

Breakthrough in Low Gloss and Abrasion Resistance of Molded-in-Color Automotive Interior Components

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The luxury impression of a vehicle's interior is strongly determined by the surface quality of the plastic interior trim parts. In higher level vehicles, this is achieved by covering the plastic surfaces with Polyvinyl Chloride (PVC) or Thermoplastic Olefin (TPO) skins, fabrics, or paint. However, in the majority of cases, cost constraints dictate the use of unpainted, molded-in-color plastic parts. The critical factors that determine the quality of unpainted interior part surfaces are low gloss appearance along with good scratch and abrasion resistance. The typical materials currently in use for molded-in-color parts are Polypropylene, talc-filled Polypropylene (TF-PP), talc-filled Thermoplastic Olefin (TF-TPO), Acrylonitrile Butadiene Styrene (ABS), Polyamide/ABS (PA/ABS), and Polycarbonate/ABS (PC/ABS). Through extensive development efforts over the past several years, the performance of these materials has significantly improved with respect to scratch resistance and low gloss aesthetic appearance. However, a significant gap in surface quality and robustness in comparison to the painted solution is still present. A development project aiming to reduce these specific deficiencies resulted in new innovative material formulations, which provide breakthrough improvements in low gloss appearance with excellent scratch and mar resistance. The resulting new material family, named Velvex™, makes use of the latest advancements in elastomer technologies from Dow Automotive. This Advanced Reinforced Elastomer material solution will enable the automotive OEM to realize significant cost savings through the elimination of paint in higher segment vehicle interiors, or with aesthetically more demanding applications.

Quality Perception

A consumer's perception of quality is influenced by a multitude of sensory inputs. When the consumer is first introduced to a new vehicle, their perception of quality is dominated by visual observation. The automotive OEM's (Original Equipment Manufacturers) have found that visually low gloss interior surfaces provide a soft, warm, and luxurious impression that gives the perception of quality. Following this visual impression, the consumer then receives additional sensory input that includes touch (haptic), acoustic, and smell, all contributing to the overall perception of quality. Lastly, these sensory inputs from the interior components must not change much over time. In other words, the parts must be durable through multiple customer interactions and environmental changes. In general, low gloss, softer touch materials that have low sound transmittance, neutral odor, and durability are sought after by the OEMs for interior trim applications due to the perception of quality that they impart to the consumer.

Challenges of Low Gloss with Molded-in-Color Materials

The predominant molded-in-color thermoplastics (PP, TF-PP/TPO, ABS, PA/ABS, PC/ABS) typically produce gloss readings in the 2-5 unit range (Gardner 60 degree measurement) on textured interior trim components, which varies significantly with grain pattern and depth. Deep, aggressive textures usually are lower gloss than shallow textures, because they reflect less light. Deeper textures also tend to show "scratch"

damage (high load/point contact) more, while “mar” damage (low load/distributed contact) is actually more visible with shallow texture surfaces. Injection molded part surface flaws such as knit lines, inconsistent gloss, and back side feature “read through” are always a challenge, but can be especially problematic on parts with shallow textures. Applying paint to the part covers up these visual flaws, while improving scratch and mar resistance, as well. Paint can also deliver a softer touch, or haptic, with a significantly more expensive 2K system option. However, the additional cost of paint, along with the associated environmental issues, make it less desirable for interior trim applications. As a result, the goal is to develop a material that can deliver paint-like performance with a molded-in-color part surface.

Material Characteristics Needed to Address the Performance Gaps

To better define the targets for material development, we need to understand which material characteristics are critical to closing the performance gaps between current molded-in-color thermoplastic and painted surfaces. The performance gaps identified are inconsistent gloss, knit line visibility, poor scratch/mar durability, and hard touch (haptic).

