Performance Evaluation of Magnetic Field Intensity on Iron Ore Slime Samples

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Abstract

Iron ore industries facing a problem of huge slime generation, dumping causing not only environmental issues but prime natural resources are wasted also. A detailed characterization followed by beneficiation of two different slimes of iron ores generated during processing of ROM and dump fines was studied using hydrocyclone followed by wet high intensity magnetic separator to recover the valuables and as these are already in fine state can be converted to pellets for DRI or blast furnace application. Slime sample-I, generated from ROM through scrubbing and sizing for coarse lump as well as fines and classification assayed 59.25% Fe, 5.14% Al_2O_3, 4.11% SiO_2, and 4.83% LOI. The Slime sample-II generated from dump fines after classification assayed 58.4% Fe, 5.27% Al_2O_3, 4.67% SiO_2, and 5.22% LOI. Although the slimes chemical composition is different, XRD analysis shows that hematite and goethite are major phase whereas gibbsite**,** kaolinite and quartz are minor gangue minerals phases. One interesting aspect of the observation is that Slime –I indicated higher percentage of goethite compared to low grade slime –II. Multi-stage processing has been done at different magnetic field intensity for two different slimes. Detailed characterization of product sample has been carried out to study the performance of field intensity on separation efficiency.

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1. Introduction

Wet High Intensity Magnetic Separators (WHIMS) are used to separate magnetic from non-magnetic or weakly magnetic from strongly magnetic materials. Magnetic fields of different intensity may be employed for selective separation of materials having different susceptibility. Dobby and Finch(1977) have developed an empirical model for the operation of the wet high intensity magnetic separator. The authors demonstrate that recovery of magnetic particles in WHIMS is dependent on the magnetic susceptibility and size of the particle. The Probability of capturing of particles is mainly based on the competing magnetic force (F_m) and hydrodynamic drag force (F_d) acting on the particles [1].

$$F_m = \frac{\chi V_P (B - \nabla B)}{\mu} \qquad (1)$$

Where, χ is magnetic susceptibility of particle with volume V_P, B is applied magnetic field, ∇B magnetic field gradient and μ is constant (4x 10^{-3}H/m).

Drag force can be derived by the stokes law expression;

$$F_d = 3\pi\eta d(u_p - u_o) \qquad (2)$$

Where η is the fluid viscosity, u_p is the particle velocity and u_o is the fluid velocity.

Thus the performance of the wet high intensity magnetic separator is mainly depends upon particle properties (size and susceptibility), design or equipment dependent factor (matrix selection) and experimental parameter (feed slurry, field intensity). In the present work, design variables were fixed and the effect of field intensity and magnetic susceptibility were studied simultaneously. The aim was to study the behavior of different iron minerals constitute in iron ore slime having different susceptibility in different magnetic field.

2. Experimental studies

Two different slime samples were collected for the investigation. Slime-I generated from ROM through scrubbing and sizing for coarse lump and fines having assayed 59.25% Fe, 5.14% Al_2O_3, 4.11% SiO_2, 4.83% LOI and the slime -II generated from dump fines after classification having assayed 58.4% Fe, 5.27% Al_2O_3, 4.67% SiO_2, and 5.22% LOI.

2.1 Characterizations

The characterization of iron ore slime samples was carried out through microscopic analysis and X-ray diffraction study. Fig 1 & Fig 2 shows the mineralogical microscopic characterization studies of slime-I and slime-II samples respectively. Both Slime samples contain mainly hematite, goethite, kaolinite, gibbsite and quartz along with sporadic occurrence of magnetite. However, due to presence below the detectable level, XRD study could not trace individual minerals of kaolinite, gibbsite and

quartz in iron ore slime which is verified by chemical analysis of both the samples. Through the mineralogical studies it is clear that hematite and goethite are the major iron bearing phases for both the slime samples. Photomicrograph of slime samples shows that the slime-I have higher percentage of goethite which is also supported by the XRD analysis of these slime as shown in Fig 2(a & b). It is cleared from the Fig 1(b) that the slime sample-II generated from dump fines is very fine in nature as evident from size analysis data. Approx 26% material is below 7 µm. To study the effect of magnetic field intensity on iron ore slimes, detail characterization has been done for various products.

