MAGNETIZING ROASTING OF IRON LATERITE ORE BY SUB-BITUMINOUS COAL AS REDUCTANT

NURYADI SALEH AND PRAMUSANTO
R & D Centre for Mineral and Coal Technology
Jalan Jenderal Sudirman 623 Bandung 40211, Ph. (022) 6030483-5, Fax. (022) 6003373

ABSTRACT

The overburden of Pomalaa's laterite ore is characterized by its high content of iron with average Fe content of 41.8 % and can be classified as iron cap deposit. As a significant iron ore resource to be used as raw material for iron and steel industry, upgrading of laterite ore is necessary to meet the requirement for iron making. The ore was treated by magnetized roasting technique followed by magnetic separation to produce high iron content of magnetic concentrate. The ore were dominated by limonite iron minerals and has low magnetic property. However, roasting reduction treatment increased the magnetic properties of the ore due to transformation of magnetite.

Keywords : laterite ore, davis tube, magnetized roasting technique.

1. INTRODUCTION

Overburden of Indonesia's laterite ore from Pomalaa, Sulawesi is characterized as a low grade iron ore with 41.88% of iron as well as high content of silica and aluminum oxide, namely 18.47 % and 9.46 % respectively. The ore was classified as iron cap by the UN Survey Classification System (Habashi, 1997). Its distributions is 54.74 % (w/w) of minus 325 mesh. Limonite iron minerals is dominant in the ore within the range 80-90% and water content of around 40%. Proven deposits of laterite iron ore up to 222 million tons and still unutilized (PT Antam Tbk, 2004). As significant resources of iron ore to be used as raw material for iron and steel industries, it is necessary to upgrade the iron content to meet the requirement for iron making industry.

Magnetized roasting technique can be conducted to transforms paramagnetic mineral (hematite, goethite, limonite or siderite) into magnetite (Purwanto, 2003); to make it suitable to concentrate using low intensity of magnetic separation. As the combined water in the ore is high, then dehydration step must be applied prior to magnetizing roast. Several reactions take place in dehydration and reduction of the iron ore are (Stephenson, 1980):

1. Dehydration
   $Fe_2O_3.3H_2O \rightarrow Fe_2O_3 + 3H_2O(v)$
2. Magnetizing roast
   $3Fe_2O_3(s) + CO(g) \rightarrow 2Fe_3O_4(s) + CO_2(g)$
   $Fe_3O_4(s) + CO(g) \rightarrow 3FeO(s) + CO_2(g)$
3. Gasification of carbon
   $2C(s) + O_2(g) \rightarrow 2CO(g)$
   $C(s) + CO_2(g) \rightarrow 2CO(g)$

The corresponding gas ratio CO/CO_2 is shown in Figure 1, it seen that the ratio varies between 0.4-0.6 for the reduction Fe_2O_3 to Fe_3O_4. Magnetite (Fe_3O_4) will be reducing to FeO above 650ºC and FeO to Fe above 700ºC (Rosenqvist, 1983). The use of sub-bituminous coal as reductant is investigated. This is a preliminary step to the possibility of using lower rank coal reductor.

2. METODOLOGY

2.1 Experimental Set Up

General properties of the sample studied were determined by screen analysis, chemical composition and mineralogical constitution. After dehydration, magnetizing roast tests of sample up to1 kg was conducted using a Lurgi's Laboratory Electric Powered Rotary Kiln. The roasted of both

