ONE PIECE DLFT AUTOMOTIVE RUNNING BOARDS

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Abstract

Decoma International has developed a one piece composite running board utilizing Composite Products' patented Advantage ™ inline compounding technology. Running boards are currently in production on the F250/350 Regular, Super and Crew cabs, Explorer and Mountaineer vehicles. The replacement of the 43 piece metal and plastic assembly translates into a running board that meets or exceeds performance requirements at a significant cost savings to the OEM at half the weight. Composite Products, Inc. has commercialized this in-line compounding technology to produce long fiber thermoplastic composite solutions for various automotive applications. Advantage ™ systems continuously compound thermoplastic resin with fiber reinforcements such as chopped fiber glass, carbon or natural fibers to produce finished composites with outstanding toughness and excellent exterior appearance characteristics.

Introduction

For the past 10 years CPI has been developing structural automotive and non-automotive applications utilizing its proprietary Advantage™ DLFT (Direct Long Fiber Thermoplastic) process. Applications ranging from automotive seat bases, front end modules, door modules, convertible header bows, and other structural components including non automotive parts have been made using the CPI Advantage™ process. The cost to performance ratio of the CPI DLFT material allows for the replacement of a variety of structural materials including metal weldments, die casting, SMC, and precompounded thermoplastics. CPI has been actively replacing metal weldments in automotive applications since 1991 when in conjunction with Volvo began development of an integrated front end module. This single composite front end replaced a metal weldment of 23 components including the hood latch, radiator support, grill support, and headlights. The development resulted in a successful launch and production for the Volvo S70 platform. In a similar development effort CPI began working with Decoma, International several years ago to develop a one piece composite automotive running board.

Demands of the Running Board Application

Traditionally Running Boards were made from a metal assembly with a TPO molded cover fastened to the assembly. The goal in creating a one-piece composite Running Board was to replace the metal assembly and TPO cover with a lighter and stronger Running Board that looked as good as or better than the TPO cover, but at a much lower cost. Strength was a major consideration in the development process with design and materials as drivers. CPI developed a material formulation specific for this application to meet the load requirements and UV resistance while matching the in-molded color of the TPO. CPI also assisted in the design process with design features specific to long fiber molding and tool design. Superior materials and design allowed the one-piece composite to exceed the metal requirements by a factor of three with less deflection.

Advantages of a One Piece Composite Running Board

Strength

The materials chosen for the Composite Running Board consisted of fiberglass reinforced polypropylene with additional additives and in mold color. These materials were combined to create a composite with a density that is one-sixth that of steel. The result was a composite Running Board with a weight that is over thirty pounds less per vehicle than that of its predecessor. Even with this lighter weight the performance of the one-piece composite Running Board far exceeded that of the previous steel waffle and TPO overlay Running Board. The DLFT composite Running Board held close to three times the weight of the original board, without as much deflection even at the higher weight loading.

Figure 1 provides further proof of the “long fiber” nature of CPI in-line compounded material. The photograph to the left shows a before and after view of a molded part section. The part section was placed in a muffle furnace at 600° Celsius to burn off the polymer matrix. The increase in volume and the glass skeletal structure are normal behaviors for long fiber materials. The photograph on the right shows the ability of the glass skeletal structure, minus polymer, to maintain the original shape of the molded part.

Aesthetics

Aside from its strength requirements, the Running Board application is an exterior show surface which needs to be free from imperfections and UV resistant. CPI's Advantage™ process coats each filament of glass with a layer of resin with out damaging the fiber. This allows CPI to produce parts that are free of imperfection while retaining long fiber properties. The bulk molding material exiting the accumulator has the reinforcing fiber homogeneously dispersed throughout the preform thus ensuring uniform fiber distribution throughout the molded part. Figure 2 shows weight percent fiber content test values for samples taken at several locations on the compression transfer molded Jeep door surround. The test measurements demonstrate a variation of less than one (1) weight percent in fiber content independent of the length of flow or cross-sectional thickness.

Part Consolidation

In the process of designing a one-piece composite Running Board, Decoma was able to eliminate forty-three pieces that included brackets, steel waffle, TPO overlay, bolts, nuts, and end pads. The elimination of all these components led not only to a savings in purchased parts, but also in the manpower and equipment needed to put all of these parts together (figure 3).