Inconsistent Gloss

Separate from the inherent gloss of a thermoplastic, we know that to achieve a uniform low gloss part surface, the material must reproduce the mold texture very well. Material characteristics needed to achieve this are primarily high melt flow (low viscosity) and low elastic modulus during the injection molding process (Fig. 1). In general, the lower the elastic modulus of the material during the injection and cooling phases, the less retraction of the material from the texture details on the mold surface, which produces greater texture reproduction on the part surface. The new Advanced Reinforced Elastomers have elastic modulus similar to TF-TPO and PA/ABS low gloss materials, which aids in delivering very consistent, very low gloss surface appearance.

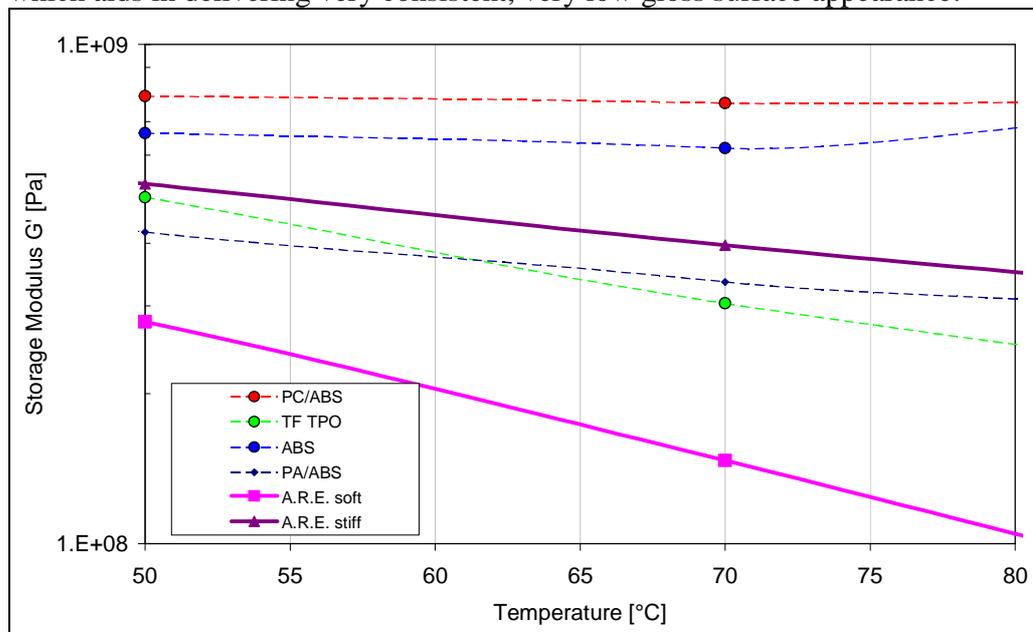


Fig. 1- Texture reproduction is dependent on the elastic modulus of the thermoplastic with the temperature of the part surface between injection and ejection.

Knit Line Visibility

Knit line visibility is affected most by material melt viscosity and compositional morphology. In general, the easier the material flows, and the more consistent and compatible the composition, the better the knit line appearance. Figure 2 is a photomicrograph of the new Advanced Reinforced Elastomer illustrating the continuous phase of elastomer blended with polypropylene, which produces low knit line visibility similar to that of neat PP. Whereas, the distinctly separate phases of elastomer and polypropylene in a TF-TPO (Fig. 3) tend to produce more visible knit lines, as well as, tiger striping (intermittent high and low gloss appearance).

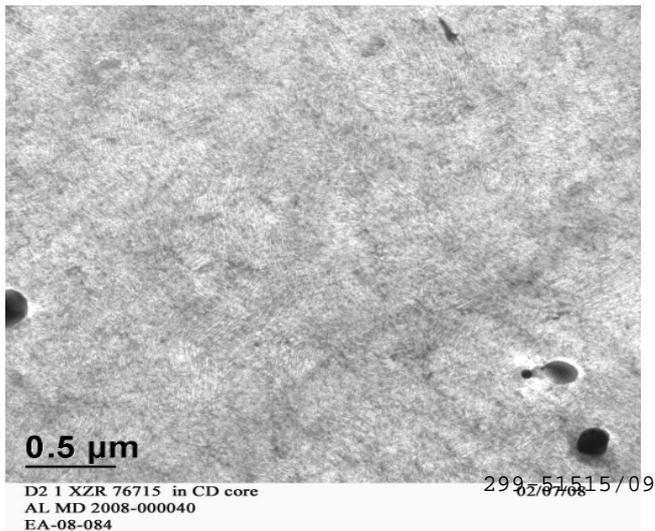


Fig. 2- Continuous elastomer and PP phase in the new Advanced Reinforced Elastomer

