Hot-melt technology takes the pressure off low-cost overmolding

A new, unique hot-melt polyamide molding technology enables custom overmolded cable/interconnect solutions using standard low-cost connector components.

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Overmolding has long been a proven strategy for transforming functional but not particularly robust connectors into superior interconnections that will stand up well under punishing conditions. This may involve encapsulating the connector to protect it from moisture and providing a better mating seal. At the same time, the cable/connector interface can be protected with enhanced strain- and bend-relief features. Unfortunately, a wide range of connector systems do not adapt well to conventional thermoplastic molding.

Depending on the application, hot-melt polyamide molding can be used as a single-step approach for encapsulating low-cost connectors, or as a pre-mold process to prepare for the rigors of injection molding. In either case, this approach can reduce unit costs by as much as 80%, while dramatically shortening lead times for a wide range of connectors used in industrial, military, and medical-device applications.

The problem has to do with the high pressures developed within the injection mold. While injection pressures at the nozzle of the mold machine are relatively low, the pressure generated within the mold cavity is exponentially greater, enough to crush a fragile connector. Since many low-cost connectors were not designed for thermoplastic overmolding, they are likely to have interstices that make it difficult to seal off the part in the mold. This makes the process difficult to control effectively, resulting in poor manufacturing yields. Polyamide hot-melt molding can provide a solution to both of these pressure-related problems.

Polyamide advantages

Hand potting is the method widely used to waterproof connectors that cannot be overmolded, or to pre-treat them so that they can be overmolded. Unfortunately, hand potting is too variable a process to hold consistent dimensional tolerances. It is also labor-intensive. There is, however, a common adhesive polyamide, which can be applied accurately to connector assemblies via a hot-melt molding process.

The advantages of pre-molding and encapsulation with polyamide are numerous. The low-viscosity polyamide material is molded at low pressure, so mold shut-off is not cause for concern. The low-pressure, hot-melt molding technique will not crush fragile connector designs.

Polyamide is environmentally stable, which makes it perfect for encapsulation. This material is stiff, resulting in high-integrity encapsulations that resist shock and vibration damage. Polyamide has a high dielectric constant. It can be used freely to fill in between contacts and solder joints without creating conductivity issues between them. The material is recyclable so that the sprues and runners trimmed from the finished parts can be reintroduced into the process. Material utilization is essentially 100%.

Hot-melt polyamide molding equipment is portable so that it can be rolled into place to produce parts in line with an assembly operation. This eliminates an expensive and space-consuming step of staging and transporting parts for assembly. The process uses standard machining technologies and aluminum tooling that can be manufactured quickly, and at about half the cost of conventional injection-molding tools.

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Rapid tooling evolution

The key to making hot-melt polyamide molding work to the customers' advantage is in tooling designs that reduce connector unit costs, slash lead times, eliminate components, and/or reduce subsequent device assembly steps. Since the inception of the hot-melt polyamide-molding program in 2002, substantial progress has been made in each of these areas.

Two years ago, hot-melt polyamide molding was used primarily as a pre-mold process to fill in connector interstices, and provide a stable and geometrically consistent platform for high-yield conventional overmolding of low-cost connectors. Since then, the approach has evolved rapidly to accommodate many applications.

Because small prototype tools can be manufactured easily with a short turnaround, optimizing two or more tooling design concepts at once rarely presents a cost or time penalty. In the beginning, almost every application led to new design concept innovations. These were cataloged and stored

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as electronic design archives.

Another impetus for rapid evolution was the cross-pollination of ideas from applications developed for many different industries, including handheld bar-code scanning, mobile communications, medical devices, industrial equipment, and military applications, to name a few. It was not long before tooling expertise had become sufficient to deliver a big payoff in many applications, replacing conventional thermoplastic molding with the polyamide technique. In general, tooling cost and tool design/development time can be reduced as much as 50%, due to the cavity material used and simplified tooling designs.

Developing tooling with modular interchangeable components added even more value to the polyamide hot-melt process. As a result, connector solutions can be prototyped rapidly within a few days or less by making inserts for tooling that already exists. Proof of concept is almost immediate, and multi-cavity production tooling can be ready within a few weeks of approval. Providers with available tooling for the hot-melt polyamide encapsulation of selected connectors can further reduce the cost impact of tooling development to the customer.

