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Diameter Effect In Initiating Explosives, Numerical Simulations

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DIAMETER EFFECT IN INITIATING EXPLOSIVES, NUMERICAL SIMULATIONS

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The ability to safely machine small pieces of HE with the femtosecond laser [1][2][3] allows diameter effect experiments to be performed in initiating explosives in order to study the failure diameter, the reduction of the detonation velocity and curvature versus the diameter.

The reduced diameter configuration needs to be optimized, so that the detonation products of the first cylinder will not affect the measurement of the detonation velocity of the second cylinder with a streak camera. Different 2D axi-symmetrical configurations have been calculated to identify the best solution using the Ignition and Growth reactive flow model for LX16 Pellet [4] with Ls-Dyna.

1.1 CONFIGURATION OF THE NUMERICAL SIMULATIONS

The experimental and numerical configurations of the reduced diameter set-up are presented Figure 1. The first cylinder is 6 mm in diameter and 4 mm height, the second cylinder is 6 mm height, and the diameter varies.

2D axi-symmetrical configurations have been used with a lagrangian description and a mesh resolution of 20 elements/mm. 100 elements / mm has been tested also.

Many parameters have been investigated to study the motion of the detonation products from the first stick and the effect on the second stick:

- The influence of the initiation (point, or plane)

- The influence of the lateral confinement (PMMA, Copper)
- The influence of the top 2 or 3 buffers confinement (PMMA/Copper, Copper/PMMA, PMMA/Steel, Steel/PMMA, Water/PMMA, Water/Steel, PMMA/Aluminum/Steel, Aerogel/copper)
- The influence of water immersion
- The influence of a wedge configuration for the first stick

1.2 MODELS DESCRIPTIONS

A Jones-Wilkins-Lee (JWL) equation of state has been used for the reaction products of the donor LX 16 composition. The donor charge is point-initiated at the bottom axis or flat initiated within the entire inner diameter of the first stick. The Ignition and Growth reactive flow model has been chosen for the second stick with the reduced diameter [4][5]. For the possible buffers and confinements as Water, PMMA, Aluminum, Copper, Steel, Aerogel, classical Gruneisen equations of state have been applied.

1.3 NUMERICAL SIMULATION RESULTS

1.3.1 Critical diameter

A mesh resolution analysis has shown that the critical diameter could be below 0.6 mm, Table 1. Further analysis is needed to see the effect of the mesh resolution for these set-ups.

Table 1 : Influence of the mesh resolution on the failure diameter of LX16

2^{nd} stick Diameter (mm)	Go / No Go	
	20 elements / mm	100 elements / mm
0.4		To be performed
0.5	No Go - failure	
0.6	No Go - failure	Go
0.8	Go	Go
1	Go	Go

The reduction of the detonation velocity is calculated along the axis and presented Figure 2. For the first cylinder (6 mm in diameter) the detonation velocity is 7.919 mm/microsec. At the end of the second cylinder (1 mm in diameter), the detonation velocity is 7.285 mm/microsec. The detonation velocity drop is 8 %. This result was obtained with 20 elements / mm, and needs to be confirmed by a finer mesh resolution: 100 elements / mm. The curvature can be calculated too.

1.3.2 Influence of the buffers and confinement

The influence of the top buffers and lateral confinements has been calculated with a mesh resolution of 20 elements / mm and a 1 mm in diameter of the second stick .

The displacement of the detonation products of the first stick is calculated and compared to the displacement of the possible buffers with or without plane initiation, with or without confinement. The best solution for two buffer, meaning the less displacement, is obtained for aerogel / copper without confinement and point-initiated. A three buffer solution has been also calculated with PMMA / Aluminum / Steel and it reduced the displacement even more. The best three buffer solution could be aerogel / PMMA or Aluminum / copper.

The water immersion has been also investigated. This is a good solution to stop the detonation products from the first cylinder, but the water plays a confinement role for the second cylinder. This water confinement will change the failure diameter, because of the focusing shock waves on the axis.

The inner diameter of the buffer could be difficult to machine and also to adjust. Some gas leakage could appear. Therefore a wedge solution has been calculated with a buffer on top. Without a buffer, the wedge should not reduce the projection of the detonation products at the junction between the wedge and the second cylinder, which are as fast as the detonation of the second stick.

