A Cradle to Grave Testbed: Formulating and Screening Solid Rocket Motor Insulation Using In-House Capabilities

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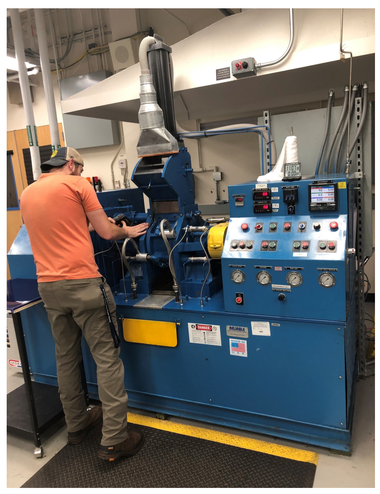
Background

Since 2013, NASA and Jacobs contractors have worked together to develop the capability to mix rubber insulation for solid rocket motors. This capability was born out of the need to replace obsolete materials in the original rubber insulation used in full scale boosters. As a result of this effort, EM41 currently has the capability of mixing a variety of rubber insulations and characterizing them rheologically, mechanically and thermally completely in house and with minimal turnaround time.

Rubber Mixing

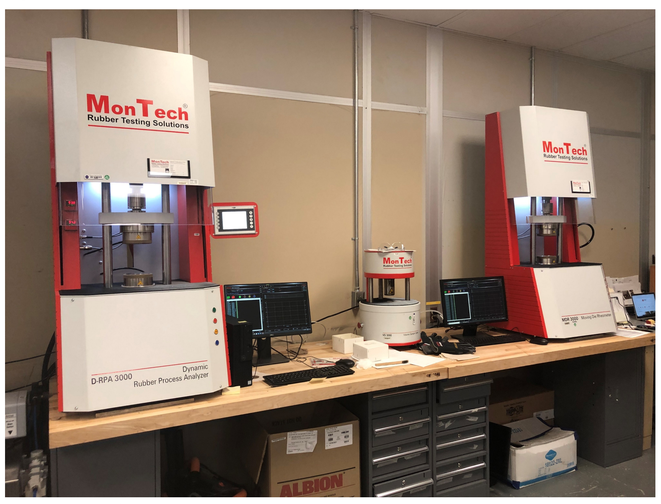
Rubber Mixing capabilities include a 4.6L Banberry style rubber mixer, a 2-roll mill and a lab scale calender. These capabilities allow EM41 to be able to mix up to eight different formulations in only two days which allows a variety of different variables to be investigated and examined. Additionally, the entirety of the process can be controlled including mixing speed, mixing temperature, milling time, milled or calendered sheet thickness, and calender and mill roller speed.



Caption: A technician checks the temperature of the mixer seals during mixing

Rheology Testing

After the material is mixed EM41 has rheology testing equipment to fully characterize the behavior of the material during cure. This includes a Moving Die Rheometer, Mooney Viscometer, and a Rubber Process Analyzer. With these three machines it is possible to investigate both the cure mechanics and also the material flow characteristics at different temperatures. These capabilities allow the processing of the materials to be tailored to the specific materials being fabricated.



A picture of the rubber process analyzer and the moving die rheometer

Autoclave Curing

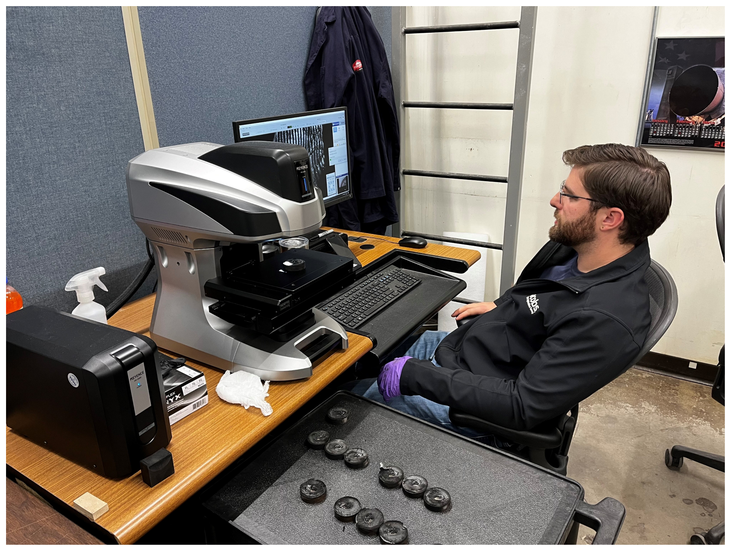
After an optimal cure temperature and time have been determined, the rubber formulations can then be cured in one of two autoclaves. The autoclaves are fully programable in order to match the desired cure profile. Typically, standard tensile “dog bone” specimens are made, as well as thermal specimens for testing in the Plasma Torch Test Facility. Because EM41 has access to two different autoclaves, it is possible for over 500 specimens to potentially be cured at one time. This allows a large number of different formulations to be evaluated in a relatively short amount of time.
Additionally, EM41 has the flexibility to fabricate custom test specimens according to customer requirements. This flexibility includes both curing different specimen geometries, as well as machining specimens after the cure has occurred.

