Two-Shot Molding of Thermoplastic Elastomers

By

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INTRODUCTION

Injection molding is a major processing method for both thermoplastics and thermoplastic elastomers (TPEs). Approximately 35% by weight of all thermoplastics and TPEs is processed through injection molding machines. The technology of injection molding continues to become increasingly sophisticated, with Europe leading the USA. The successful injection molder must stay up-to-date on fabrication technology. His/her goal is to profitably produce molded parts that satisfy the end user. Injection molded TPE parts are being manufactured economically and efficiently in massive quantities. This paper will explore an attractive opportunity for TPE processors to produce injection molded parts from two different thermoplastic materials for a wide variety of uses.

The materials may differ in polymer type and/or hardness, and can be fabricated from numerous types of two-shot molding techniques such as insert molding, dual injection molding (two-shot molding) and co-injection molding. Whatever its designation, a sandwich configuration has been made in which two or more polymers are laminated to take advantage of the properties each contributes to the structure.

TPE parts from these moldings offer excellent performance characteristics and reduced cost.

INSERT MOLDING

In the insert molding process, a solid preform (plastic or metal) is placed into a mold and the polymer is shot around it. Preforms are usually produced with a plain exterior, without serrations or knurls. They are bonded by melting of the outer skin, which creates a weld between the insert and the outer skin material. The generation of a satisfactory weld requires that the preform material and the overmolded polymer be compatible.

In Figure 1, the preform (or insert) is a polypropylene hub for a caster wheel application. Please note that the hub also incorporates slots for a flow-through of the material being shot around the preform. Figure 2 shows a caster wheel in which a TPE (Santoprene thermoplastic rubber by Advanced Elastomer Systems, L.P.) has been shot around the preformed hub. The preform material is compatible with this particular TPE and a natural weld is thus created. Since flow-through channels were engineered into the preform, there is also a mechanical-type bond.

When the two materials are not of the same polymer type and thus incompatible, it is necessary to use an adhesive on the preform surface prior to molding the second material. Figure 3 shows a cable connector in which the jacketing material is a thermoset rubber. With an adhesive, the connector end can be molded from a TPE with a suitable bond resulting. Metal preforms must be cleaned and degreased prior to applying an adhesive. Once this step is completed and adhesive applied to the preform, bonding is accomplished through the regular molding cycle.

The overmolding process is similar to insert molding, except that bonding requirements are not as critical because the part is being totally encapsulated by the polymer. Figure 4 shows a transformer housing which is totally encapsulated with a TPE over the wire windings of the transformer.

TWO-SHOT MOLDING

The two-shot (or two-color) process requires a machine with two independent injection units, each of which shoots a different material. The first material is injected through a primary runner system, as in a normal injection molding cycle. During this injection, the mold volume to be occupied by the second material is shut off from the primary runner system. The mold is then opened and the coreplate rotated 180 degrees. The mold is again closed and the second runner sysetm connected to the volume to be filled. After sufficient part cooling, the mold is opened and the part is ejected. The injection of the first material through the primary runner system and the second material through the secondary runner system occurs at the same time.

This process also enables two dissimilar materials to be mechanically bonded. If the first shot totally solidifies before the second material is injected, a crack will usually form between the two, due to the differential shrinkage.

The two-shot process can also be accomplished with an indexing system (a round table rotating around a horizontal axis) with a primary and secondary station. While the first injection is accomplished at station #1, the second injection is accomplished at station #2. Each injection station is run by an independent injection unit. This allows injection speeds and pressures to be controlled for each material being utilized.

The two-shot or two-color process can also be accomplished by either indexing the mold in the machine or with a rotary table. Figure 5 shows a notepad holder produced in an indexing mold. The base material is polypropylene and the insert is a TPE.

CO-INJECTION MOLDING

Co-injection molding is a process in which two or more different polymers are laminated together by injection molding. These polymers may be identical except for color or hardness, or they may be of different polymer types. When different polymers are used they must be compatible (i.e., weld together) andmelt at approximately the same temperature.

The term co-injection can denote different processes, such as sandwich construction, double shot injection, multi-shot injection or structural foam construction. Whatever its designation, a sandwich configuration has been made in which two or more thermoplastics are laminated together to take advantage of the different properties each contributes to the structure. Most commonly, the skin material is solid while the core material contains a blowing agent. However, any combination of foamed and/or unfoamed skin and core is possible. For heavy walled parts, cooling time may be substantially reduced by running the skin material at a higher melt temperature for a smooth surface and the core material, which essentially determines cycle time, at a lower melt temperature.

There are three basic co-injection molding techniques -- one-, two- and three-channel. In the one-channel system, the plastic melts are shot sequentially into the mold by shifting a valve. Because of the flow characteristics of the melt and the tendency of the skin material to adhere to the cooler mold surface, a dense solid skin is formed. Thickness of the skin can be controlled by varying the injection rate, melt temperature and flow compatibility of the two materials. Figure 6 illustrates the one-channel process.

In the two-channel system (Figure 7), sequential or simultaneous injection of both the skin and core materials is possible. This permits control of the skin thickness, especially in the gate areas on both sides of the part. In this type of molding, it is best if profile injection is used. The use of profile injection permits greater control of the surface appearance. The machine can be profiled by the number of velocity settings a machine has. The velocity can be varied from 0.1 inch per second to 4 inches per second.