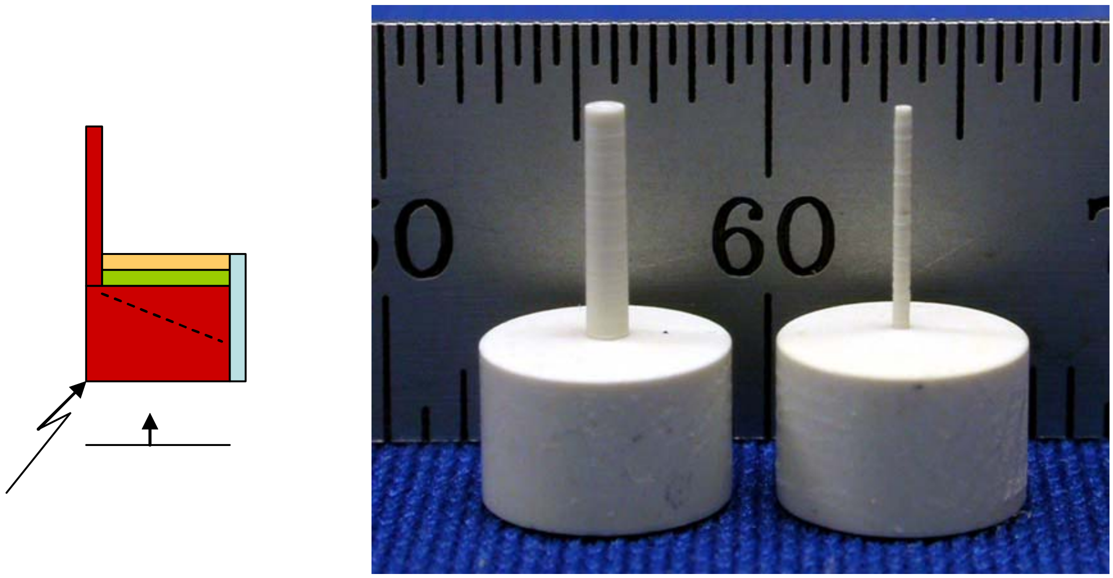

Figure 1 : experimental and numerical set-up, reduced diameter effect, 1 mm and 0.5 mm in diameter

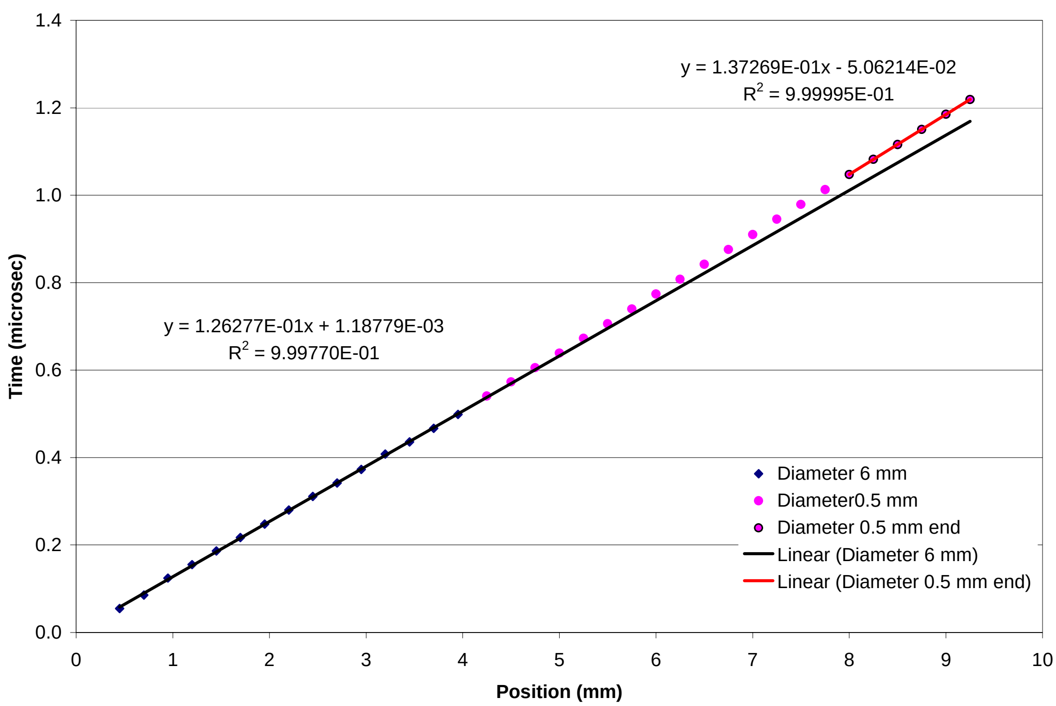

Figure 2 : Reduction of the detonation velocity due to the reduced diameter

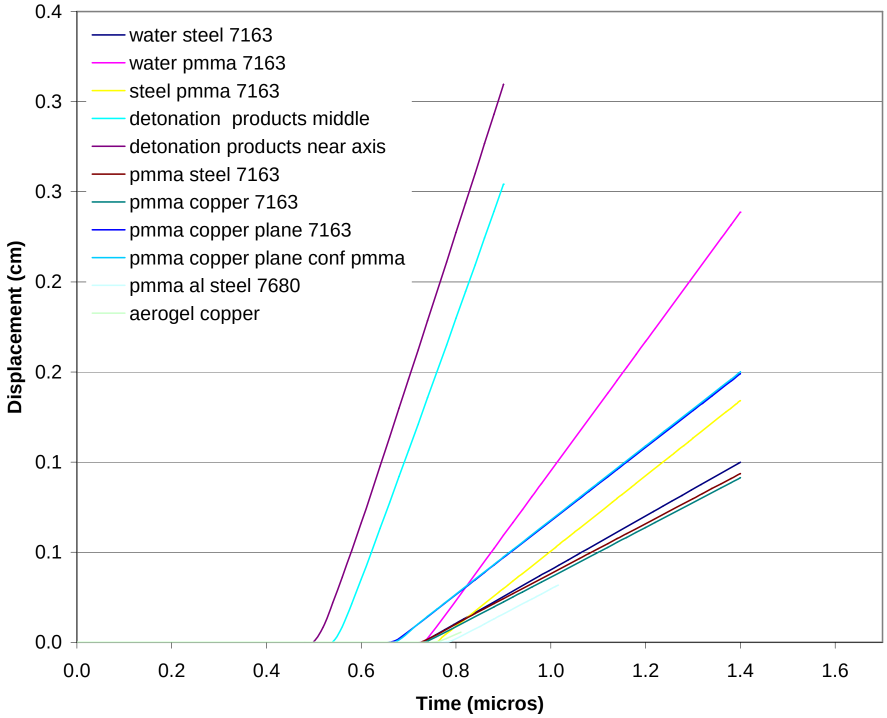

Figure 3 : Displacement of the detonation products of the first stick compared to the displacement of the buffer with or without plane initiation, with or without confinement

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