GENERAL INFORMATION
CPM–Crucible Particle Metallurgy

The proprietary Crucible Particle Metallurgy (CPM®) process has been used for the commercial production of high speed steels and other high alloy tool steels since 1970. The process lends itself not only to the production of superior quality tool steels, but to the production of higher alloyed grades which cannot be produced by conventional steelmaking. For most applications the CPM process offers many benefits over conventionally ingot-cast tool steels.

Conventional Steelmaking vs.Particle Metallurgy Processing

Conventional steelmaking begins by melting the steel in a large electric arc furnace. It is usually followed by a secondary refining process such as Argon Oxygen Decarburization (AOD). After refining, the molten metal is poured from the furnace into a ladle, and then teemed into ingot molds.

Although the steel is very homogeneous in the molten state, as it slowly solidifies in the molds, the alloying elements segregate resulting in a non-uniform as-cast microstructure. In high speed steels and high carbon tool steels, carbides precipitate from the melt and grow to form a coarse intergranular network. Subsequent mill processing is required to break up and refine the microstructure, but the segregation effects are never fully eliminated. The higher the alloy content and the higher the carbon content, the more detrimental are the effects of the segregation on the resultant mechanical properties of the finished steel product.

The CPM process also begins with a homogeneous molten bath similar to conventional melting. Instead of being teemed into ingot molds, the molten metal is poured through a small nozzle where high pressure gas bursts the liquid stream into a spray of tiny spherical droplets. These rapidly solidify and collect as powder particles in the bottom of the atomization tower. The powder is relatively spherical in shape and uniform in composition as each particle is essentially a micro-ingot which has solidified so rapidly that segregation has been suppressed. The carbides which precipitate during solidification are extremely fine due to the rapid cooling and the small size of the powder particles. The fine carbide size of CPM steel endures throughout mill processing and remains fine in the finished bar.

The powder is screened and loaded into steel containers which are then evacuated and sealed. The sealed containers are hot isostatically pressed (HIP) at temperatures approximately the same as those used for forging. The extremely high pressure used in HIP consolidates the powder by bonding the individual particles into a fully dense compact. The resultant microstructure is homogeneous and fine grained and, in the high carbon grades, exhibits a uniform distribution of tiny carbides. Although CPM steels can be used in the

as-HIP condition, the compacts normally undergo the same standard mill processing used for conventionally melted ingots, resulting in improved toughness.

CPM Eliminates Segregation

Conventionally produced high alloy steels are prone to alloy segregation during solidification. Regardless of the amount of subsequent mill processing, non-uniform clusters of carbides persist as remnants of the as-cast microstructure. This alloy segregation can detrimentally affect tool fabrication and performance.

CPM steels are HIP consolidated from tiny powder particles, each having uniform composition and a uniform distribution of fine carbides. Because there is no alloy segregation in the powder particles themselves, there is no alloy segregation in the resultant compact. The uniform distribution of fine carbides also prevents grain growth, so that the resultant microstructure is fine grained.

Advantages of CPM

For the End User:

- Higher Alloy Grades Available
- Improved Wear Resistance
- Improved Toughness (less chipping)
- Consistent Tool Performance
- Good Grindability (on resharpening)

For the Tool Manufacturer:

- Consistent Heat Treat Response
- Predictable Size Change on Heat Treat
- Excellent, Stable Substrate for Coatings
- Excellent Grindability
- Improved Machinability (w/sulfur enhancement)
- Efficient Wire EDM Cutting

Return to top of page