COMPOSITE ENVISIONS KNOWLEDGE HUB
PRACTICAL AND INSIGHTFUL COMPOSITES INFORMATION

WHAT TEMPERATURE RATED (TG) RESIN DO I REALLY NEED FOR MY JOB?

COMPOSITE ENVISIONS

INTRODUCTION

Glass-Liquid Transition, Glass Transition or simply "Tg" is a transition of a given polymer from a solid state to a liquid. Thermoplastics can shift back and forth between these two physical states as thermosets cannot.

These Glass Transition temperatures, respective to the resin type, control service temperatures and physical characteristics at a given temperature in which it will be used or exposed to. As in prepreg fabrics, the Tg typically controls the temperature in which it will cure. When selecting a given resin system, Tg is one of the most important properties when considering a resin for end-use. Tg gives thermosets such as epoxies, polyesters, BMI, and vinyl esters an exceptional range in which they can be optimally used and provide a quick means of comparison for applications.

It is important to note that most resins will not have a Tg significantly higher than that of which is it is cured in. These Tg temperatures are highly dependent on the type of hardener used during the fabrication process. Slower hardeners are generally going to have a higher Tg than that of a fast or "snap" cure system. Tg can also be affected by the cure temperature of the hardener as explained in "Why Post Curing Matters". Tg will not always give the composite's "maximum working temperature".

This maximum temperature describes the criteria in which the composite will keep its structural integrity under loading. The Tg provides more of a range in which to go by. The Heat Deflection or Distortion Temperatures generally relates to the optimum temperature for applicable uses while a composite is under a small load.

IN PRACTICE

A boat hull for example will not need a high temperature capable resin system. Most boats manufactured today have a Tg much higher than that of what is expected in regular use. Therefore, its mechanical characteristics remain the same during its entire lifecycle given applied stresses do not become as high to cause degradation issues. Most room temperature cure resins would work in this application.

For areas that are exposed to more heat, such as a car hood in which temperatures of ~250F are possible with the addition of turbochargers in some vehicles today. A higher capable resin would need to be used unless planning to make a new part every 6 months or so. Limited exposure to temperatures close to a resin's Tg will not have as much of an effect on the part. However, prolonged exposure will lead to degradation of mechanical properties.

Lower temperature rated resins will fade quickly and lead to part deformation or warping affect. Use of a 300 F or higher Tg rating would be needed as a minimum to ensure a quality part. In addition, the hood should use a resin with UV protection to mitigate the effects of sunlight degradation. Sunlight degradation can cause a “browning” effect on certain resins and / or limit the life of the composite. Sunlight degradation may also be mitigated by use of a UV resistant Topcoat.

The use of composites on parts such as valve covers likely sees slightly lower temperature exposure to that of a car hood. Temperature exposure of a valve cover is generally limited to and controlled by the engine’s safe operating temperature, which should not get over 200F in most vehicles.

For a gas tank, temperatures exposed to a resin or composite system will not get over 100F or ambient temperatures within the environment for conventional vehicles. While it is best practice to keep gas, tanks stored or kept in a relatively cool environment, some gas tanks are exposed to direct sunlight. If this is the case, some design features should be built around to ensure that vapors do not build pressure within the tank. Resins used in direct sunlight should be rated with a Tg of ~ 200F in order to avoid possible warpage issues.

An additional rule of thumb to use for judging a Tg for a resin system is knowing what the component is currently made from in existing processes. Spoilers, for example, are commonly made from ASA plastics. (Acrylate Styrene) The service temperature of the plastic is 167F. Knowing this fact, using a resin capable of a service temperature in the range of the ASA plastic would serve as a safe bet for a spoiler on a car.

CURING CONSIDERATIONS

Resin properties are highly affected by their cure parameters. As shown in Composite Envisions INK-114 & INF-211 resins, heat deflection temperatures can variate more than 40F based upon its post cure parameters (129 F to 173F). If there is not significant loading upon the composite part, temperatures the composite may be exposed to can reach close to 200F with the proper post curing parameters. This fact makes it possible to engineer cure parameters for use of a single type of resin for differing end use temperature needs.

When designing around a specific resin system, additional options are available. Options such as lowering temperatures that composite components may be exposed to. Temperature resistant coatings can be placed in areas that may be susceptible to higher temperature exposure. Economical options include the addition of fabrics and mats used commonly today in the auto industry, to protect the inside of hoods or other parts from high temperature exposure. If mats are used to insulate from temperature on a car hood, a lower Tg resin would be possible to use. The overall goal is to mitigate the exposure of heat and humidity placed upon parts that are close to their optimum design parameters for temperature.

In the aerospace industry, but not limited to, autoclave and oven cured epoxies are common. In most cases prepreg resins provide service temperatures exceeding 350F. This would

be effective for body panels and structurally loaded parts that do not see much friction. (Friction may expose the laminate to higher temperatures)
If service temperatures beyond 400~500F are needed for structural parts, use of resin types such as BMI or Polyamides may be of a better use, though more expensive.

When planning to fabricate any component, questions pertaining to if & how a component has been made in the past should be asked, researched, and vetted thoroughly. The materials used for the part before will likely tell what temperatures a resin of the same capabilities should or could be made from. The knowledge gained on the existing conditions of the parts original structure will help better the design phase of the composite component. Always reference the resin's Technical Data Sheet (TDS) for information regarding the heat capability and cure parameters of any resin.

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