QUADRANT PLASTIC COMPOSITES

Technical Information

Structural Bumper Beams made in GMTex™

Introduction

High performance GMT or **GMTex™** is a multilayer combination of traditional **GMT** (Glass Mat reinforced Thermoplastics) and technical **tex**tiles such as woven or stitched fabrics impregnated by a thermoplastic matrix resin, usually polypropylene. The composite laminate is consolidated on a double belt press in a one step process and is supplied as pre-cut blanks. Molding of GMTex™ is as easy as normal GMT. Parts made out of GMT are shaped either by hot stamping or by flow molding, of which the latter is the most commonly used. The GMT sheet is preheated in an infrared or air convection oven, where the matrix polymer of the composite is molten through the thickness of the blank. The blank is transferred into the mold cavity, usually by a robot equipped with needle grippers and are placed in the lower mold half. The press closes at high speed and the material is compressed and flows to fill the mold cavity. The mold temperature is below the solidification temperature of the resin, usually at 40 – 60°C for PP matrix. The mold is held closed at a pressure of 15 to 25 MPa until the part is solidified. Over-all part to part cycle times range between 20 and 90 seconds, depending mainly on part thickness and mold temperature. When one or several of the blanks are fabric reinforced, the glass mat portion (the non-woven part) of these blanks will flow to fill the mold, whereas the woven or stitched fabrics will stay in the inlay zone where the blank was put into the mold.

Many factors influence the physical properties of high performance GMT, the most important are listed below:

- Fiber type (fabrics with glass, or polymeric fibers or blends thereof)
- Fabric type (stitched or woven)
- Fiber content of the non- woven portion and the technical fabric portion
- Fiber orientation and distribution in the fabrics (e.g. unidirectional or +/-45° etc.)

High performance GMT is a very suitable material for bumper beams (specifically the non-visible, structural longitudinal element of a bumper). The components are traditionally made in steel sections or extruded aluminium sections and to a certain extent in GMT with partial UD-reinforcement. Over the last few years some factors have made this application more interesting for high performance GMT, these are:

- Increased demand on vehicle weight reduction. In addition, the component is far from the center of gravity of the vehicle and is thus critical to the inertia, which yet increases the interest of weight saving.
- Higher required energy absorption: Given energy absorption at bumper mounting points to protect the structures behind it in the vehicle at low speed crashes (insurance rules, 16 km/h in Europe)
- Controllable fracture behavior: Part integrity and stabilization function at very high speeds (65 – 80 km/h), at these rates primarily the deformation behavior is important.

When planning to mold a component in high performance GMT, we recommend to discuss the following points with QPC:

- Material combination (material grades of GMT and GMTex™, type of fibers etc.)

- Blank layout in consideration of part design since it influences both processing and properties of the component. Advice on the prediction of local properties in molded high performance GMT components is given in a separate “Quadrant technical information” paper.

The influence of the design is instrumental for the performance of the bumper beam, but it is strongly affected by the material properties and for an optimum combination it is necessary that during the design of bumper beam some discussion should be made between material supplier and part developer. Numerical simulation of the most critical load cases is an advantageous method to optimize the component geometry.

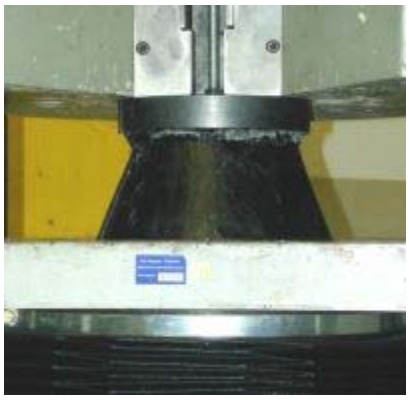
The most suitable GMTex™ materials for bumper beams are the ones with a high fiber content in the main direction of the bumper loading. Examples of specified materials are GMTex™ 4/1 - 0/90° and unidirectional GMT (GM20UD20) in combination with a randomly oriented GMT. GMTex™ 4/1 - 0/90° is a glass weave reinforced GMT where the weave has four times more fibers in longitudinal direction than in the transverse direction. UD-GMT is reinforced by unidirectional glass fibers in the longitudinal direction. In practice, GMTex™ 4/1 – 0/90° has been observed to give a higher safety due to a better resistance against splitting. This good deformation behavior is guaranteed by the complex crack propagation redistribution promoted by the transverse fibers in the 4/1 weave of the GMTex™. A combination of UD-GMT and GMTex™ has proven to be very advantageous if a high stiffness is required in complex sections. Another material with interesting properties for bumper beams is the polyester fiber weave reinforced GMT (C100F23DG13), it has a low stiffness, but excellent energy absorption properties and it can insure post-crush part integrity which is important for so-called “crash cones”.

