and monazite. The mining and the processing of Kaolin are being carried out by the Ceylon-Ceramic Corporation, at its Clay Refinery in Boralesgamuwa.

The entire process of refining (see Figure 1) is a wet physical concentration process, in which the clay mineral is removed from gritty and foreign materials by water washing using gravitational techniques. No chemical processes are invoved at any of the stages. After removing associated gritty particles and other non-clay substances from the raw Kaolin, China Clay with high purity is recovered. At the Boralesgamuwa refinery clay substance is processed mainly for the industries such as ceramic, pharmaceutical, paint and paper while the waste sand (coarse) is sold for masonary work and the balanced diverted into the used up pits for reclamation.

At the Refinery, equipment such as Hydrocyclones, fine sand collectors and settling tanks are used for refining and concentration of clay. The non-clay materials together with small amounts of clay are discharged through the underflow nozzles of the hydrocyclones and eventually discarded.

Although the percentage of heavy minerals in raw Kaolin is very low, it is relatively high in the rejects from the hydrocyclones.

When a sample of rejects is allowed to settle in a measuring cylinder, a layer of ilmenite can be observed in the cylinder base as a black coloured zone.

In this paper, writers briefly discuss the attempts made by them to separate heavy minerals from rest of the materials in the hydrocyclone underflow discharge.

Uses of ilmenite, rutile and monazite

Rutile (TiO_2) is at least 95% titanium oxide whilst ilmenite ($FeTiO_3$) contains between 50-60% titanium oxide. Titanium is a late comer into the field of usefulness. The Titanium paints consist of pure titanium oxide as a mineral base. This is also known as an opecifier.

