CROSSLINK TECHNOLOGY INC.
FORMULATED EPOXIES, URETHANES • CUSTOM CAST ELECTRICAL PARTS

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Key Considerations for Casting Systems

There are a number of considerations for selecting the best material to provide a solid, bubble free, crack free, functional and cosmetically pleasing casting. The key material properties are:

1. Mixed viscosity
2. Reactivity
3. Exotherm
4. Shrinkage
5. Thermal expansion
6. Thermal shock
7. Thermal stability
8. Thermal conductivity

The above properties are especially important when casting electrical and electronic components.

1. Mixed Viscosity

   The lower the mixed viscosity the easier it is to process the material. Materials that contain fillers to impart certain cured properties are higher in viscosity than those that are unfilled. Viscosity can be decreased by the application of heat. Reducing the viscosity by heating can be achieved by heating the resin and hardener components separately or by heating the mixture after the resin and hardener are mixed together in the specified ratio.

   It is preferable to heat the individual components since heating the mixture will result in a shortened pot life. As a "rule of thumb", **the pot life will be reduced by 50% for every 10^0C rise in temperature** when heating the mixed material.

   Some casting systems include highly filled, high viscosity resins and un-filled low viscosity hardeners which, when mixed in the recommended ratio, yield quite acceptable mixed viscosities. The best range of mixed viscosity will depend on the application.

   The lower the mixed viscosity the better.

2. Reactivity

   The reactivity of Epoxy and Polyurethane compounds will depend on the type of hardener employed and the chemistry involved. All reacting (curing) materials generate heat as a by-product of the reaction. The amount of heat generated will depend on the chemistry involved and can reach very high temperatures. for example; epoxy systems formulated for thin film bonding applications can generate enough energy to self-ignite in large mass castings.

   The un-dissipated heat generated as a by-product of the curing process will intern speed the reaction further until the material solidifies. Depending on the chemistry involved, systems that are designed to be heat cured, will generate negligible amounts of exotherm and require the application of external energy (heat) to commence the reaction. These materials have very long pot lives.

   Pot life is defined as the period of time, commencing from the time the resin and hardener are mixed together, the mixture remains pourable in its intended application. As a rule of thumb, the faster the reaction the higher the exotherm.

The slower the reaction the better.

3. Exotherm

Exotherm is defined as the increase in temperature above the cure temperature due to the energy released by the reaction. Excessive exotherm can damage components especially in encapsulating electronic circuits. If the resin and hardener are heated to lower the mixed viscosity, the resultant greater reactivity will cause the exotherm (heat) to be generated in a shorter period of time. The ultimate temperature will be much higher as there is less time for the mix to dissipate the internal heat being generated.

High reactivity hardeners used in large mass casting can result in "runaway exotherm" because the heat being generated can not be dissipated at a sufficient rates from the center of the mass. In extreme cases, the temperature in the center of the mass can reach extremes to the point where it actually chars or even explodes.

The lower the exotherm the better. Use low reactivity hardeners for large mass castings and faster reactivity hardeners for small mass casting or thin film applications.

4. Shrinkage

Shrinkage is the reduction in volume or linear dimensions as a result of cure. Excessive shrinkage will result in damage to embedded components and residual built in stresses in the casting. Built in stresses make the finished casting prone to cracking.

As a rule, un-filled products shrink more than those containing fillers and slow reactivity materials will shrink less than high reactivity systems. In most cases, the higher the filler content the lower the shrinkage and the better the thermal conductivity of the casting.

The lower the shrinkage the better.

5. Thermal Expansion

Thermal expansion is a function of the chemistry employed and the filler loading of the system. The higher the filler loading the lower the thermal expansion. In general, more flexible resin systems will exhibit higher thermal expansion properties.

The thermal expansion properties should be as close as possible to those exhibited by the rest of the components in the casting.

6. Thermal Shock

The ability to withstand thermal shock is generally a function of flexibility. The more flexible the cured system the better its ability to withstand thermal shock. This can be a problem if the potted component is required to operate at elevated temperatures because many flexibilized casting systems are not well suited to high temperature operation. The most suitable casting systems are those that possess a good combination of toughness and flexibility.

Depending on the application, the most thermal shock resistant material can be developed through formulating techniques to yield the required combination of shrinkage, tensile strength, elongation and thermal expansion for the part in question.

7. Thermal Stability

   Thermal stability is determined by the ability of a given casting system to maintain a certain set of minimum cured properties at elevated temperatures for a given period of time. Most casting systems will experience progressive loss of strength and overall reduction in properties as they age at elevated temperatures. The detrimental effects of the loss of properties on the component performance will be determined by the demands placed on the part in service.

   For example; if a component is not subjected to any mechanical stresses in service, an encapsulant with a lower set of minimum properties at elevated temperature would be very satisfactory. On the other hand, if the service conditions demand sustaining mechanical or internal stresses, the required minimum properties to be maintained by the encapsulant will be much higher.

   The operating temperature capabilities of a given material will be dependent on the demands placed upon the encapsulated component in service.

8. Thermal Conductivity

   Unfilled Epoxy and Polyurethane systems are, by their nature, excellent insulators which means that they are relatively poor at conducting heat. Thermal conductivity can be greatly improved by incorporating certain types of fillers. The higher the filler loading the better the resultant thermal conductivity. Formulations have been developed to maximize heat transfer through the casting system.

   Highly filled systems are also high in mixed viscosity and usually require heating for ease of processing.

   The higher the filler content the better the thermal conductivity.

Many of the key properties listed above are somewhat opposing one another and represent a set of trade-offs and compromises in developing the correct material for a given application. It is important to consider all the service requirements for a given component in order to find the correct combination of cured properties to satisfy those requirements.

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