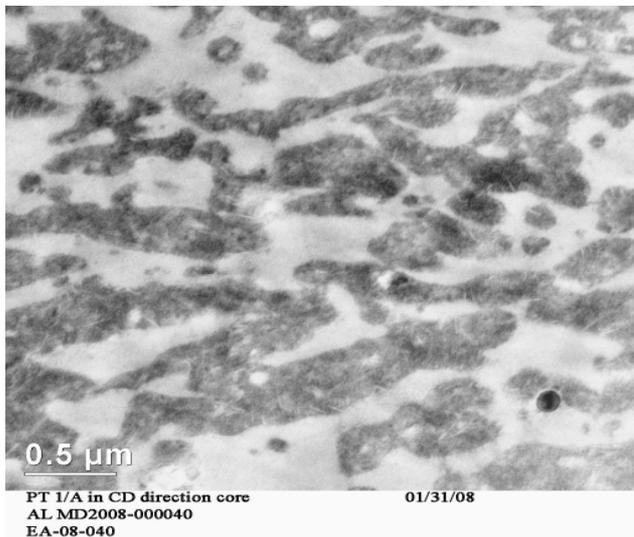


Fig. 3- Separate elastomer and polypropylene phases in TF-TPO.

Of course, the best test for knit line visibility is with an actual production part evaluation. Figure 4 is a photograph of a current production trim part molded with talc filled TPO. This part has multiple submarine type gates that produce four knit lines around an

opening. Figure 5 shows the same part molded with Advanced Reinforced Elastomer producing virtually no knit lines, while using the same process conditions as TF-TPO.

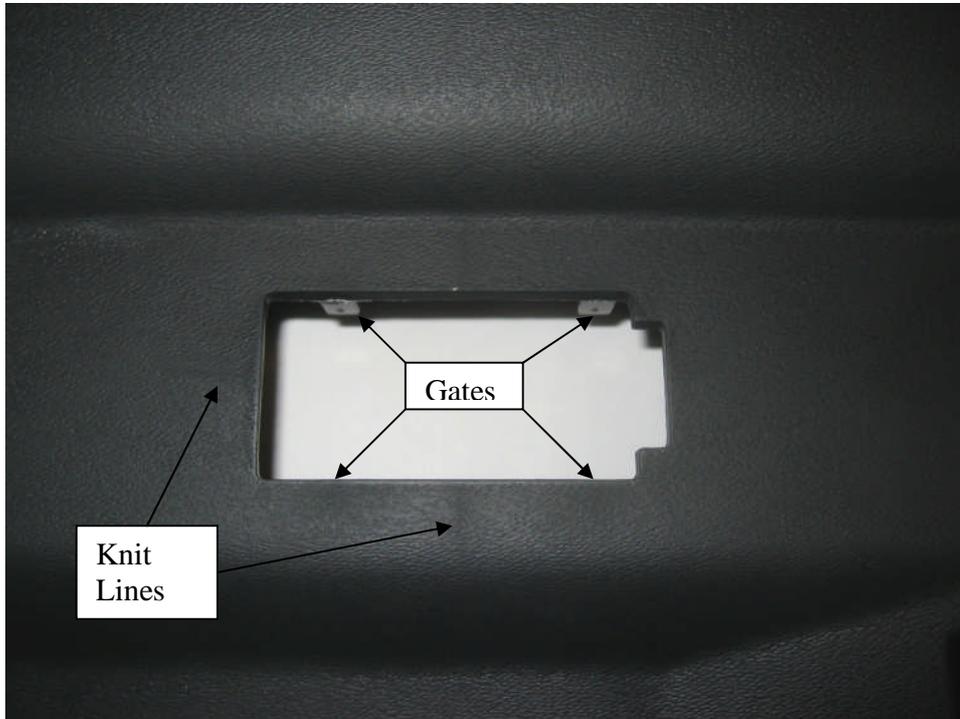


Fig. 4- Knit lines with talc filled TPO in current production part.