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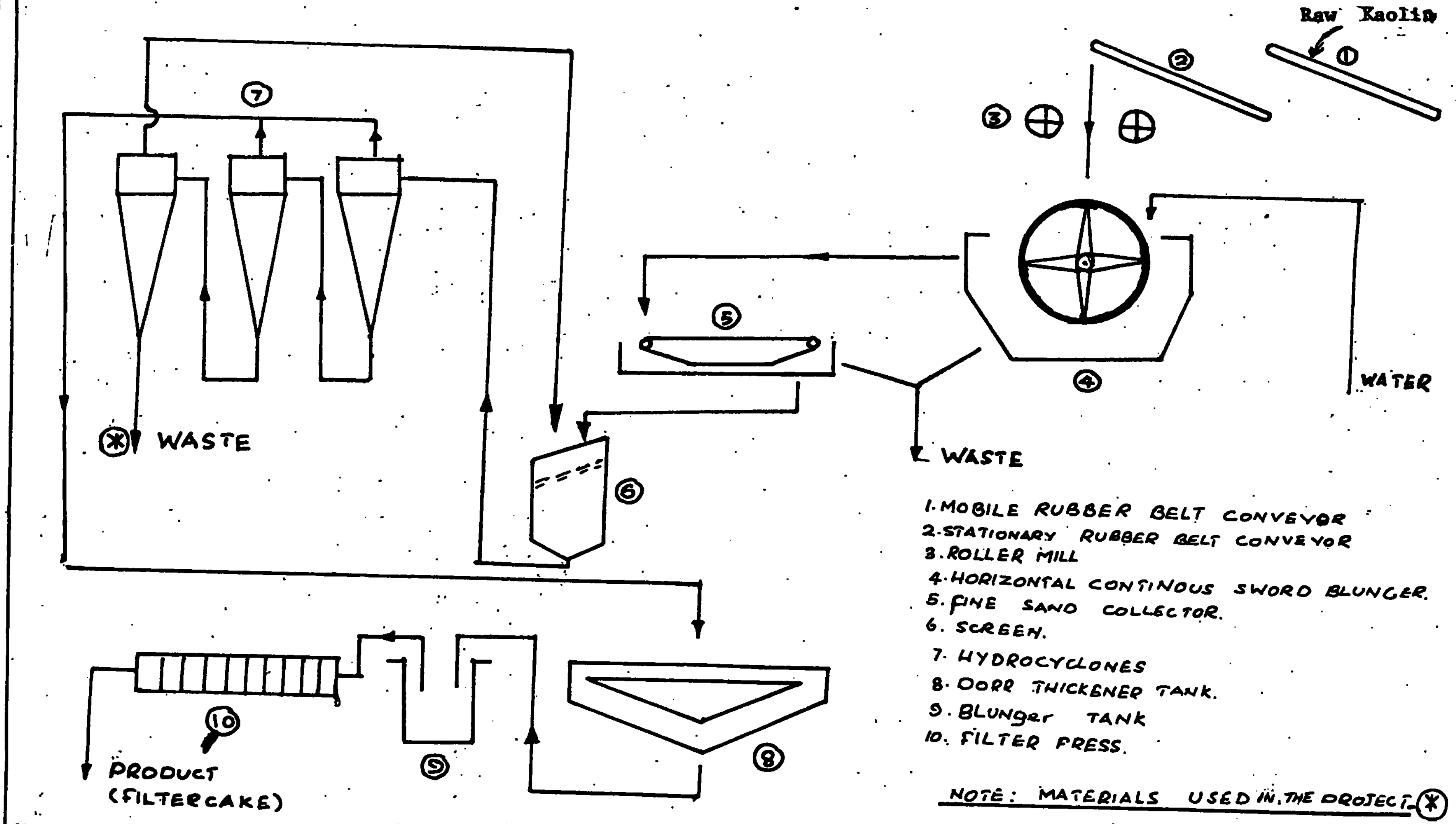
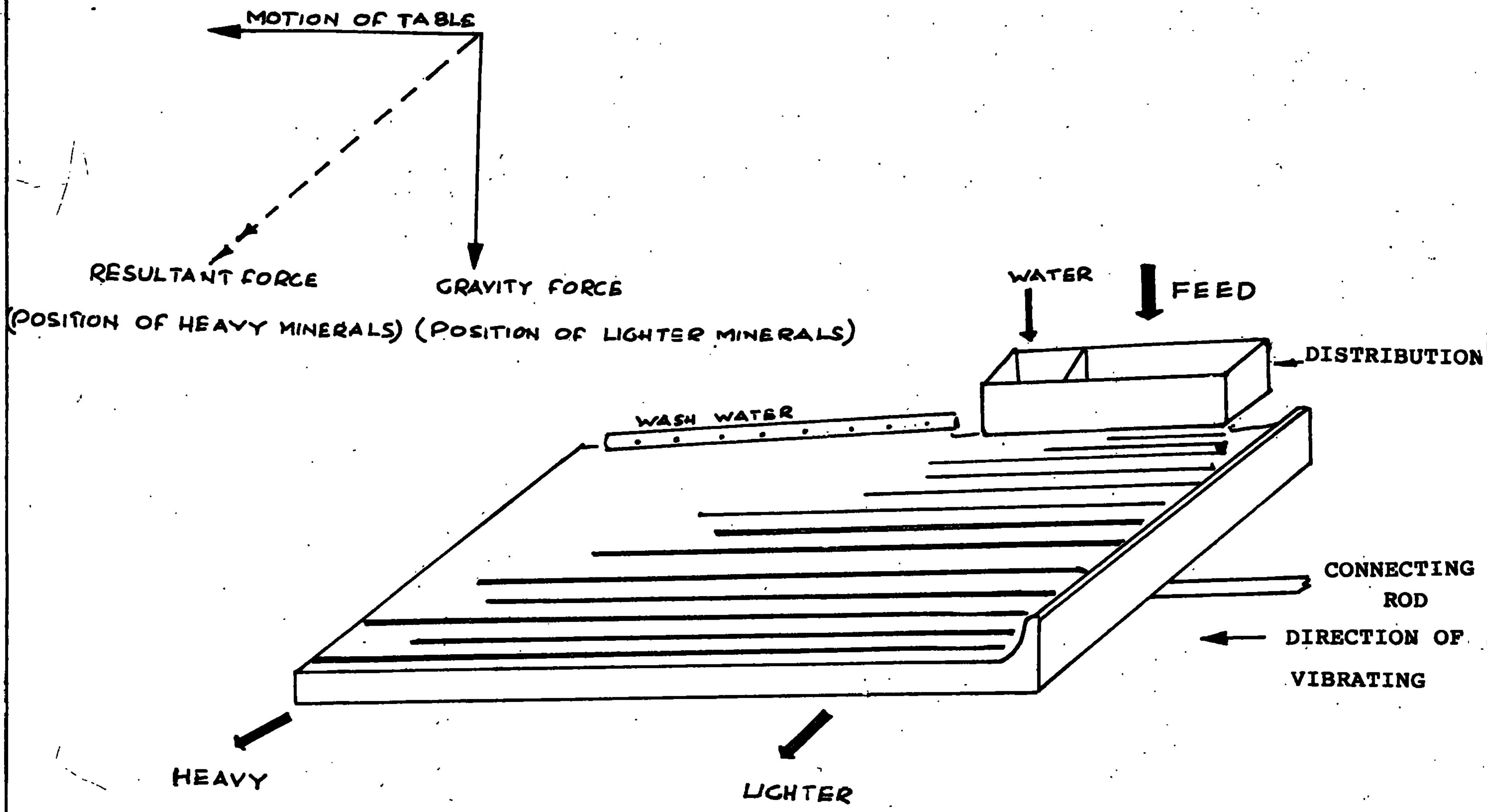