The three-channel system allows simultaneous injection with a direct sprue gate. The skin thickness may be influenced on both sides of the part. With this system, the foamed core progresses farther toward the end of the flow path than that of the one- and two-channel techniques. Parts can also be designed to be lighter in weight. Figure 8 illustrates the three-channel process.

ECONOMICS

The real payoff of two-shot injection molding of TPEs is an economic one. Rubber parts of two different materials can be fabricated with the speed, efficiency and economy of thermoplastic processing. This eliminates the labor-intensive secondary operations used for so many years and replaces them with high-speed automated operations, to yield a more consistent, higher quality fabricated part at a significantly lower cost.

The major hurdle to two-shot molding is one of capital investment. Two-shot injection presses cost approximately 25 percent more than a standard single-shot press. Further, the mold cost is normally 20 to 35 percent higher, and only a small minority of established mold makers in the USA are capable of producing a satisfactory two-shot mold. Thus, two-shot injection molding requires volume production of multi-component parts, if superior bottom-line part costs are to be attained.

CONCLUSION

The production of multi-component injection molded articles by multiple-shot processes has been widely used in Europe for some time and is now appearing in the USA. The demand for greater economy and reproducible quality has brought about a stream of molding innovations. By combining different materials and ever-improving molding technology, complex functional parts can now be produced. Otherwise they would have required labor-intensive, complicated assembling processes.

Figure 1 *Wheel insert.*

Figure 2 *Complete wheel.*

Figure 3 *Cable connector.*

Figure 4 *Transformer housing.*

Figure 5 *Notepad holder*.

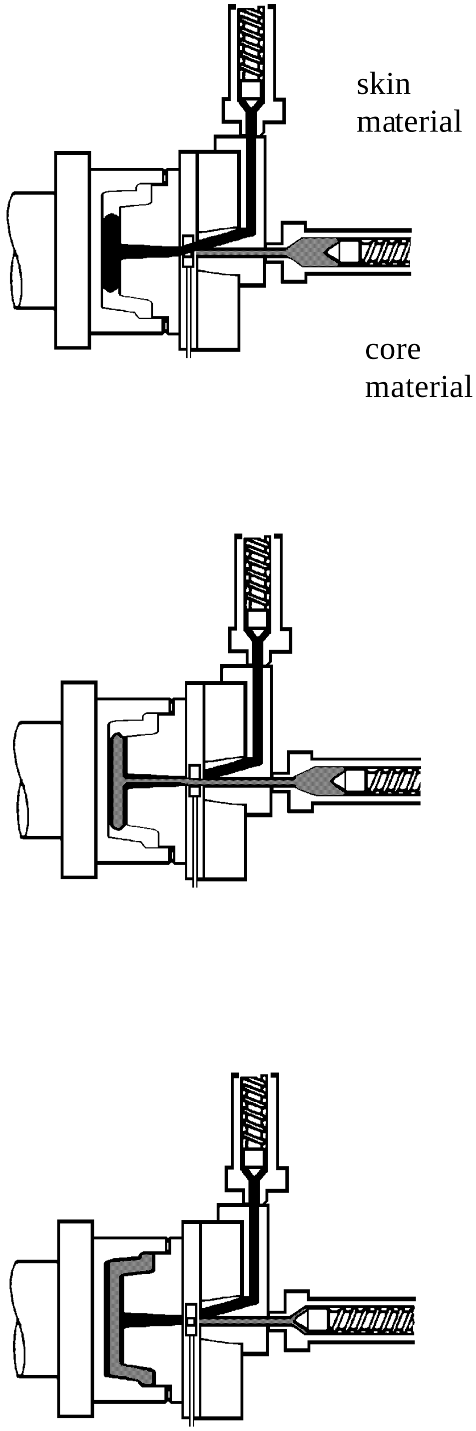

Figure 6 *In the one-channel co-injection system, the sequence of mold filling starts with the skin being injected, then the core.*

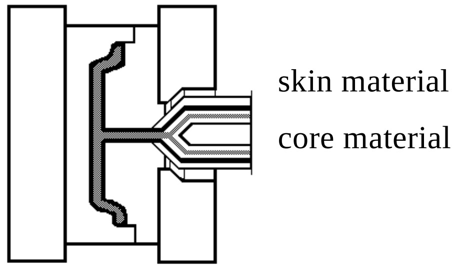

Figure 7 *Two-channel co-injection system showing core and skin materials.*

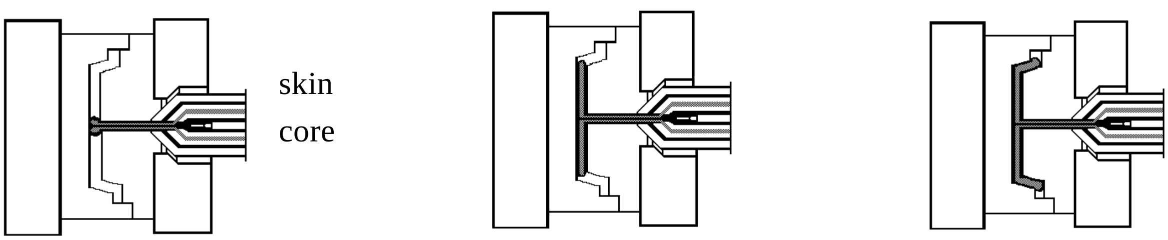

Figure 8 *The three-channel co-injection system simultaneously injects two different plastic melts.*

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