New Composite Molding Method

The low pressure injection molding process makes it possible to combine nonwovens and low cost plastic resins in a single step.

By Siebolt Hettinga

Dr. Hettinga is the owner and principal scientist of Hettinga Equipment Inc., based in Des Moines, Iowa. The company markets Hettinga technologies and multi-station injection-molding equipment. The following article was presented by Dr. Hettinga at the 4th International Textiltech Symposium in Frankfurt, Germany.

Nonwoven textiles are moving rapidly into tough and demanding new applications, thanks to a major development in plastics processing, low pressure injection molding. The process takes nonwoven textiles from limited functions, as inexpensive backings and short-lived disposable products, and moves them into applications in indoor and outdoor furniture, carpeting and automobile and airplane interiors.

The low pressure injection molding process makes it possible to combine nonwoven textiles and low cost plastic resins in a single step, to produce a range of high quality parts. In composite molding of nonwoven textiles, the textile and the resin are mutually reinforced.

The textile acts much like glass fiber reinforcement, strengthening the plastic substrate while simultaneously providing a decorative finish. The plastic serves as a substrate or structure that captures individual textile strands. This gives the fabric a strength and wear-resistance that is unheard of in nonwoven fabrics. Not only does the nonwoven provide strength and modulus, but it can convey other properties such as fire resistance, sound deadening and insulation.

Important Alternative

Composite molding of nonwoven fabric represents an important alternative to glass fiber reinforcement. Essentially a continuous fiber, less nonwoven textile fiber must be embedded to achieve a part strength comparable with most glass fiber reinforcement. This translates into lower part weight and better modulus. And, since abrasive fibers are not moving continuously through the system as in the case of glass fiber reinforcement, wear and tear on the screw, barrel, nozzle and mold is minimized.

Composite molding also eliminates the labor and added materials required to install a glue backing. For example, one-fourth of the thickness of a nonwoven carpet textile can be absorbed in the plastic substrate. Since it is thoroughly embedded in the plastic, it is impossible to strip the textile from the plastic structure. There are no loose edges to pull away or chance that the fabric will buckle over time.

Not only does the nonwoven textile strengthen the plastic part, but the durability of the textile itself is greatly enhanced. A good example would be carpeting on automobile floors. It is not the top of the carpet that wears out but

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Figure 1: Weight savings in seat using low vs. high pressure injection molding.
the backing, as sand and grit work their way down and in, breaking the fragile bonds at the glue interface. This problem is eliminated in composite molding of nonwovens since no glue is used and a portion of the fibers are totally entrapped by the plastic.

Nonwoven composite molding allows automotive and furniture manufacturers to use low cost commodity materials instead of expensive substructures. This can reduce costs by as much as 50%. For example, ABS (acrylonitrile butadiene styrene) typically is used because it is compatible with adhesives. Eliminating the need for glue means that less costly resins, such as polypropylene, can be substituted. This can result in dramatic weight and cost savings. (Figures 1 and 2.)

Besides strength and durability, moisture problems — odor, mildew and rot — are eliminated also. Since water cannot penetrate beyond the fiber/resin interface, moisture can be wiped off easily, allowing the surface to dry within minutes. In highly humid climates or in family automobiles where the chance of liquid spills is high, this can be a real plus.

Any type of fabric and plastic resin can be composite molded; material compatibility is no longer an issue. Materials such as polypropylene and nylon, or polypropylene and PET (polyethylene terephthalate) can be combined to produce durable, high quality parts at a fraction of the cost of standard methods.

**Composite Molding**

Composite molding of non-woven textiles is simple.

First, the nonwoven fabric is needle punched. The punched holes provide a point of entry for the plastic melt and access to the individual strand surfaces for entrapment by the resin. The density and depth of the holes are varied to suit the application.

Once prepared, the fabric is placed in the female half of a mold, the mold is closed and a precise volume of molten plastic is injected at low pressure into the mold cavity.

The use of low pressure injection is essential to the success of this operation. The work described here involves the use of low pressure Thermoplastic Solid Molding (TSM™), a proprietary technology developed by Dr. Siebolt Hettenga.

Low pressure injection fills the cavity gently and evenly. This means that the textile is not deformed in any way and the resin can migrate evenly through the subsurface, creating a uniform textile/resin composite structure.

Low pressure TSM represents a radical departure from traditional high pressure/high speed methods. It is based on maintaining a solid melt front by injecting, at low pressure, a fully plasticized and uniform melt.

This, in turn, eliminates the need for packing out and the high injection and clamping pressures associated with the packing out process. Because the material is not subject to the high temperatures and pressures that can degrade the physical properties, less costly commodity resins can be used, and delicate textiles and films can be incorporated into the part.

**Back To Basics**

To best understand low pressure molding, one needs to look back at the earliest injection molding machines — machines powered by hand, not hydraulics.

Injection was achieved by
pulling on a wooden handle which forced the material into the cavity. The operator's brain was the control system, with a feedback loop from the hands and arms.

Molding was done by feel — too little pressure and the cavity did not fill, too much and the part flashed. This arm-powered system worked well until parts became too large and complex to mold by hand. Thus, steam power and later hydraulics were introduced, but with these advances, the ability to control by "feel" was lost.

Greater injection pressure meant a higher clamp force was required; with greater clamp force, a stronger and costlier tool was needed. And now a better control system was also necessary. That is how today's modern injection molding machine evolved, with its high clamp forces and lightning fast injection speeds, but with limitations brought about by the high pressures and the lost "feel" of the process.

Hettinga's approach has been to go back to basics — to try to recapture the feel of the process by combining low pressure injection with advanced hydraulics and sophisticated electronic control. This "new" technology has opened the door to a host of possibilities, from molded in textile, delicate film and electronics to localized reinforcement, and hollow core molding.

The key to the process is the ability to maintain a solid melt front throughout the filling process. This requires injecting at low pressure, a fully plasticized and uniform melt. Low pressure injection molding contradicts conventional molding wisdom that asserts that unless high speeds and pressures are used, the melt will cool and freeze up before the

Figure 5. During low pressure injection of a fully plasticized and uniform melt, the melt front maintains its integrity throughout the filling process.

Figure 6. Gentle, even pressure fills the cavity so packing is eliminated and internal stresses are not created.

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Studies conducted by Hettinga show that during conventional molding, it is not freeze up but a choking off of the melt that occurs. As the photos clearly show, low pressure injection produces an even, uniform melt front that gently fills the mold cavity. (Figures 3-6.) By contrast, high injection pressures result in breakage of the front almost as soon as it enters the cavity. Increasing the pressure only exacerbates the problem by choking off the melt because of the hydraulic melt effect.

Hydraulic Melt Effect

The theory behind the hydraulic melt effect is that as the part fills, the surface area in contact with the mold halves increases in proportion to the melt front. Thus, the proportional area of the melt front to surface area at one inch from the gate is greater than the proportional area of the melt front to surface area at two inches. As the surface area increases relative to the melt front, the pressure on the sidewall (mold halves) exceeds the pressure on the leading edge. Increasing injection pressure increases the pressure on the sidewalls so that it is possible to choke off the melt flow before the cavity has filled.

The typical remedy is to pack out the part, but the high pressure required for packing out results in molded-in stress which can have a negative effect on the part. By contrast, low pressure molding does not require packing out, and thus molded-in stress is avoided, less material is used and delicate parts such as films and textiles can be molded into the part without difficulty.

Traditional plastics processors and even some textile manufacturers now employ low pressure molding to produce nonwoven textiles/resin composites.
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