

CERAMALLOYING (CALORIZING)

Diffusion Element: Aluminum

Base Metals: Cast Iron, low carbon steels, alloy steels including stainless steels, nickel and copper alloys, copper.

Resultion Layer: Intermetallic iron aluminide for cast iron and low carbon steel, nickel aluminide for nickel alloys, copper aluminide for copper.

Process Description: Component to be ceramalloied is placed in a retort that is packed with a specially formulated metal powder. The metal powder consists of mixtures of iron aluminide, alumina, activators and other elements.

The retort is then hermetically sealed and placed into a furnace. The retort is subjected to a controlled heating cycle during which chemical reaction in the powder created an oxygen-free atmosphere within the retort, which is essential to the diffusion process. The presence of oxygen can have a detrimental effect on integrity of the alloy substrate interface.

Through the use of thermocouples and computerized temperature readouts, the internal retort temperatures are monitored. Accurate temperature control is important for creating optimum alloy layer thickness and coverage to meet customer needs.

As the temperature increases the diffusion process begins. Aluminum atoms are introduced into the substrate metal's crystal structure from gaseous aluminum chloride. Temperature, and time at temperature determine the amount of aluminum that is diffused into the substrate's surface.

Material Properties (Typical Values for Information Only) - Mild Steel Base	
Surface Hardness	464VHN (mild steel 90 VHN)
Surface Aluminum Content	approx. 23% (Maximum)
Alloy Depth	0.1mm(.004")~1.0mm(.040")
Oxidation Resistance	excellent to 1200 degrees celsius (2200 oF)
Carburization Resistance	excellent
Sulphidation Resistance	excellent

Formation of an Intermetallic Layer

- * Significant increase in surface hardness resulting in improved wear resistance
- * At elevated temperatures the aluminum oxide reforms providing excellent high temperature wear resistance
- * Seals base metal improving resistance to oxidation, sulphidation, carburization and hydrogen permeation
- * Increased service life of components, resulting in decreased maintenance, and production costs

Higher Aluminum Content Than Direct Alloying—Over 20% at Surface

- * Aluminum oxidizes preferentially resulting in better corrosion resistance and longer life, lower maintenance costs

Creation of Metallurgical Alloy in the Surface, Not a Coating on the Surface

- * Marginal build up of dimensions and the protection can only be removed by machining, will not chip off, no special handling is necessary
- * Component can be heat treated after the diffusion process to attain desired mechanical properties

Layer can be Formed after Components' Fabrication

- * Possible to save on machining costs by working with a carbon steel base and then creating an alloy surface in some applications; cost effective replacement for expensive alloys in aggressive service environments

Not a Line-of-sight technology

- * The protective layer can be created on the inside of pipes and other difficult to reach areas, allowing

for the replacement of expensive materials

Application Guidelines: Ceramalloying is used to combine the corrosion resistance of aluminum with the strength of steels. Ceramalloyed components are most effectively used in high temperature environments subjected to one or several of the following conditions:

- * Oxidation
- * Carbon-rich atmosphere
- * Hydrogen-rich atmosphere
- * Low impact of abrasion / erosion
- * Sulfur-rich atmosphere

Quantum Ceramalloy will assist with trial materials to determine ceramalloying of specific applications. Selection of the base material is critical to meeting the desired physical and mechanical properties.

Application Examples: The following are examples of successful applications of ceramalloying.

- * Oxygen lances
- * Heat exchanger tubes
- * Water cooled furnace parts
- * Nose ring castings, kiln chains, clinker cooler trates in cement production
- * Coal feed tubes
- * Converter tuyere pipes
- * Heat treating furniture
- * Thermocouple protection tubes
- * And many others

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