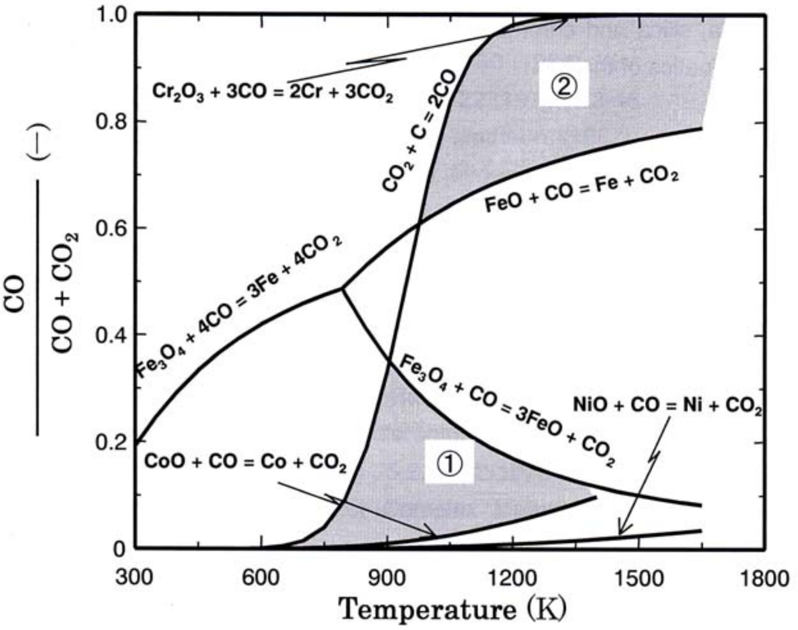

Figure 1. Diagram of reduction equilibrium of Fe, Ni, CO (Purwanto, 2003).

unground and ground products were concentrated in a Davis Tube.

2.2 Description of Sample Studied

The sample is limonitic type of overburden of nickel laterite ore originally from Pomalaa mine, PT Aneka Tambang. Chemical analyses and size distribution of sample per fraction are represented in Table 1 and mineralogical constitution is represented in Table 2.

2.3 Experiment

The sample of laterite ore were ground to minus 150 mesh. The sample was dehydrated at $650^{o}C$ for 3 hours in excess air, and then reduced for 4 hours in rotary kiln using sub bituminous coal as reductant. Composition of coal and reduction temperature varies as parameters of research. The condition of parameters is represented in Table 3. The coal content was 40.65 % of fixed carbon, 40.66 % volatile matter, 2.16 % ash, and 19.15 % H_2O. Preliminary data for series of coal based magnetizing roast tests will be described in this paper.

3. DISCUSSION AND RESULTS

Chemical analyses for ferromagnetic products and recovery of iron at different coal ratios are shown in Figure 2. As the coal composition increases from 25 to 30 %, the iron grade in magnetic concentrate increases from 46.3 to 55.9 % and it is slightly decreases to 53.6 % in coal composition 40 %. Each test using original sample assaying 41.88 % of Fe and 0.49 % of Ni. Nickel content increase accordingly with the increase of iron content. In the 55.9 % Fe magnetic product of 1500 Gauss magnetic separator, the nickel content is 1.27 %. Furthermore, magnetic separation was carried out using 500 Gauss magnetic separator following grinding the concentrate to minus 150 mesh. The final concentrate product contains of 60 % iron and 2.51 % nickel.

The iron recovery in magnetic concentrate at coal composition of 20, 30, and 40 are 55.88, 79.56, and 81.99 %, respectively. About 93.9 % of magnetite was upgraded from the laterite ore with 90 % of recovery was obtained as previously reporting (Purwanto *et al.*,2003).

Table 1. Chemical analyses of the sample

Size, mesh	Wt, %	Fe_t	FeO	Fe_2O_3	TiO_2	SiO_2	Al_2O_3	CaO	MgO	Cr	Co	Ni	LOI
60	13.69	37.3	0.0	53.3	0.0	26.7	7.88	0.037	0.8	1.55	0.069	0.53	8.53
40	12.01	39.7	0.0	56.8	0.14	21.4	9.21	0.1	0.74	1.72	0.043	0.47	8.76
40	7.14	39.1	0.64	55.2	1.00	21.0	9.68	0.065	0.74	1.64	0.037	0.45	8.59
60	5.52	38.2	0.0	54.6	0.0	23.3	9.85	0.054	0.8	1.97	0.035	0.44	8.42
125	6.9	39.0	0.73	54.9	0.0	23.3	9.81	0.094	0.81	1.84	0.03	0.42	8.48
-325	54.74	44.6	0.0	63.9	0.59	14.4	9.8	0.13	0.42	0.89	0.025	0.52	9.32
Total avg.	**100**	**41.88**	**0.096**	**59.84**	**0.45**	**18.47**	**9.461**	**0.102**	**0.581**	**1.26**	**0.035**	**0.49**	**8.99**

