USE OF RADOS XRF SORTERS: EXPERIENCE AT TATA STEEL

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ABSTRACT

The Ferro Alloys and Minerals division of Tata Steel is presently in expansion mode, with production capacities expected to scale new heights in the wake of increased demand of steel production. The small and in-situ nature of deposits and wide variation in quality within the same ore body makes Tata Steel's captive manganese mines labour intensive. The present system is not expected to match the production demands.

Therefore the need for a degree of mechanization was felt and as a primary step, it was envisaged to introduce a suitable sorting technique which engages the maximum labour.

RADOS has developed X-ray based ore sorters that have been in use in Russia and Scandinavian countries for the past two decades. The sorters use X-ray fluorescence (XRF) to analyse and sort the minerals based on chemistry. The sorters have been used for a variety of minerals – precious metals, base metals, ferrous and non-ferrous metals.

The present work details the preliminary test work carried out at the captive manganese mines of Tata Steel. The results indicate a strong correlation between the H-value and grade of manganese ore, indicating a very high accuracy of sorting.

KEYWORDS: *Manganese ore, X-Ray Fluorescence, RADOS.*

INTRODUCTION

The high grade mineral resources of the country are fast depleting with an irrational use of prime resources and increased cost of production due to stringent quality norms. In addition, Tata Steel's captive Manganese mines are highly labour-intensive due to the small and in-situ nature of deposits and wide variation in quality within the same ore body.

The Ferro Alloys and Minerals division of Tata Steel is presently in expansion mode, with production capacities expected to scale new heights in the wake of increased demand of steel production.

The present labour intensive system is not expected to match the future production demands. With acute shortages in skilled manpower faced by the industry today, the cost of production is soaring up. Therefore the need for a degree of mechanization was felt and as a primary step, it was envisaged to introduce a suitable sorting technique which engages the minimum labour.

The idea of using an advanced, mechanized sorting technology was envisaged with the following objectives:

1. Ensuring better quality control and recovery of prime product.
2. Reducing the dependence on manpower, making operations less labour intensive and more cost-effective.
3. Matching production requirements in the future.

An exhaustive survey of possible options available in the market was made. Based on a technical study comprising the sorting technology and the nature of ores, the RADOS technology was selected for further testing its efficacy.

RADOS sorters are based on the concept of X-ray fluorescence (XRF) and its advantages have been commercially exploited in Russian and Scandinavian countries to analyse and sort various minerals in real-time (figure 1).

In commercial operations, for most metals, RADOS XRF Ore Sorter detection limits range from 0.05% to 0.1%. It can process 20 mm – 250 mm size particles at a feed rate of 10 – 30 TPH depending the ore density and particle size.

Figure 1: RADOS sorter

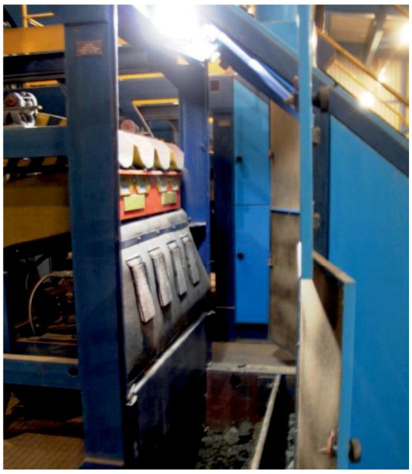

Figure 2: Commercial RADOS sorters with ejector plates and X-ray detectors

The RADOS XRF Ore Sorter has a feed hopper that discharges onto a static grizzly to remove undersize, misplaced ore particles. The oversize is then transported through channels or chutes to discharge the ore particles into a free fall zone. During free fall, the individual particles are exposed to X-rays refractions, resulting in the production of fluorescence patterns from elements of each particle; thereby giving an idea of the elements present in the particles which is then recorded in a central control unit. The control unit then determines the elemental concentrations, and compares these against the sorting matrix to determine whether the ore particle should be ejected, in which case it energises the electromechanical ejector and the ore particles drop onto the product/concentrate or discard conveyor belts.

EXPERIMENTAL DESIGN AND METHODOLOGY

When X-rays of a predetermined intensity source strikes a target sample, fluorescence emission along with diffraction of the X-rays take place that is characteristic of the elements present in the sample particle; the diffraction intensity being proportional to their concentration in the sample. This intensity is measured, with the help of detectors and ancillary software programs.

