Analytical model behavior for metal-3D woven composites joints – Experimental and numerical validation

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The new generation of aircraft engines Fan case is made of 3D woven composite material. Assembled due to bolted joints with the upstream inlet and the downstream intermediate casing - both made of metallic alloys - the study of multimaterials joint behavior including metals and composites is necessary. Actual design methods of this type of joint assemblies are based on 3D finite element models which are highly time-consuming. Thus, designers are in need of simplified methods for predesigning the assembly ensuring accurate results and decreased time calculation.

In that context, this research work deals with development of a simplified beam model for 3D woven-metal bolted joints behavior. An analytical model called "bending beam model" applied to homogenous materials has been identified and investigated. Its adjustability to our application is confirmed through comparisons with finite element models on equivalent geometric configurations and several load cases. Then, a strategy is set in order to extend the model to composite joining behavior based on beam theory. The main idea consists on searching an equivalent compressive and flexural stiffness able to describe the composite stiffness under bolt and external loads. Thus, many equivalent stiffness calculation methods were analyzed and compared. The relevant method has been selected thanks to comparisons with 3D orthotropic Finite Element models.

In order to check the validity of the developed model, tensile tests are conducted on a 3D woven composite flange until fracture. An important measurement tools such as strain gauges, Digital Image Correlation (DIC) and acoustic emission (AE) are used to analyze flange behavior at several positions and get the real bolt behavior by including strain gauges on the non-threaded section of the bolt. Comparison between tests, 3D finite element calculations and the developed simplified model is set. Results showed a good agreement between tests, numerical and analytical calculations.

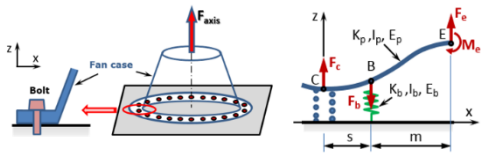

Fig. 1.Simplified illustration of analytical model

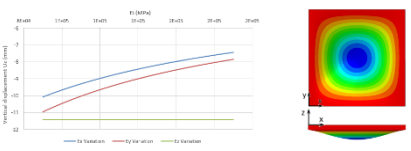

Fig. 2. Equivalent compressive stiffness identification of an orthotropic plate

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