Composite Sheet Forming in RTM and CFRTP Manufacturing

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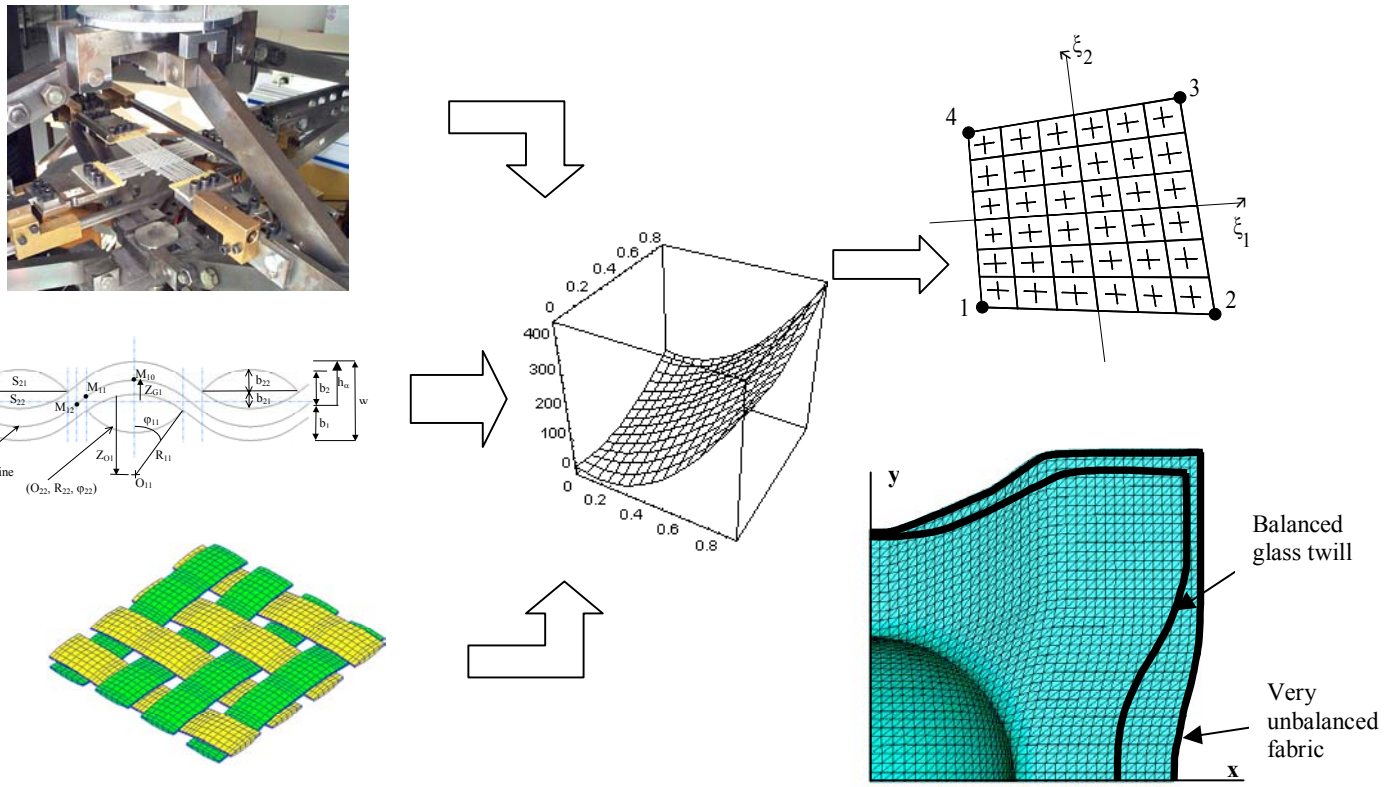
SUMMARY: Thin composite structures are intensively used in the transportation industries especially in the field of aerospace applications. In the RTM process a fibre fabric reinforcement is shaped by a drawing operation, then the resin is injected and polymerised at high temperature. Forming at high temperature plates with long fibre reinforcements and thermoplastic matrix (CFRTP) is an alternative process which have some advantages such as a shorter manufacturing time an a possible recycling. The works made at LMSP focus on the simulation of the drawing operation (concerning the dry fabrics in RTM process and long fibre reinforcements associated with thermoplastic matrix at high temperature for the CFRTP forming). For each process the deformation mechanisms during the forming are studied. Mechanical models of the behaviour of the material including the main aspects are deduced. The sheet composite forming simulations are made by implicit or explicit finite element approaches developed within the Pam-Form® code in the last case.