Economics

All of these specifications, weight, strength, appearance, and parts consolidation, had to be met while still maintaining an economic advantage over the original steel and TPO running board, as well as other composite materials that were candidates for the application. By starting with the same constituent raw materials that a sheet or pellet manufacturer starts with, the CPI Advantage Process is able to compound the material together and directly make a molded article rather than a sheet or pellet that would need to be packaged, shipped and reheated at another molding location. The elimination of the forty-three pieces that made up the metal Running Board, as well as the reduced labor and time required to assemble each metal Running Board, led to a cost savings of over $10 per Running Board to the OEM by converting to the one-piece composite Running Board.

Current Running Board Production

As a result of the tremendous success that the one-piece composite Running Board has displayed, there are many Running Boards in production today that utilize the CPI Advantage in-line compounding process. As mentioned above, CPI is currently molding the F-250/350 Regular, Super and Crew Running Boards. Because of the advantages seen with the CPI Advantage Process, Decoma decided to obtain a license to purchase and practice the process for utilization in their own production of Running Boards. CPI has granted Decoma an exclusive license for the Advantage Process in the production of Running Boards. Today Decoma is molding Running Boards for the Explorer, Mountaineer, and the Aviator line of SUV's for Ford Motor Company. In addition, Decoma will begin molding the Running Boards for the F-150 line of trucks starting in the summer of 2003. There are also other programs for which Decoma is exploring the feasibility of utilizing the Advantage™ technology. Figure 4 shows the production Ford F250 and Ford Explorer Running Boards.

DLFT Process Advantages

The following is a summary of several process advantages of in-line compounding.

5.1 Reduced Screw Wear - Fiber or abrasive fillers are not present at the solid/melt interface found in most extrusion compounding systems. In-line compounding brings the thermoplastic resin to a homogeneous melt temperature prior to addition of preheated reinforcements. Separation of resin melting and solids compounding significantly extends the useful lifetime of compounding feedscrews.

5.2 Single Heat History - Virgin resins for in-line compounding are received in pellet form and are converted in-line, via a single compounding step, to the desired thermoplastic composite formulation. Unlike precompounded pellets, resins entering the in-line system have undergone a single heat history during resin pellet manufacturing. This reduced exposure to the effects of thermal degradation translates into improved initial and long-term properties for molded composite articles produced with the in-line compounding process.

5.3 Custom Formulations - In-line compounding is ideally suited to matching the material formulation to the requirements of the application. Materials selection is not constrained by a materials supplier's production efficiencies. The composition of the molding material can be changed at will during the production cycle simply by manipulating the feed rate values for constituent raw materials delivered by computer controlled gravimetric feeders.

5.4 In-Line Recycling - In-house generated regrind, post industrial and post consumer recyclates can be readily introduced as feedstocks for the in-line compounding process. Dispersive mixing imparted by two single screw extruders ensures that recyclates are completely homogenized with virgin resin. Formulation costs can be significantly impacted by addition of recyclate feed stocks, as well as enhancing the "green" connotation of molded parts. Regrind content as high as 15% can be added to some formulations with no significant loss of properties.

5.5 Custom Colors - Color concentrates or liquid colorants delivered to the resin or fiber compounding sections of the in-line system are uniformly dispersed in the resin matrix of the composite material. Custom colors are prepared in-line as needed to meet production scheduling requirements, eliminating the need to maintain inventories of custom compounded precolored pellet feed stocks.

5.6 JIT Compounding - Thermoplastic bulk molding compound is continuously produced on demand for the molding process. Only the material required for the scheduled run of production parts is produced.

5.7 Reduced Inventories - Maintaining inventories of multiple grades of precompounded pellets to meet unanticipated demand is not necessary. Bulk storage of ingredients common to several formulations further simplifies inventory control and warehouse storage space requirements.

5.8 Reduced Packaging - Primary raw materials purchased for in-line compounding are delivered by bulk truck or in returnable bulk sacks. Cardboard and multiwall paper bag waste is eliminated from the production environment.