Table 2. Mineralogical analyses of the sample

MINERALS	**SIZE FRACTION**					
	+60	-60+100	-100+140	-140+200	-200+325	-325
Magnetite	-	-	2.25	2.59	1.67	1.04
Hematite	1	0.63	-	-	-	-
Limonite	90.44	96.23	91.57	90.84	82.57	83.37
Mag-Hem.	1	0.96	0.74	-	1.74	0.59
Chromite	-	-	0.65	0.99	2.28	1.55
Gangue minerals	6.75	1.98	4.39	4.7	10.19	9.23

Table 3. Matrix of experiments

Coal Based Magnetic Roasting				
No.	Condition Of I Magnetic Roasting		Davis Tube Results At 500 Gauss	
	Temp (^oC)/Time Reduction (Hour)	Coal composition, %	Magnetic concentrate, % Fe	Recovery,%
1	650/6	25	44.24	40.23
2		30	47.47	56.34
3		40	43.56	50.55
4	750/6	25	45.24	54.25
5		30	51.38	60.74
6		40	47.67	65.23
7	950/6	25	46.30	55.88
8		30	55.90	79.56
9		40	53.60	81.99
10	1200/3	50	66.00 (for 500 gauss)	65.66

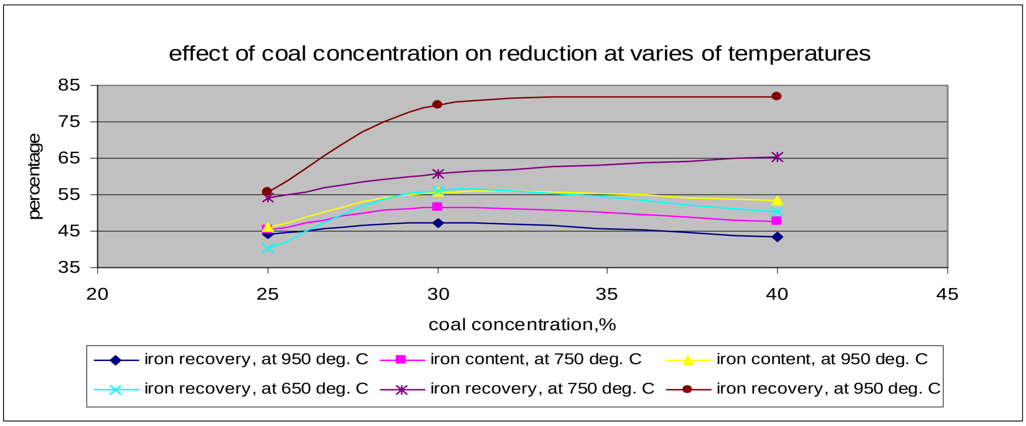

Figure 2. Effect of coal concentration on reduction performances

The transformations of limonite ore to magnetizing roast product is shown in Figure 3. It is presented the fresh limonite before reduction (Figure 3 A), limonite ore appear in earth color and gangue like silica or aluminum oxide appear in dark gray color. Minor mineral like hematite (white) and magnetite appear in bright color.

