Validation of a novel asymmetric RAM vessel to enable the scale-up of mixed in case energetic paste explosives

Aims

- Commission a novel Resonant Acoustic Mixing (RAM) vessel to allow a six-fold increase in mix capacity.
- Develop a resource to help visually assess mix quality
- Investigate the effect of asymmetric loading
- Investigate the effect of the solids loading on a formulations processability

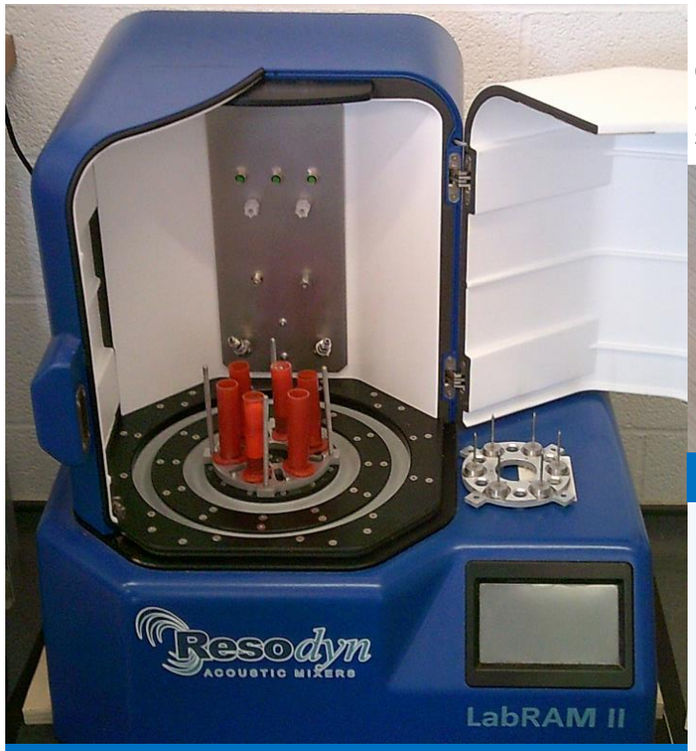

Figure 1 Resodyn LabRAM II and Disassembled Hex-Vessel

Equipment

RAM (Figure 1) mixing utilises a vibrating platform to transfer sound-induced mixing energy. Operating at the resonance frequency of the system allows for rapid and uniform mixing at a reduced energy cost.
The MikeBot (Figure 5) is a type of rheometer that measures the force applied to a known set of geometries to calculate an extrusion pressure. It is bespoke built to analyse the extrudability of materials.

Results

The Hex-Vessel's structural integrity was verified through an acceleration ramp up to 100G. It's ability to mix similarly to previous vessels was proven through material analysis on the MikeBot. Additionally, the Hex-Vessel was loaded asymmetrically and tested, no horizontal movement or difference in mix quality was identified.
In Figure 3, the binder quantity in the formulation ranges from 22- 24.5%. As the binder quantity increases, the gradient decreases meaning the extrudability of the formulation increases. Syringe 1 experienced a momentary drop in pressure, likely caused by an air bubble.
Figure 4 shows the results of extruding the formulations with different dyes with the MikeBot. Overall the Ram Displacement increased by almost double compared to the liquid dye. Graphite exhibited the most shallow gradient, making it a good candidate for future inert formulations.