Fig. 5- Same trim part molded with Advanced Reinforced Elastomer (no knit lines).

Poor Scratch and Mar Durability

Mechanical surface durability for automotive interior materials is typically determined with tests that fall under the categories of scratch and/or mar performance. Scratch testing usually involves a weighted stylus with a small radius point (0.5 mm) that is dragged across an injection molded plaque with a target texture. The resulting scratch is then rated as a pass or fail depending on the visibility of its appearance versus the weight that was applied to the stylus. In general, the automotive OEM's prefer a material to pass this test with at least a fifteen (15) Newton load applied. Both the surface hardness and the elasticity of a material play an important role in scratch performance. Higher modulus materials resist the deformation and resulting damage to the part surface, but can produce a hard touch or poor haptic. Highly elastic, lower modulus materials have a softer touch, but tend to deform and show more damage during the scratch test, although the deformed section rebounds somewhat when the load is removed. The new Advanced Reinforced Elastomers produce lower scratch visibility with moduli similar to hard materials, assisted by elastic rebound from the stylus deformation. During the test, the scratch tester stylus displaces material while pressing down into the plaque surface. The displaced material is typically pushed to the side and upward, forming "banks" along the sides of the resulting depression. Typically, the greater the distance from the bottom of the depression to the top of the banks in the scratch profile, the greater the visibility of the resulting scratch. Figure 6 compares the profiles of scratch deformation in a plaque for TF-TPO, ABS, and low modulus elastomer versus the new Advanced Reinforced Elastomer. Figure 7 illustrates the difference in appearance between a scratch resistant talc filled TPO and Advanced Reinforced Elastomer when tested using a 1.0 mm diameter stylus (needle) with an 18 Newton load.