After coal reduction, limonite transforms into metallic iron as shown in Figure 3 B, C, and D. The rich phase of metallic iron increases along with the addition of coal 25 % and 30 % of coal ratio, as shown in Figure 4 B and 4 C. However; at 40 % of coal addition, the rich phase of metallic iron decreases. XRD examinations revealed that he-

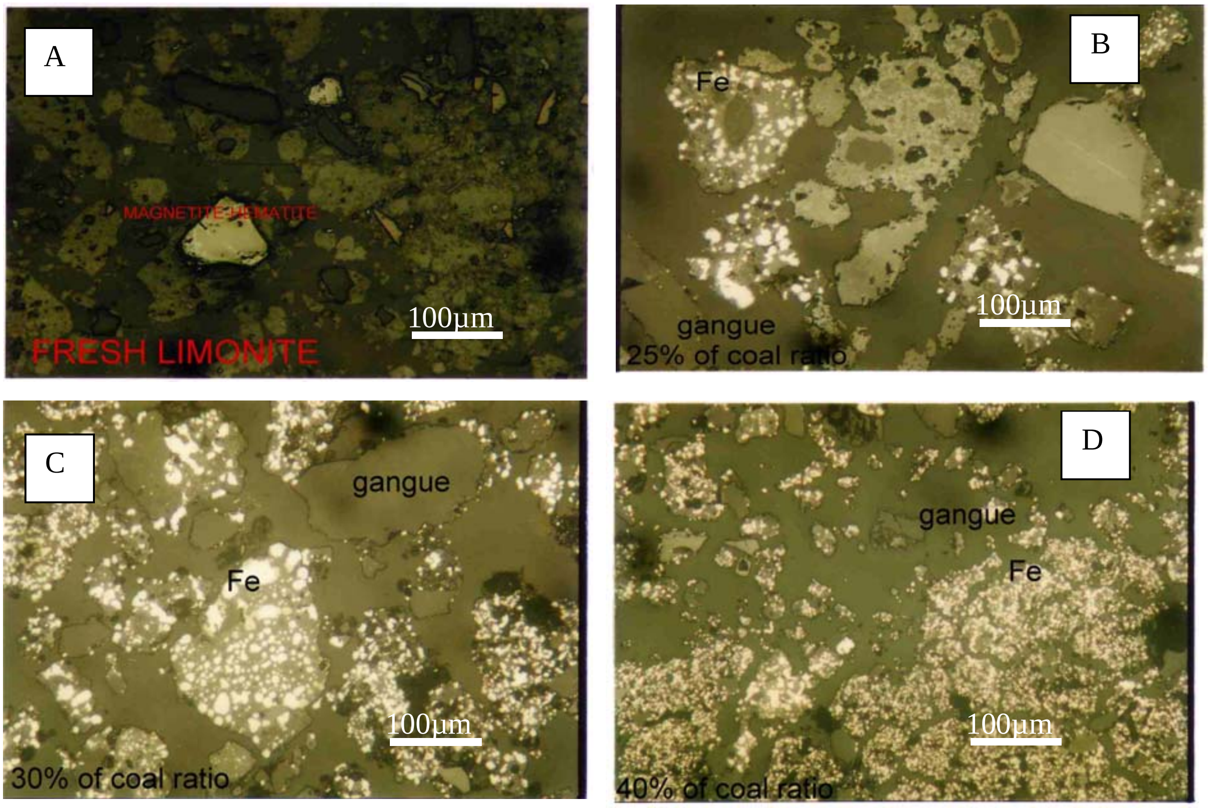

Figure 3. Laterite mineral transformations to magnetizing product,
A limonite ore, B 25% of coal ratio, C 30% of coal ratio, D 40% of coal ratio

matite found in the original sample and after 2 hours drying at 650ºC, a mixture of magnetite and hematite are present indicating the oxidation process of the ore proceeded. And lastly; in the reduction product, only magnetite and iron are detected.

4. CONCLUSIONS

1. Limonite mineral in laterite iron ore can be transformed into ferromagnetic product using coal as reductant in rotary kiln. Then, the roasted product can be concentrated using low magnetic intensity.

2. Grade of iron in magnetic concentrate in 20% and 30% coal increases from 46.3 to 55.9% Fe, as well as iron recovery from 55.88 to 79.56%.

3. In 40% of coal ratio, the iron grade decrease to 53.6% but iron recovery is reasonably high 81.99%.

4. The transformation of limonite to metallic iron that performed at temperature of reduction about 950ºC suggested the temperature condition was beyond the magnetite phase stability region.

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