FLOW SHEET – BORALASGAMUVA KAOLIN REFINERY

Fig. 1



WILFLEY TABLE (LABORATORY TABLE)

Fig.2

Metallurgically ferro-carbon titanium is alloyed with steel to make high speed steels. Metallic titanium when produced commercially processes unusual properties for many applications, particularly in the aircraft industry. The presence of radio-active elements in monazite sands is well known. They contain between 8.9 to 9.2% oxide of thorium (ThO_2), and small amounts of several other elements.

Procedure adopted to separate heavy minerals from rest of the materials

The heavy minerals such as, ilmenite, rutile and monazite were separated from the rest of the materials using a Wilfley table and a frantz-isodynamic separator. The volumetric and the mass flow rates of the hydrocyclone underflow were estimated using a graduated measuring cylinder, specific gravity bottle and a stop watch. Specific gravity of heavy mineral is above 4.5 whilst that of the rest of the materials (in the hydrocyclone underflow discharge) such as quartz, feldspar and mica etc. is below 2.5. This difference in specific gravity was exploited to effect the separation using a Wilfley table. Furthermore magnetic properties of heavy minerals are also quite different from those of the rest of the materials. This difference in magnetic properties viz. magnetic susceptibilities, was the basis of magnetic separation in the next stage.

Wilfley Table Separation

Use of Wilfley table (Figure 2) is one of the easiest and most economical methods for separating heavy minerals from lighter ones. The process makes use of a flowing water film on a riffled deck, which is being given a toggle action by means of a special attachment. Water and the sand mixture is fed on to the table at the feed end when the table is in operation, it is slanted so as to obtain maximum separation. When the minerals have different specific gravities and colours, the degree of separation can be monitored by the naked eye. The visual monitoring was possible and used in the project under investigation.

Specifications of the Wilfley table:

Length of the deck	= 1.016 M
Breadth of the deck	= 0.457 M
Normal Speed	= 250-350 strokes/minutes
Maximum inclination	= 25 to the horizontal
Deck material	fibre glass

FRANTZ - ISODYNAMIC SEPARATION

Magnetic separator exploits the difference in magnetic properties of different minerals to effect the separation of magnetic and non-magnetic portions. In general, heavy minerals are magnetic and can be separated from non-magnetic materials such as quartz, feldspar and mica, using a Frantz-isodynamic separator. (Fig. 3). It is a sophisticated device which allows fractionation of even weakly magnetic materials.

