

Transverse Initiation

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ABSTRACT

The name transverse initiation was given to a situation where two explosives have a common interface, a detonation wave moves in the stronger explosive of the two perpendicular to that common interface, and the stronger explosive initiates the weaker explosive through the interface. In [1] they report on three configurations of transverse initiation tests, and on computer modeling of those tests. One feature of transverse initiation is the formation of an initiation layer in the weaker explosive along the common interface. Here we model those same tests using our reactive flow model TDRR (= reactant Temperature Dependent Reaction Rate). We get an initiation layer for the first two configurations but not for the third one. Also, there are some differences between our modeling results and those presented in [1], but there's not enough information from the tests to conclude in favor of one of them.

INTRODUCTION

A paper presented at the 16th detonation symposium [1] discusses tests and modeling of transverse initiation. The name transverse initiation was given to situations where two different explosive pieces have a common interface. A detonation wave moves in the stronger explosive perpendicular to that interface, and the stronger explosive initiates the weaker explosive through the interface. In [1] the strong explosive is PBX9501 (HMX based), and the less strong explosive is PBX9502 (TATB based). The paper [1] reports results of three kinds of tests: 1) sandwich configuration; 2) cylinder test configuration, where the strong explosive is the central rod; and 3) TRIDENT configuration, where the initiating explosive is in both, a central rod and an outer shell. The tests show that an initiation layer may form in the weaker explosive near the interface. In the third configuration a small dead zone is also formed at the boundary of the receiving explosive and an inert disc.

In [1] they simulate the three kinds of tests with two different reactive flow models. The first is CREST from a British group [2-3], and the second is AWSD from a LANL group [4-5]. From the point of view of their reaction rate equations, those two models are similar. In CREST the reaction rate depends on the entropy of the reactant (which changes only as a result of shocks). In AWSD the reaction rate is a function of the temperature that the reactant reached by the last shock it encountered. And as entropy and temperature are close variables when shock loading is considered, those two reactive flow models are similar.

In this context we should mention that our own reactive flow model (TDRR) that we use here is also similar in a way to the two models used in [1]. In TDRR the reaction rate is a function of the reactant current temperature. Therefore, as long as the explosive is mainly shock loaded,

the reaction rate of TDRR should be close to that of CREST and AWSO. Differences would occur for a long non-shock loading, like a slow rarefaction.

In what follows we try to reproduce the test results of the above three configurations using our TDRR reactive flow model.

SANDWICH TEST

As seen in Fig. 1, a slab of PBX9501 is laid upon another slab of PBX9502. The upper slab is the stronger explosive that would initiate the lower slab. In the tests the lower (initiated) slab is 8mm thick, and the upper (initiating) slab thickness is between 0.5 and 2.5mm at different tests. The width of the slabs is 150mm and their length is 130mm. Both slabs are initiated together at their edge by an explosive lens and a booster. The thin slab of PBX9501 is the strong explosive (the initiating explosive). Its detonation wave runs forward and initiates the thick slab of PBX9502 (the initiated explosive) by transverse initiation. In [1] they assume that after a distance of 130mm the detonation waves become steady, and they relate to those steady waves. The main finding in [1] is that an initiation layer is formed in the weaker explosive near the common boundary. But they don't discuss the nature of this initiation layer.

In our computations the length of the explosive is 60mm (from practical reasons), and see an approach to steady state only at the front of the detonation wave. To simplify the computations, we load the explosive slabs by a pressure pulse. It has a fast increase to $P=P_{in}$, and a slow constant rate decline to zero during $\Delta t_{\mu s}$. It turns out that the resulting detonation process is