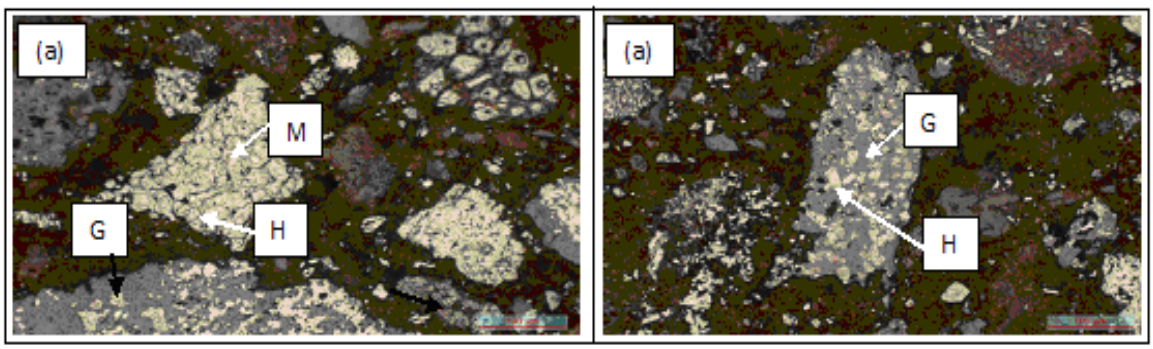

Fig 1(a): Photomicrograph of Slime-I head sample

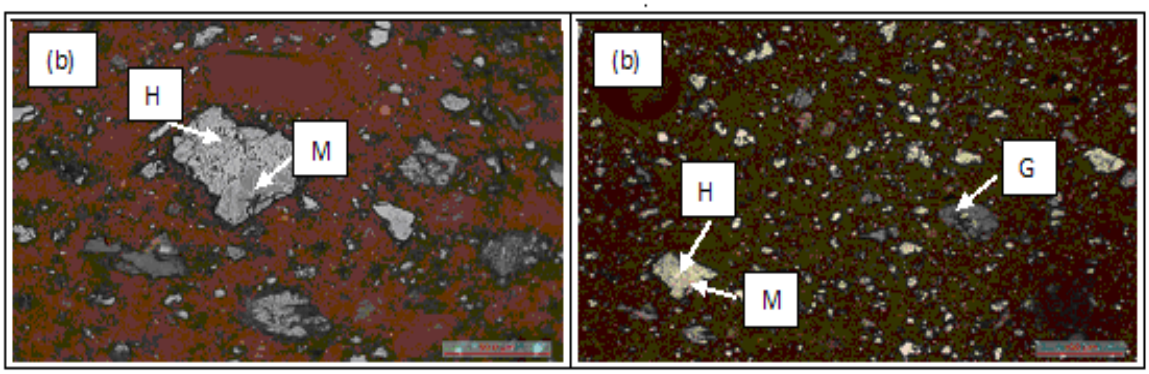

Fig 1(b): Photomicrograph of Slime-II head sample

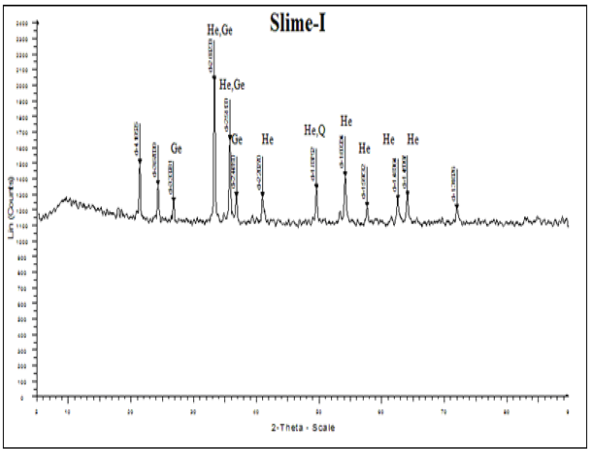

Fig 2(a): XRD pattern of Slime-I head sample

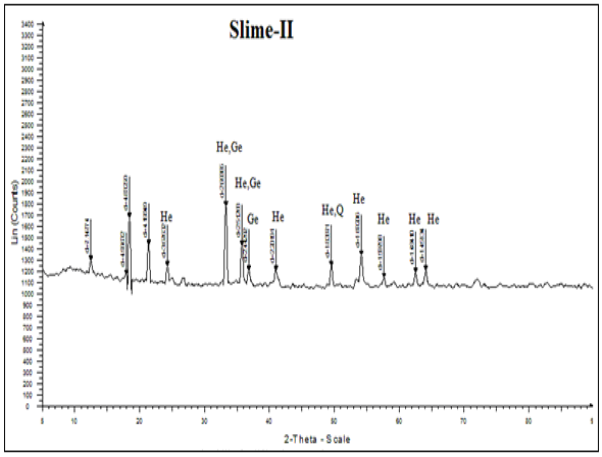

Fig 2(b): XRD pattern of Slime-II head sample

2.2 Beneficiation Studies