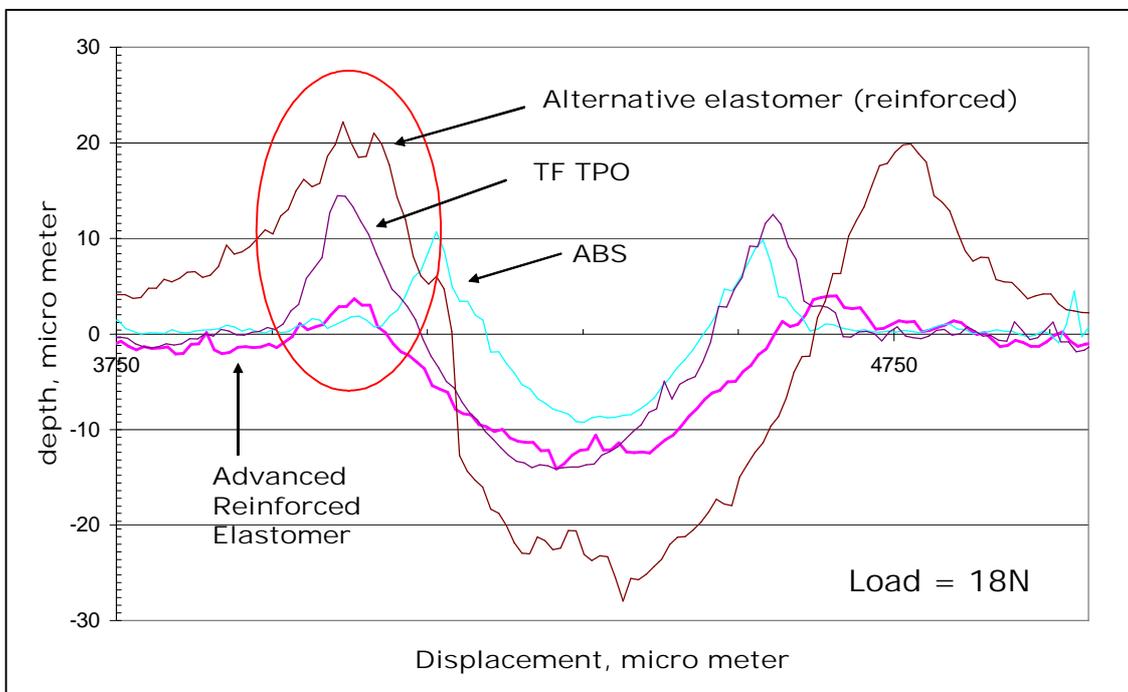


Fig. 6- Profile of the scratch deformation on the plaque surface with different materials

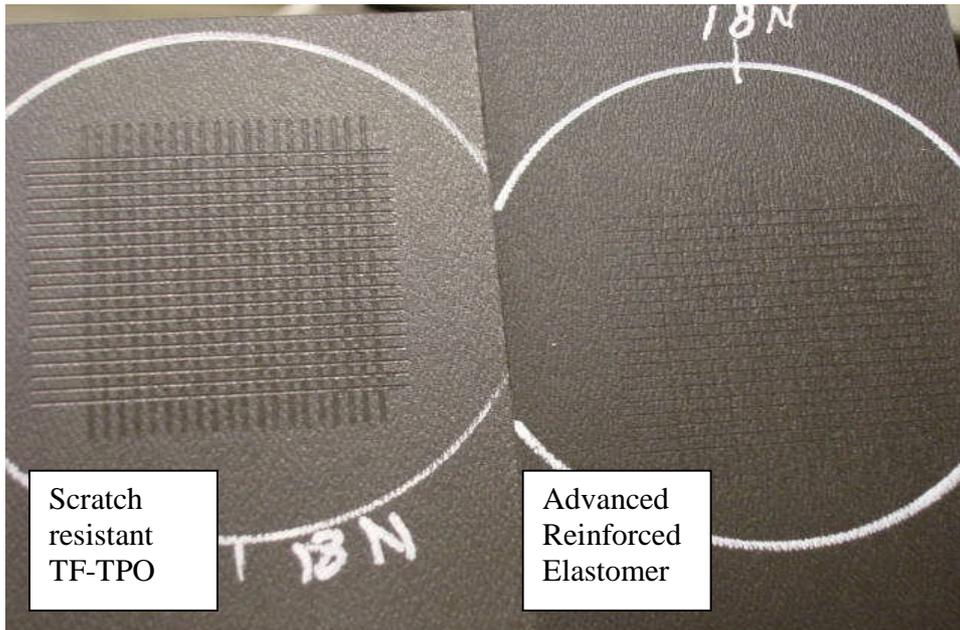


Fig. 7- Scratch appearance with 1.0 mm diameter stylus and 18 N load comparing TF-TPO to Advanced Reinforced Elastomer.

Mar or abrasion resistance is another surface durability performance gap that mold-in-color thermoplastics have versus paint. Marring can be defined as local surface damage at lower loads, often over a wider swath (distributed contact), which creates an unacceptable increase in gloss. Marring tends to be more visible on the lower depth textures with finer “micro” structures that assist with imparting a low gloss appearance. This is due to the deformation of the micro (secondary) texture, with less damage to the macro (primary) texture (Fig. 8). The micro texture is created through a secondary texturing process, such as grit blasting or acid etching.

