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GBI ups the ante with the purchase of new Brookfield Cone and Plate Rheometer

by Bruce Niederer

The most recent addition to the Gougeon Brothers instrument lab is a Brookfield R/S-CPS+ Rheometer. The R/S-CPS+ is a rotational stress controlled instrument, meaning the material being tested fills a gap between the bottom measuring plate of the instrument and the rotating measuring element (cone).

The measuring drive features a highly dynamic system of an integrated motor and optical encoder without gearing and without mechanical force transducers which allows for detailed and very accurate viscosity and rheological analysis. Measuring cones and plates follow DIN (the German industrial standards organization) specification 53018.

The Rheometer can measure materials in two different modes:

- controlled shear rate (CSR)
- controlled shear stress (CSS)

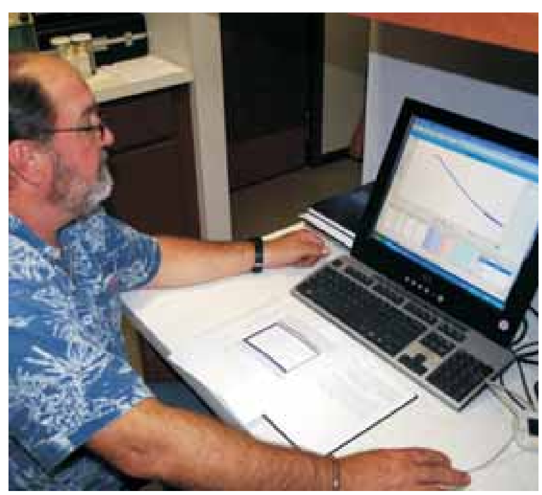
CSR is a measurement taken where the shear rate (rpm of the conical measuring element) is pre-set at either a specific shear rate or over a range of shear rates. This enables us to understand how a material's viscosity behaves over a wide range of induced shear.

CSS is a measurement taken where the shear stress (the force applied to the conical measuring element) is controlled. This is useful to determine with precision the yield point of plastic materials—without shearing the sample.

The R/S-CPS+ measures Newtonian and non-Newtonian fluids and will record flow curves and determine viscosity functions in steady shear flows. It is used for quality control, product development and R&D. It has proven itself to be a valuable method for measuring heavily filled or highly viscous materials that can't be measured with our trusty Brookfield RVF helical viscometer.

The R/S-CPS+ Rheometer enables us to paint a much more detailed picture of a product's rheological profile to our customers by adding shear and recovery data that augments viscosity and flow data. ■

The rotating element is lowered onto a small amount of filled resin on the measuring plate.



The rheometer is controlled by a nearby laptop which records and displays the results.

Building Molds and Tools with PRO-SET Epoxy

We're frequently asked which PRO-SET epoxy products to use for building durable molds and tooling for production of molded composite parts. The answers are not always simple, but we will define several resin and hardener combinations that are appropriate for this application. This article will help you select products to match the requirements of the tool.

To properly choose the epoxy materials, the fabricator first must answer some questions about the expectations for the particular mold or tool: How many parts are planned for the mold? Will this be a positive mold or a negative mold? What is the part manufacturing process? What is the cure temperature for the part? Will the part have an in-mold coating? Will the part be finished after molding? What will the finish be? How will the mold be supported? Will the mold need to be rotated or moved during the part fabrication? There are probably more questions to consider, but these will help the fabricator make the initial decisions for product selection.

Let's use as an example tooling we are building for a decked canoe that will build 10 to 50 parts. We intend to paint the parts once they're removed from the mold, but we will want a fair surface that will need only a quick scuff sanding prior to paint. The parts will be infused and will be built in a right half and a left half that includes hull and deck. There will be a centerline seam. This will require female (negative) molds. The part is small enough for the laminator to reach the entire area of each mold standing on the floor of the shop, so we won't need to move or rotate the molds. We intend to cure the infused hull halves at 150° F for six hours following gellation of the resin. This post cure will require stable tools that can handle multiple heating and cooling cycles and have proper flanges along the perimeter to create a space for the vacuum bag seal.

