Static and dynamic crush performance of in-situ foam-filled tubes

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The current trend in transport industry is to increasingly integrate lightweight materials into vehicle designs to reduce their overall weight. This can be effectively achieved with a combination of light metals and cellular materials, like the aluminium alloy (Al-alloy) foams. Such foams have been tested for use as fillers in multifunctional construction elements for energy and sound absorption, vibration damping and heat dissipation.

The most common and cost-effective solution to bond foams with other materials is by using polymeric adhesives. However, such bonding is limited due to high-temperature sensitivity, recycling difficulties and consequently environmental impacts. Usability of some other joining processes (e.g. welding, brazing and soldering) has thus been investigated. The tests have demonstrated that the cellular structures are damaged during these bonding processes and have been deemed not suitable to fabricate foam filled tubes (FFTs) which are widely used key components in automotive body parts. Moreover, this additional joining step makes the process expensive, resulting in non-competitive products.

Alternatively, we have developed and tested lightweight, recyclable, non-inflammable *in-situ* FFTs made of light Al-alloys through powder compact foaming method wherein the joining between the foams and tubes is achieved during the liquid foam formation, resulting in good metallic interface bonding, a pre-requisite for better mechanical response of the composite structure. Fig. 1 shows the main results in which the mechanical crushing behaviour and the failure mechanisms were assessed by compression and three-point bending tests supported by infrared thermography. The mechanical response of the *in-situ* FFTs was compared to the individual components and *ex-situ* FFTs prepared by insertion of the pre-shaped foam into the tube.

The results clearly demonstrate that the new *in-situ* FFTs have a superior mechanical performance and that they ensure high ductility and very good crashworthiness behaviour since they deform under compressive and bending loads without formation of cracks and without abrupt failure. A good interface bonding also contributes to a more axisymmetric deformation. We believe that the incorporation of such structures into the automotive structures can further reduce the vehicle weight, increase the active safety in case of an accident and increase the passive safety by reducing the noise and vibrations while driving.

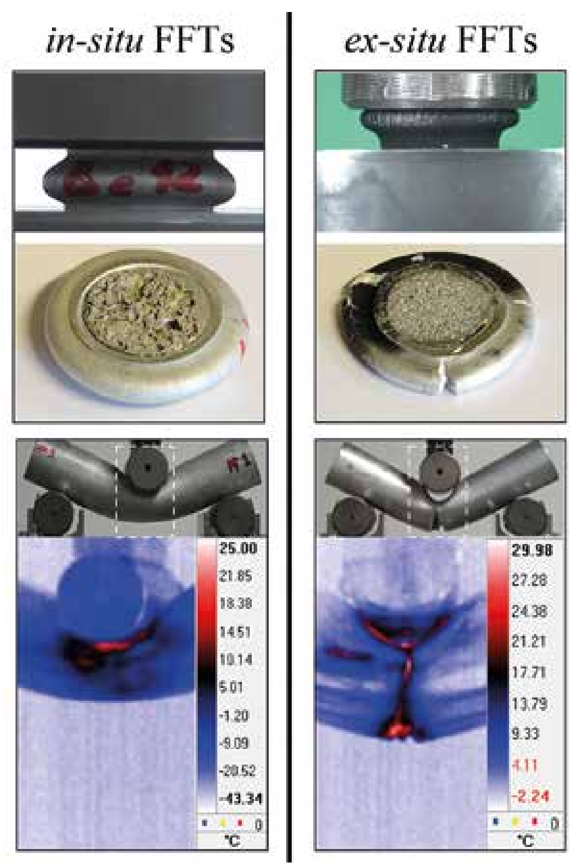

FIGURE 1
Compressive and bending responses of *in-situ* and *ex-situ* FFTs.