Beneficiation study was carried out through hydrocyclone followed by wet high intensity magnetic separator. Flow sheet was designed as shown in Fig 3(a & b) to study the effect of magnetic field intensity for slime-I and slime-II respectively. Multi stage beneficiation was done in WHIMS at different filed intensity.

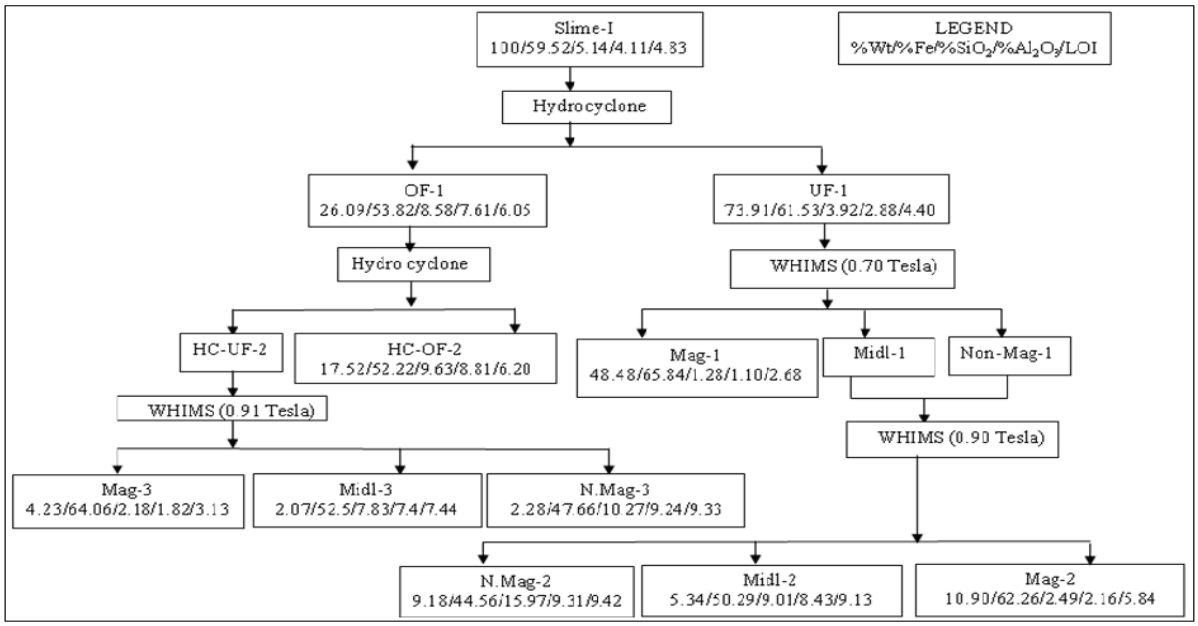

Fig 3(a): Process flow sheet for Slime-I: Beneficiation of iron ore slime through Hydrocyclone &WHIMS