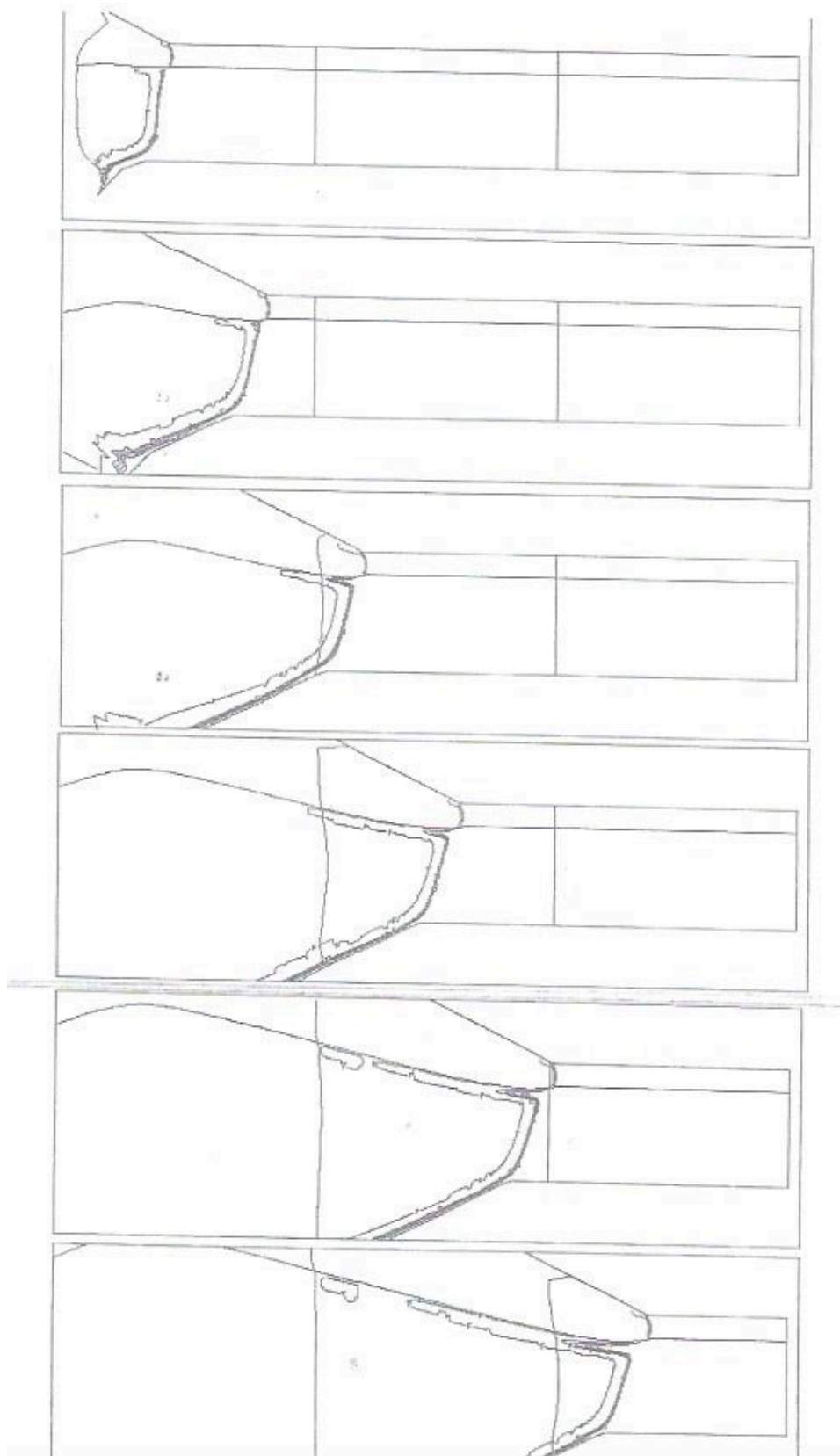


Figure 1. Includes 6 plots $1\mu\text{s}$ apart with lines of equal degree of reaction progress parameter