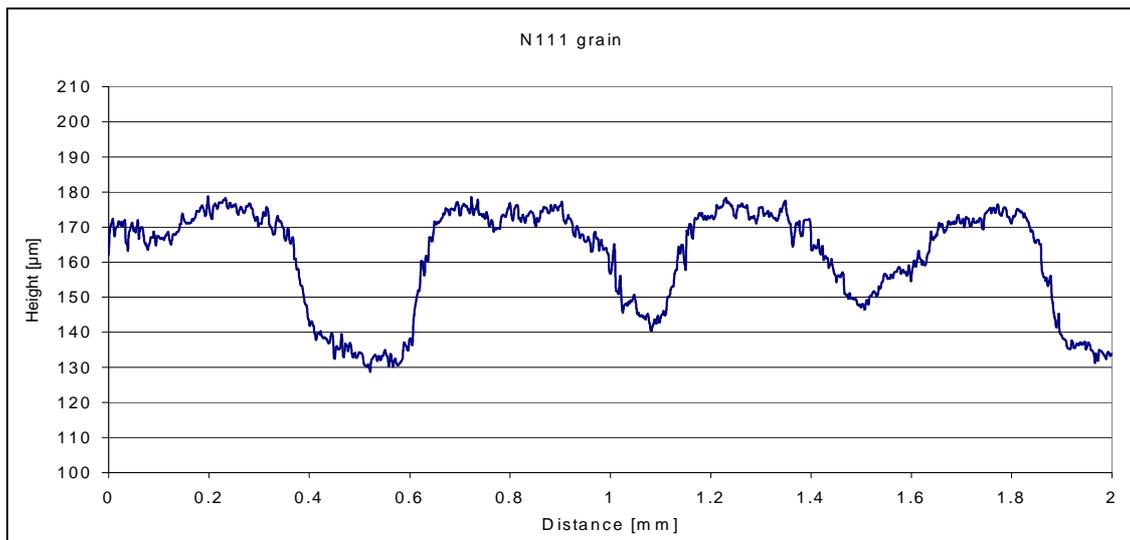


Fig. 8- Texture profile showing micro (secondary) texture on macro (primary) texture

The OEM's often make a subjective visual assessment of mar performance after using their own in-house test method. Mar testing is typically performed with a disk shaped object at a lower load than the scratch test. One test uses the Erichsen apparatus (Fig. 9), which is a weighted disk (6.0 mm in diameter with a 0.5 mm edge radius) that is dragged over the textured sample plaque with a seven (7.0) Newton load.



Fig. 9- Erichsen mar tester disk

A more objective mar evaluation method was developed using the Erichsen tester to create a grid pattern of mar lines in a rectangular area large enough, such that a standard gloss meter can be placed over the mar grid to record the gloss level on the sample plaque before and after the test (Fig. 10).

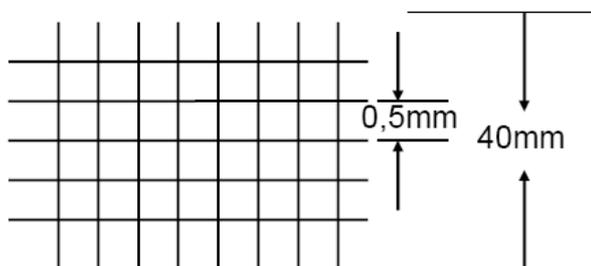


Fig. 10- Mar line grid pattern for gloss measurement

The mar performance can then be rated objectively by the measured change in gloss level for any given material with any given texture using a gloss meter (60 degree light angle). Several materials currently used for mold-in-color interior trim applications are compared for gloss before and after the mar test in Figure 11. Advanced Reinforced Elastomer has the best performance in both beginning gloss level and the resulting change in gloss, or mar visibility. Figure 12 illustrates the visual improvement after marring produced by the greater elastic recovery of the micro texture with Advanced Reinforced Elastomer versus a typical talc filled TPO.

