PLACER DEPOSITS OF BRAHMAGIRI COAST, ODISHA - A NEW RESOURCE FOR INDUSTRIAL HEAVY MINERALS

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ABSTRACT

Characterization and beneficiation studies have been carried out on Brahmagiri placer deposits of Puri, Dist., Odisha. The studies show that this deposit contains potential amount of heavy minerals. The dune sands contain higher heavy minerals than that of beach sand. One of the dune sand samples collected from this deposit shows heavy mineral content of about 29% also. A composite sand sample is prepared and heavy mineral recovery is studied from this by using gravity table. During recovery of heavy minerals both fresh and sea water are used to see their effect on grade and recovery of concentrate. Sea water rougher gravity table data shows better results than fresh water rougher gravity table. The gravity table study of composite sample shows a yield of 14.8% with a grade of 91.2% and 93.2% recovery.

Key words: Placer Deposits, Beach Sand, Dune Sand, Characterization, Total Heavy Minerals, Gravity Units

1. INTRODUCTION

The beach and dune placer sands in India contain heavy minerals like ilmenite, rutile, garnet, zircon, monazite and sillimanite, which are derived from parent rocks by weathering process and transported by wind and rivers. Ilmenite-rich major beach and dune sand deposits occur in the coastal stretches of Kerala (Chavara), Tamil Nadu (Manavalakurichi, Midalam, Vayakallur), Andhra Pradesh, Maharashtra and Odisha. The coastal sand of Odisha also possesses more or less same minerals with variable mineral composition all along the coastline of 480 kms and has a beach placer heavy mineral resource of about 128 Mt (5% to 30% grade) and has a beach placer heavy mineral resource of about 128 Mt (5% to 30% grade) and shares about 12% of country’s heavy mineral resource. In spite of such large deposits in this State, only one mineral sand plant operates at IREL, Chhatrapur, Department of Atomic Energy, India, gives an formation about potential resource of heavy mineral deposits all along Brahmagiri to Puri coast covering with an average width of 1.91 km accounting for ilmenite deposit alone 37.98 million tons and the heavy minerals deposit ranging from 1.73% to 24.78% with an average grade of 5.76% up to the depth of 18m, but work related to R&D on beneficiation to recover heavy minerals has not been attempted so far [1-5]. Brahmagiri deposit is bounded by latitude 19° 47’ N and longitude 85° 38’ E and is shown in Fig 1.

An attempt is made in the present investigation is specially to study the heavy mineral distribution all along the Brahmagiri to Puri coast. In addition to this, it is also aimed to recovery total heavy minerals by using laboratory gravity tables with natural fresh water and sea water media.
2. MATERIALS AND METHODS

At first instance, samples were collected in Bramhagiri area from beach and dunes covering above 2 kms distance by a grid pattern with an equal intervals of 700 meters. At each grid around 100 kgs samples were collected and from which representative samples of each 10Kg were collected by coning and quartering. These beach placer sand samples were named from 7C to 20 C and dune sand samples were named from 7D to 20 D.

All collected samples were washed with fresh water before characterization studies to remove the salt content. The samples contain around 0.1 % salt. Physical characterization such as size analysis, true density, bulk density and angle of repose of all the samples were carried out using standard sieves. The d80 percent passing size of each sample has been calculated from the size analysis data. Heavy liquid separation studies were carried out using bromoform (specific gravity 2.89 g/cm³) to determine the total heavy minerals present in the feed samples.

After complete physical characterization study mineral separation studies were carried out on a composite sample using a laboratory model gravity table (Type Concenco, The Diester Concentrator Company Ltd, Model No. Denver 13A). The composite sample was prepared by mixing three beach and three dune sand samples (7C, 14C, 19C, 7D, 10D and 12D). Physical characterization was done for the composite sample. Sink-float study was also carried out for each size fraction of the composite sample. Gravity table was used for beneficiation studies by using fresh and also sea water. The operating conditions used in the present study were feed rate 20 kg/hr, wash water 3 liter/min and deck angle 1.4°. Heavy liquid separation studies were carried out using bromoform (specific gravity 2.89 g/cm³) for determining the total heavy minerals grade of concentrate and tailing samples.

3. RESULTS AND DISCUSSION

The placer sands of beach and dune are subjected to physical characterization including size analysis, density as well angle of repose and the data are given in Table 1. It is observed that the d80
passing size is varying from 210 μm to 510 μm for beach sand samples and from 350 μm to 450 μm for dune sand samples.

**Table 1:** Typical physical properties of some of the Beach and Dune sand samples of Brahmagiri coast

| Sl.No | Sample name | Angle of repose (°) | Density, [g/cm³] | THM, % | d80 passing size, μm |
|-------|-------------|---------------------|------------------|--------|----------------------|
|       |             |                     | Bulk             | True   |                      |
| 1.    | 7C          | 46.02               | 1.548            | 2.72   | 15.21                | 340        |
| 2.    | 8C          | 29.31               | 1.474            | 2.71   | 8.95                 | 370        |
| 3.    | 10C         | 33.4                | 1.603            | 2.66   | 4.16                 | 500        |
| 4.    | 12C         | 34.41               | 1.625            | 2.7    | 9.75                 | 415        |
| 5.    | 15C         | 43.49               | 1.493            | 2.7    | 10.44                | 335        |
| 6.    | 19C         | 31.7                | 1.511            | 2.73   | 13.95                | 310        |
| 7.    | 20C         | 39.8                | 1.463            | 2.7    | 7.27                 | 325        |
| 8.    | 7D          | 29.85               | 1.694            | 2.78   | 17.78                | 370        |
| 9.    | 8D          | 29.73               | 1.791            | 2.75   | 17.54                | 450        |
| 10.   | 10D         | 27.74               | 1.75             | 2.82   | 19.14                | 400        |
| 11.   | 12D         | 29.05               | 1.775            | 2.83   | 20.33                | 410        |
| 12.   | 15D         | 29.51               | 1.69             | 2.79   | 16.98                | 460        |
| 13.   | 17D         | 30.95               | 1.854            | 2.93   | 29.4                 | 350        |
| 14.   | 20D         | 30.62               | 1.725            | 2.73   | 13.88                | 390        |

