

Scaling Controlled Fragmenting Cases

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Findings:
Due to limitations in data collection from the results of 16 simulations, it was not possible from this study to outline any definitive conclusions regarding the effects of scale on controlled fragmenting cases. However, initial indications suggest that there is a negative effect on the fragment mass produced at a smaller scale when compared to the predicted mass the fragment should be based on the original geometrical size. Analysis of other investigated factors suggest that case material hardness, scoring depth, and scoring being internal or external, had the least effect on fragment mass deviation.

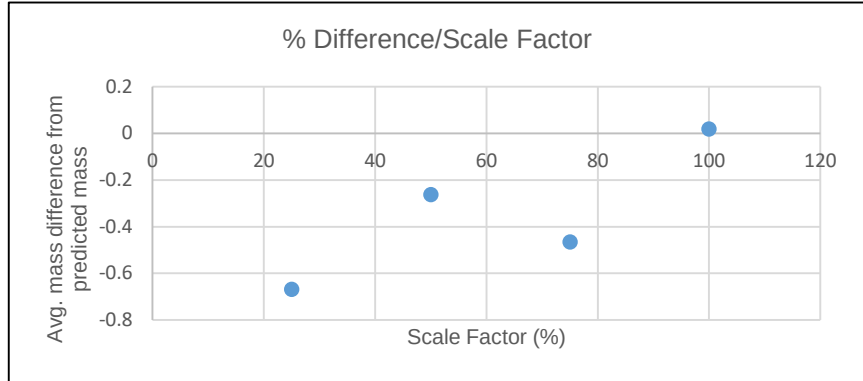


Figure 1: Graph showing the results for the effects the scale factor had on fragment formation

Background:
This work aimed to investigate the effects scale had on the fragments produced by controlled fragmenting cases. The reason for doing so was because no previous work was identified on the topic and, if possible, such a technique could reduce time, cost, reduce environmental impact, and improve the safety of carrying out work like fragmentation arena trials.

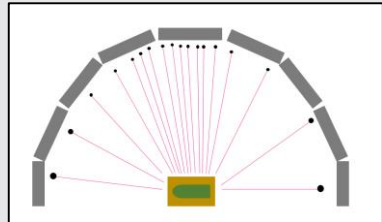


Figure 2: typical fragment arena trial set-up



Figure 3: Example of a fragmentation arena trial [1]

To this end, a Design of Experiments approach was selected, making use of a Taguchi L16 34 62 test matrix [2]. This allowed the following factors to be explored:

Factors								
Scale (%)	Pattern	Case Thickness (% of diameter)	Case Hardness (rockwell hardness test)	Velocity of Detonation (m/s)	Scoring Depth (% of case thickness)	Scoring Density	Internal/external scoring	Scoring width

- References:
- [1] Naval Weapons Centre, China Lake, California, "Photograph of Continuous Rod Warhead Arena" 1972
 - [2] R. R. K. A Primer on the Taguchi Method, Florence, Kentucky: Van Nostrand Reinhold, 1990.
 - [3] G. R. Johnson and W. H. Cook, "FRACTURE CHARACTERISTICS OF THREE METALS SUBJECTED TO VARIOUS STRAINS, STRAIN RATES, TEMPERATURES AND PRESSURES," Engineering Fracture mechanics Vol 21. No. 1 , pp. 31-48, 1985.
 - [4] B. M. Dobratz, LLNL Explosives Handbook - Properties of chemical explosives and explosive stimulants, LLNL, 1981

Modelling:
The modelling for this study was done using 3D Computer Aided Design (CAD) models meshed in the Hypermesh 22 software. These meshes were inserted into the Impetus modelling software package where a series of Smoothed Particle Hydrodynamics (SPH) simulations were executed. The modelling used Johnson-Cook material models [3] and Jones-Wilkins-Lee equations of state [4] alongside predefined modelling parameters which were kept constant for each simulation.