5.9 Uniform Fiber Content - The bulk molding preform is uniform in temperature and fiber distribution. Analysis of fiber content in molded parts (See Figure 3) has demonstrated that areas at the end of long flow paths or deeply ribbed cross sections contain fiber loadings equivalent to the bulk of the molded part.

5.10 Reduced Energy Consumption - The total energy expenditure for in-line compounding of raw materials to produce thermoplastic bulk molding preforms is significantly less than incurred with the pellet compounding process. Energy spent transforming raw materials into precompounded pellets, transporting the finished pellet to the end user and subsequent reheating of the pellet feedstock prior to injection molding are totally eliminated from the manufacturing cycle.

5.11 System Versatility - In-line compounding is an extremely versatile process. Material combinations, defined by the end-use of the molded part, can be direct molded from raw material formulations defined in-line with the molding process. Flax, hemp, wood fiber, carbon fiber and aramid fiber reinforcements can be compounded with a variety of thermoplastic resins such as polyolefins, nylons, polyesters and polyurethanes. Particulate fillers including mica, talc, wollastonite, and calcium carbonate can be compounded in-line with similar ease.

5.12 Overall Cost Reduction - All of the factors previously discussed for in-line compounding work in combination to define an extremely cost efficient production model. In-line compounding is an evolutionary step in the economics of thermoplastic composite parts manufacturing similar to what has already occurred in the manufacture of thermoset products. The combined efficiencies of in-line compounding and direct molding provide the lowest total manufacturing cost for large high volume molded parts.

Conclusions

The development of an all composite Running Board utilizing the latest in Long Fiber technology represents a true innovation over previous materials.

- $10 reduction in cost to OEM per vehicle
- 30.18 lb. Weight reduction per vehicle on P131 Super Cab
- Savings in tooling, secondary operations and gauging
- Reduction in part complexity over conventional running boards which have multiple stamped steel brackets, rolled steel reinforcement and a molded in color TPO cover
- Improved quality and better dimensional control
- Corrosion Resistant
- Environmentally Friendly and Recyclable

Tables & Figures

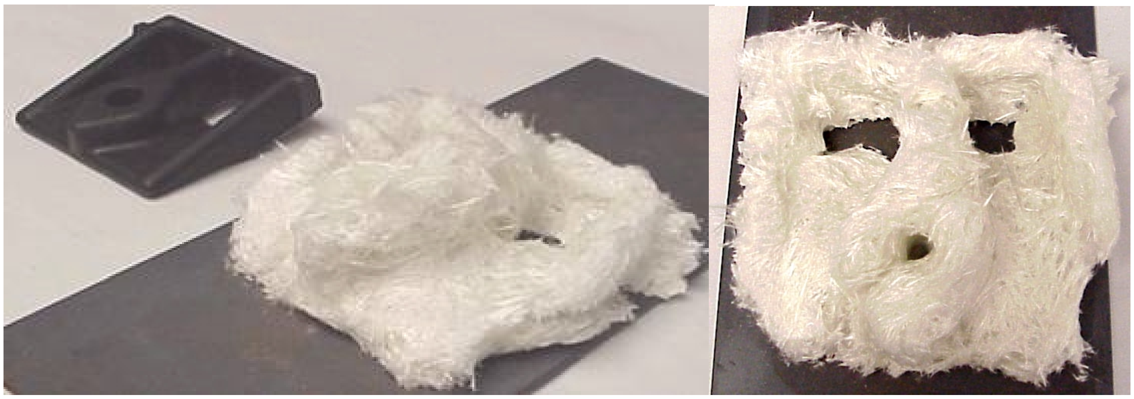

Figure 1:

