RRIM DESIGN MANUAL ADDENDUM FOR EXTERIOR BODY PANELS

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Reinforced RIM Background

Reinforced Reaction Injection Molding (RRIM) is a process used to produce polyurethane and polyurea thermoset polymers. Initial product efforts were directed at non-reinforced polyurethane products for fascia, spoilers, and bumper covers. With the use of fillers and reinforcements, the modulus range of polyurethane polymers was increased, and vertical body panels resulted as an extension of the technology.

Further chemistry developments have extended the versatility of the Reaction Injection Molding (RIM) process in making both polyurethane and polyurea polymers. This technology continues to grow through improved equipment and formulations, resulting in cost-effective engineered parts.

Automotive applications comprise the largest area of use for RIM-produced products. Polymers have been developed specifically for exterior body panels for the automotive industry. Non-E-coat polymers offer an excellent combination of stiffness, impact resistance, and thermal resistance for body panel applications. These provide excellent paintability and solvent resistance with the ability to achieve high distinction of image (DOI) when painted.

E-coat capable polymers have improved thermal resistance that, while maintaining excellent stiffness, impact resistance, paintability and solvent resistance, results in an E-coat capable material that can withstand 400°F (205°C) for limited time periods.

Molding (RIM) Formulation

The resins, which are two-component polyurea systems, are designed to offer improved thermal stability and processing advantages over conventional polyurethane RIM polymers. They contain internal mold release and provide thermal stability for applications in automotive paint ovens reaching 350°F (177°C). The base flexural modulus of most systems are 80,000 psi (552 MPa) with modulus values of over 200,000 psi (1379 MPa) achieved through the incorporation of a variety of reinforcements including: flake glass, milled glass, mica, talc or wollastonite.

All RIM systems are two components, an A and a B side. B Side components comprise a fully-formulated compatible system containing an internal mold release agent, as well as the aforementioned reinforcing filler. The B side including the filler is referred to as the slurry. Isocyanate (A Side) components comprise a formulated isocyanate based on methylene diphenyl diisocyanate (MDI).The two-component system is easily processed in conventional RIM equipment with typical processing information given on the following pages.

E-coat capable resins are comprised of fully formulated, two-component polyurea systems designed to offer improved thermal stability over lower temperature resistant polymers, while maintaining the processing advantages of most RIM formulations. The materials have been developed to withstand assembly plant E-coat processing temperatures and to work effectively with a variety of design criteria.

Physical property data is available from suppliers Bayer and Dow.

Processing Conditions

RIM equipment has conditioned vessels with agitators and temperature controllers for proper material temperature (usually between 90°– 150°F [32°– 65°C]). Nitrogen is used as a blanket on both A- and B-side day tanks because it is free of oxygen and water. In the case of the resin B-side slurry, nitrogen is used as an aid for improved surface quality, efficient component mixing, and enhanced polymer flowability in the RIM equipment. The nitrogen concentration is usually 30 to 40 percent by volume and is typically called "nucleation" because of the small bubble formation.

Both the resin slurry and the isocyanate prepolymer in the day tanks are usually circulated (by pump) through the RIM dispensing equipment and the mixhead before returning to the tank. This circulation, in combination with the in-tank agitation, ensures homogeneity of the components. Where necessary, nitrogen can be added to the A side as well, improving the flowability even further.

The RIM dispensing operation parameters are preset prior to the actual RIM "shot" (injection of components through the mixhead and into the mold initiating a polymerization reaction). These parameters include injection rate, shot size, the polymer curing time and the A/B ratio (predetermined weight ratio of prepolymer to slurry for complete reaction of components in the polymerization reaction). Additionally, the desired injection pressures are set by adjusting mixhead orifices and setting the prepressurization points.