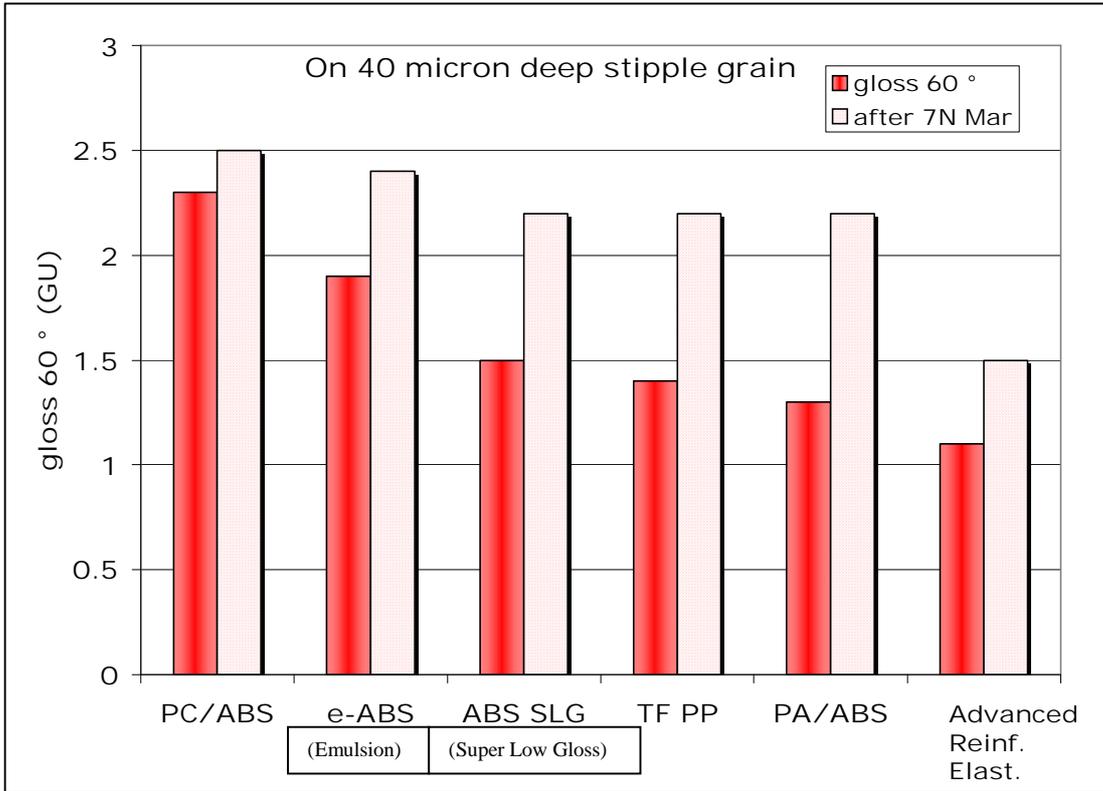


Fig. 11- Benchmark comparison of material gloss before and after the mar test.

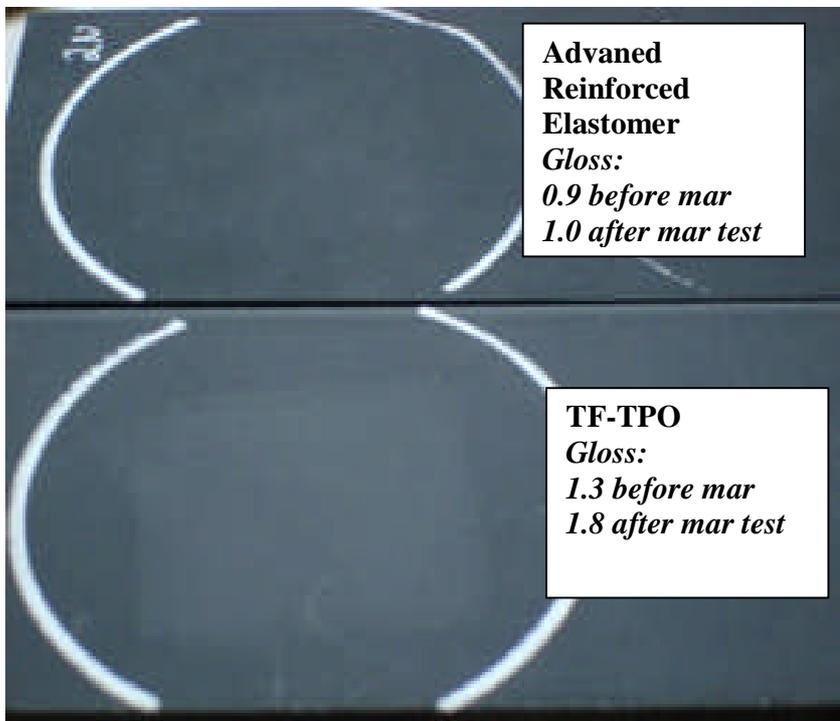


Fig. 12- Mar appearance of Advanced Reinforced Elastomer versus talc-filled TPO.

