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Quickstep

Press Release

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Henkel and Quickstep present study of benzoxazine components and OoA manufacturing process for aircraft and helicopters

Composites for High Temperature Applications

Fiber reinforced polymer composites are increasingly considered for replacing metals in high temperature-resistant components for aircraft and helicopters. With very limited resin options available to manufacture such composite components, Henkel and Quickstep analysed a Loctite benzoxazine resin, which offers high glass transition temperatures and excellent hot/wet performance, combined with room temperature storage and easy processing to develop an energy efficient and manufacturing friendly Out-of-Autoclave (OoA) process.

The use of liquid resin processes such as resin transfer molding (RTM) and vacuum assisted RTM (VARTM) has developed rapidly in recent years. There is a strong desire to use these processes more extensively in future aerospace structures because large and complex parts can be manufactured economically, and the costs of autoclave processing of prepreg materials can be avoided. Despite the benefits of liquid resin processes, there are challenges to extending their use to primary structure and high temperature applications due to the limitations of the resin systems available including:

- Toughness
- High temperature performance
- Infusion conditions
- Stable viscosity at infusion temperature
- Cost-effective and controlled heating and cooling during processing

In the study conducted by Henkel and Quickstep, a benzoxazine resin was combined with a rapid heating and cooling manufacturing approach to produce high temperature resistant composite laminates and parts at significantly lower cycle times. Key mechanical strength properties were measured and are reported. The technique was then applied to a curved, integrally stiffened composite panel to

demonstrate the ability of the process to produce complex parts suitable for use in aerospace applications.

Materials for high temperature performance

Epoxy, polyimide, polyurethane, bismaleimide (BMI), benzoxazine and cyanate ester thermosetting polymers are commonly used in high temperature composite applications; the specific material system is selected based on the application area. Nevertheless, processing of each resin type differs greatly and requires attention towards the issues of foaming, pot life, and the possibility to use as an infusion resin, including viscosity, infusion temperature, curing temperature, etc.

Being related to the chemistry of phenolic resins, benzoxazines offer excellent flame retardancy and very low cure shrinkage. In contrast to phenolic resins, they cure without elimination of volatiles and show significantly better properties of the cured material. Henkel has introduced a number of commercial benzoxazine systems suitable for use in prepregs, adhesives and infusion processes. For this study, Loctite BZ 9130 AERO resin was selected and characterized using the Quickstep process for the infusion processing. Key characteristics of the resin include:

- Room temperature stability, requiring no refrigerated storage
- A one-part system, so no mixing required by the processor
- Broad processing window, suitable for large parts and complex shapes
- Stable, low viscosity at infusion temperature
- Low heat release during cure, reducing exotherm risk
- High hot/wet property retention for higher service temperature applications
- Increased toughness

Environmentally compatible processing

Preform resin infusion technology is the main target to avoid prepreg and autoclave processing. This alone is beneficial by eliminating the needs of pre-impregnation processes, cold storage and wastage of specially treated materials. For the laminate and demonstrator curing the Quickstep process was chosen. The Quickstep process is based on the principle of conduction heating. This process utilizes a heat transfer fluid (HTF) to apply heat and pressure to the uncured component during processing. Rapid transfer of heat energy into the curing substrate (fiber and resin) is the heart of this technology.

Conventional mold heating, such as that in an oven or autoclave, causes uneven temperature distribution over the mold surface. The use of the fluid-based Quickstep process solves this problem, while achieving the fast ramp-up rates. Uneven temperature distribution over the laminate also affects resin shrinkage and may cause changes in polymer morphology. The Henkel benzoxazine resins have lower heat of cure compared to conventional resins and therefore can be heated rapidly without risk of uncontrolled exotherm.

A heated fluid and slightly pressurized Quickstep process (up to 0.8 bar) accurately achieves the required mold temperature all over the surface with faster ramp rates

and effective utilization of energy. This helps to modify the cure cycle and dwell time without affecting the physical and chemical nature of a polymeric resin.

By combining the cure kinetics of selected resin, OoA curing and online temperature monitoring during the process, the dwell times to complete the laminate curing can be shortened to a great extent. Ultimately, this also causes lower energy consumption during the manufacturing processes. Additionally, fewer molds are required for serial production and reduced machine work hours and maintenance, etc., resulting in lower costs.