When the operator is ready to fire a "shot," he/she applies an external mold release (EMR), if needed, to the mold and then initializes the automatic equipment for the dispensing operation. The RIM dispensing operation is started once the mold is closed. The recirculation lines are blocked automatically and the lines between the dispensing cylinder, or pump, are close-looped to the RIM mixhead. The A- and B-side materials in the lines are prepressured to a setpoint between 1800-2200 (12.4 –15.1 MPa) psi, in preparation for the shot.

Once the prepressure point is reached, the mixhead pin is opened allowing the B-side slurry and the A-side prepolymer to impinge in the mixhead chamber (which is the space provided in the mixhead when the mixhead pin retracts) and flow through an aftermixer, a gate and runner, and into the heated mold. Once the correct amount of material has been injected, the mixhead pin closes, sweeping the mixing chamber clean. The recirculation lines are then opened and circulation returns to normal.

The typical press used to hold the mold closed during the filling and curing process is a booked hydraulic clamp which provides a clamping pressure of 50-400 psi of projected pressure; flash is reduced which, in turn, reduces trimming. After reaching the preset curing time of 20-30 seconds, at 150°-180°F (66°– 82°C), the mold is automatically opened and the part can be demolded by the operator. The operator will clean any excess polymer flash from the mold, apply external mold release (EMR) if necessary, and start the RIM operation again. For a 30-second polymer cure time, an overall cycle time of between 90 and 120 seconds is normal with conventional RIM equipment. The cycle time will be contingent on the complexity and size of the mold. Generally, parts are randomly selected from a day's production for mechanical property testing. This gives the feedback required to determine whether the process is staying in control.

Production Requirements

It is difficult to ascertain the exact amount of people and equipment necessary to carry out the entire RIM production of body panels without taking into account the size of the production facilities. However, assume that you are producing two fenders for a vehicle utilizing two RIM clamps and dispensing units. During molding operations, it will take approximately one to two people for bulk handling and slurry blending, two people for molding and trimming the parts on each mold (four total), and approximately two people for painting, testing, and inspecting the parts.

The larger the facility, the easier it is to spread out the manpower over multiple jobs. However, the two people per mold in the molding and trimming operation will usually remain constant.

Capital expenditure depends on the size and current facilities of a given RIM production site. For large volume body panel production, a minimum of two bulk tanks will be needed for storage of raw materials, more if the separate resin components are shipped for in-plant blending. A slurry blending tank equipped with reinforcement handling capabilities is needed along with a holding tank. Assuming the parts will be processed on two RIM machines, two RIM clamps, two molds and dispensing units are necessary along with respective day tank farms. With existing paint facilities, an additional expense will be postcure/paint fixtures for priming the molded parts. The number of fixtures is based on postcure/paint line capabilities.

One way to reduce manpower and capital investment is to consolidate molding operations; if the parts are not too large, two fenders can be molded with one RIM dispensing unit and clamp, thereby reducing monies needed for RIM equipment and reducing manpower to three instead of four– namely, two trimmers and one operator. Furthermore, one day tank can be used for two dispensing units if the same blend is operational on more than one clamp and injection unit.

Equipment sizing will depend upon production volumes and the size of the molded part. It is assumed that this line would be integrated into existing RIM production facilities to give lower overhead cost and eliminate the need for building new post-mold handling facilities. Economic models are available from suppliers, which take into account many different production scenarios and provide estimates of the final cost of the proposed part. In addition, these models are useful in comparing different polymer technologies (such as RIM vs. Engineering Thermoplastics vs. SMC) based on varied capital costs, manpower needs and material costs.

Mold and Part

Nominal Wall Design & Part Thickness

For large parts (larger than six pounds), a minimum thickness of 3.5 mm (0.138 in) should be used to facilitate mold filling. For critical design parameters refer to design manuals from the supplier of raw materials or the OEM.

Part thickness is also determined by performance criteria and material selections. A fender which is going through the electro-deposition and bake process (E-coat) unsupported may have a normal thickness of 3.5 mm (0.14 in) but will be 4.0 mm thick along a support rail. A fully supported fender with curvature may be molded at 3.0 mm (0.12 in) wall thickness if it does not go through E-coat. Therefore, the manufacturing process must be considered as well as the final part performance on the car when determining the part thickness.

