Thermal Analysis of Composite Integral Armor

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The Army's Future Combat System (FCS) requires a lightweight alternative to the current M1 series Main Battle Tank. In order to replace the M1 series armor, extensive testing of ballistics, survivability, and structural integrity must be performed on the FCS's composite armor. Nested within structural integrity analysis, the thermal properties of armor must be investigated to ensure the equipment is able to be deployed in extreme climates. In this paper, a thermal analysis of proposed FCS armor specimens was conducted to compare the thermal strains in several composite material recipes. Titanium, aluminum, and a S2-glass blend were used for the armor backplate. These backplate materials were bonded to an exterior ceramic tile of silicon carbide. In order to reduce the thermal stresses of the composite material, an intermediate rubber layer was used between the backplate and ceramic tile. The purpose of the rubber layer was to reduce the thermal strain mismatch near the interface due to the dissimilar coefficients of thermal expansion of the top and bottom layers by providing a more compliant layer. An experiment was conducted which exposed several composite recipes to temperature ranges from $-51.1^{o}C\ (60^{o}F)$ to $82.2^{o}C\ (180^{o}F)$. Strain gages were attached to the composite materials to determine thermal deformations and strains. In addition, a finite element analysis was conducted using ANSYS 8.1 which modeled the laminar composite material. Furthermore, a theoretical model using Composite Materials Analysis of Plates (CMAP) was used to determine strains using classical laminar plate theory. Strains calculated from the finite element model and CMAP were compared to the strains from the experiment. The results served to validate or invalidate the current thermal properties for the composite armor recipes, helping to integrate thermal effects into ballistic and other structural testing for FCS armor research.

Keywords: Future Combat System, composite armor, thermal properties, finite element analysis.