New Technology “Flotation to Form Agglomerates and Magnetic Separation” Allows Great Breakthrough for World Low-Grade Light Rare Earth Ores

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Rare earth resources are relatively scarce worldwide, but their global consumption is increasing year-by-year. At present, China has about 36% of the global rare earth reserves, but provides 90% of the world’s supply, which has generally met world demand and promoted the development of the world economy. In order to continuously and stably supply rare earths to international markets, the Chinese Government has financially supported the Institute of Multipurpose Utilization of Mineral Resources within the China Geological Survey to study the utilization of low-grade rare earth ores. Following many years of experimental research, the project has developed a new technology entitled “Flotation to Form Agglomerates and then Magnetic Separation”, which will bring a technological revolution to the world’s light rare earth ore dressing.

In 2009, the project team researched how to separate the Muluo REE deposit in the Panxi area of Sichuan Province (Xiong and Chen, 2009). A heavy-duty mine operated this deposit, and the predicted rare earth reserves (REO) exceed 5 million ton. The ore minerals are simple, with the main RE minerals comprising hamaritite and bastnasite, with small amounts of parsite. The main gangue minerals are calcite, fluorite, and feldspar, with minor amounts of quartz, barite, pyrite, galena, sphalerite, chalcopyrite, siderite and aegiritte-augite, occasionally with brannerite. The main RE mineral hamaritite has grain sizes ranging from 0.1 to 1.0 mm, with a few of 0.01 to 0.05 mm; it is light yellow in color, and distributed in calcite veins or between quartz grains as granular crystal textures. The chemical composition of the raw ores is listed in Table 1.

The pretreatment for the magnetic and gravitational separation and flotation desliming technology eliminates the influence of fine-grained gangue minerals on the flotation, which simplifies the doses of the subsequent rare earth flotation and the process structure. The REO grade of the removed slime is 1.91%, with a loss of REO of only 2.93%. By using modified hydroximic acid Wr as an rare earth mineral collector and adopting water glass as a calcic gangue mineral inhibitor, this project adopted flotation circuit tests of “one roughing, twice selection and twice scavenging” to obtain RE concentrates at an REO grade of 62.10 with a REO recovery rate of 86.98%. This process flow and reagent dosage has thus realized good floatation indices.

In 2014, the project team further studied the separation and purification of a very low-grade rare earth deposit (Zeng et al., 2014). The main RE mineral is hamaritite, with associated fluorite, strotntianite, celestite and barite. The gangue minerals include calcite, feldspar, muscovite, clay minerals, quartz, and small amounts of pyrite, galena, magnetite, pyrrhotite and chalcopyrite. The main RE mineral hamaritite has grain sizes ranging from 0.5 to 0.01 mm, which is distributed independently or is associated or wrapped with fluorite, calcite, barite and celestite. The chemical composition of the raw ores is listed in Table 2.

Magnetic separation was first used to upgrade the REO grade of raw ores to 1.98%, removing 68.82% of the tailings. Water glass was then adopted as an inhibitor of the gangue minerals, and modified hydroximic acid Wr was used as a rare earth collector; flotation was done in weakly alkaline conditions (pH=7.5~8.0), and concentrates with REO grade of 30.06% and a recovery rate of 52.77% were obtained. Magnetic separation was further utilized to purify the concentrates, effectively separating hamaritite and the non-metal minerals. Through the combined technology of “pretreatment of magnetic separation–flotation–purification through secondary

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**Table 1 Main chemical composition of the raw ores (%)**

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<thead>
<tr>
<th>Element</th>
<th>REO</th>
<th>SiO₂</th>
<th>CaO</th>
<th>BaSO₄</th>
<th>Fe₂O₃</th>
<th>Al₂O₃</th>
<th>MgO</th>
<th>CaO</th>
<th>S</th>
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<tr>
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<td>3.61</td>
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<td>1.14</td>
<td>1.78</td>
<td>0.31</td>
<td>3.40</td>
<td>3.21</td>
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</tbody>
</table>

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Table 2 Chemical composition of the raw ores (%)

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<tr>
<th>Element</th>
<th>REO</th>
<th>SiO₂</th>
<th>Fe₂O₃</th>
<th>MnO</th>
<th>Al₂O₃</th>
<th>MgO</th>
<th>CaO</th>
<th>K₂O</th>
<th>Na₂O</th>
<th>CaF₂</th>
<th>SrO</th>
<th>ThO₂</th>
<th>RbO</th>
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<th>Pb</th>
<th>Ba</th>
<th>S</th>
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<td>48.97</td>
<td>4.99</td>
<td>0.16</td>
<td>15.37</td>
<td>1.80</td>
<td>4.57</td>
<td>2.95</td>
<td>2.58</td>
<td>4.61</td>
<td>3.48</td>
<td>0.006</td>
<td>0.022</td>
<td>0.29</td>
<td>0.11</td>
<td>0.85</td>
<td>1.44</td>
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</table>

separation”, rare earth concentrates with REO grade of 60.12% and recovery rate of 30.01%, and secondary concentrates with REO grade of 18.12% and recovery rate of 22.76% were ultimately available, all of which has realized the development and utilization of low-grade rare earth ores.

In 2014, a plant with 2500 tons output per year was successfully operated in a mine. Supposing the yearly processed raw ores are 0.9 million tons, the use of the new technology will produce more than 11,000 tons of rare earth concentrates at REO grade of greater than 60% per year. The annual output value will increase by about 0.33 billion Yuan. Until now, the project has used the new technology for Australian rare earth ores, which has greatly increased the recovery rate and concentrate grade. During research on low-grade rare earth ores in the USA, the enrichment ratio of RE minerals has reached 100:1. Moreover, the whole beneficiation and metallurgy process has realized the comprehensive utilization of a variety of minerals.

Acknowledgement

Thanks are given to Susan Turner for her improvement of English.

References