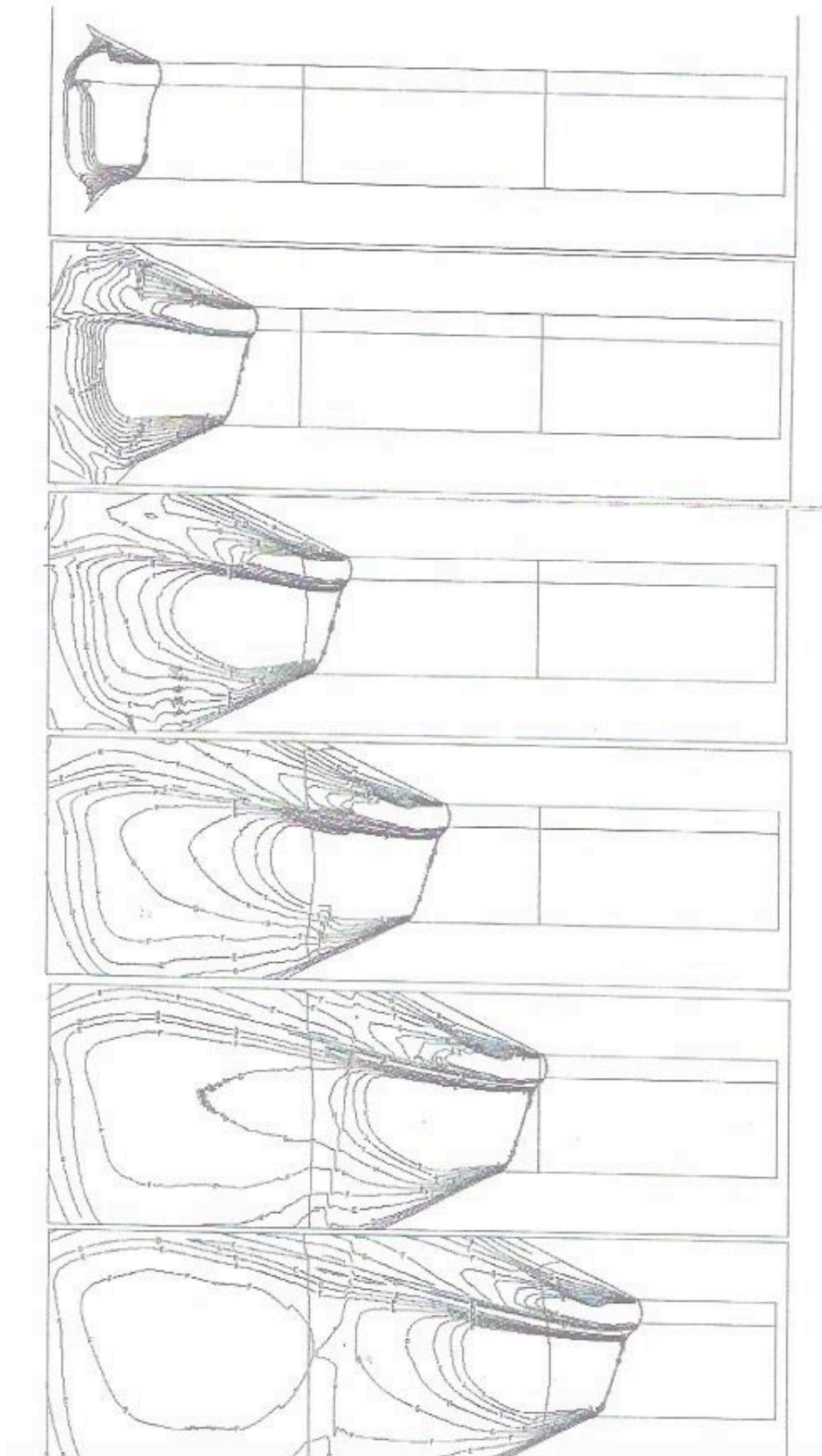


Figure 2. Includes 6 plots $1\mu\text{s}$ apart with lines of equal reactant temperature, between 500 and 1500K

sensitive to details of the initiating pulse. In the tests described in [1] the weaker explosive has a density somewhat lower than the standard, 1.87 instead of 1.89g/cc. To take this into account we changed the coefficient R_T of our reaction rate equation [6-9] from 82 to 120/ μ s. In Figures 1 and 2 we show examples of our computations. In those figures: the initiating pressure pulse is 20GPa and it lasts 1 μ s; the initiating slab thickness is 2mm; the computation duration is 6 μ s. We show two series of figures. The first (Fig. 1) has lines of equal reaction progress parameter every microsecond into the initiation process, and the second (Fig. 2) has lines of equal reactant temperature between 500 and 1500K every microsecond into the initiation process.