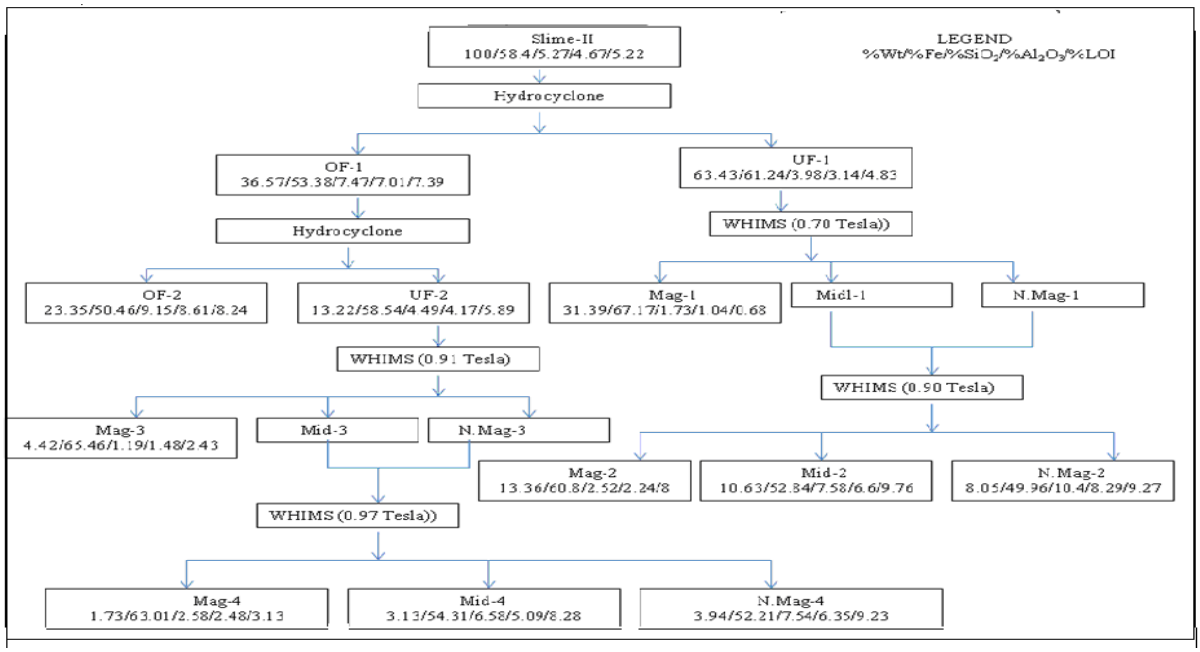

Fig 3(b): Process flow sheet for Slime-II: Beneficiation of iron ore slime through Hydrocyclone &WHIMS

3. Result and discussion

Theoretically the capacity of magnet to lift a particular mineral is dependent not only on the value of the field intensity, but also on the field gradient [2]. The higher the magnetic susceptibility, the higher is the field density in the particle and greater is the attraction towards increasing field strength. The magnetic susceptibility of some major iron bearing minerals (of interest for the present study) and their corresponding magnetic field intensity are shown in Table 1.

Table 1: Magnetic susceptibility vs. magnetic field intensity of different minerals [1].

