ERMS Roasting Process: Technology for the Separation of High Grade Ilmenite from Murray Basin Heavy Mineral Concentrate.

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1. Introduction

Heavy mineral concentrate (HMC) produced from many heavy mineral sand deposits, including those in the Murray Basin, contains deleterious minerals such as chromite, garnet and minor impurities such as uranium, thorium and phosphorus. If conventional high tension and dry or wet magnetic separation techniques are used the chromite, minor garnet and other impurities report with ilmenite, often making the concentrate unsaleable or unusable. Further magnetic treatment of chrome-bearing ilmenite concentrate does little to lower the chrome content and results in significant ilmenite losses.

Ilmenite concentrate produced by magnetic separation can be roasted in a fluid bed reactor to enhance the magnetic susceptibility of ilmenite with little effect on any other mineral in the concentrate. Roasted ilmenite can then be separated using a simple low-intensity magnetic circuit to produce a clean ilmenite product suitable for slag making, acid leaching or other upgrading processes. Roasted ilmenite is not suitable for the sulfate process.

This paper examines the effect of fluid bed roasting on both fresh and weathered or leucoxenised ilmenite. The term “fresh” means an ilmenite in which the majority of iron content occurs as FeO, whereas in a “weathered” the majority of the iron occurs as Fe_2O_3.

2. Fluid Bed Roasting of Ilmenite

Fluid bed roasting involves feeding an ilmenite concentrate and fuel into a bed fluidised with air. Many investigators have reported an increase in the magnetic susceptibility of roasted ilmenite over unroasted ilmenite[(1,2,3,4)]. The increase in magnetic susceptibility is caused by changes in grain morphology resulting from the interaction between ilmenite ($FeO.TiO_2$) and hematite (Fe_2O_3) during thermal processing at between 800°C and 900°C. At these temperatures iron diffuses to the grain surface, where the oxidation state is altered to produce an artificial magnetite shell.

Standard fluid bed roasting aims for complete combustion of the fuel by ensuring an excess of oxygen is maintained in the atmosphere of the bed. As practised with fresh ilmenite, standard fluid bed roasting initially magnetises the ilmenite rapidly, but as roasting continues the magnetic susceptibility drops as the reaction reaches an equilibrium approaching hematite, as shown in Figure 1. Standard roasting systems can only achieve high ilmenite magnetic susceptibilities with fresh ilmenite and clearly residence time is critical. Residence time in a continuous fluid bed roaster follows an approximate Gaussian distribution. Although the average residence time can be adjusted with feed rates or bed depth and optimised with baffles, it is inherent that in fluid bed systems some material will remain in the roaster for a short period and some for longer periods. Under-roasted and over-roasted ilmenite will report to the middling fraction, where it cannot be separated. While under-roasted ilmenite could be re-roasted, over-roasted ilmenite cannot be re-roasted to bring it back to a magnetic state. Therefore, unless the middling fraction is rejected, with consequent loss of ilmenite, there is an unacceptable build up of over-roasted ilmenite in the system. Losses in a standard fluid bed roasting system can be as high as 30%.

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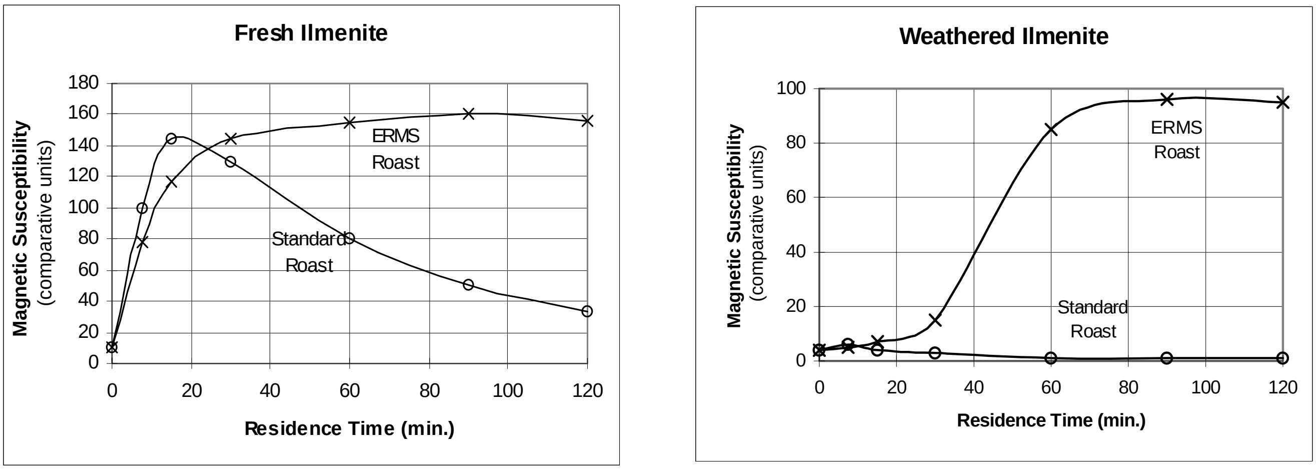

Figure 1: Comparison of magnetic susceptibility achieved by standard roasting and ERMS fluid bed roasting techniques for fresh and weathered ilmenites. From experience, a magnetic susceptibility of >130 units is necessary for clean separation of fresh ilmenite, and >80 units for weathered ilmenite.

Austpac's proprietary ERMS fluid bed roasting system controls the oxygen potential in the fluid bed atmosphere by adjusting the level of fuel in the bed, so that equilibrium in the magnetite zone is reached and maintained for either fresh or weathered ilmenite. As a result magnetic susceptibility levels off near a maximum making residence time control much less important, as illustrated in Figure 1. This gives the ERMS process the unique ability to magnetically enhance both "fresh" and "weathered" or leucoxenised ilmenites, whereas standard fluid bed roasting can only treat fresh ilmenites.

