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While pelletization of iron ore concentrate has been used for many years, the process was for the most part developed empirically, and so the chemistry and physics of the actual pelletization process had not been studied. In particular, the behavior of binders was poorly understood, and it was not known whether bentonite clay binders were being used with the best possible efficiency, or whether lower-cost alternatives (such as local, non-bentonite clays or modified coal fly ashes) could be used as replacement binders.

A persistent problem in iron ore pelletization has been the difficulty in determining in advance how well bentonite from a given source would perform as a pellet binder. While many bentonite characterization methods have been proposed, none have proven to have a good correlation with binder performance. In this study, it was discovered that this problem was largely caused by very high levels of dissolved calcium compounds being retained in the moisture of iron ore concentrate filter cake. When bentonite came in contact with this moisture, the calcium ions degraded the bentonite performance dramatically, reducing the ability of the bentonite to absorb water by approximately a factor of four. Bentonites also varied in their sensitivity to calcium ions, and so some bentonites that performed poorly in distilled water, were actually the best choices for water containing large amounts of dissolved calcium.

In the course of examining the response of bentonite to dissolved calcium ions, a new standard technique for evaluating binder effectiveness was developed. This method used a highly standardized substrate (glass beads) to produce test specimens that were bonded together by the binder being evaluated. This method not only produced highly reproducible results, but also gave excellent correlation with binder performance when it was actually used to bind iron ore concentrate pellets.

Examination of glass beads bonded with bentonite under a scanning electron microscope showed that the binding mechanism of bentonite was different than had been believed previously. Instead of dispersing into a uniform suspension that coated the particles, the bentonite was found to be spread over the surface of the particles, drawing into sheets and fibers that bridged between the particles. Based on this observation, a new mixing method was developed, "compressive shear mixing". Instead of mixing the particles conventionally, which tended to tear the particles apart from each other, the compressive shear method presses particles together so that they slide past one another. This takes advantage of the tendency of bentonite to form sheets and fibers, and reduces the amount of bentonite needed to produce a given bonding strength by 50%. This produces a marked savings in bentonite requirements. It was also determined that the compressive shear mixing could be used with other clays. Using this method, locally-produced clays that previously had been considered to have insufficient binding capability, had their performance enhanced to the point that they were competitive with conventionally-mixed bentonite.