Polymer Shrinkage

Thermoset chemistry results in a polymer being formed on the tool. Reaction kinetics, filler type, and filler content determine part shrinkage on the tool. Because of the high modulus and shrinkage on the tool, body panel tools require moving slides and cores to allow their release from the tool. The final part size occurs after the postcuring or annealing becomes stable. Once postcured, the part is at its final size for all subsequent handling, painting and baking operations.

The tables (A and B) below give typical shrinkage values for body panel formulations. These numbers are used in the computer model to predict part dimensions after shrinkage and aid in part design.

TABLE A – TYPICAL MATERIAL SHRINKAGE

	BAYFLEX 180		BAYFLEX 190	
FILLER TYPE %	20 % MINERAL*	20 % MICA†	20 % MINERAL*	20 % MICA†
SPECIFIC GRAVITY G/CC	1.25	1.24	1.24	1.24
MOLD SHRINKAGE AVERAGE %	.90	.75	.80	.85

* RRimgloss 1Wollastonite

† Himod 270 SMAL

TABLE B – TYPICAL MATERIAL SHRINKAGE[4]

POLYMER	FILLER	PARALLEL	PERPENDICULAR
SPECTRIM BP80	WOLLASTONITE[1]	0.45	1.2
SPECTRIM BP80	MICA[2]	0.68	0.75
SPECTRIM HH390	WOLLASTONITE[1]	0.45	1.2
SPECTRIM HH365	MICA[3]	0.68	0.75

1 RRIMGLOS1 wollastonite

2 Himod 270 SME

3 Himod 270 SMAL

4 20% mineral filled and specific gravity of 1.24 grams per cc.

Post Mold Fixtures

Fixtures are required to support the part from processing to assembly and even during assembly in some instances. These fixtures will vary depending on the performance criteria. At the mold, the fixture needs to keep the part from distorting, not scratch the part surface, and leave open areas for trimming or sanding. The postcure fixture should be the correct shape and size. Oversized postcure fixtures will distort the part through postcure. Postcuring at elevated temperatures requires certified postcure fixtures to eliminate distortion induced by the fixtures. The prime and paint process requires fixtures that will hold the part in position and provide adequate grounding.

Post Mold Handling and Finishing
(See Paint addendum for additional details)

Typical RIM parts are trimmed, postcured, power washed, primed and (sometimes) painted before shipping to an assembly plant. This serves several purposes:

- Postcure develops ultimate mechanical properties and completes the reaction in a timely fashion, driving gases from the polymer
- Power washing removes contamination from the part surface that could otherwise cause paint adhesion failures or poor paint wetout
- Prime coating provides a quality control measure to prevent defective parts from being shipped, plus, if it is conductive, it improves the transfer efficiency of topcoats
- Priming can also assist the prevention of long-term ultraviolet light discoloration of the molded panel

Generally, the topcoat is applied at the assembly plant for color match; however, it may be applied immediately after curing the prime coat if desired. A breakdown of each of the post molding handling steps follows.

Postcure

RIM parts are to be postcured before washing and painting. Usually it is recommended that parts be postcured for one hour at 280°F (138°C) for non-E-coat capable polymers and 365°F (185°C) for one hour for E-coat capable polymers. If parts are not postcured, excessive outgassing of the plastic can occur, trapping bubbles in the paint. If parts are to be painted at temperatures above 280°F, higher postcure temperatures of up to 320°F (160°C) are suggested for the non-E-coat capable polymer.

When the molded parts are received in the paint facilities, they are placed on painting fixtures called “bucks”, which are generally made of aluminum. The bucks are mounted on a conveyor and run through the paint facilities. These fixtures are designed to provide dimensional support during the entire paint process. They should also provide for expansion and contraction of the part.