

Development of Dynamic Mechanical Analyzer (DMA) Calibration and Testing Procedures

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Abstract

The service temperature of polymer matrix composites is often defined based on the wet glass transition temperature (wet T_g) of the material; most often, a 50°F margin is applied between the wet T_g (obtained at 85% relative humidity) and the service temperature. Dynamic mechanical analysis (DMA) is the most widely used quality control technique for determining glass transition temperature (T_g). Both the material service temperature and repeatability/reproducibility of T_g tests are vital to the integrity of the material, subsequent part integrity, and overall flight safety of composites structures.

The current DMA procedures produce very good repeatability (variability of the measurements obtained by one person or piece of equipment while measuring the same item repeatedly), but very poor lab-to-lab and equipment-to-equipment reproducibility (variability of the measurement system caused by differences in operator or equipment behavior). This observation has been confirmed by several material qualification programs for FAA aircraft certification and ASTM D7028 round robin program (report number D30-1004 dated December 15th, 2007) where a total of seven laboratories (including WSU NIAR) tested four different materials. In the ASTM D7028 round robin report, repeatability coefficient of variation averaged an acceptable 0.78% but reproducibility had very poor average of 4.72% coefficient of variation under a strictly controlled test program. A higher degree of variation has been seen under less controlled test programs.

The goal of this research is to reduce the lab-to-lab and equipment-to-equipment variability of T_g measurements by developing universal guidelines for temperature calibration and testing procedures for DMA equipment. Initially, the research effort will investigate the effects of thermocouple location, specimen size, fixture type, support material for calibration standard, location of calibration standard, support size, and moisture in specimen. Based on the understanding gained from the initial research effort, guidelines and test procedures will be developed, and a round robin experiment will be conducted with various laboratories. The research proposed in this paper will help bring knowledge and understanding to an area that has brought confusion and frustration to the aviation industry since the advent of DMA technology. Ultimately, the creation of the calibration and testing guidelines will lead to improved material service temperature definition, quality control, and in-flight safety.

Research

Before beginning research testing on this topic, the research team felt it was important to present the topics of interest at the JAMS technical meeting, held April 5th, 2012, to judge the worthiness of the proposed research, and gain valuable feedback. This technical meeting provided the feedback and assurance the research team was hoping. Given the short duration between the technical meeting and paper submission, there are not any presentable results at this particular time. The research will be carried out over the next few months.