The first half-mold for the starboard side of the decked canoe is laid up, ready for a framework and lay up of the port half-mold.

The molds will require a fair, smooth surface in order for the resulting parts to have smooth, easily painted surfaces. This means the molds need a durable surface coat that can be repaired and buffed if necessary. The elevated temperature part cure requires high thermal properties in the resin systems used to fabricate the molds. To insure adequate thermal properties, we will post cure the tools prior to building the first parts.

For these specific molds, we used M1019 black surface coat resin as the first coat on the plug. Using a faster hardener like 224 allowed us to apply the first ply of mold laminate a couple of hours after the application of the surface coat. We let the surface coat cure until the surface was slightly sticky, but didn't leave a fingerprint when pressing a thumb gently onto the surface.

We used PRO-SET 145 resin with 226 hardener to laminate the mold shells. This combination will provide a Tg temperature of approximately 175°F (80°C) with the cure temperature we will use. Because the intent was to post cure the parts in the molds, no core was used. So, the mold shells needed to

Tom Pawlak applies M1019 black surface coat resin with 224 (fast) hardener to the waxed, wooden plug.

Pawlak and Ben Gougeon apply sheets of 1 oz/yd^2 fiberglass veil as an intermediate layer between the surface coat and the heavier mold laminate.

be thick enough to provide the stiffness required to keep the tools stable and fair. For molds the size of this canoe, 5⁄16" skin thickness is probably sufficient.

If higher temperature molds were required, we would have used PRO-SET M1012 resin with M2010 hardener to laminate the mold shells. This combination can reach a Tg of up to 270°F (135°C) with proper cure.

The molds need framing to support them over their length. Some folks use plywood and some use steel to frame molds. The best method is to make flat composite panel stock with the same fiber and resin system as the mold. This flat stock can be cut up and used like plywood to form the framing and stringers. This framing stock should be post cured on the flat table prior to removing it and cutting it up. The framing can be glued in place and filleted with PRO-SET 175/273 Adhesive, then taped to reinforce the structure. For these particular molds, we'll use plywood.

When post curing a mold, it is generally left on the plug. In instances such as this, the plug is made of materials that cannot withstand the post cure temperature, so a lower temperature cure will be done with the molds on the plug, followed by a free standing post cure. During the post cure cycle it's critical to control the cure temperature. To minimize movement or distortion, we will use a slow temperature ramp rate—raising the temperature about 10 to 15°F per hour until we reach the part cure temperature plus 10°F. Since we are planning to cure the canoe halves in the molds at 150°F (65°C), we will cure the molds at 160°F (71°C).

Once the molds are completely post cured, any surface profile can be wet sanded and buffed out to get a smooth surface for molding the canoe halves.

If you have any questions about building tooling with PRO-SET Epoxy products, contact our Technical Support staff at 888-377-6738. ■

Quality Control in the Shop part duex

In the last issue of the PRO-SET Report, we discussed a number of ways to minimize the potential for failure in the manufacture of epoxy composite parts. In this issue, we will expand on a few of those ideas and include some recommendations to improve shop cleanliness and productivity.

