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Effect of particle filling and size on the behaviour of the ball load and power in a dry mill.

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ABSTRACT

This study on the effects of particle filling and size on the ball load behaviour and power in a dry mill was initiated at the University of the Witwatersrand in 2003. The aim of the study was to make available a better understanding of the underlying causes in the different power draws that occur in mills when ore particles are being added to the ball load. This mimics the process of filling an industrial grinding mill after a grind out has been performed. Typically after a grind out, the mill operator would refill the mill with ore up to the point where maximum mill power draw is registered. At maximum power draw it is assumed that the void spaces within the ball load are filled with ore particles and that the charge is well mixed.

In order to conduct the study an inductive proximity probe was used to measure the dynamics of the load behaviour. This novel technique in measuring load behaviour was chosen due to the fact that the probe could sense the presence of steel balls independent of the presence of particles in the mill. The probe's response to a load comprised of steel balls only at the fillings of 15-45% and mill speeds of 60 – 105% indicate that the various changes in load behaviour such as cataracting, centrifuging, ball packing and toe and shoulder responses were easily distinguished in probes responses. Further tests were conducted in a mill with a 20% ball filling with increasing coarse or fine silica sand particle filling from 0 – 150% at the mill speeds of 63-98% of the critical mill speed. These tests clearly reveal radial segregation of coarse silica sand, increased ball cataracting and centrifuging of just silica sand or a combination of

balls and silica sand. The impacts of these phenomena have been discussed with reference to industrial mills.

The physical parameters defining the load provided by the inductive probe made it interesting to make use of Morrell's C model to simulate the power drawn by the mill. Modifications to Morrell's model were made thus leading to a modification in the toe and shoulder model and proposals for a segregated charge model, a centrifuged charge model and a particle pool model. Furthermore a modelling study based on the torque-arm modelling approach was conducted. Here Moys power model was used to study the effect increasing coarse and fine particle filling has on the power drawn by a mill. A liner model was proposed to define N* as a function of particle filling. In both modelling cases the models were used to account for the various conditions arising within the load as particle filling and mill speed increases.