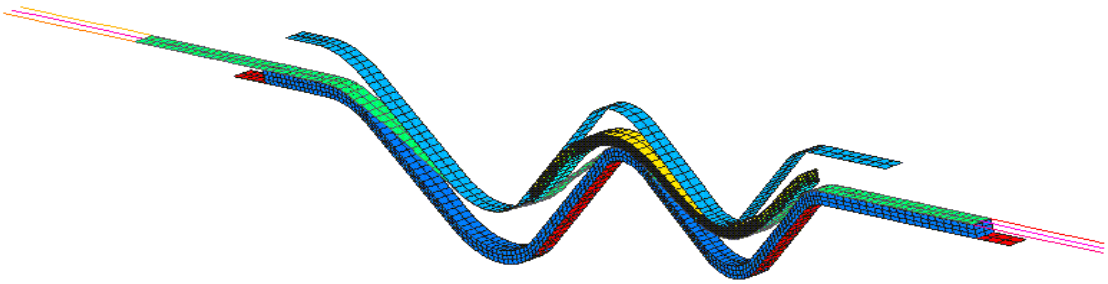
The presented studies are supported by different companies, especially EADS, PSA and Matra BAE.

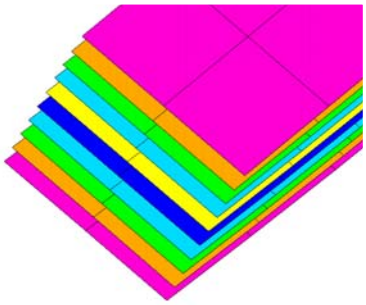
SIMULATION OF FABRIC REINFORCEMENT SHAPING IN RTM PROCESS

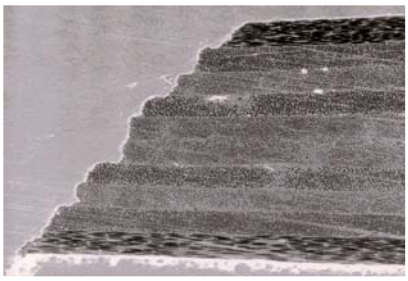
The forming simulation of dry fabric during the first stage of the RTM process is based on a finite element approach. Specific elements made of woven unit cells are built. The deformation energy of each patterns is obtained from the biaxial tensile behaviour surfaces of the fabric. Three methods are investigated to determine these surfaces : biaxial tensile tests, 3D FE analyses of the unit cell and analytical models.



CFRTP FORMING SIMULATION







The analyses are based on the use of one shell set per ply. Each shell set is in viscous contact with the upper and lower ply.
Experimental analyses have been performed at EADS Suresnes. The current works are mainly done on:

- Bending during the forming stage
- The re-compaction stage

Recent publications :

[BOI 95] Boisse P., Cherouat A., Gelin J.C., Sabhi H., "Experimental study and finite element simulation of glass fibre fabric shaping process", *Polymer Composites*, 16, n°1, p. 83-95, 1995

[BOI 97] Boisse P., Borr M., Buet K. and Cherouat A. "Finite element simulation of textile composite forming including the biaxial fabric behaviour", *Composites B*, Vol 28B, p.453-464, 1997

[GAS 99] A. Gasser, P. Boisse, S. Hanklar, Analysis of the mechanical behaviour of dry fabric reinforcements. 3D simulations versus biaxial tests. *Computational Material Science* , 17, 1, pp 7-20, 2000