Mathematical spectrum analysis allows making qualitative and quantitative estimates of sample elements.

For qualitative and semi-quantitative evaluation of analysed element content, the equipment uses an analytical parameter which is a distinctive feature of the equipment, called as H-value, and defined as:

$$H = \frac{N_{Mn}}{N_s + \left(k * \frac{N_{Fe}}{N_{Mn}} * N_{Fe} \right)} \tag{1}$$

N_{Mn}, N_{Fe} is the number of impulses, registered in the Mn and Fe X-ray emission area; N_s is the number of impulses, registered in the diffused emission area.

On analysing the surface properties, the machine gives one output for the entire ore particle as its H value. There is an actuator arm in the machine which is controlled by RADOS software and functions based on the H value to either push the material away if it is above the threshold limit of H specified (i.e. concentrate) or allow it to fall directly (i.e. rejects). The software also reports the average H value of all the particles that have been analysed as well as average H value of particles partitioned as concentrate or rejects.

Every lot of ROM was first run on the machine which gave 2 products. These products were again run with different sets of threshold values giving different ranges of concentrate and rejects. These products were than analysed by conventional chemical analysis and plotted with the corresponding average H value as given by the machine. Figure 3 shows the schematic of the total experimental plan.

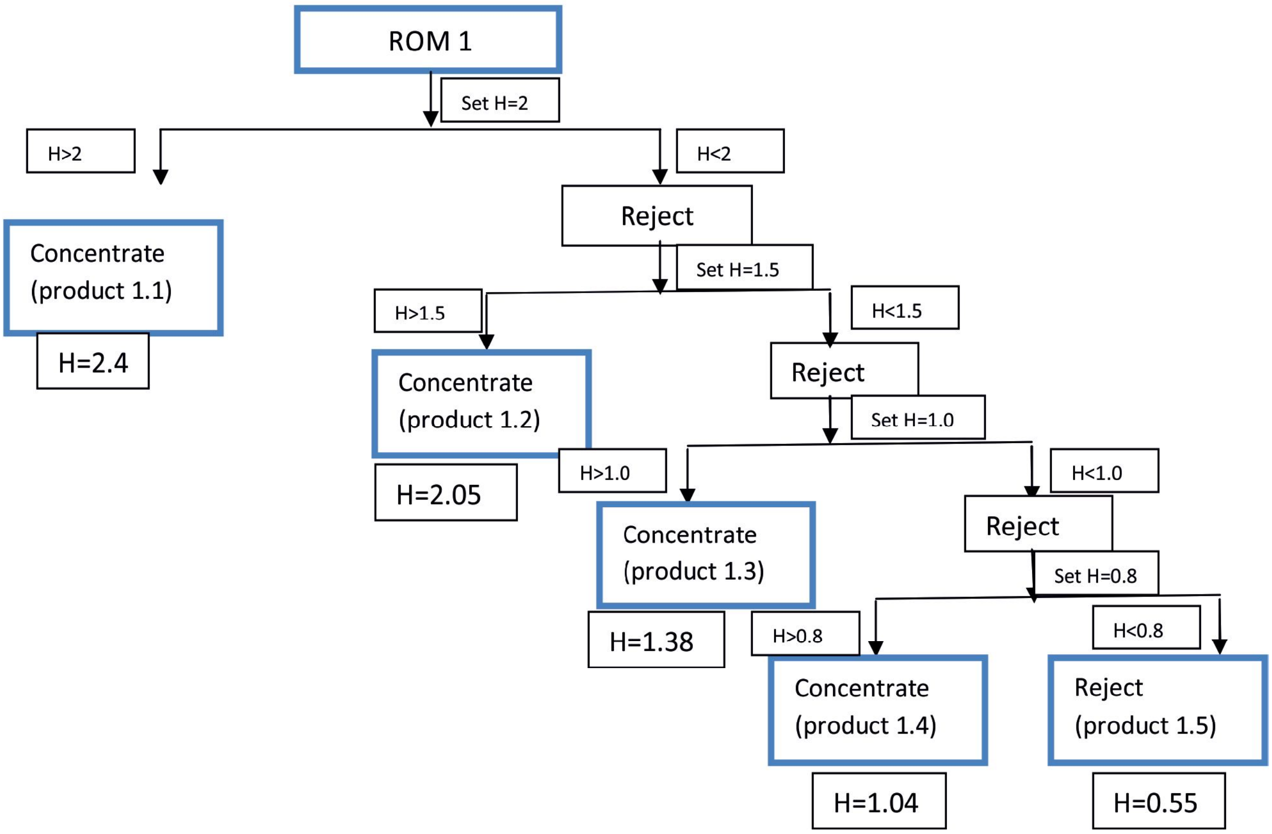

Figure 3: Experimental plan for efficacy testing of RADOS Sorters

The tests were carried out at the captive Mn mines, using a pilot scale machine supplied by M/s. Nityam Resources, New Delhi, the technology provider of RADOS sorters in India. The machine had the following limitations:

