Composites materials show high performance requirement in different industrial fields such as boating-yachting, aeronautical or aerospace industry [1]. To reduce test time and costs of fatigue tests, several methods have been proposed to study rapidly and consistently the various damage phenomena. In this work, the fatigue behavior of GFRP is studied and the onset of damage is discussed by adopting the TSA approach [2], [3]. In particular, a novel procedure is shown based on the analysis of thermoelastic phase variations capable of describing the fatigue behavior of GFRP composites and of rapidly evaluating the fatigue limit of material.

Experimental campaign
The specimens (twelve in number) were obtained from a laminate panel made of an epoxy-type resin reinforced with the following layup +45°/0°/-45°/90° sized according to ASTM D 3039. All the specimens were tested on a MTS (model 370, 100 kN capacity) servohydraulic machine. The test method is called stepwise procedure consisting in sequentially and incrementally applied loading blocks at stress ratio of 0.1 and a loading frequency of 7 Hz. FLIR X6540 SC has been used either to collect the thermal data and for monitoring superficial temperature of specimens. Thermal sequences were analyzed by software IRTA® and thermoelastic signal (S1) and thermoelastic phase shift \( \phi \) are assessed as pixels matrices.

Results: fatigue limit evaluation
The fatigue limit by phase data is the first point after the minimum of the curve representing a percentile variation (\( \Delta \phi \) means that \( \phi \) 98 percentiles minus \( \phi \) 2 are evaluated), as reported in figure 1. The results in terms of fatigue limits provided by thermoelastic phase signal provide an estimation of 54 MPa (st.dev. 4.2 MPa) and fits very well with those provided by S-N curve. As already demonstrated in other works [2], [3], TSA leads to localize the damaged areas of material.

References

Fatigue limit evaluation of composite materials by means of TSA

R. De Finis, D. Palumbo – Politecnico di Bari, Department of Mechanics, Mathematics and Management (DMMM)
U. Galietti – Diagnostic Engineering Solutions srl

Special PCD tools
Every kind of Composite Materials you will use, PCD (PolyCrystaline Diamond) can be of help: PTFE (PolyTetraFluorEthylene – Teflon™), PMC (Polyester Matrix Composites), CFRP (Carbon Fiber Reinforced Plastics). Every kind of Composite used in aerospace, medical or automotive industries can be reliably machined with the help of a special PCD tools, like this in the picture. In recent tests carried out in the advanced workshop of a F1 Customer (whose Name is under No Disclosure Agreement), chip machining special tools with dedicated PCD profiles on Carbon Fiber gave excellent results. Though it is not possible to report the case history precise technical data, those, laser sharpened polycrystalline diamonds tools for the intended machining has once again highlighted that using diamond cutting edges can achieve benefits of 30% in terms of cost reduction. The optimal sharpening of the diamond cutting edge is the sine qua non requirement for the use of diamond in the machining process of composites: this will avoid the development of heat due to the friction of the cutting edge on the machined material. Heat development is the main cause of deformation. Additional problems resulting from incorrect machining may be: shrinkage, fibrous outcrop, chipping of edges, delamination. All these difficulties can be avoided paying attention to further general parameters, which must be aligned case by case in different machining of different composites:
- select high cutting speeds (300-400 m/min)
- select very low forward speed (<0.05 mm/min)
- use very high tip angles (150-180°)

More than this, the PCD tool pictured is only an example, because the latest technologies of diamond profiling opened new doors. Bespoke solutions can be developed case by case in short time and short delivered, writing a new case history of success. PCD simplify the machining process, by application of the needed cutting edge wherever wanted, and the range of solution is only delimited by the needs that every customer can have. Delamination can be avoided, surface quality can be improved, tooling life can be prolonged. Cutting edge can be sharpened more and more times. Machining cost can be decreased.