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Tom, Phakamile

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Optimization of dense medium cyclone plant for the beneficiation of low grade iron ore with associated high proportion of near-density material at Sishen Iron Ore Mine

By Phakamile Tom (9110806D)

ABSTRACT

The research report is premised on three aspects which are critical in the heavy mineral beneficiation. These aspects are classified as (i) understanding the densimetric profile of the available ore body, (ii) understanding the properties of the heavy medium utilised at the plant to beneficiate the ore, and (iii) the automation and modelling of the processing plant in order to maximise plant efficiency.

Ore characterisation is mainly focused on understanding the densimetric profile of the ore body, in order to determine the probability of producing a saleable product as well as predicting the expected yields and quality. This is done to utilise the endowment entrusted upon the operating entity by the government and shareholders to treat the mineral resource to its full potential. Understanding of the beneficiation potential of the ore body will assist the mine planning and processing plant to optimise the product tons and quality. This will ensure the marketing plans are in accordance with the expected product as beneficiation will vary depending on the mining block reserves. The mining blocks have potential to produce varying product grades with different recoveries.

Ore characterisation was conducted on the GR80 mining block, low-grade stockpiles (i.e. C-grade ore reserves & Jig discard and dense medium separation (DMS) run-of-mine (ROM) material. The GR80 material was characterised as having low proportion of near-density material and would be easy to beneficiate as well as produce high volumes of high grade product. Furthermore, it was revealed that the 2014 DMS ROM had an increased proportion of low-density material; however this material was also had low proportion of near-density material.

The low-grade stockpiles was characterised by high proportion of near density material, which necessitate the beneficiation process to operate at high density in excess of 3.8 t/m^3. Maintaining a higher operating density requires more dense medium which leads to viscosity problems and impact performance.

The characterisation of the FeSi medium was imperative to understand its behaviour and potential influence on beneficiation of low-grade stockpiles and mining blocks with elevated proportion of near-density material. As the proportion of near-density waste material increases in the run-of-mine (ROM), it is necessary to beneficiate the material at elevated operating

medium densities. However, when cyclones are operated at high densities, the negative influence of the medium viscosity becomes more apparent and thus influences the separation efficiency.

Heavy medium, ferrosilicon (FeSi) characterisation looked at identifying the effects of viscosity on the FeSi stability and whether there would be a need for a viscosity modifier. Thus, the importance of controlling the stability, viscosity, and density of the medium cannot be under-estimated and can very often override the improvements attainable through better designs of cyclones. Furthermore, the slurry mixture of the heavy medium utilised for the purpose of dense medium separation should be non-detrimental to the effectiveness of separation in the DMS Fine cyclone plant. Medium characterisation showed that removal of ultra-fines leads to unstable media as indicated by faster settling rates. This would result in medium segregation in the beneficiation cyclone thereby leading to unacceptable high density differential which will negatively impact the cut-point shift and cause high yield losses to waste.

The overall control of the metallurgical processes at Sishen's Cyclone Plant is still done on manually and thus operation still varies from person-to-person and/or from shift-to-shift. This result in some of the process data and trends not being available online as well as being captured inaccurately. Furthermore, this negatively affects the traceability and reproducibility of the production metallurgical key performance indicators (KPI's) as well as process stability and efficiency.

It has been demonstrated that real-time online measurements are crucial to maintaining processing plant stability and efficiency thereby ensuring that the final product grade and its value is not eroded. Modelling and automation of the key metallurgical parameters for the cyclone plant circuit was achieved by installation of appropriate instrumentation and interlocking to the programmable logic control (PLC). This allowed for the control of the correct medium sump level, cyclone inlet pressure, medium-to-ore ratio as well as online monitoring of density differential as "proxy" for medium rheological characteristics.

The benefit of modelling and simulation allows the virtual investigation and optimisation of the processing plant efficiency as well as analysis of the impact of varying ore characteristics, throughput variations and changing operating parameters. Therefore it is imperative that all cyclone operating modules are operated at the same efficiency which can be achieved by optimized process through proper automation and monitoring, thereby improving the total plant profitability.

Keywords: *dense medium separation; densimetric profile; dynamic modelling; FeSi rheology; iron-ore beneficiation; process automation; process control*.