TOUGH SHEET MOLDING COMPOUND

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Abstract

One of the biggest challenges facing molders of automotive exterior body panels is the reduction of paint pops. Minimizing or eliminating paint pops would greatly reduce manufacturing costs by minimizing rework, painting, and scrap material.

A new SMC formulation has been developed that is more resilient and durable than standard Class A SMC. The material is more resistant to micro cracking, the primary source of paint pops, while maintaining the physical properties and surface quality required for Class A exterior body panels.

Background

The development of a Class A SMC system was motivated by the OEM's desire for a material that "paints like steel." In order to develop a material that "paints like steel," the number of paint pops on SMC panels had to be significantly reduced. Paint pops are the primary defect that occurs on SMC during painting. During normal processing, such as painting and shipping, SMC parts are subjected to flexing that can result in the formation of micro cracks, particularly along the edges and in areas of high stress. Paint pops appear on the edges of the molded part at the site of the micro cracks. Consequently, development began on a "tougher" material that was resistant to micro cracking and thus paints pops. Reduced paint pops leads to less rework and subsequently lowers cost, which is a key driver for the Automotive industry.

Experimental

Development of a tough SMC system began with fifteen systems. Each system was screened using several tests. Paint pop testing was the controlling factor, but LORIA[1] Index and water absorption were also considered.

Much time and effort was expended to develop an appropriate paint pop simulation test that truly demonstrated tough performance of the candidate polymer matrices. The sequence chosen induces a greatly exaggerated level of paint popping to clearly measure the magnitude of improvement over the standard control Class A SMC systems.

The paint pop testing was done by cutting 2" x 18" strips from a plaque molded according to industry standards. A minimum of five strips were used in each set, with two controls. After priming each strip, the center of the 2" x 18" strip was placed on an 8.25" diameter mandrel with the primed surface facing out. The ends were then pressed down until the strip was fully wrapped around the mandrel. The strip was held in the fully wrapped position for five seconds. After flexing, the strips were elpo baked at 365°F for 30 minutes. The strips were then placed in a humidity chamber at 100% relative humidity and 100°F for 16 hours. The strips were removed from the chamber and towel dried. Following drying, either a clear coat or an industry prime surfacer was applied. When cured, the paint pops on each strip were counted and compared.

Based on the results of these tests, the number of potential systems was narrowed to three

[1] Trademark of Diffracto Ltd.

approaches with nine process formula variations. The systems were then tested for LORIA Index and water absorption. Results of these tests determined the final two systems, MT1A and MT2C using two unique polymer chemistry approaches.

Physical properties including tensile strength, tensile modulus, flexural strength, flexural modulus, IZOD, and HDT were measured using ISO standard testing methods.

Screening bond tests were performed using epoxy and urethane based adhesives. Testing was performed per GM 3629M, Ford ESB-M11P27-A, and Ford ESB-M11P27-B. All surface preparation was dry wipe and the substrates were adhered to themselves.

Paint adhesion testing is currently in progress.

The tough SMC systems, MT1A and MT2C, were then compared to two current industry standards for exterior body panel Class A materials.

Results and Discussion

The physical properties of each of the four systems were tested and compared. The results are shown in Table I. A graphic comparison of physical data is shown in Figures 1 – 4. In all cases, MT1A and MT2C have comparable or slightly better results than the standard and enhanced Class A systems.

The water absorption data is summarized in Table II. As with the physical property results, the water absorption results show the MT1A and MT2C systems to be comparable to or better than the standard and enhanced Class A systems.

Table III summarizes the surface quality of each system. In measuring the surface quality via the LORIA surface analyzer, a lower number indicates a better surface. The surface quality of the MT1A and MT2C systems are significantly better than the standard and enhanced Class A systems.

The results of the paint pop flex test are shown in Table IV. In each case, three lots of material were tested and the results were averaged. The reduction of paint pops is very significant with MT2C performing the best followed by MT1A, as shown in Figure 5. The toughened systems are better able to withstand flexing consequently there are fewer micro cracks which lead to fewer paint pops.

Screening bond test results are report in table V – VIII. These initial results show that MT1A and MT2C pass both the Ford and GM specifications.

The crack propagation in each sample was examined using an optical microscope. These photographs are shown in Figures 6 - 8. In the enhanced Class A panel and the MT1A panel, the cracks are easily seen and appear as dark black lines. The cracks in the MT2C sample were more difficult to see and could only be observed when the light was hitting the surface at a certain angle.

Two cracks of each panel were then cross-sectioned and SEM micrographs were obtained. Micrographs of enhanced Class A, MT1A and MT2C are shown in Figures 9 – 11. The crack in the MT2C sample was difficult to observe at 60x magnification so a second micrograph was obtained at 240x, shown in Figure 12.