As seen in Figure 1, weathered ilmenites require longer residence time to reach maximum magnetism due to their lower iron content. However, ilmenite cannot be over-roasted in an ERMS roasting system because the equilibrium condition maintained in the roaster bed favours the formation of magnetite. Under-roasted ilmenite reports as a middling fraction during magnetic separation, and it is recycled back to the roaster. In ERMS roasting, all the ilmenite is ultimately adequately roasted, magnetised and separated, and therefore losses are very low (< 5%).

A low intensity agitated ferrite drum magnet is generally used for magnetic separation, the efficiency of which is related to the degree of induced magnetic susceptibility. Because higher recoveries are obtained with an ERMS system compared to a standard system, an ERMS roaster is smaller than a standard roaster for the same volume of ilmenite product. This is reflected in a lower capital cost for the ERMS system. Combustion in an ERMS roaster is close to stoichiometric and therefore fuel consumption will be slightly higher than that of a standard fluid bed roasting system. However this is more than offset both by the increased efficiency of ilmenite recovery, and by using the roaster exhaust gases as a fuel for drying, pre-heating or steam raising elsewhere in the mineral separation plant.

Austpac has conducted most roasting trials using coal, as it is generally a cheap source of fuel, but other fuel types such as gas or oil can also be used. Coal needs to be < 8mm in size for use in a fluid bed roaster and many types have been successfully used in the ERMS roaster, including low cost coal fines, which are often discarded by coal washeries. Ash from the coal reports both to the cyclone dust and to the non-magnetic fraction during magnetic separation. Any remaining char is screened off and recycled to the roaster, reducing the fuel consumption.

Table 1 shows the effect of ERMS roasting on both fresh and weathered ilmenite. The results shown for two Murray Basin samples were obtained using brown coal briquettes from the Latrobe Valley. Other coals and gas have also successfully been used on this type of ilmenite, and economics will dictate the type of fuel used for any roasting operations in the region.

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Table 1: Examples of chrome-rich ilmenite concentrates treated by the ERMS process.

Component	MURRAY BASIN (A)(w)		MURRAY BASIN (B)(w)		TASMANIA(w)		QUEENSLAND(f)		INDONESIA(f)	
(%)	IC	ERIP	IC	ERIP	IC	ERIP	IC	ERIP	IC	ERIP
TiO_2	56.6	60.8	60.2	68.3	57.2	60.5	48.1	51.4	23.2	46.5
Fe_2O_3	30.3	18.3	25.6	28.7	25.9	19.1	19.1	25.3	6.8	28.7
FeO	2.3	15.0	2.6	19.5	8.9	17.7	21.2	24.4	29.1	23.4
SiO_2	2.36	0.94	3.11	0.93	0.71	0.82	3.15	0.12	14.47	1.25
Cr_2O_3	1.25	0.15	1.14	0.09	1.71	0.15	1.41	0.03	10.39	0.07
ZrO_2	0.25	0.01	0.40	0.06	0.08	0.05	0.76	0.08	2.45	0.11
Al_2O_3	1.94	0.76	2.02	0.97	1.12	0.70	2.10	0.21	9.71	0.49
CaO	na	na	0.11	na	0.05	0.06	0.19	0.13	3.00	0.53
MgO	2.08	1.82	0.83	na	0.92	0.62	1.30	0.62	3.43	0.36
MnO	0.97	1.13	na	na	1.58	1.72	1.44	1.44	0.47	0.74
V_2O_5	na	na	0.26	na	0.22	0.23	0.23	0.20	0.17	0.23
P_2O_5	0.28	0.06	0.29	na	0.08	0.08	0.06	0.00	0.22	0.04
Nb_2O_5	na	na	0.07	na	0.11	0.12	0.07	0.05	0.00	0.02
U (ppm)	24	8	36	10	<5	<5	10	<5	<5	10
Th (ppm)	294	109	338	53	15	15	75	10	10	<5
U+0.4Th (ppm)	142	52	171	31	<11	<11	40	<9	<9	<12

Notes: IC Ilmenite Concentrate
ERIP ERMS Roasted Ilmenite Product
na not analysed
(f) fresh ilmenite
(w) weathered ilmenite

3. Conclusions

Ilmenite from the coarser strand line heavy mineral sand deposits of the Murray Basin is highly weathered (leucoxenised), and so potentially is a premium >60% TiO_2 ilmenite. However, ilmenite concentrates produced from these deposits by normal magnetic separation methods contain unacceptably high levels of chromite and so cannot command a premium price in the market.

Roasting can be used to enhance the magnetic susceptibility of fresh ilmenite, so facilitating its separation from chromite by simple magnetic methods. However, standard roasting techniques are not effective on weathered ilmenites because they employ an oxidising atmosphere in the roaster. The patented ERMS roast maintains a low oxygen potential in the fluid bed. This allows a skin of magnetite to form on the weathered ilmenite grain, which is then easily separated from non-magnetic mineral such as chromite.

ERMS test work on two Murray Basin ilmenite concentrates successfully reduced the chrome content to acceptable levels and lowered the levels of other impurities with a corresponding increase in TiO_2. One head sample contained 56% TiO_2, 1.3% Cr_2O_3 and and the other contained 60% TiO_2, 1.1% Cr_2O_3, while the ilmenite product after ERMS treatment contained 61% TiO_2, 0.15% Cr_2O_3 and 68% TiO_2, 0.1% Cr_2O_3 respectively; both premium products.

Because of the weathered nature of the ilmenite, it is believed that Austpac's ERMS system is the only process that can economically produce a premium product from a chrome-rich Murray Basin ilmenite concentrate.

4. Acknowledgements

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