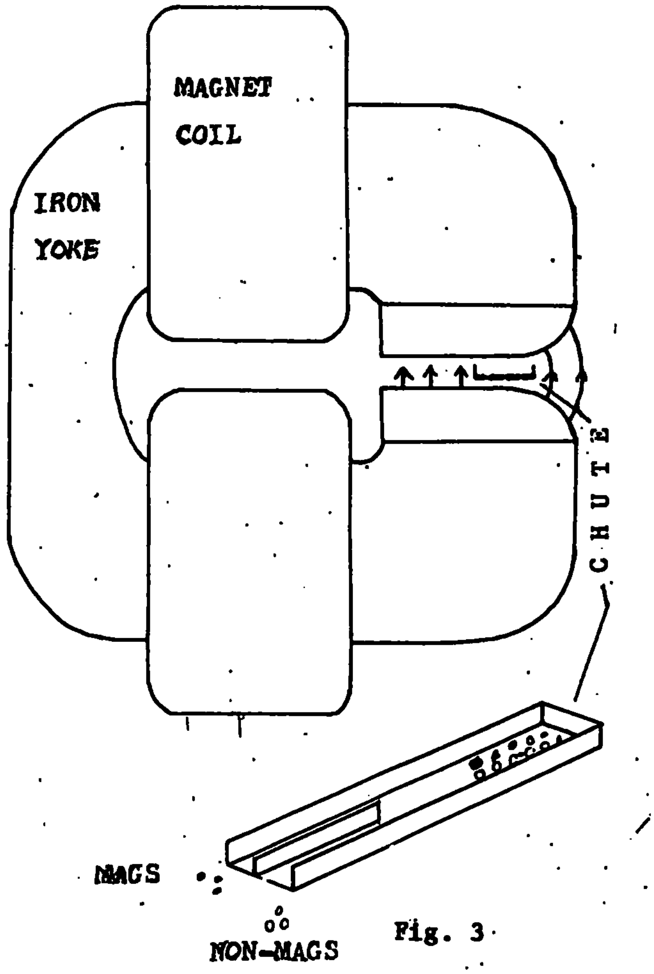


Fig. 3

Frantz-Isodynamic separator

Specifications of the Frants - Isodynamic Separator :

Model	= Frantz F -1
Voltage supply	= 115v at $50H_z$
Current	= 2.5 amp.

FLOW SHEET OF THE PROCESS

Hydrocyclone underflow discharge

↓

Wilfley Table

↓

Drying

↓

Frantz - Isodynamic Separator

↓ Magnetic materials (ilmenite etc.)

↓ Non-magnetic materials (Quartz etc.)

Results

MASS AND VOLUMETRIC FLOW RATES OF THE HYDROCYCLONE UNDERFLOW

Weight of 50 cc bottle filled with water = 70.397 gm

Weight of 50 cc bottle with materials of the underflow discharge (Reading taken on an average working day)

Tims	Wt. of bottle with samle(gm)	Wt. of solids (gm)
1. 8 am	74.517	4.120
2. 9 am	75.417	5.020
3. 10 am	74.101	3.704
4. 11 am	77.640	7.243
5. 2 pm	75.397	5.00
6. 3 pm	75.647	5.25
	Average =	5.056 gm

verage volumetric flow rate during his period = 664 ml/sec.

Wilfley table separation - Sample 1

Weight of concentrate	= 230 gm
Weight of midlings	= 590 gm
weight of gangue	= 380 gm
Total	=1200 gm

Sample 2

Weight of concentrate 1	= 500 gm
Weight of concentrate 2	= 750 gm
Weight of midlings	= 550 gm
Weight of gangue	=3000 gm
Total	=4800 gm

Frantz-isodynamic separation

Sample 1

	Magnetic Portion gm	Non Magnetic Portion gm
Concentrate (50 gm)	24.6	24.4
Midlings (50 gm)	9.2	40.7

Sample 2

Concentrate 1 (50 gm)	30.3	28.7
Concentrate 2 (50 gm)	8.0	41.3
Midlings	2.8	47.2

Analysis

Using simple arithmetic, weight of materials discharge in one day (in 6 working hours) = 1.45 MT

Amount of heavy minerals in sample 1 =18.5%

Amount of heavy minerals in sample 2 = 9.5%

Average amount of heavy minerals

$$= \frac{18.5 + 9.5}{2} = 14.0\%$$

Amount of heavy minerals that can be collected in a day

$$= \frac{14.00 \times 1.45}{100} \text{ MT} = 203 \text{ kg}$$

Conclusion

Our experimental results show that approximately 200 kg per day of heavy minerals concentrate can be obtained from the hydrocyclone underflow discharge of the Boralesgamuwa clay refinery. Services of one person is sufficient for this purpose and no chemicals are needed. Refining cost involves the cost of electricity and labour only.

Acknowledgements

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