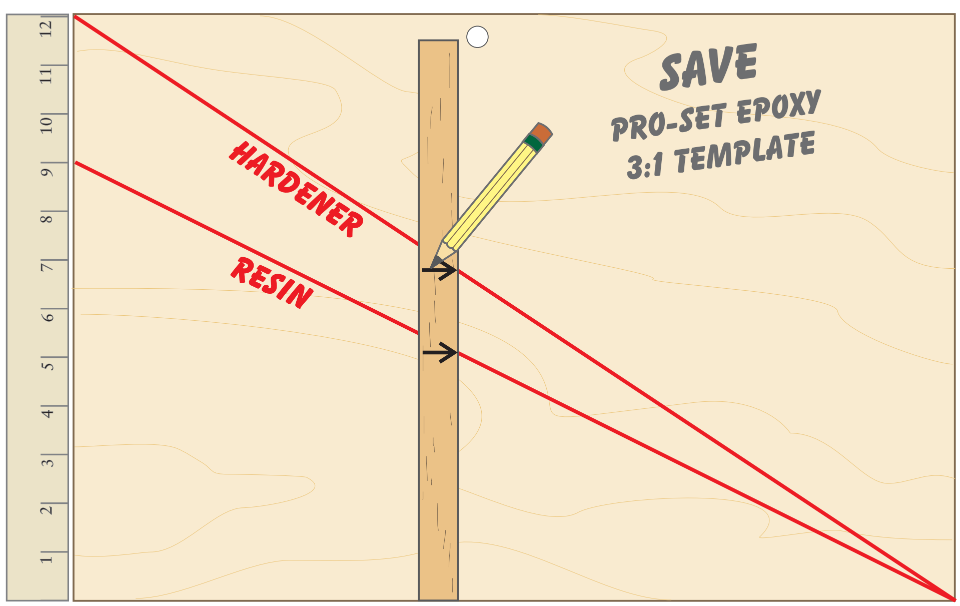
Epoxy metering and mixing station

Maintain a dedicated area in the shop, preferably away from the actual lamination area, where metering and mixing of the epoxy can be done comfortably. This area should have a supply of mixing pots and buckets, mixing sticks or paddles, the QA record documents, data sheets to identify the correct ratio for the resin/hardener combinations you will be using, plenty of gloves, a supply of paper towels, a good ventilation system and any filler necessary for thickening. There should be an accurate scale for checking pump ratios as well as any volumetric measuring containers regularly used. As a handy reference, keep nearby a summary sheet of all resins and hardeners used in the shop. A neat, well organized mixing area reinforces that metering and mixing are critical to the quality of finished components.

Large batch measuring

There are several good methods for metering large batches of epoxy resin and hardener at the correct ratio when undertaking large part fabrication. Using an accurate scale is always a reliable approach.

For volume measurements, use a straight sided container and calibrated mixing sticks. To create a 3:1 volume ratio template for marking the stick, use a rectangular piece of scrap plywood or laminate approximately 12" high × 18" wide. Along one edge of the scrap, measure up 9" and make a small mark with a fine line marker. Using a straightedge, draw a line from that mark down to the bottom opposite corner. Then draw a second line from the top corner above the first line (12" mark) to the opposite bottom corner (*see illustration*). Now you can stand the template on the bench



A 3:1 epoxy measuring template. Move the marking stick right or left to adjust the volume of epoxy. Be sure to label the template so it doesn't get lost.

top. When you hold a mixing stick up to the template with its bottom end on the bench, you can transfer the line onto marks on the stick. The ratio between the marks will be 3:1 anywhere along this template. So if you need a lot of material, slide the stick toward the tall side of the template and if you need a smaller amount, slide it to the low side. To have enough resolution to see the marks on the stick clearly, use the larger half of the template. Stand this stick in the straight-sided pot or bucket. Pour resin to the first mark on the stick, and then add hardener to the second mark.

Large batch mixing

Several large buckets with lids are handy for use with a drill powered mixer. Cut a hole in the lid to slide the mixer through. When using this type of mixer, do not run it at high speed as this will add a great deal of air into the epoxy mixture. Once the bulk of the mixing is done, scrape the sides of the bucket with a paddle or mixing stick to fully blend the resin and hardener. Pour the mixed epoxy into an application pan or tray.

Another option is a pail mixer that uses a rotating turntable to spin a bucket of metered epoxy around a stationary mixing paddle. These are effective mixers and can blend thick materials like our 185/285 Fairing Ccompound or core putty. A reliable unit is available from INDCO Inc., www.indco.com. (*photo right*).

With any large batch mixing method it is critical to get the epoxy distributed into smaller containers once it is fully mixed. This prevents the batch from heating up and generating an uncontrolled exotherm. Larger batches will cure more quickly, so distributing them into smaller containers for application will extend working time. Also, if there is any unmixed resin or hardener clinging to the side of the mixing pail, you do not want to transfer this to the part you are working on because it may leave an uncured area.

INDCO Inc. Pail Mixer.

The most significant quality improvements are easy to implement. Make sure the shop is clean and well organized and let your personnel know that their efforts, attention to detail and skills are the most important contributors to a quality part. Provide the tools and methods for those employees to provide your company with quality work. ■

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