Mineral	Magnetic field(Tesla)	0.4	0.6	0.7	0.8	0.9
Hematite	Magnetic susceptibility	5.20×10^{-2}	3.59×10^{-2}	3.15×10^{-2}	2.74×10^{-2}	2.49×10^{-2}
Goethite	Magnetic susceptibility	2.44×10^{-2}	2.15×10^{-2}	2.05×10^{-2}	1.97×10^{-2}	1.91×10^{-2}

Usually magnetic susceptibility of minerals decreases with increasing applied magnetic field [3], but the susceptibility of weakly paramagnetic minerals like goethite is nearly constant with applied magnetic field. As magnetic field increases, susceptibility difference between hematite and goethite will narrow down and it is difficult to separate the minerals at high magnetic intensity. Therefore in order to separate the goethite and hematite mineral it is preferable to operate WHIMS at low field intensity usually 0.4-0.7 Tesla [4, 5], though this data is valid for pure minerals.

Different magnetic products were obtained from slimes using hydrocyclone followed by WHIMS as shown in Fig 3(a & b).

Details characterization of magnetic product from two different slimes was carried out as shown in Fig 4 and Fig 5.It is clear from Fig 4(a) & 5(a) that Mag-1 which is recovered at 0.70 Tesla from the slime-I and slime-II respectively mainly contained hematite, magnetite and minor goethite mineral; in other hand Mag-2 which is recovered at 0.90 Tesla from slime-I and slime-II respectively contained more goethite mineral as shown in Fig 4(b) & 5(b). Same case for Mag-3 and Mag-4 recovered from slime-II as shown in Fig 5(c & d). Qualitatively it was observed that Mag-2 recovered from slime-I have more goethite minerals as compared to Mag-2 recovered from slime-II.

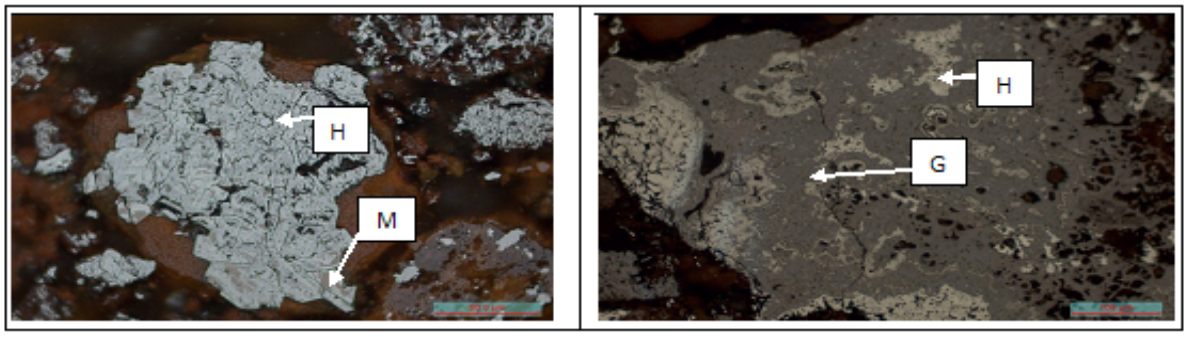

Fig 4(a): Photomicrograph of Mag-1from slime-I Fig 4(b): Photomicrograph of Mag-2 from slime-I

(0.70 Tesla) (0.90 Tesla)