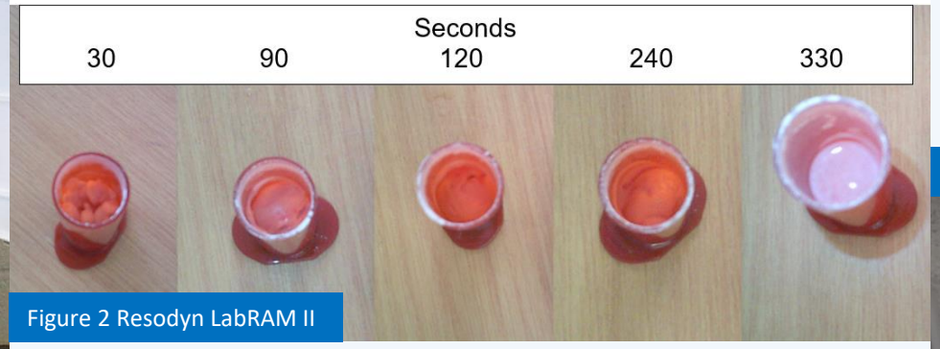

Figure 2 Resodyn LabRAM II

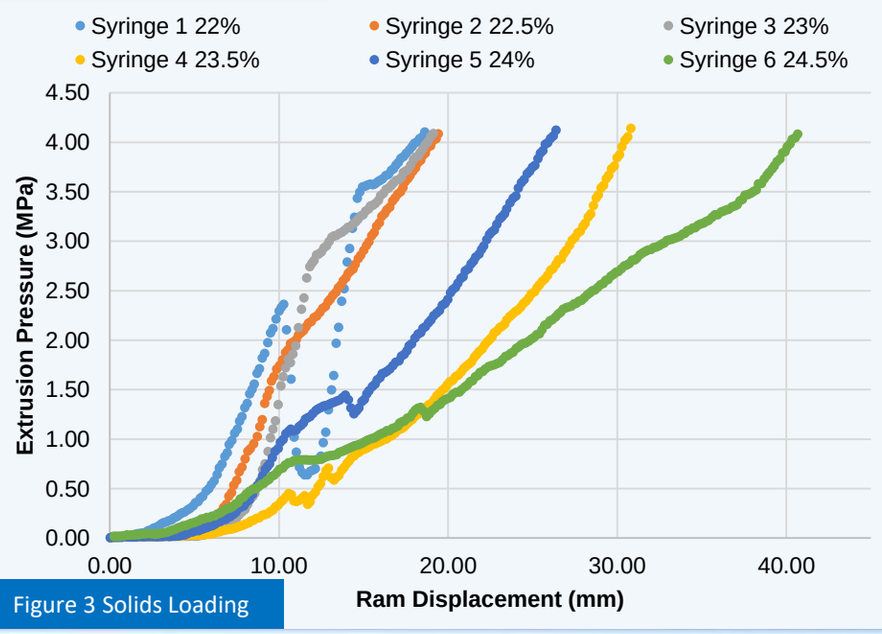

Figure 3 Solids Loading

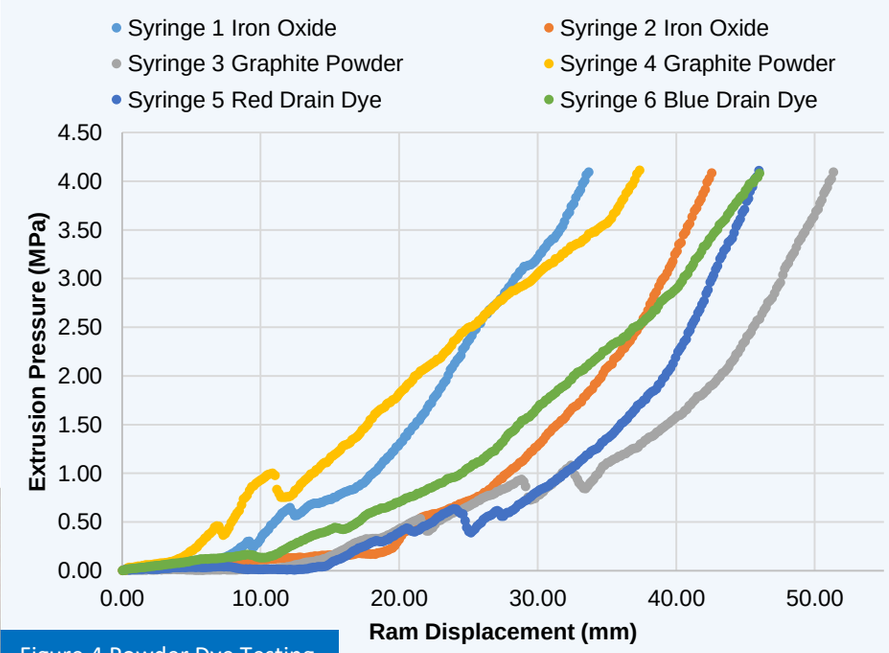

Figure 4 Powder Dye Testing

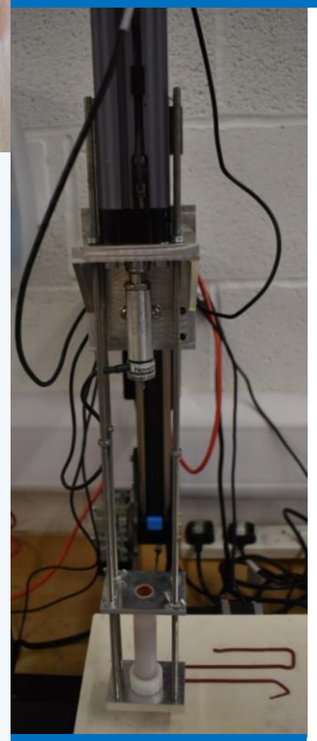

Figure 5 MikeBot Printer

Print Bed Testing

Aim: Identify the best candidate for the print bed of a 3D printer from a range of materials.
Materials were graded on their print quality (/3) and ease of removal (/5). Both antistatic bags and PEI powder coated spring steel received an 8/8 score and are recommended for future use.

Conclusion

The Hex-Vessel was commissioned and is now serviceable on the Resodyn LabRAM II, allowing for a six-fold increase in mix capacity.
A dye colour chart was developed which can be referred to when assessing the mix quality of future formulations.
Although an ideal extrusion profile (a horizontal line) was not reached within the solids loading investigation, the trend eluded to it existing in a formulation with a >24.5% binder quantity.
Powdered dyes mixed more consistently than the liquid food dye and graphite performed particularly well in both providing the material colour and the formulations extrudability.

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