Peugeot Expert

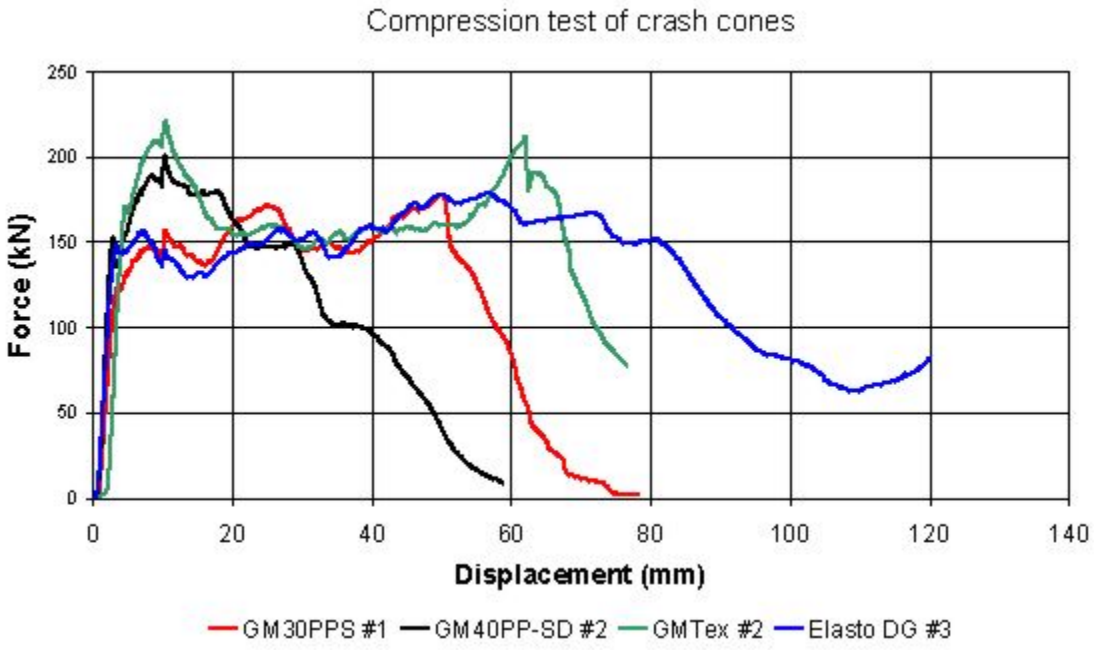
The bumper beam in the figure below is from Peugeot Expert and is produced with a combination of GMT and GMTex™ 4/1-0/90°. The blank layout was optimized for stiffness in the center section, the outer areas are not fabric reinforced and the geometry there has been optimized for energy absorption.

Energy absorption – crash cones

Below is a compressive- test which compares the energy absorption of GMT (30 & 40% glass fibers) and the high performance GMT types GMTex™ 4/1 - 0/90°and C100F25DG13. The tested parts were all molded and tested with the same conditions.



Compression test of crash cones



This compression test results in the table below show, that the energy absorption of C100F25 DG13 (written with Elasto DG #3 in chart) is higher than GMTex™, but regarding the stiffness and the compressive strength, the GMTex™ is superior. An other important point is also the maximum force which is considerably lower with C100F25DG13 than with GMTex™.

Material	**Max Force (kN)**	**Energy (kJ) first 100 mm**	**Standard deviation (kJ)**	**Integrity after compression**
GMT 30% GF	200	10.6	4.2	Poor
GMT, 40% GF	210	6.9	4.3	Poor
GMTex 4/1-90°	230	10.0	4.7	Good
C100F25DG13	**180**	**13.2**	**0.8**	**Very good**

High speed test with high performance GMT

Extensive tests have been made with GMTex™ Bumper Beams and one of the last achievements was published by Peguform (Venture). In the 2 photos below, the post impact pictures of a GMTex™ bumper beam are presented (Source: Peguform-Venture: un pari gagné", L'Usine Nouvelle, No. 2787, 07-2001).

The component was subjected to an offset crash at 65 km/h. The longitudinal beams to which the bumper beam was attached took up the intrusion energy, whereas the GMTex™ bumper guided the longitudinal bars along the whole deformation and the component stayed intact after impact. This achievement is only possible with a very suitable geometry (cross section) and with the right weave reinforcement, in this case it was a glass fiber weave reinforced GMT.