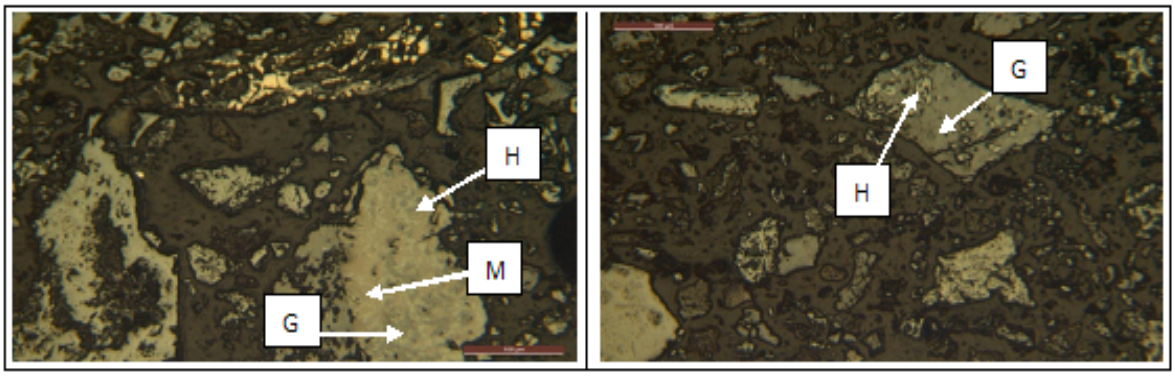

Fig 5(a)Photomicrograph of Mag-1 from slime-II (0.70Tesla)

Fig 5(b) Photomicrograph of Mag-2 from slime-II (0.90 Tesla)

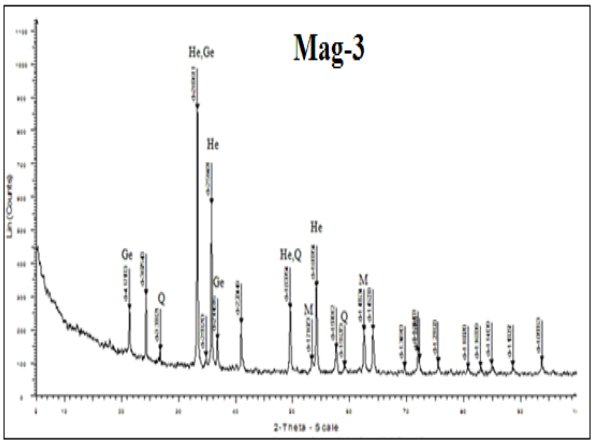

Fig 5(c) XRD pattern of Mag-3 from slime-II (0.91 Tesla)

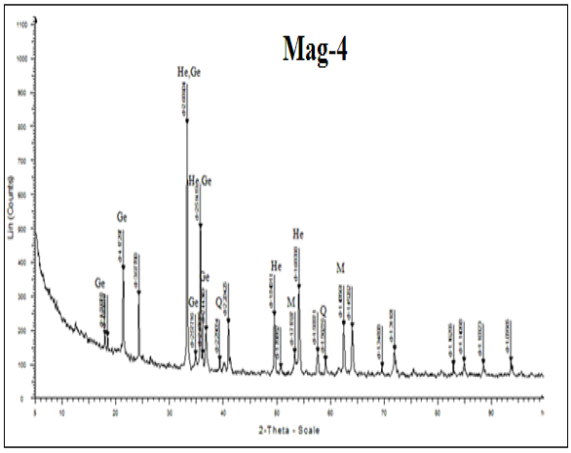

Fig 5(d) XRD pattern of Mag-4 from slime-II (0.97 Tesla)

It is because of nature of slime-I which have higher goethite mineral in head sample as shown in Fig 2(a).

4. Conclusion

Studies indicate that hematite bearing iron particles are mostly attracted around 0.7 tesla, whereas large amount of goethite mineral is attracted at & above 0.9 Tesla. Excessive presence of goethite materials brings down the concentration of ore and the concentrate. If both are attempted to be recovered in single pass, the probability of loosing goethite in non-magnetic is very high. In order to efficiently recover hematite and goethite minerals it is recommended that two stage wet high intensity magnetic separator should be operated. The first product will be hematite rich fraction with high Fe and the second fraction will be mostly goethite with marginally lower (2-3%) Fe as indicated by the experiments. Hence, to recover iron values with suitable grade from slime samples containing high goethite, it is necessary to process through the multi stage processing with first stage being medium intensity to recover hematite values and subsequently at higher intensity for capturing other iron values. This would lead to simultaneous optimization of yield & grade of product.

5. Acknowledgement

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6. References

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