From Fig. 1 we see that an initiation layer as discussed in [1] is formed in the weaker explosive near the interface. Towards the end of the computation time (6 μ s) the front part of the detonating explosives becomes steady, but the back part does not. From Fig. 2 we see that the structure of the initiation layer keeps changing.

CYLINDER TEST CONFIGURATION

The second configuration discussed in [1] is that of a standard cylinder test, where the explosive is made of two parts: the inner part (14mm diameter) is made of the strong explosive (PBX9501), and around it up to the diameter of 25.44mm is the weaker explosive PBX9502. In Figs. 3 and 4 we show plots of the reaction progress parameter and the reactant temperature at three times after the shock enters the cylinder: 2, 4 and 5.6 μ s.

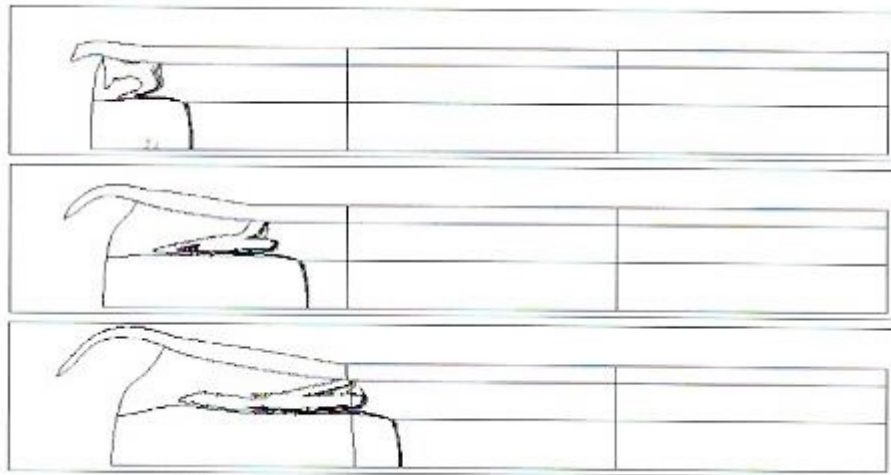


Figure 3. three plots of the cylinder test configuration at 2, 4 and 5.6 μ s, with lines of equal reaction progress parameter. The inner explosive is PBX9501 and the outer is PBX9502

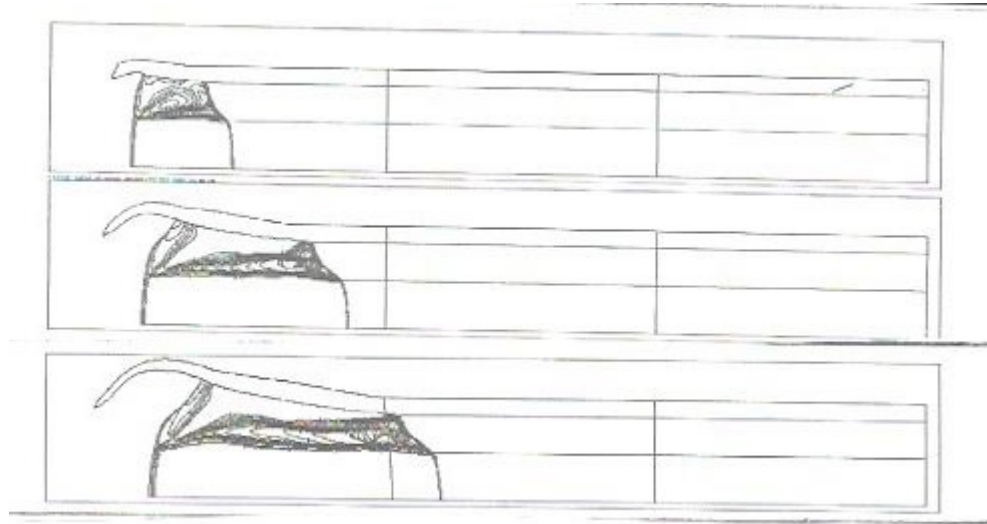


Figure 4. three plots of the cylinder test configuration at 2, 4 and 5.6 μ s, with lines of reactant temperature. The inner explosive is PBX9501 and the outer is PBX9502

From Figs. 3 and 4 we see that in this case the whole cylinder of PBX9502 is actually an initiation layer.