1. The filters and detectors in the machine are not of high precision as comapred to the commercial machine. Hence the machine needs frequent calibration with Mn ore. In the actual machine, the calibrating mechanism is housed within the machine itself.
2. The machine has very small diaphram of X ray emitter and detector. Thus as compared to actual machine where almost 90% of ore surface is scanned, here only 40-50% of area is exposed.
3. As compared to the actual machine where the machine is kept in closed environment, the pilot machine's detectors are easily influenced by the temperature and moisture.

RESULTS AND DISCUSSION

For a given set of ROM and H values, different products (concentrates and rejects) are obtained and these are analysed chemically for their Mn%. For each product the average values of H is given by the ancillary software. The experimental results of each grade (high, medium and low) are shown in figure 4.

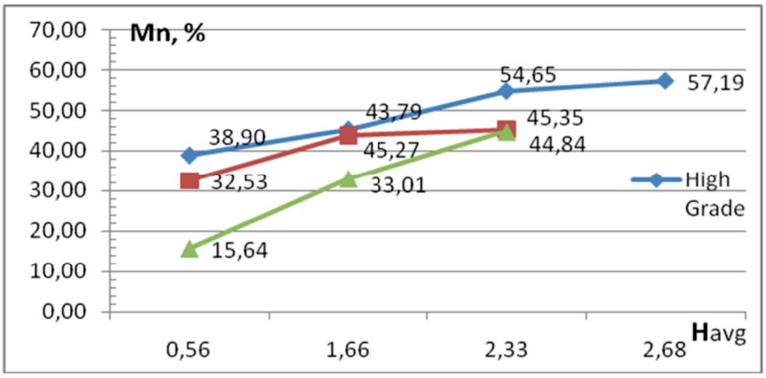

Figure 4: Variation of Mn grade with H value for different types of ores

Overall experimental result plotted on a scatter diagram is shown in figure 5.

The correlation coefficient of various ROMs is given below in table 1. The regression analysis shows a very strong correlation indicating a high accuracy in the sorting technique, based on Mn content.

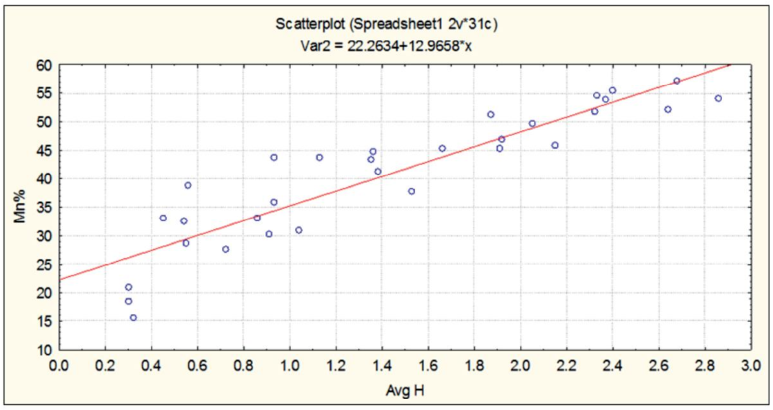

Figure 5: Scatter plot for Mn produst grade as a function of H-value

Table 1: R-square value Mn grade Vs. H-value for different grades of ore

ROM	Correlation Coefficient
Set 1	0.98
Set 2	0.96
Set 3	0.97
Set 4	0.94
Set 5	0.98
Set 6	0.88
Set 7	1.00
Overall	0.91

CONCLUSION

Based on the test work carried out at our captive mines, it is found that the pilot RADOS XRF sorter is able to sort ores based on their grade with very high accuracy, despite its limitations. The results show a very strong correlation within a given set and a correlation of 0.91 for all the ROMs combined.

ACKNOWLEDGMENT

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