Molded Part vs. Burnoff — Glass “Skeleton of Molded Part

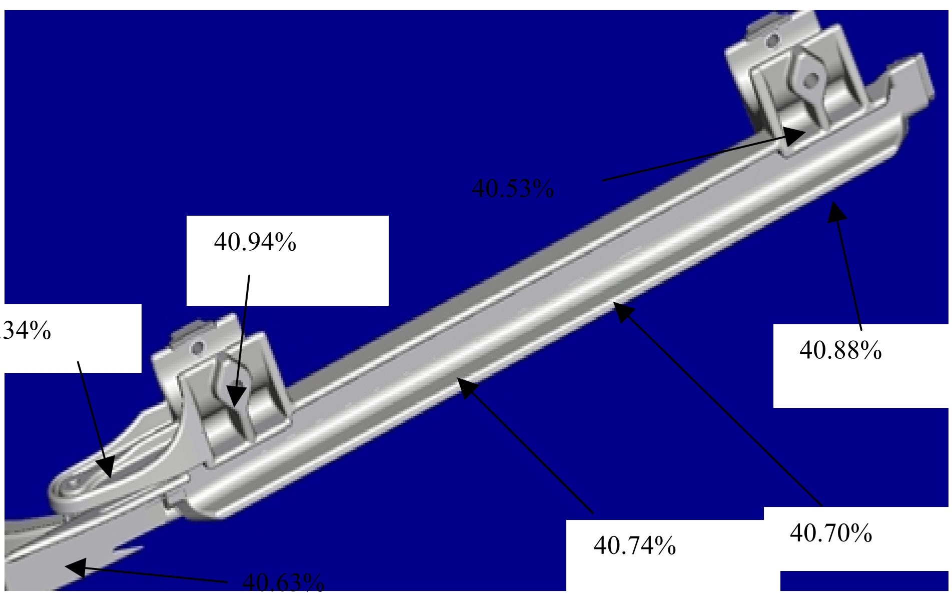

Figure 2:

Molded Article Demonstrating Uniform Fiber Content

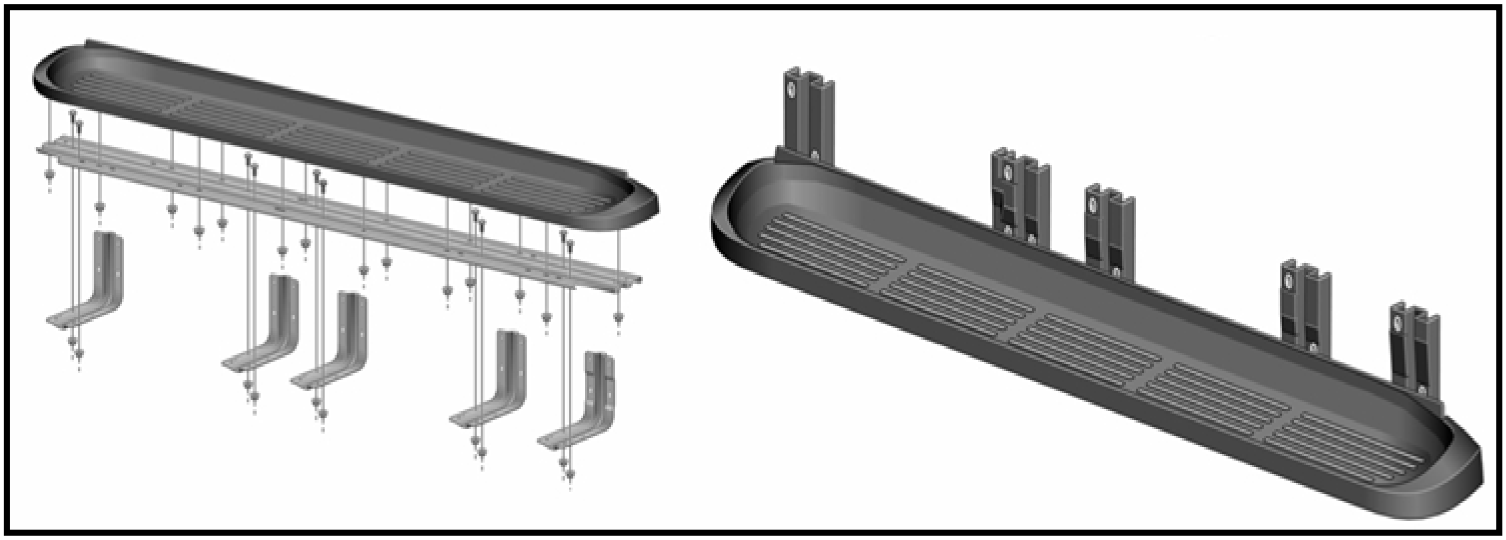

Figure 3

Figure 4:
Ford F-150 and Ford Explorer production one piece composite running boards