The d80 passing size values vs. true density, THM content are shown in Figures 2 to 5. Figure 2 and 4 represent the data for the true density of beach and dune sand minerals with d80 passing sizes. It can clearly be seen from Figure 2 and 4 that with increase of particle size, the true density of minerals is falling down. These experimental data are justified, as with increase in particle size the concentration of total heavy mineral content decreases as well as the percentage of gangue minerals increases, which is having specific gravity less than 2.6 gm/cc. The Figure 3 and 5 shows the variation of d80 passing size with total heavy mineral content for beach and dune sand samples. Both the graphs show decreasing trend i.e. with increase in d80 passing size, the THM % decreases. This is because; the THM is concentrated in finer fraction.
Figure 6 shows the histogram presenting the THM content of beach and dune sand samples. It is observed in all cases that the dune sand samples contain higher THM than beach sand samples.

Figure 7 and 8 present the size analysis data for beach and dune sand sample. In Figure 7, it is observed that weight % of -425μm + 250 μm fractions are more in almost all samples. The Figure 8 also shows the similar type of behavior for dune sand samples. The next highest weight % lies in the fraction - 250 μm+212 μm for both beach and dune sand samples.

The physical characterization of the composite sample is presented in Table 2. The THM content is 14.5 % and the d₈₀ passing size is 370 micron. The close size sink-float study reveals that maximum percentage of THM i.e. 4.9 % lies in -150+75 micron fraction (Table 3).

The rougher gravity table operation was done using sea water at different operating conditions obtained for fresh water to assess the effect of medium on separation. The results of sea water gravity table are given in Table 4. Under the conditions Wash water 2.5 lit/ min, pulp density 15%, deck angle 1.3°, the rougher gravity table operation with sea water shows grade of 61.3% and recovery of 93.1 %. Then under the conditions of Wash water 3 lit/ min, pulp density: 20%, deck angle 1.4°, the rougher gravity table shows grade of 63.8 % and recovery of 96.4 %. Rougher gravity table operation under the conditions Wash water 3.5 lit/ min, pulp density: 25%, deck angle 1.5°shows grade of 63.0% and recovery of 95.3 %.
Table 4: Results of rougher spiral concentrator using sea water and fresh water as medium

| Conditions                        | Sea water | Fresh water |
|-----------------------------------|-----------|-------------|
| Grade, %                          | Recovery, %| Grade, %    | Recovery, %|
| Wash water 2.5 lit/min, pulp density 15%, deck angle 1.3° | 61.3 | 93.1 | 59.8 | 92.3 |
| Wash water 3 lit/min, pulp density: 20%, deck angle 1.4° | 63.8 | 96.4 | 61.0 | 95.1 |
| Wash water 3.5 lit/min, pulp density: 25%, deck angle 1.5° | 63.0 | 95.3 | 60.2 | 94.1 |

In all cases sea water rougher gravity table produces better results than fresh water rougher gravity table. It is expected that with sea water as the separation medium, the grade and recovery of heavy minerals will be better than that of fresh water. It is because concentration criterion ‘C’ achieved for separation of heavy minerals is better in sea water than that for fresh water. The concentration criterion ‘C’ is defined as an indication whether a given ore is amenable for processing by gravity methods or not. It is expressed as $C = (d_h - d_m)/(d_l - d_m)$ \[Eq 1\] Where, $d$ = specific gravity and Subscripts h, l and m = heavy mineral, light mineral and medium respectively. If this value is less than 1.25 practical separations is substantially impossible.

Then the composite sand sample with 14.5 % THM is subjected to number of stages of gravity table to recover THM under the optimized conditions (Table 4) of wash water 3 lit/ min, pulp density 20%, deck angle 1.4°. The rougher gravity table is again subjected to cleaner and recleaner gravity table to achieve a THM of more than 91.2 % grade. The cleaner and recleaner tailings are subjected combinely to three stages of scavenging gravity table operations to recover values from it. The tailings from all scavenging circuit are rejected. The flowsheet with mass balance is presented in Figure 9.

4. CONCLUSIONS

From the study on the assessment on characterization of physical properties of beach placer deposits of Puri district, Odisha and its application on gravity units to recover heavy minerals for metallurgical applications, the following conclusions are drawn:

- The true density of all beach placer and dune placer samples decreases with increase in $d_{80}$ passing size
- The composite sample prepared from beach and dune sand samples contain 14.5 % THM.
- Sea water rougher gravity table shows better results than fresh water rougher gravity table.
- The gravity table study shows a yield of 14.8%, grade of 91.2 % and recovery of 93.1 %.
Fig 9. Flowsheet with material mass balance for recovery of total heavy minerals from placer beach sand

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