TRIDENT CONFIGURATION

(TRIDENT = Transverse Radial Initiation Exploration Test)

This is a rather complex configuration. It's made of the following parts: 1) a disc of PBX9501 10mm thick and 100mm in diameter; 2) a rod of PBX9501 10mm in diameter is connected perpendicular to the disc at its center, on the other side of its initiation point; 3) a cylindrical shell of PBX9501 10mm thick is joined to the disc at its circumference parallel to the rod. These three parts are made of the stronger explosive PBX9501, and together they form the initiating explosive; 4) between the rod and the cylindrical shell there is a cylinder with a hole made of an inert plastic material, 40mm thick; and 5) beyond the plastic cylinder there is another cylinder with a hole, made of the weaker explosive PBX9502 which is 50mm thick.

In Fig. 5 we show the last plot from our computation of this configuration, with lines of equal values of the reaction progress parameter. The last plot is at 12.6 μ s and not 14 μ s, as our computation time step became too small. We see from the Fig. 5 that: 1) there's no initiation layer in this case, and 2) a small dead zone is formed at the boundary of the inert cylinder.

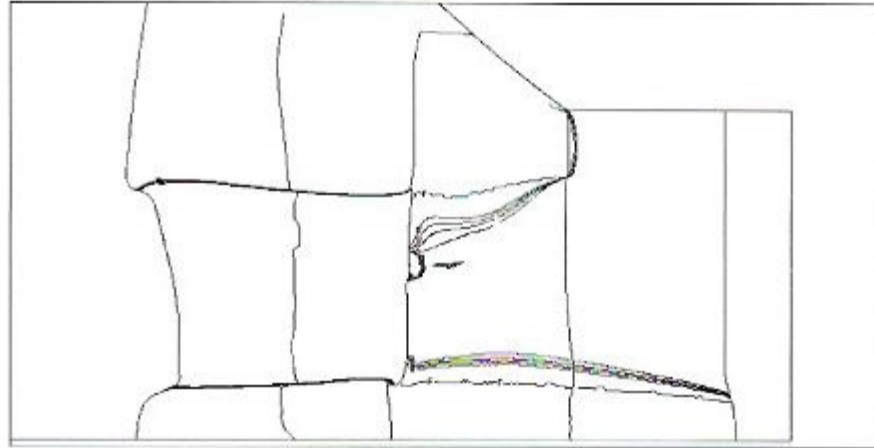


Figure 5. Last plot of the TRIDENT configuration at 12.6 μ s. Lines of equal reaction progress parameter

SUMMARY

In [1] they report on three kinds of tests where a stronger explosive initiates a somewhat weaker explosive through their common interface, which is perpendicular to the original detonation wave in the stronger explosive. They refer to such an initiation as transverse initiation. In [1] they also run computer simulations to model these three kinds of tests, using two reactive flow codes. The first is CREST which has a reaction rate that depends on the entropy of the reactant. The second is AWSO which has a reaction rate that depends on the temperature of the reactant upon the last shock it encountered. As shown in [1], both simulation models are doing a reasonable job in reproducing the tests results.

We're using here our reactive flow model TDRR (= reactant Temperature Dependent Reaction Rate) to model the same tests reported in [1]. Our simulations are also doing a reasonable job in reproducing the tests. In the first test configuration (Sandwich test) we get an initiation layer in the receiving explosive near the interface. In the second configuration (Cylinder test) we get that the whole thickness of the receiving explosive is acting as an initiating layer. In the third configuration (TRIDENT) we don't get an initiation layer, and near the inert disc we see a small dead zone as shown in the test results.

References

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