In-Mold Coating Process for Sheet Molding Compound (SMC)

Elliott Straus – Manager, Technical Service

Introduction

Compression molded sheet molding compound (SMC) is a product which is light, strong, as well as recyclable, and has many applications such as automotive and truck body panels, marine decks and hulls, and a variety of industrial and structural uses. SMC is a type of fiber-reinforced plastic (FRP) which primarily consists of a thermosetting resin, glass fiber reinforcement, and filler. Additional ingredients such as low profile additives, cure initiators, thickeners, and mold release agents are used to enhance the performance or processing of the material. As with any material system, SMC can be formulated to meet specific performance features such as strength and cosmetic appeal.

During the SMC molding process, a pre-measured polymer charge is placed between the heated halves (270^{o}-320^{o}F) of a mold which are then brought together to squeeze the polymer and fill the mold. At molding temperatures, the material is typically cured for 50 seconds. A detailed analysis and measurement method of SMC cure is outlined by Castro and Straus.[i]

Fiberglass reinforced polyester parts compression molded from SMC are prone to such defects as porosity and sinks. Some types of defects can be reduced by current techniques such as vacuum molding, but the resulting surface is not up to automotive standards for exterior panels in many cases. In-mold coating acts to fill porosity, reduce sinks, and furnish a primer-like or topcoat-like coating, thus upgrading the part surface to automotive standards. There is no orange peel associated with IMC parts as is often the case with wet primered parts. High and low spots (amplitudes of 0.1 mm) are leveled out using IMC and the distinctness of image (DOI) is enhanced. IMC also offers the option of providing a surface which can be conductive or color matched to suit specific finish coating needs. As a consequence, IMC is generally an integral part of the molding cycle when producing compression molded SMC exterior automotive body panels.

In-mold coating (IMC) is a single component product designed to enhance the surface of FRP moldings in functional and cosmetic properties. IMC is a reactive fluid which when applied (injected) onto a cured SMC part under pressure and elevated temperature (270^{o}F-320^{o}F), cures to provide a primer-like coating to the surface.

In early development, General Motors demonstrated various ways of applying in-mold coating.[ii] In the manner most commonly used, at the end of the SMC curing stage the mold clamping force is removed and the mold is opened slightly (approx. 1 mm) so that one mold half, usually the cavity, is separated from the other mold half. IMC is injected into the gap, the press is re-closed and force applied to spread the coating across the surface of the part. Typical cycle times for flow and cure of the IMC are around 40 seconds. The cycle time for the cure of SMC can be reduced when IMC is used. Ideally the combined cycles for SMC and IMC processing are not much greater than for SMC alone. This method is sometimes referred to as low pressure injection (LPIMC).

An alternative method involves maintaining a clamping force during the IMC injection process at injection pressures ranging from 3,000-5,000 psi. This method is sometimes referred to as high pressure injection (HPIMC) and relies on the combination of the compressibility of the SMC substrate and the ability of the injection system to overcome the clamping force of the press and displace the upper tool half. A detailed mathematical modeling of both processes has been outlined by Castro and Griffith.[iii]

Both methods of IMC injection require a process which involves a hydraulic compression press with moderately good control features. With the evolution and quality demands of the reinforced plastics industry, press manufacturers have responded by providing presses with good force, velocity (opening and closing), and parallelism control. Although not always necessary, state of the art presses can reliably yield consistent, high quality parts.

Tool Design/IMC Nozzle Placement

Tooling plays a major role in overall part quality for both the SMC and IMC processes. A tool (mold) designed with SMC compression molding and IMC in mind will result in a more trouble free process. Items like vertical wall draft angle and temperature control are important factors. A good review of this subject is found in an SMC design manual published by the SMC Automotive Alliance.[iv] The optimum placement of the IMC injector in a tool is crucial to the successful outcome of the IMC process. Several flow/mold filling computer modeling techniques are available to aid in determining the injector placement.[v] This technique, tempered with common sense and experience, will usually result in an optimum IMC injector placement in a tool.

Vacuum usage in the IMC process

Vacuum generally not used because of part lifting and flash/debris drawn in on the part, also the monomer components in the IMC will tend to "boil-off' and contaminate the vacuum oil and additionally will effectively "change" the IMC formulation.

Use or not of tabs:

If at all possible, we advise that tabs be avoided since they require secondary operations for removal, and if not properly installed, lead to many processing problems which include cracks, IMC under shots, and slow injection times.

Design of injector tip to mold surface/ Mating surface:

When mating the IMC nozzle tip to the mold, it is preferable to be normal (90^0) to the surface. However it is sometimes impossible to do this. By design the nozzle pin cannot retract properly if the angle of incident is 52^0 or less. Furthermore the wear on a slanted injector pin tip is greater than if the pin is not slanted at the tip.

Also, the part/nozzle interface should allow for mold separation. In other words, the nozzle should not be located in a vertical section if at all possible.

Finally the nozzle location should be on a non-cosmetic surface and accessible for maintenance.

Design of tabs to avoid IMC leaking:

Tab design should include:
1. Rails or rim approximately 1 mm high surrounding the nozzle tip
2. Part wall stock thickness/slightly thicker at nozzle location
3. Angled (30°-45^0) if nozzle is horizontal

References

i. J.M. Castro and E.J. Straus, Monitoring Cure in Sheet Molding Compound Processing, *Polymer Engineering and Science*, Mid March 1989, Vol. 29, No. 5.

ii. E.D. Ditto, U.S. Patent 4076788 (1978).

iii. J.M. Castro and R.M.Griffith, Mathematical Modeling of the In-Mold Coating Process, *PolymerEngineering and Science*, Mid June 1990, Vol. 30, No.11.

iv. SMC Design Manual, Catalog #AF-180. SMC Automotive Alliance, (Troy, Mich.)

v. T.A. Osswald, Ph.D. thesis, Department of Mechanical and Industrial Engineering, University of Illinois (1987).

OMNOVA Solutions Inc. · 2990 Gilchrist Road · Akron, OH 44305
Telephone 830-794-6258 · www.omnova.com