These new Advanced Reinforced Elastomer materials can meet a wide range of performance requirements. Figure 13 shows the properties for three proto-type formulations of the Advanced Reinforced Elastomer technology.

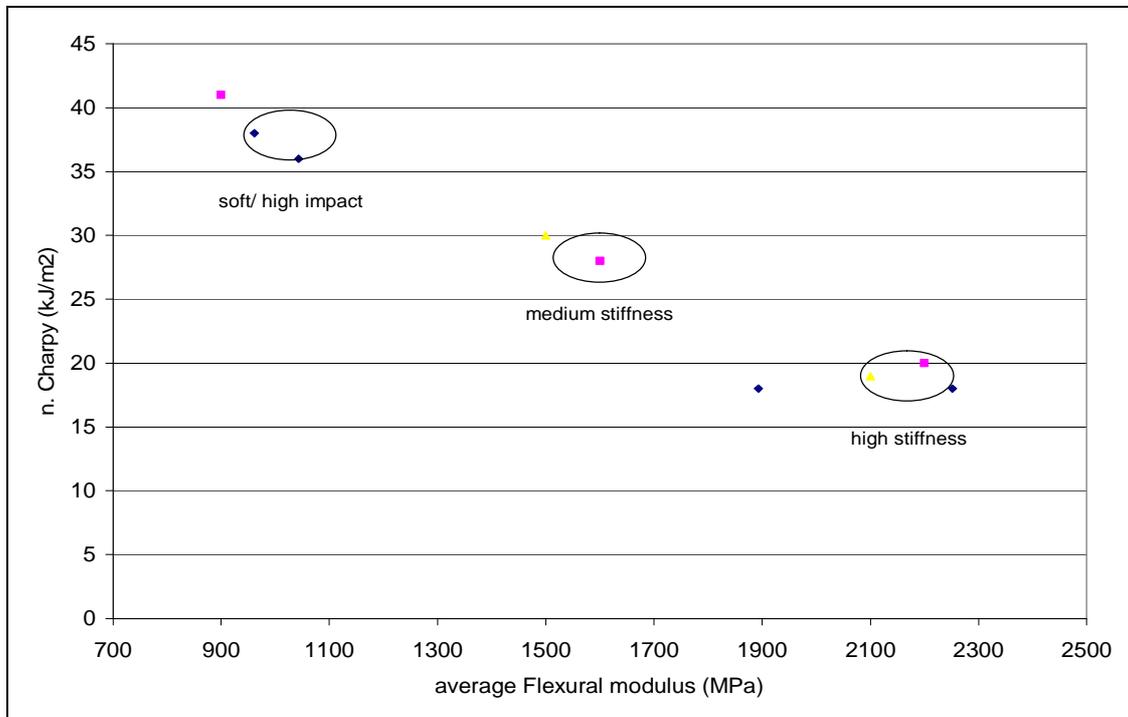


Fig. 13- Advanced Reinforced Elastomer property range for selected grades.

Summary

A new family of mold-in-color thermoplastics named Velvex™, based on Advanced Reinforced Elastomer technology from Dow Automotive, has been developed for automotive interior trim applications. These materials are inherently softer in touch than typical interior thermoplastic materials, while demonstrating the following improvements against the performance gaps versus paint:

- 1) Consistent lower gloss
- 2) Lower knit line visibility
- 3) Greater scratch resistance
- 4) Superior mar resistance
- 5) Softer touch (haptic)

The result is a cost effective mold-in-color material alternative to paint for interior components that delivers a higher quality impression to the customer through improved visual, haptic, and durability performance.

References

Breakthrough in Low Gloss, Abrasion Resistance, and Tactile Properties of Mold-in-Color Interior Parts, Plastics in Motion 2008, Prague (Norwin Van Riel, Jef Van Dun, Tom Traugott, Marjolein James).