

(U. S. Bureau of Mines and Dow Chemical Company, 9/1/1982-9/30/1993)

It was observed by an operating iron ore concentrator that there were significant seasonal variations in grinding mill efficiency, with the efficiency being degraded during the coldest winter months. It was unknown whether this loss of efficiency was due to changes in the fracture resistance of the rocks themselves as they were chilled, or due to changes in properties of the mineral slurry in the grinding mill.

Extensive examinations of operating plant data confirmed that there was a correlation between specific grinding energy and the temperature of the mill slurry feed, with grinding energy increasing up to 18% in the winter months. “Drop test” studies were carried out to determine whether frozen ore had a greater resistance to fracturing than room-temperature ore. In these experiments, ore samples that had been adjusted to the desired temperature were dropped a height of 20 feet onto a steel plate, and the degree of fracturing was measured. It was found that dry ore pieces had the same fracture resistance regardless of whether they were frozen or unfrozen, while porous rocks that were saturated with water were considerably more fracture-resistant when they were frozen. Since the iron ore had very low porosity, there were no changes in ore fracture resistance that could have caused the observed increase in grinding energy.

Laboratory grinding experiments confirmed that there was a variation in grinding efficiency with temperature. A system was developed for measuring the viscosity of mineral slurries with the advice of personnel from Dow Chemical Co., and it was determined that chilling of the slurry caused an increase in viscosity that in turn increased the energy required for grinding. It was also determined that viscosity increases due to lowered temperature changed the separation performance of hydrocyclone classifiers that are used for size control in the grinding circuit.

To confirm these results, pilot-scale experiments were carried out using an instrumented autogenous grinding mill (6 feet in diameter x 2 feet long), grinding chilled and unchilled ore. Again, a good correlation was found between temperature, viscosity, and grinding energy. An additional effect was also noted, where very cold ore coming in contact with chilled water could freeze a layer of ice around the ore pieces, which could freeze ore to the side of the mill briefly and prevent it from being ground.

Based on the results of this project, the iron ore concentrator has taken measures to control temperature of their mill slurry in the winter, and grinding efficiency has been improved.