Thermal Testing

Marshall Space Flight Center is home to a state-of-the-art thermal testbed called the Plasma Torch Test Facility. This test facility is able to subject specimens to a variety of different thermal conditions. These different thermal levels can be used to mimic the conditions in different parts of the motor. The facility has the ability to add an abrasive powder to the torch as well which is used to simulate the particle impingement that happens in full sized solid rocket motors.

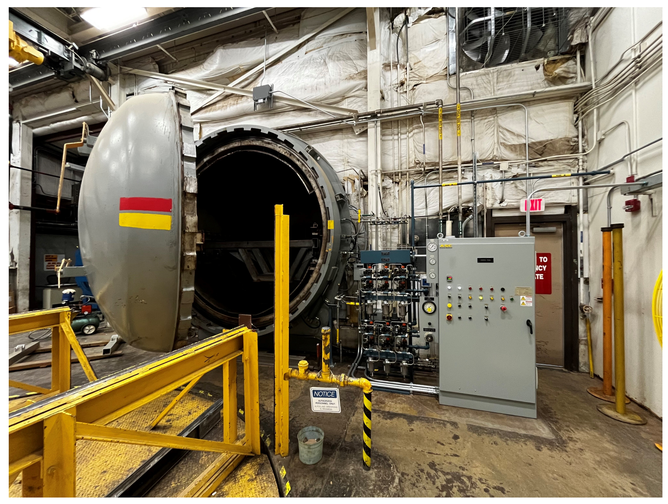
Caption: A set of rubber specimens after being tested

In addition to the torch itself, the lab is also outfitted with a white light scanner that is used to determine the surface profile of the specimens before and after testing. This scanner also allows the burn pattern itself to be studied more accurately as it measures the erosion at all points instead at only a few discrete points.

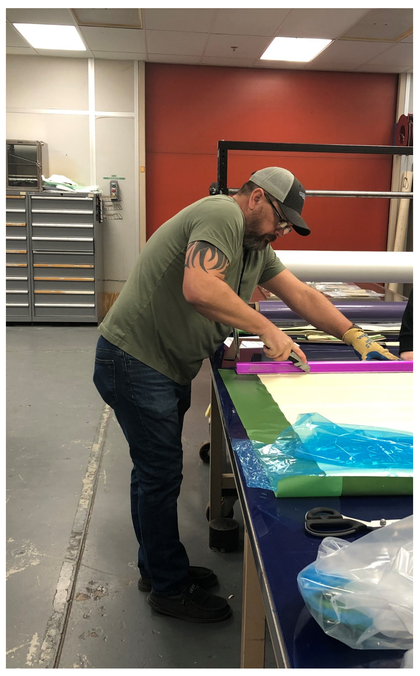


Caption: A technician scans post test plasma torch specimens

Mechanical Testing



Mechanical testing is also done in house by EM22. Multiple different testing conditions are possible ranging from elevated to sub zero temperatures. Additionally, EM41 and EM22 have collaborated in the past to work on developing new test procedures to determine different physical characteristics of the rubber such as tackiness. This close working relationship allows for good collaboration for tackling difficult and novel problems.



Caption: Technician cuts rubber for specimen layup

Caption: A technician working at a two-roll mill