Imperial College London

E7

PRODUCTION AND CHARACTERISATION OF GLASS PROPPANTS FOR APPLICATION IN HYDRACULIC FRACTURING

Anthony Wong **Supervised by Prof Christopher Cheeseman and Dr Way Way Sim**
Department of Civil and Environmental Engineering, Imperial College London.

INTRODUCTION

In hydraulic fracturing, the key to achieving high permeability paths for resource recovery lies within the particles injected as part of the hydraulic fracturing fluid. These particles are known as “proppants”, for they continue to prop the fracture open after stimulation pressure ceases. High quality proppants can be developed from recycled glass cullet with high-cost thermal processes. The feasibility of using alternative low-cost processes to improve the shape of angular glass cullet was investigated in this research. The sphericity, aspect ratio and convexity were 3 key shape factors identified for improvement.

EXPERIMENTAL METHODS

A variety of apparatus was utilised to process the recycled glass cullet. A total of 4 distinct methods were tested:

- Method 1 was carried out with rotary ball mills, and was modelled after the production of artificial sea glass
- Method 2 was carried out with a high energy vibratory mixer mill, to test the abrasive limits of different additives
- Method 3 was carried out with a pan pelletiser, to maximise control over the critical tumbling action
- Method 4 was carried out with a customised pan pelletiser, to best simulate the natural abrasion of sea glass

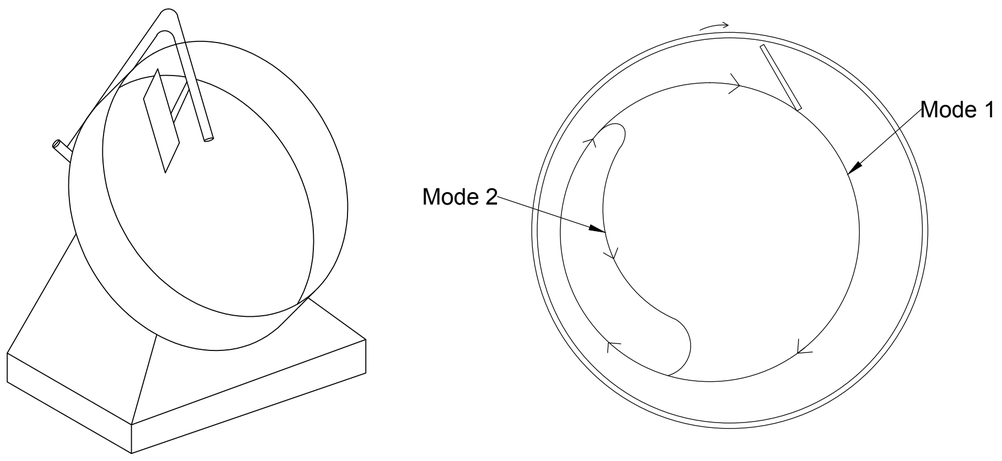

FIGURE 1. Perspective and plan views of pan pelletiser and pan indicating the flow patterns in two different modes (Method 3)

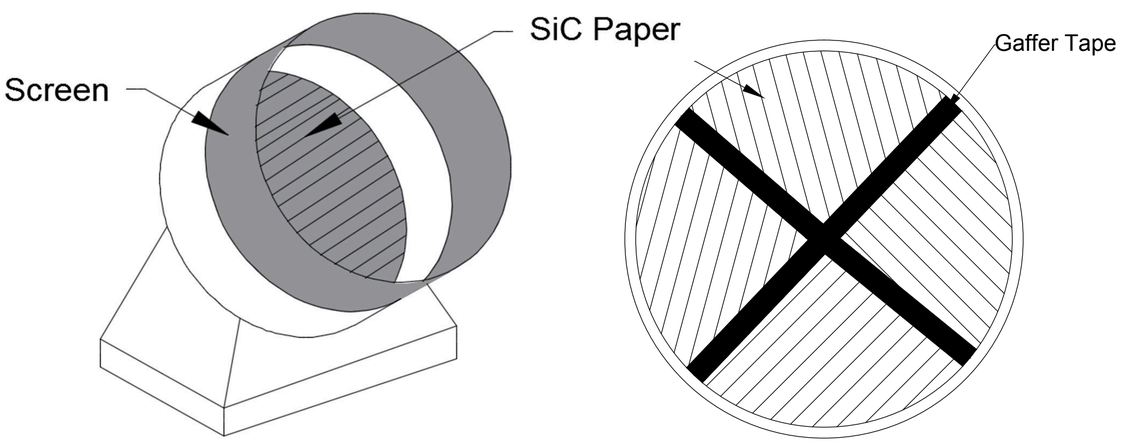

FIGURE 2. Perspective and plan views of customised pan pelletiser and pan (Method 4)

For Method 4, an individual experiment was carried out for each of the 3 different grades of silicon carbide paper (i.e. coarse, medium and fine). An additional experiment was undertaken first with medium-graded paper, then subsequently with fine-graded paper.

RESULTS

All particle size and shape analyses were performed with Sympatec’s QICPIC image analysis sensor. Characterisation results from the first 3 methods were undesirable. The resultant glass particles were either reduced to powder, or unaffected in terms of overall angularity.

