Stainless Steel Metal Injection Molding and Sintering Techniques Revolutionize the production of Barbed Stainless Steel Hose Fittings

The introduction of metal injected hose fittings for commercial production is fairly recent. The Eldon James Corp. of Loveland, CO began manufacture of 316L Stainless Steel hose fittings in 2001 and was the first company to use metal injection molding and sintering to commercially produce Stainless Steel fittings.

Previously, metal hose fittings were fabricated using conventional metal forming processes in a machine shop and, in the case of complex parts like Tees and Ys, welding was used to join components. This method places various constraints on design and requires alloys that are soft enough for machining. In addition, grooves left by machining and welding scale can produce less than desirable surfaces. Metal injection molding technology allows for the production of parts that are impractical or impossible to fabricate using traditional methods of production, and the process results in cleaner parts with more uniform surfaces.

Metal Injection Molding - MIM

The first step in creating a metal injected stainless steel fitting is designing a mold. Shrinkage factors must be taken into account since green-molded parts decrease in size some 20% as they are heated in a furnace to become solid metal. Two primary factors influence the amount of shrinkage:

1) Feedstock shrinkage related to the off gassing and burnout of binders (mixtures that hold the powdered metal particles together in the green stage).

2) Particle consolidation - as metal particles are heated, pore space between the particles decreases and bridging occurs (see sintering below for more details). In most respects, the injection molding process is similar to plastic injection molding; however, green-molded stainless steel parts require special handling as they emerge from the molding machine, because physically, they are somewhat clay-like and fragile.

Sintering

The next stage in the production of a MIM stainless steel hose fitting is called sintering. Sintering is defined as "*The thermal treatment of a powder or compact at a temperature below the melting point of the main constituent, for the purpose of increasing its strength by bonding together of the particles."* In a specially designed furnace with a controlled atmosphere, "green" parts molded from a powdered metal mixture are brought to a temperature just below the alloy's melting temperature. For 316L Stainless alloy this temperature is about 1800° F. In the first stage of sintering, impurities and binder materials are off gassed leaving only small traces of

carbon in the metal powder. To prevent oxidation of the metal powders, an oxygen-free atmosphere is created within the furnace. In the case of stainless steel, this is most often a vacuum. As the part approaches the alloy's melting temperature a process called solid state bonding occurs forming a solid metal part. It is critical that the temperature not go above this point or the part may collapse. This back-down temperature becomes extremely critical when hollow parts such as stainless steel hose fittings are being produced.

The physical changes that take place in a sintering furnace are fairly complex. In general, the welded areas formed during compaction grow as a result of solid-state diffusion; grain growth and Re-crystallization often follow decreasing the total porosity as a percentage of volume. These changes, if properly controlled, result in a part that resembles a cast or forged metal part.

History

In 1999 Tom Robinson of the Eldon James Corporation began research into the possibility of producing stainless steel hose fittings by injection molding powdered metal combined with small amounts of a binder material. This process had been used successfully in other industries (medical & semiconductor) to produce small intricate parts that would be impossible to machine. Working with metallurgists, a search was made for a blended product exhibiting a uniform distribution of particle sizes and shapes that could be uniformly injected into a molding machine and later, be sintered in a furnace to produce a solid metal part. The success of the project required the resolution of several technical issues: 1) some of the larger size fittings approach a theoretical size limit for sintering, and 2) maintaining dimensional stability of the hollow parts during the high temperature phase of sintering presents a challenge. Fine-tuning of mold and part designs along with process control measures in the sintering environment emerged as the key factors in addressing these technical issues.

Conclusion:

Significant gains have been made in fine-tuning metal injection molding methods to expand the availability of Stainless Steel hose fittings. Research and development continues to influence efficiency and economy as the scope of products becomes broader. Industries like dairy, beverage processing, pharmaceutical, bioscience and water bottling, are increasingly demanding durable, long-life fittings that are resistant to harsh environments. To meet these demands, research is currently underway to develop a diversified range of metal injection molded Stainless Steel fittings that will include: threaded Tees, threaded elbows and threaded adapter fittings.