Production of prototype demonstrator

In order to demonstrate the capability of the resin and infusion/curing techniques on a scale larger than flat laminates, a demonstrator panel, approximately 1 m^2 was preformed and infused. This panel consists of 5 layers of 370 gsm 5HS carbon fabric for the skin plies, resulting in a skin thickness of 2 mm, onto which a series of four hat-shaped, or omega-type stiffeners were placed using removable mandrels. The assembly was bagged and placed into the Quickstep curing chamber for infusion and cure.

Fiber volume and laminate quality measurements

After molding and post cure, the panels were tested by Henkel. Thickness measurements were in the expected range for woven fabric panels produced using the VARTM process. The hat-stiffened demonstrator panel was inspected for thickness and any evidence of dry spots. Visual inspection indicated no evidence of dry areas throughout the panel. Microscopy analysis of trimmed edges confirmed no visual internal voids in the panel or stiffeners.

Promising results

The processing of the Loctite BZ 9130 resin proved to be “infusion-friendly” in the Quickstep process, and void-free panels were produced with fiber volumes in the 55 to 57% range, which is considered high for a woven fabric laminate. Mechanical evaluation of the panels confirmed values similar to or higher than those achieved in standard oven-based VARTM processing. The Quickstep process provided a faster heating and cooling of the laminate and uniform temperature during the infusion process. The results demonstrate the synergistic benefits of the Henkel benzoxazine infusion resin and the Quickstep process technology.

Henkel and Quickstep presented the full study at CAMX in Orlando, USA, in mid-October.

For more information, visit our website www.henkel-adhesives.com/aerospace.

Background on Quickstep Holdings Limited

Quickstep Holdings (ASX:QHL) is a manufacturer of advanced carbon fibre composites for the aerospace and defence and automotive industries. The company operates state-of-the-art manufacturing facilities at Bankstown Airport in Sydney, Australia, and has offices in Germany and the United States.

Quickstep is also developing patented manufacturing technologies to produce high-volume A-grade finished composite components for automotive and specialist thick parts such as spars and wing skins for large defence and commercial aircraft. The company is currently working to qualify its patented Quickstep Process for the F-35, and is also conducting a major research and development program with car maker Audi aimed at delivering high quality finish, low cost, fast processing of carbon fibre composite, together with specialised resins, particularly adapted to the automotive industry.

About Henkel

Henkel operates worldwide with leading brands and technologies in three business areas: Laundry & Home Care, Beauty Care and Adhesive Technologies. Founded in 1876, Henkel holds globally leading market positions both in the consumer and industrial businesses with well-known brands such as Persil, Schwarzkopf and Loctite. Henkel employs about 47,000 people and reported sales of 16.4 billion euros and adjusted operating profit of 2.5 billion euros in fiscal 2013. Henkel's preferred shares are listed in the German stock index DAX.

Photo material is available at http://www.henkel.com/press

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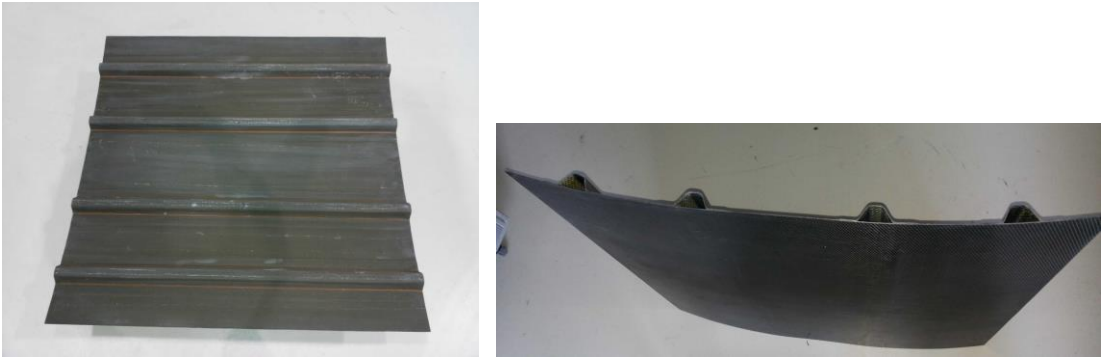

Hat-stiffened curved panel demonstrator produced using BZ 9130 resin.