FIGURE 3. Failed products from the first 3 methods

The end products from all four experiments conducted with Method 4 displayed considerable improvements in shape.

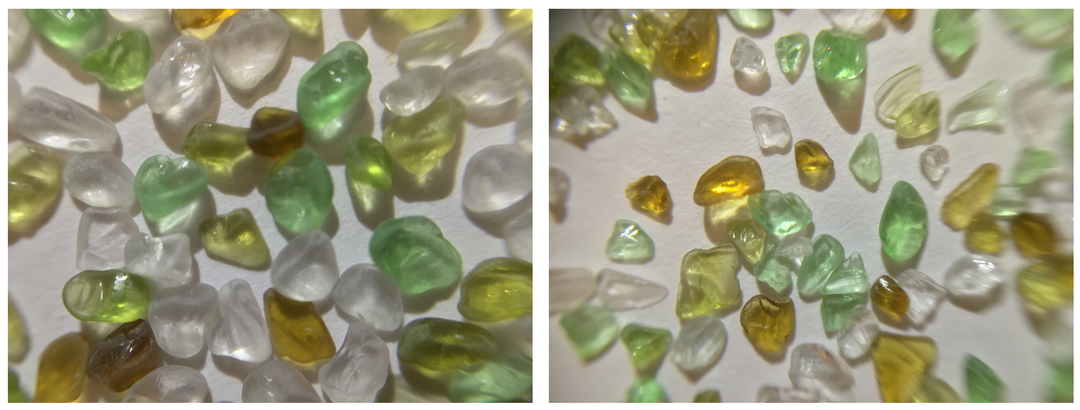

FIGURE 4. End products from Method 4, displaying significant improvements in shape

Before characterisation, the end products were further sieved into a finer group (i.e. 0.6 mm – 1.4 mm) and a coarser group (i.e. 1.4 mm – 2.0 mm) to allow better understanding of the process in relation to the particle size.

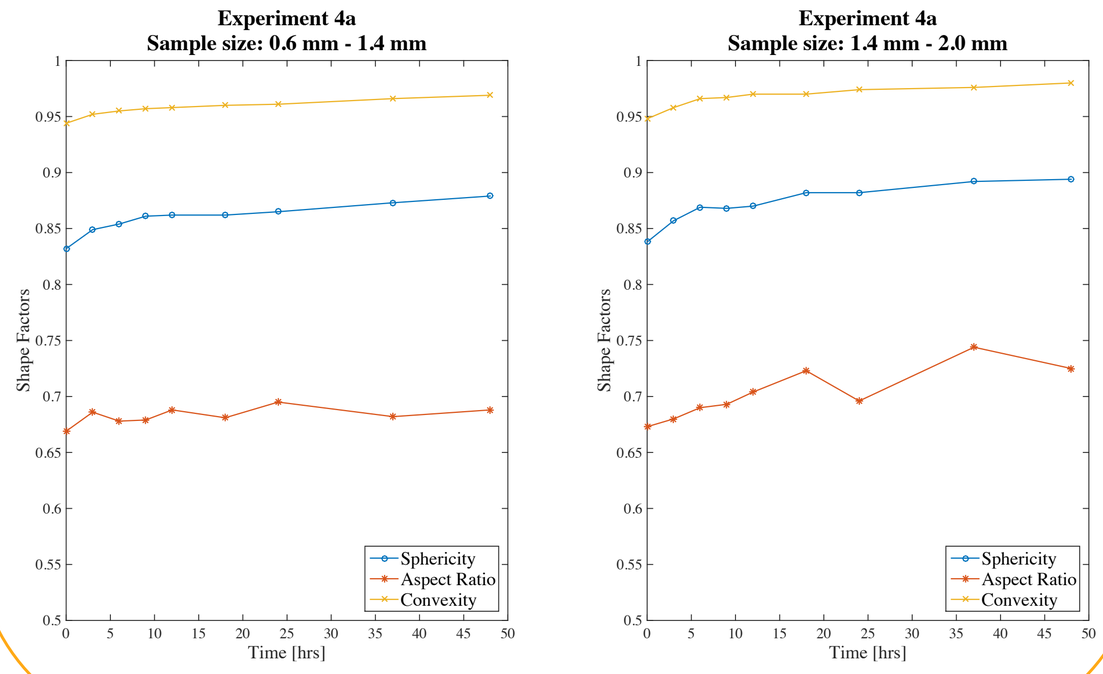

FIGURE 5. Effect of processing time on shape factors

CONCLUSIONS

- Conventional rotational and vibratory milling apparatus were ineffective in improving the shape of glass cullet.
- The process was fairly effective at rounding coarse glass particles but less effective at rounding fine glass particles.
- The best product was achieved with coarse-grade silicon carbide paper. The coarser fraction of the product (i.e. 1.4 mm – 2 mm) was comparable to Brady sand in terms of sphericity and convexity, whereas its aspect ratio was marginally worse than Brady sand.

ACKNOWLEDGEMENTS

I would like to give special thanks to Professor Jingshen Wu and his team of research students in Hong Kong University of Science and Technology, who provided guidance and resources.

REFERENCES

Jaunzemis, E.E. & Jaunzemis, C.S. (2007) *Tumbled, polished, vibrated broken tempered glass pieces.* US 2007/0099786 A1 (Patent).