Dynamic behaviour of polyolefin thermoplastic hot melt adhesive under impact loading conditions

Dynamic behavior of polyolefin thermoplastic hot melt adhesive under impact loading conditions

R. Ciardiello[1], A. Tridello[1], G. Belingardi[1], L. Goglio[1].

[1] Politecnico di Torino, Department of Mechanical and Aerospace Engineering, Torino, 10129, IT.

The mechanical behaviour of adhesive joints under impact loadings is an active area of research due to significant industrial interests. Furthermore, the absence of a unique adopted standard for the study of bonded joints under impact loading increases the academic interests for this topic [1]. In this work, the static and the dynamic response of adhesive joints, bonded with a polyolefin hot-melt adhesive (HMA), were investigated by means of Single Lap Joint (SLJ) tests. The adhesive studied in this work is used in automotive application for bonding plastic internal and external plastic components [2], such as plastic bumpers that can be subjected to impacts during its life. The mechanical and thermal properties of this adhesive are presented in [3]. The main aim of this study is to test standard specimens, SLJ, under dynamic impacts with the use of a modified Charpy pendulum in order to compare the differences between static and dynamic behaviour. The substrate used in this activity are made of a polypropylene copolymer with 10% in weight of talc. Figure 1 shows the testing machine with the clamping system of the specimen. These special fixtures were designed by Goglio et al. [4] with the aim to apply a dynamic load on the tested SLJ. The specimen is fixed to the hammer at the front end, as shown in the right part of Figure 1; the back end is connected to a transverse tail, which hits the two stoppers fixed on the pendulum base, shown in the red circle of Figure 1. The fixtures hold the specimen during the fall of the hammer and transmit the load. A tail in aluminium alloy with T cross section was used, in order to guarantee a high stiffness during the impact, without adding excessive inertia to the system. The system is able to perform dynamic tests for SLJ specimens up to 3.75 m/s.

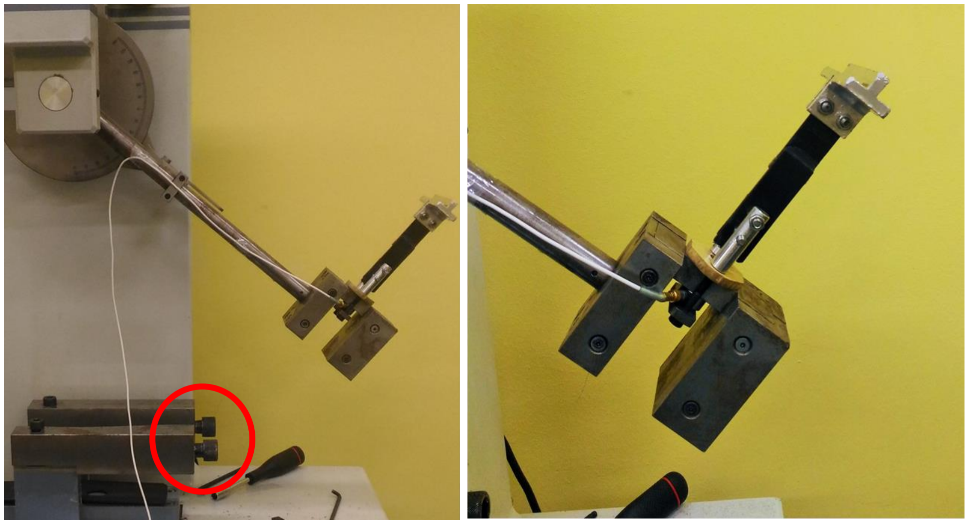

Figure 1: Charpy pendulum used for the experimental tests.

Mechanical tests show that there is a clear influence of the load rate on force-displacement diagram and on the maximum force for the tested adhesive. Figure 2 illustrates the differences between a representative curve of quasi-static test and dynamic tests with two different velocities.

