Improvement of Energy Efficiency of Rock Comminution through Reduction of Thermal Losses

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Introduction

Theoretical calculations show that only some 0.1 to 2 % of the energy supplied to rock during comminution is effectively utilised for fracturing. This project investigates the accumulation in thermal energy of rock, using an advanced thermal imaging camera, to quantify how much energy is lost into increased thermal energy of rock, and to explore potential relationships between this heat accumulation, the physical and/or mineralogical characteristics of the rock, the produced fragment size distribution and operational parameters of the comminution process. Ultimately it is hoped that such better understanding of heat losses, will generate options for modification of operational and equipment parameters of comminution equipment to reduce heat losses and improve efficiency of rock crushing.

Obtained results demonstrated that substantial fraction of net energy delivered to rock ends up as the heat energy radiating from the rock after crushing. Obviously this indicates more energy is delivered to the rock that what is required to crush the rock. From the practical point of view, question is what can be done with existing equipment to reduce such thermal losses. We were focused on the potential improvement of the efficiency of crushing that can be archived through modification of the feed size distribution. Testing was performed during HPGR crushing of Rio Tinto's Bingham Canyon copper ore.

Thermal Radiation

Any object will emit energy due to its temperature, as long as temperature of the object is above absolute zero. From the measured radiation energy and emissivity constant of the surface, it is possible to calculate surface temperature of the materials. Assuming that surface temperature represents average temperature of the materials, it is then possible to calculate thermal energy stored within materials, from equation.

Experimental Results

We performed a range of rock crushing experiments which was monitored using sensitive infrared (IR) camera. Measurements of thermal losses that occurred during High Pressure Grinding Roll (HPGR) crushing of local basalt were performed. HPGR crushing was performed on the six samples of equal mass (18.86kg). Initial pressure of the HPGR were set to 20, 30 (2 samples), 40, 50 and 60bar. Infrared imaging was performed during crushing, Figure 1. Crushing products were sized and compared against feed size distribution and introduced net comminution energy.

Figure 1: *Setting used during HPGR testing.*

Increase in the specific comminution energy (applied pressure), results in finer fragmentation. However, there is tendency that after certain amount of energy is introduced, further increase in consumed specific energy, produce only minor or insignificant improvements in fragmentation. This is observed in the diagrams of fragment size distributions which show asymptotic behaviour of the fragment size distribution as applied pressure increase, or amount of net energy consumed increases, Figure 2.

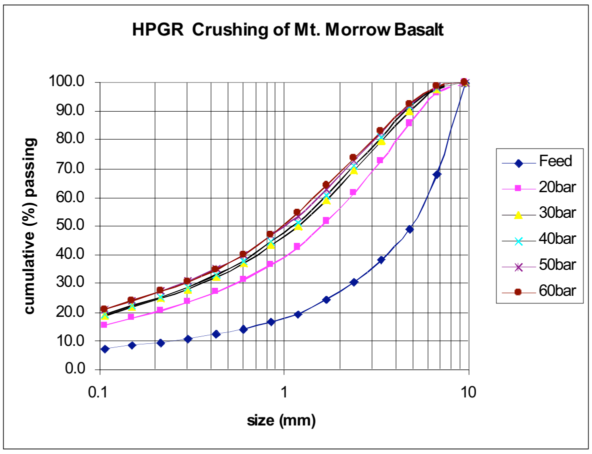

Figure 2: *Feed size distribution and fragment size distribution after HPGR crushing under different pressure.*

Results of IR imaging of the crushed rock, shows that large fraction of net energy supplied to rock is transformed in to heat, rising temperature of the rock, Figures 3.

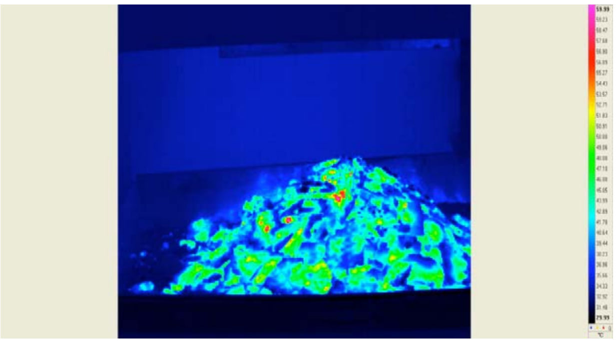

Figure 3: *Infrared image for set pressure of 30bar, copper ore (temperature scale min. 30degC, max. 60degC).*

From the temperature and measured net energy supplied to rock, efficiency of energy utilization was calculated as function of the HPGR pressure setting, Figure 4.

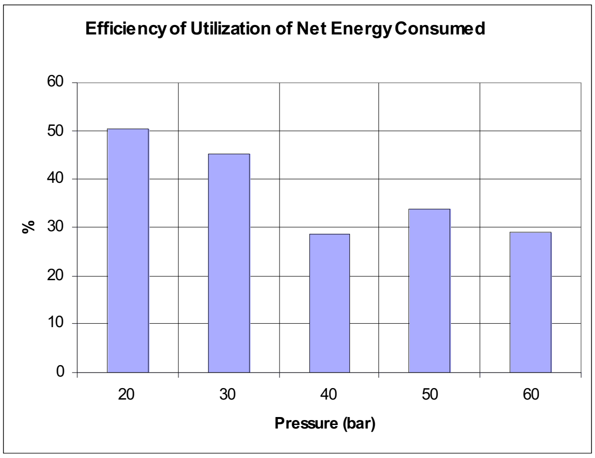

Figure 4: *Efficiency of energy utilization as function of HPGR pressure.*

Conclusions

Presented results and interpretation are restricted on comminution aspects of energy transfer and thermal losses. We were able to perform reproducible measurements of temperature increase that occur during highly transient events such as dynamic rock breakage. Obtained results show that with increase of energy introduced, there is increase in the temperature along the fractured surface as well as increases in the overall amount of thermal energy.

Results obtained during HPGR testing clearly indicate that there is optimum intensity of pressure to which given rock needs to be exposed. Any further increase in pressure results in only marginal increase in fragmentation and significant increase in unproductive heating of rock.

Feed characterised with relatively narrow size distribution (i.e., without large amount of very fine material) is prone to more efficient crushing at significantly lower pressure than feed with same top size, but including relatively large amount of fines. Experimental results indicate that up to 40% of energy can be saved through optimization of the applied pressure and modification of feed size distribution.

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