Representative applications

Hot-melt polyamide molding has been used to date on a variety of connector systems for encapsulation or preparation for injection overmolding. The following cases are representative of the advantages.

The military Objective Force Warrior (OFW) program integrates sophisticated electronics within the soldier's uniform. A flat woven material (with embedded wire), to be used inside the uniform, had to transition to a round connector and also meet rigid MIL/Spec standards for waterproofing, pull strength, and other tests. The OEM failed to find a cable supplier that could shut off on the uneven woven surface, and provide a flash-free thermoplastic transition. Two-thirds of the lead time for developing the prototype had already been consumed when pre-molding the cable with polyamide was recommended (see Fig. 1).

The hot-melt system was used to encapsulate a portion of the flat woven cable and a portion of the connector in polyamide. This created a stable and controllable platform for precision overmolding. The pull strength between the polyamide and the woven cable was in excess of 60 lbs—three times greater than that required for the termination. The concept was proven within three days, and production tooling was ready in less than four weeks.

In another case, a simple stereo jack was chosen as the connector on an RS-232 data interface cable for

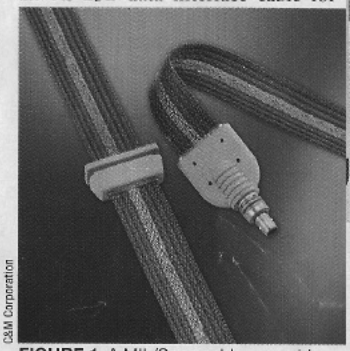

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FIGURE 1. A MIL/Spec cable assembly used pre-molded polyamide as a quick solution to marry a wire embedded in a flat woven material to a round connector.

a portable defibrillator used in the field by emergency medical technicians. The jack met the limited space requirements on the console and ensured that other RS-232 devices would not be mistakenly plugged into the unit. Attempts to waterproof the connector via conventional techniques, such as hand potting with UV materials, two-part epoxies, or premixed silicones, failed to produce consistent results.

The hot-melt polyamide process was used to encapsulate a similar connector system for another medical-device manufacturer. Prototypes were provided within a day. Polyamide encapsulation brought this connector up to the IP67 level of connector systems that cost $20 to $45. Encapsulation added just $0.30 in value to the cost of the $0.98 stereo jack.

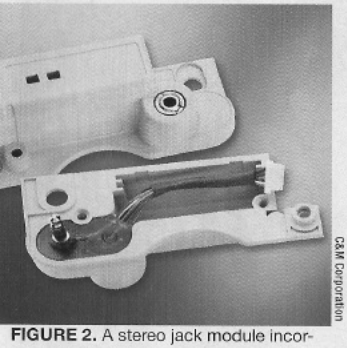

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FIGURE 2. A stereo jack module incorporating Bluetooth technology was waterproofed using the hot-melt polyamide process, saving steps and costs for the OEM.

In the same product, a similar stereo jack was used to incorporate an external Bluetooth RF accessory (see Fig. 2). The customer asked for a quote on waterproofing the connector. We reviewed the design and determined that it would be possible to waterproof the entire subassembly, which included two connectors and a polycarbonate/ABS housing. An innovative process used the housing as the mold, which not only eliminated several installation and waterproofing steps for the OEM, but also the cost of gaskets and o-rings that would have been required if the entire assembly had not been sealed with polyamide, with an additional bonus of lower tooling costs.

The original design for an RFID bar-code scanner interface included two high-end circular waterproof connectors that cost about $25 each. The required performance was met by substituting two polyamide hot-melt waterproofed mini-DINs (with a polyurethane overmold) that cost $0.38 each. Total assembly cost went from $50 to $14 per device.

Manufacturers are evaluating the possible substitution of all applications that require pre-mold processing for hot-melt polyamide encapsulation. If a "non-moldable" connection is selected, this process is preferred. If the part does not require flexible, thermoplastic bend relief at the cable interface, and tooling designs do not require EDM machining, hot-melt polyamide is being used with increasing frequency as the primary connector/interface encapsulation method. It allows for the encapsulation of fragile or previously difficult-to-overmold, low-cost connectors. At the same time, the process reduces tooling costs and trims lead times for both prototyping and part delivery. **CS**