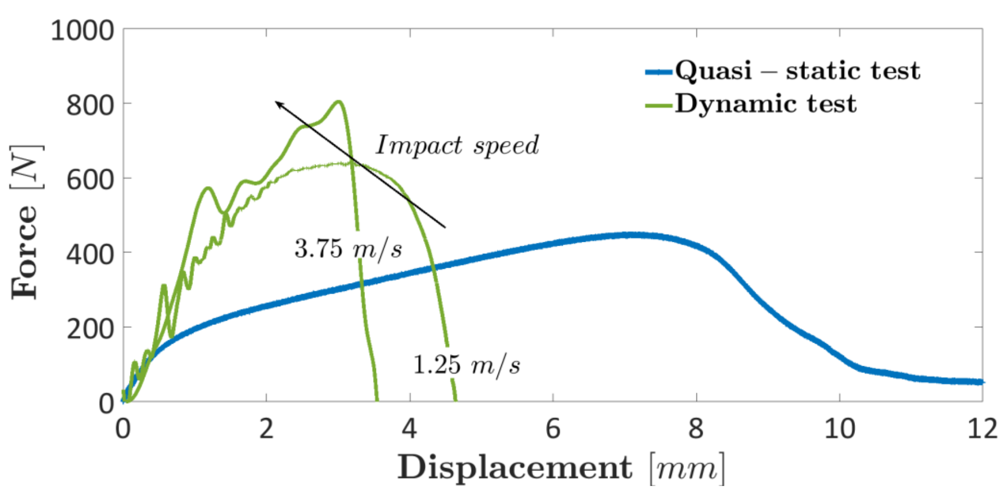

Figure 2: Force vs linear displacement: comparison between quasi-static and dynamic tests.

Figure 3 shows the average values of the peak force and absorbed energies. This Figure illustrates that the velocity increase leads to an increase of the maximum force while the adsorbed energy significantly decreases by comparing quasi-static and dynamic tests.

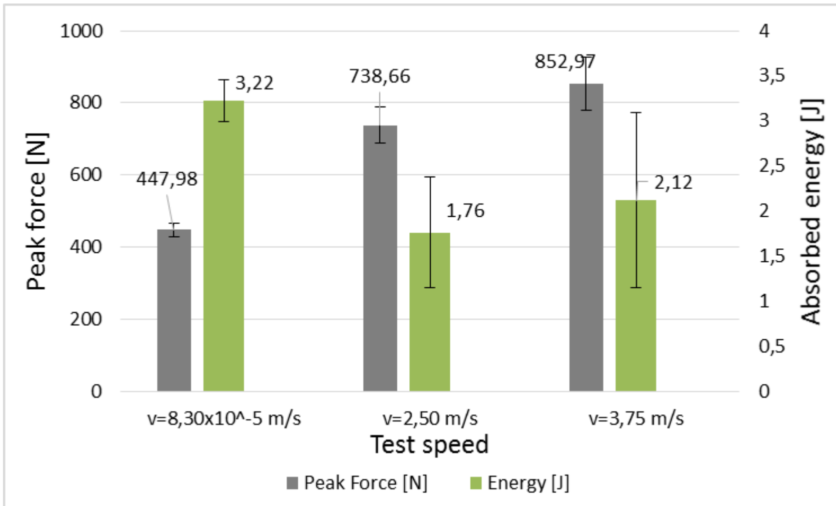

Figure 3: Peak loads and absorbed energy of the quasi-static and dynamic tests.

Finally, the fracture surfaces of the SLJ specimens were assessed by means of visual inspection. This analysis showed that the joint separation in the quasi-static tests is mostly cohesive, whereas it becomes completely adhesive in dynamic tests.

[1] J.J.M. Machado, E.A.S. Marques and L.F.M. da Silva, J. Adhes., (2017). https://doi.org/10.1080/00218464.2017.1282349.

[2] G. Belingardi, V. Brunella, B. Martorana and R. Ciardiello, in Adhesives applications and properties, Cap.13, p.341, A. Rudawska Ed. (INTECH, Rijeca, 2016).

[3] E. Koricho, E. Verna, G. Belingardi, B. Martorana, and V. Brunella, Int. J. Adhes. Adhes. 68, 169–181 (2016).

[4] L. Goglio and M. Rossetto, in Proceedings of ESDA2006 8th Biennial ASME Conference on Engineering Systems Design and Analysis, 637-643 (2006).