A visual comparison of molded parts shows the dramatic reduction of paint pops with the tough systems. Figure 13 shows enhanced Class A on the top and Class A on the bottom. There are slightly fewer paint pops on the enhanced Class A panel. Figure 14 compares the tough system MT1A on the top to Class A on the bottom. There are significantly fewer paint pops on the MT1A panel. Figure 15 compares the tough system MT2C on the top to Class A on the bottom. In this case, there are virtually no paint pops on the MT2C panel. In the final figure,

Figure 16, the two tough systems are compared, MT2C on the top and MT1A on the bottom. The MT2C panel is clearly the best with virtually no paint pops.

Overall, based on physical property testing, water absorption data, surface quality and the number of paint pops both of the tough systems, MT1A and MT2C, perform better than the standard and enhanced Class A systems. The MT2C exhibits performance superior to the MT1A system.

Conclusions

A new Class A system has been developed with many advantages. A part made with MT2C has significant advantage in the reduction of paint pops and superior surface quality as well as maintaining Class A physical properties. The toughened systems are more durable and resilient and are better able to withstand the flexing that is associated with normal processing, painting, and shipping. By reducing paint pops, processing costs are reduced as is the scrap rate which leads to a significant cost savings.

Table I – Physical Properties

	Class A	enhanced Class A	MT1A	MT2C	Industry requirement
Tensile Strength @ break (MPa)	83	73	86	92	58 minimum
Tensile Modulus @ break (GPa)	12.6	13.2	12.0	11.6	8.6 minimum
Flex Strength (MPa)	202	167	199	200	120 minimum
Flex Modulus (GPa)	9.6	9.2	9.0	9.0	6 minimum
IZOD at 73°C (kJ/m^2)	104	115	104	97	80 minimum
HDT (°C)	-	-	274	274	230 minimum
Glass Content (%)	28	28	28	28	25 - 31

Table II – Water Absorption Data

	Class A	enhanced Class A	MT1A	MT2C	Industry requirement
24 hour Water Absorption (%)	-	0.7	0.3	0.3	General Motors Specification - 0.8% maximum
10 day Water Absorption (%)	0.5	NA	0.62	0.62	Ford Motor Company Specification - 0.7% maximum

Table III – LORIA Results

	Class A	enhanced Class A	MT1A	MT2C	Industry requirement
LORIA	70	68	53	57	85 maximum

Table IV – Paint Pops

	Class A	enhanced Class A	MT1A	MT2C
Lot 1 – paint pops	350	200	93	15
Lot 2 – paint pops	350	200	52	39
Lot 3 – paint pops	350	200	84	9
Average – paint pops	350	200	76	21
% Reduction	-	-	78	90

Table V – Bond Testing per Ford ESBM11P27A (Epoxy Adhesive)

	Class A	**MT1A**	**MT2C**
Tested @ Room Temperature Minimum MPa = 2.8	3.4 Fiber Tear	3.6 Fiber Tear	3.8 Fiber Tear
Conditioned and Tested @ 204°C Minimum MPa = 0.3	1.6 Adhesive	1.0 Adhesive	0.7 Adhesive
Conditioned and Tested @ -29°C Minimum MPa = 2.8	4.0 Fiber Tear	4.5 Fiber Tear	4.4 Fiber Tear

Table VI – Bond Testing per Ford ESBM11P27B (Urethane Adhesive)

	Class A	**MT1A**	**MT2C**
Tested @ Room Temperature Minimum MPa = 2.8	4.3 Fiber Tear	4.3 Fiber Tear	4.9 Fiber Tear
Conditioned and Tested @ 177°C Minimum MPa = 0.3	1.1 Thin Film Cohesive	0.8 Thin Film Cohesive	1.0 Thin Film Cohesive
Conditioned and Tested @ -30°C Minimum MPa = 2.8	4.5 Fiber Tear	4.6 Fiber Tear	4.8 Fiber Tear

Table VII– Bond Testing per GM 3629M (Epoxy Adhesive)

	Class A	**MT1A**	**MT2C**
Tested @ Room Temperature Minimum KPa = 3400	4147 Fiber Tear	3545 Fiber Tear	3812 Fiber Tear
Conditioned and Tested @ -30°C Minimum KPa = 3400	5039 Fiber Tear	4676 Fiber Tear	4558 Fiber Tear
Conditioned and Tested @ 82°C Minimum KPa = 1400	3932 Fiber Tear	3037 Fiber Tear	3366 Fiber Tear

Table VIII– Bond Testing per GM 3629M (Urethane Adhesive)

	enhanced Class A	**MT1A**	**MT2C**
Tested @ Room Temperature Minimum KPa = 3400	3861 Fiber Tear	4846 Fiber Tear	4988 Fiber Tear
Conditioned and Tested @ -30°C Minimum KPa = 3400	3492 Fiber Tear	4417 Fiber Tear	4588 Fiber Tear
Conditioned and Tested @ 82°C Minimum KPa = 1400	2309 Cohesive	3244 Fiber Tear	2997 Fiber Tear