Flow Visualization Techniques for Improving Encapsulation Processes

*Howard W. Arris, Organic Materials Department, Sandia National Laboratories**

The ability of weapons component assemblies to survive environmental conditions such as shock, vibration and thermal cycling is often dependent on the appropriate use of polymeric encapsulating materials. Encapsulants also provide electrical components high voltage protection and isolation. These systems are designed specifically to meet the needs of the component and include consideration of component lifetime, operating conditions, shock and thermal exposure.

The encapsulation process for the MC4368 neutron generator is a "dual pour" encapsulation process. Two different encapsulants are poured in series while in a liquid state. The first encapsulant is an alumina filled Epon 828 epoxy, aromatic amine cured, and is intended to stand off high voltage in the power supply and transmit shock from the timer driver to the ferroelectric ceramic power supply. The second encapsulant, a rubber modified epoxy, filled with high compressive strength glass microballoons (GMB) and amine cured, is intended to provide high voltage stand off and shock mitigating properties to the tube.

Historically, the encapsulating process consisted of a gravity fill at atmospheric pressure for the alumina-filled epoxy around the power supply, and a vacuum pour of the GMB epoxy through the top sprue of the neutron generator mold. The MC4368 neutron generator utilized this type of pour process in the development stages. Voids in the GMB encapsulant proved to be a continuous problem, resulting in high voltage breakdown (HVB) failures.

Model Accreditation Via Experimental Sciences for Nuclear Weapons (MAVEN) funded the development of flow visualization equipment and studies to analyze the flow properties of filled polymer systems. The neutron generator production process is a mission critical Sandia program, and flow visualization was utilized to try and understand void entrapment in the MC4368. Production neutron generator molds were modified to enable flow visualization during the "dual pour" process. Flow visualization demonstrated that the "top pour" process was responsible for void entrapment around the neutron tube. The epoxy effectively blocked trapped air release. Sandia process engineers developed a "new" side pour process where the GMB epoxy is injected through the alumina epoxy side pour sprue. Large voids within the cured encapsulant and surface voids on the finished parts have been eliminated resulting in fewer scrapped parts and reduced re-work costs.

An overview of the MC4368 neutron generator flow visualization techniques, flow visualization of the MC4368, and the resultant "new" side pour process, including a short video of the encapsulation process along with still images captured from the video, will be presented.

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