Bonding Cast Polyurethane to Metals

In this white paper, we’re going to cover the principals of bonding cast polyurethane to metals.

When we say that a part is bonded, we mean that the urethane elastomer is chemically bonded to the substrate – in most cases metal. There are other methods of attaching cast polyurethane during molding – such as a mechanical lock – but those won’t be covered here.

Our polyurethane elastomers in raw form are a liquid. This allows them to be cast -- similarly to how metals can be cast in a foundry.

Part designs that call for metal reinforcement can be accommodated by bonding cast polyurethane and forming a chemical bond during the casting process.

When bonding cast polyurethane, the metals are coated with a primer that we call a bonding agent. The bonding agent reacts with the metal surface and will react with the liquid urethane as it cures. The result is an extremely tough chemical bond that is stronger than the urethane itself.

The key to a good bond is proper metal preparation. Because most bond tests are destructive and because you can’t physically see the bond before placing a part into service, it’s vital that a tightly controlled bonding process be followed.

The process of bonding cast polyurethane to metals that has been refined over the years here at Gallagher Corp includes: degreasing the metal, abrasive grit blasting of the metal, applying the chemical primer, and finally casting the part.

NOW LET’S TAKE A CLOSER LOOK AT EACH STEP OF THE PROCESS OF BONDING CAST POLYURETHANE TO METALS.

• DEGREASING THE METAL

  o In the first step in the process of bonding cast polyurethane, the parts are thoroughly washed with a solution of hot alkaline detergent and water. The washing cycle is timed such that each part is bombarded with direct spray from the high-pressure nozzles in the washing cabinet.
  o After a short dwell to let the solution drip off, the parts are then rinsed with fresh water to remove any residual detergent. Daily titrations are done on the washing solution to ensure that the concentration level of the detergent is correct.
o It’s vitally important that all oils are removed from the raw metals at this step in the process as any residual oil would prevent the chemical primer from properly adhering to the base metal.

o Following the washing step, sample parts are tested for cleanliness using a tool called the **Surface Analyst**. Essentially, this tool performs the water break test on a sample part and provides a numerical data point indicating the cleanliness of the sample. A high angle reading indicates that the part still has residual oil on the surface, think of when a water droplet beads up on a freshly waxed car. After the part is washed, it’s important not to touch the part again with bare hands. Oils from the skin would contaminate the part and threaten bond strength.

• **ABRASIVE GRIT BLASTING**
  o After a part is washed it is abraded by grit blasting. The grit blasting operation removes any scale or oxidation.
  o Grit blasting also produces an anchor pattern on the metal which increases surface area and helps the primer to fully attach to the base metal.
  o Typically, this is what the metal surface would look like if you magnified it following the blasting step. By increasing the surface area and achieving an anchor pattern of peaks and valleys, the mechanism for peeling the elastomer from the base metal becomes a combination of shear and tensile stress as opposed to pure tensile stress on a perfectly smooth surface.
  o It’s important that the blasted surface isn’t too rough or too smooth. A surface that’s too smooth doesn’t take full advantage of the operation. A surface that is too rough will complicate the process of properly applying the primer. When a surface is too rough, the primer will not be applied uniformly. The peaks of the blasted surface are exposed – without any primer – while in the valleys, the primer will puddle and become too thick.
  o The target roughness average for the grit blasting step is approximately 250 Ra. Surface roughness is checked regularly using a roughness gauge to ensure the process is within spec.
  o After the parts are grit blasted, any residual dust from the blasting process is removed. A simple test for cleanliness after the blasting operation can be done with clear packaging tape. This **tape test** will pick up any dust or residual blasting media from the surface of the blast part.

• **APPLYING THE CHEMICAL PRIMER**
  o At this point, the part is ready to have the primer applied.
  o A primer can be applied by a variety of methods including brushing, dipping or spraying.
  o The most important aspect of applying the primer is the final dry film thickness.
  o Dry film thickness is checked using a thickness gauge according to the beta-backscattering method. If the primer thickness is too thin, you run the risk of not fully coating the surface of the metal. If the primer thickness is too thick, then the shear strain on the primer will be higher than necessary when a load is applied to the part. Dry film thickness is controlled by monitoring the viscosity of the primer.
  o After the parts are primed and the solvent is fully evaporated, they’re almost ready to be cast with urethane. However, before the elastomer can be cast, the primed metal must be prebaked. The primer is heat activated, thus by prebaking, the primer bonds itself to the base metal and becomes active for reaction with the liquid urethane material.
CASTING THE PART

- Once the liquid urethane is cast into the mold, it begins to cure.
- As the curing process progresses, the urethane changes from a liquid into a solid. While the curing process is taking place a chemical reaction occurs between the urethane and the primer. This reaction attaches the elastomer to the metal.

The process of bonding cast polyurethane to metals at Gallagher Corporation is documented and tightly controlled to ensure quality. Sample parts are pulled from production every day for quality assurance bond testing. Bond failure is not an option for our customers. That’s why we put so much effort into getting it right every single time.