[BOI 01] Boisse P., Buet K., Gasser A. and Launay J., " Meso-macro mechanical behaviour of textile reinforcements of thin composites ", *Composites Science and Technology*, Vol. 61, 3, pp. 395-401, 2001

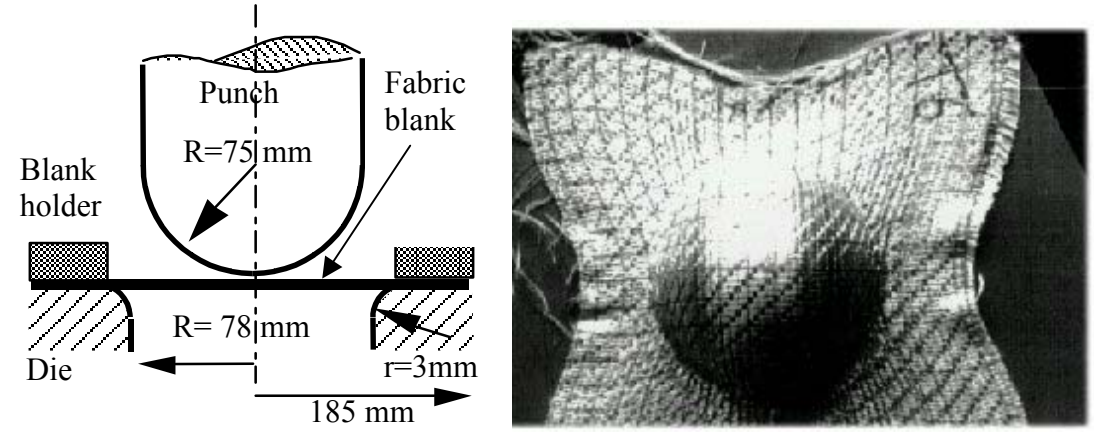
[BUE 01] Buet K., Boisse P., " Experimental analysis and models for biaxial mechanical behaviour of composite woven reinforcements ", *Experimental mechanics*, to appear in september 2001

[BOI 01] Boisse P., Gasser A. and Hivet G.., " Analyses of fabric tensile behaviour. Determination of the biaxatension-strain surfaces and their use in forming simulations ", *Composites A*, to appear 2001

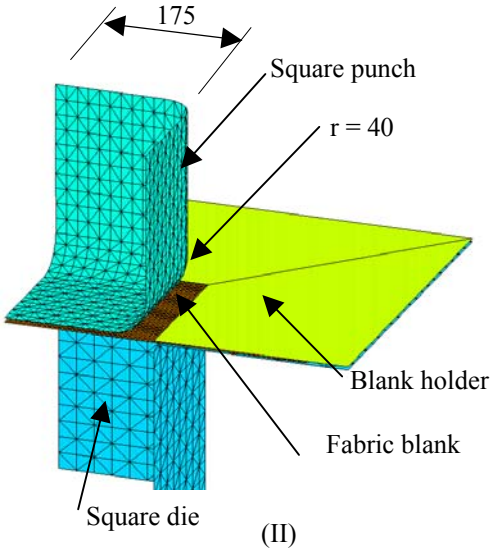
Possible benchmarks (P. Boisse)

I believe it is necessary to differentiate the forming of a single dry or prepreg fabric and the forming of a multiply composite such as CFRTP.

Concerning forming of fabric, I think the shape should be double curved but remain simple because benchmarking is not classical (yet) for composite forming. We could start with the (too) classical hemispherical punch (I) or by a square punch such as those proposed at Numisheet'93 (II). The parameters of the forming should be well defined such as : the material, the boundary conditions (loads, blank older…), the initial directions of the yarns, the speed….



(I)



(II)

In the case of multiply forming (CFRTP for instance) a single curve surface could be sufficient in a first step because the plies are sliding. A simple profile such as a Z profile or Ω profile could be considered.