Techniques and solutions for the industrialisation of composites

At the recent Seatec-Compotec, the international show dedicated to yachting technologies and composite materials held in Marina di Carrara from February, Assocompositi, the Association of reference in the sector, organised the seminar/laboratory “techniques and solutions for the industrialisation of composites”.

The workshop offered the chance of a meeting between companies and the research sector, represented by Lecco Innovation Hub, the centre of excellence of the Milan Polytechnic. Thanks to the numerous companies taking part – MVP Italia, OCV, Brandolph, Polyn, Resintex, BComp, DIAB and Scott Bader – there was a chance to combine an in-depth technical examination with application demonstrations, examining the most recent acquisitions in the field of techniques, production equipment and materials. In particular, the chances offered by the most recent refinement of Resin Transfer Moulding (RTM), by reusable membrane production and the use of dry pre-forms were examined, followed by a look at the role of software applications in prototype production and mass production of components in composite.

The technology

The use of silicone membranes is increasing in the mass production of components in composite material using such technologies as infusion or RTM Light, which also make it possible to reduce impacts on worker health. The use of closed mould working techniques offers several advantages, both for the quality and speed of production and because it reduces the exposure of workers to styrene evaporation. Reusable silicon membranes can further speed up the preliminary phases of mould preparation; it is estimated that this approach, when 40 or 50 components are produced, can reduce the amount of waste produced when working under vacuum and also shorten the time needed to prepare production equipment. The use of the membrane replaces all the consumable materials used in the vacuum process. The making of a silicone bag and its use in a cycle of pressings is the most economical method and the one that offers more advantages in the use of manpower; considering for example a mould of about 2 m² used for 40 infusion cycles, the saving in man-hours is of the order of 70% in the vacuum phase. In the session entitled “Tools for digital acquisition and simulation of processes” a case study was presented on integration between low-cost 3-D digital acquisition techniques and fluid dynamic process simulation methods for rationalising RTM and closed mould processes. The object used in the demonstration, a sled 1 m long, was first acquired by close-range photogrammetry, a precise, rapid and economic instrument that makes it possible to acquire with relative simplicity complex three-dimensional geometries; then the use of process simulation software made it possible to study the best production layout.

Photogrammetry is a method that uses the laws of descriptive geometry to reconstruct the three-dimensional shape of an object starting from photographs. The sled in the case study was first photographed from several angles (a total of about 40 photographs), using a normal reflex camera with a fixed lens, mounted on a tripod to avoid shake and permit the use of a very small stop, a necessity in producing photographs suitable for use in photogrammetry. The photographs were then imported and processed in AgiSoft PhotoScan, a software that aligns the images semi-automatically, creates the point cloud and produces the polygonal model. The geometry obtained, after rapid editing in MeshLab to repair gaps and topological errors, was then imported into the software for fluid dynamic process simulation.

The simulation

Simulation does not eliminate an initial phase of characterisation of the laminate in experimental laboratory tests to identify the specific process parameters in order to calibrate the system. Once the data and physical parameters of the materials involved in the process have been obtained experimentally, the geometry of the element is imported and spatially discretised. The experimental data are then assigned to the geometry, defining the characteristics both of the reinforcement (impermeability, percentage fibre content…) and of the matrix (density, viscosity…). At the same time the process layout is defined, consisting of injection points, aspiration points and physical parameters (working pressure and range). The software used, RTM-Worx, can simulate fluid dynamic processes by solving the equations of the Darcy law, considering the effect of gravity and of the Castro-Macosko viscosity law. In this way it is possible to control the evolution of the physical parameters and obtain a display of the simulation, for example the resin flow paths and the pressure distribution, highlighting any dry spots. Using simulation it is possible to optimise the process layout, defining the optimal moulding parameters and any variations in the properties of the resins and reinforcement materials. This makes it possible to reduce in the preliminary phase the development times of the mass production project. The debate stimulated by the content of the seminar and the practical application of the techniques illustrated made it possible to highlight possible developments of research towards increasing industrialisation of composite material production processes, with rationalised mass production. The workshops clearly and directly illustrated the executional details of the various application approaches, and were an occasion for meeting and exchanges of know-how between companies and research bodies.