Assembly Solutions

From FisherTech, division of FisherCast Global Corporation

Zinc alloy instant-cure bond outperforms most adhesives

A White Paper by
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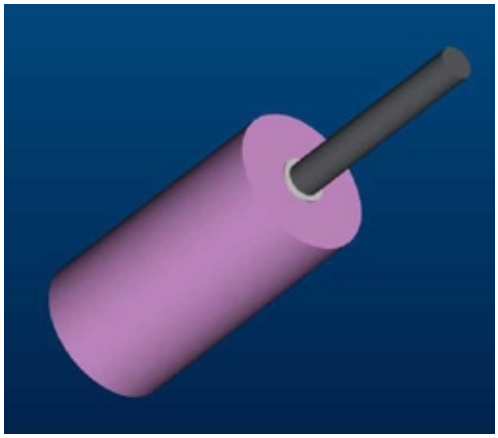
ABSTRACT:

Molten zinc alloy is a powerful bonding agent which can be a highly effective alternative to many instant-cure adhesives. It exhibits properties common to adhesives such as excellent stress distribution, and the ability to join a diverse range of dissimilar materials and those of different thicknesses. The zinc alloy bond, however, requires no special surface preparation, has no peeling and thermal degradation issues common with conventional adhesives, and performs well in harsh environments. The molten alloy bonds materials in milliseconds as it "cures", with the bonded components immediately ready for use.

Molten zinc alloy is not commonly considered as an instant curing "glue", nor as an alternative to instant-cure adhesives for bonding small components. But it has been used for over 60 years in FisherTech's Injected Metal Assembly (IMA™) process to join components in much the same way as adhesives are used. While zinc alloy can't replace adhesives in all applications, it does so in many assemblies without the problems of peeling and thermal degradation inherent with conventional adhesives, and without the need for special surface preparation.



The use of zinc alloy as a bonding agent resembles injection molding around inserts, for example a screwdriver with a plastic handle. It can join a wide range of materials such as plastics, ceramics, glass, paper, engineered synthetics, textile fibers, and elastomers, as well as metals. The method of joining the materials is such that part-to-part consistency is ensured even over long production runs.

Superior performance

The IMA process has much in common with adhesive bonding, such as excellent stress distribution, joining of dissimilar materials, and joining those of differing thickness. But the molten alloy bond requires little or no surface preparation of the materials. The bond also performs well in harsh environments where only specialty adhesives and a few injection molding resins could maintain their integrity.

In the IMA process, the components are automatically positioned in a precision fixturing tool. In less than 20 milliseconds, the molten alloy is injected into a die cavity between the components being bonded. The alloy solidifies in a fraction of a second, and the completed assembly is ejected from the tool ready for use. The alloy has a predictable 0.7% shrinkage which is compensated for in the tool design. While the injected molten alloy is at temperatures up to 815°F (435°C), the solidification speed prevents the materials from thermally degrading. Any heat distortion stresses are extremely brief as the solidification behavior of the zinc alloy mitigates them within seconds. In the case of plastics, zinc's extremely high thermal diffusivity (up to 100 times ++ higher than that of plastic) lets solidification complete before the thermal influence zone of the heat-sensitive substrate material has progressed more than a few thousands of an inch.

Eliminating surface preparation

While adhesives need a carefully prepared surface for proper bonding, zinc alloy requires little, if any, preparation as the adhesion properties of zinc alloy are forgiving of substrate impurities. The materials being bonded need

only be industrially clean. The molten alloy's high fluidity fills voids and, in fact, the mechanical bond is improved as these provide an even greater surface area for adhesion. This high fluidity compensates for the presence of release oils as well as most coatings and paints that don't outgas at low temperatures, allowing a strong mechanical bond. Even Teflon is no obstacle for zinc alloy's bonding capabilities, and that is without the application of primers.

High shrink-fit strength

Zinc alloy's high fluidity property again contributes to performance when it comes to bonding strength. Stress distributes uniformly throughout the joint as the molten alloy completely fills the space between the components. The alloy's shrinkage gives shrink-fit adhesion with high stiffness and resistance to pull-off forces. In fact, components fail before the alloy bond breaks. The metallic bond also allows nondestructive testing with x-rays or eddy current methods to verify joint integrity.

Zamak 3 zinc alloy is usually the top choice for bonding applications. Zamak 3 (acronym for zinc, aluminum, magnesium, and copper) alloy contains by weight 4% aluminum, and a small amount of magnesium. Zamak 5 alloy, which also contains copper, has 15% greater strength, plus hardness and corrosion protection. These Zamak alloys have a hardness of up to 82 BHN (Brinell), and shear and tensile strengths of 31 and 41 kpsi, respectively.

Withstanding harsh environments

Zinc alloy also accommodates harsh environments for longer-term service life. The alloy performs well in operating temperatures up to 230° F (110°C). Bonds between most materials maintain integrity even when they have different co-efficients of expansion. Where a component material's shrinkage differs from the alloy, shrink-to features may be designed to compensate for the differences. The metal bond won't become brittle or show undue stress at temperatures down to as low as -40° F (-40°C).

Zinc alloy has excellent corrosion resistance under normal atmospheric conditions, and in many aqueous, industrial and petroleum environments. It resists gases and most solvents, with the exception of strong acids and caustic solutions.

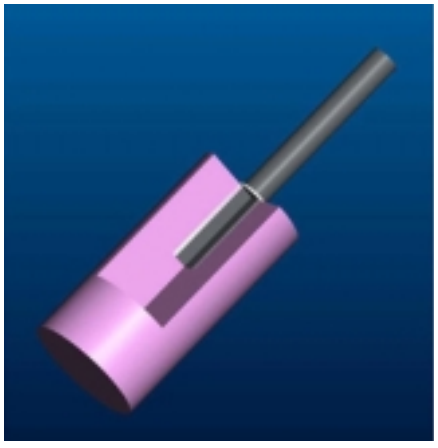
Replacing traditional joining processes

Virtually any small components, that can be joined by adhesives, soldering, welding, brazing, or mechanical processes such as staking, press fitting, and crimping, are good candidates for FisherTech's Injected Metal Assembly process. Quality, consistency and productivity are improved, usually at a fraction of the cost of these methods.

Brittle and delicate materials are well suited for zinc alloy bonding. An aluminum shaft, for example, can be joined to a glass disc in seconds, with no deformation or cracking of the glass. In a ceramic magnet and shaft assembly, the shaft can be held within unparalleled concentricity, or a prefabricated shaft can be eliminated altogether by casting the shaft in zinc alloy and adhering it to the magnet in a single operation.

The high solidification speed of the alloy allows large volume production rates up to 1,000 component assemblies per hour, depending on the complexity of the components joined.

FisherTech provides a range of Injected Metal Assembly systems to meet the specific joining needs of OEMs in the global automotive, industrial controls, appliance, electronic, power tool, hardware and telecom market sectors.



A ceramic grinding wheel and a steel shaft are joined by a thin film of zinc alloy. A small amount of the molten alloy seeps into the stone and shrinks onto the shaft as it cools, securely bonding the components. The joining operation is completed in milliseconds. Compared to similar joints done with epoxy, the zinc alloy bond eliminates curing time, and the assembly is concentric as cast.

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