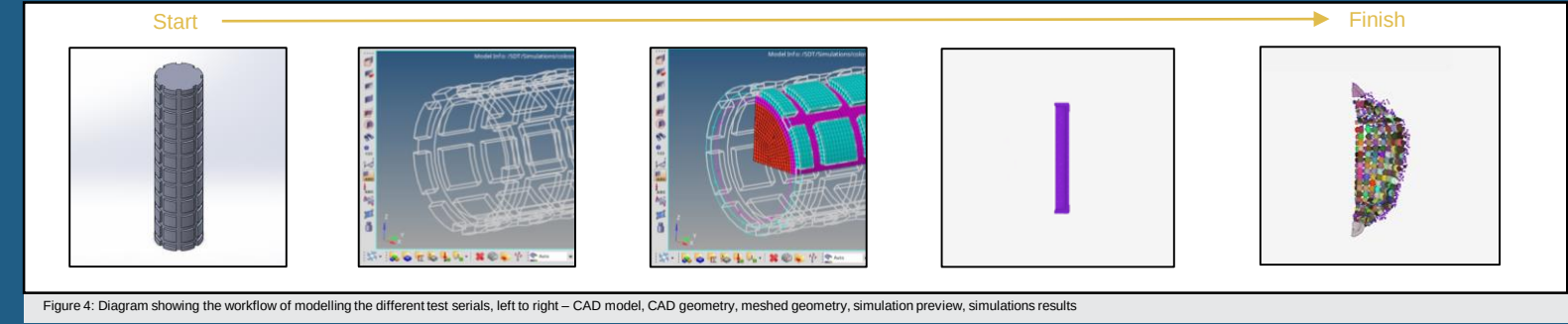


Figure 4: Diagram showing the workflow of modelling the different test serials, left to right – CAD model, CAD geometry, meshed geometry, simulation preview, simulations results

Results:
The results differed for each test serial with a detrimental effect on results collection. Due to limited ability within the Impetus software to adjust fragment identification parameters, some runs failed to produce measureable discrete fragments. This reduced the size of the overall data set used to analyse the impact of adjusting each variable on the resulting fragment masses.

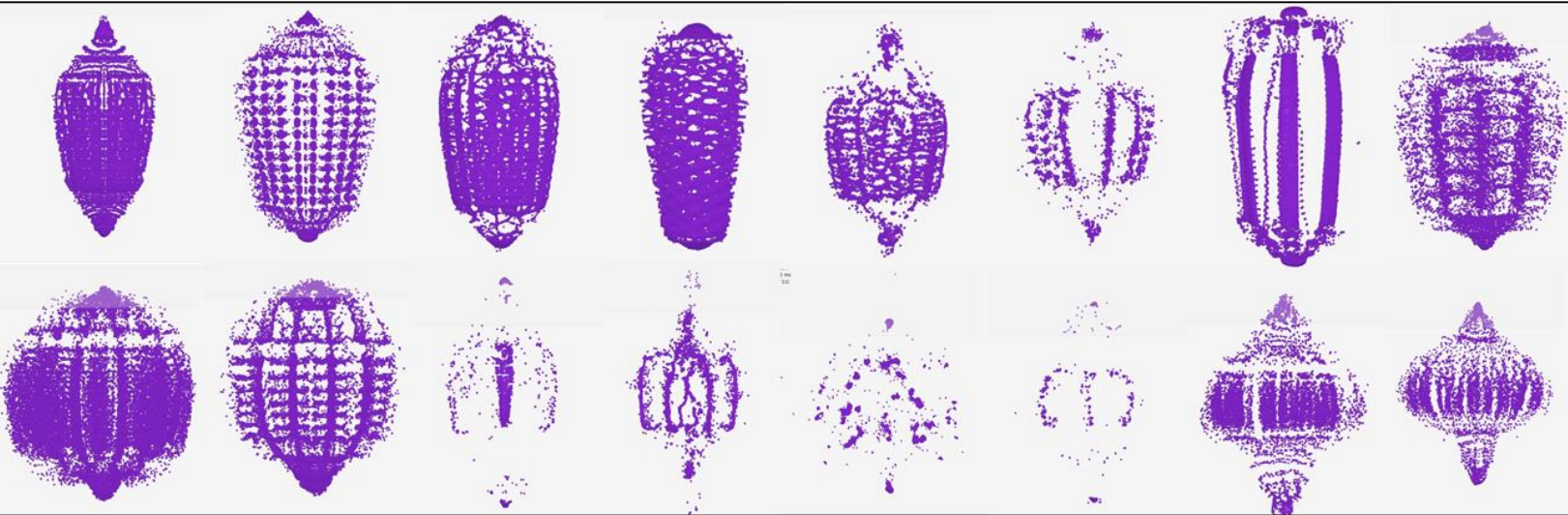


Figure 5: from top left, the modelling results from test serials 1-16 using the Impetus software, note the wide variety in responses from each serial

Future Work:
Future work in this area should build upon the lessons learnt from this study and aim to re-run the existing test matrix to obtain a full data set for each test serial. This will involve finding the optimum run time to fragments to form, which may differ for each serial, and should examine performing a resolution study to give further confidence in the results. This should eliminate errors in fragments not being able to be identified as displayed in figure 4.

After this, more focused studies on the factors that have the most influence can be commissioned.

If more promising conclusions can be made, then live explosive trials may be considered for validation of the modelling.



Figure 6: difference between retrievable fragment data result and irretrievable result