Modelling the Effects of Non-Gaseous Igniter Combustion Products on the Ignition of Gun Propellants

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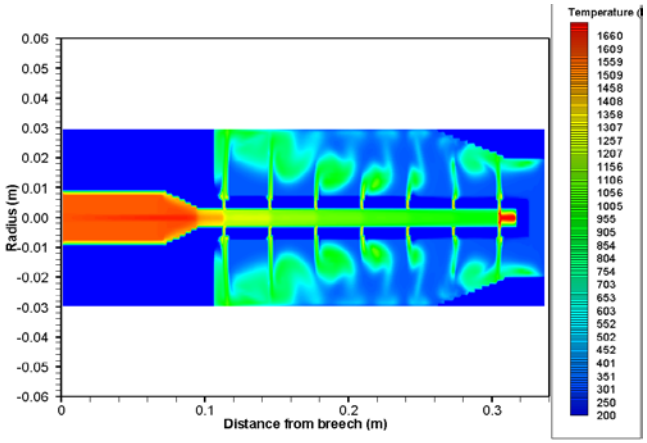

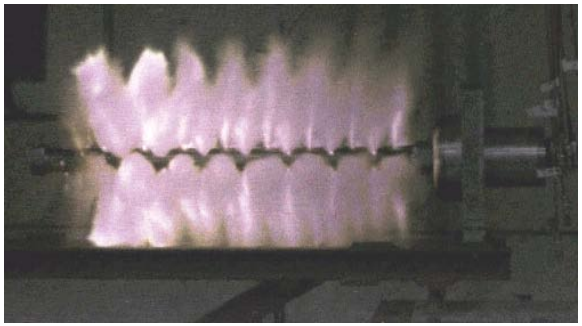

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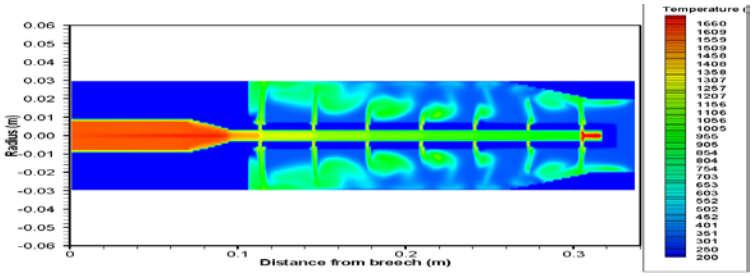
1
Background



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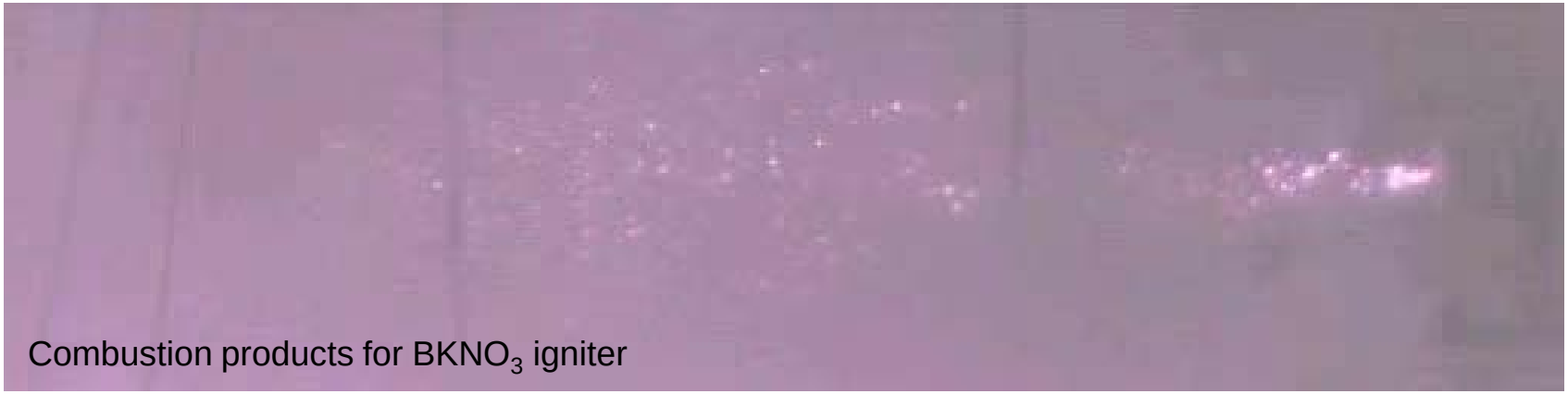
1 Background

Energy transfer model - introduction

- Internal ballistics models worldwide assume that the energy transfer process from the primer/igniter products of combustion to the solid propellant occurred by convective and/or radiative processes
- Not true in practice, even for black powder for which ~40% of the available energy is in the non-gaseous combustion products
- For thermite igniters, as much as 90% of the energy could be in the non-gaseous combustion products



Combustion products for $BKNO_3$ igniter

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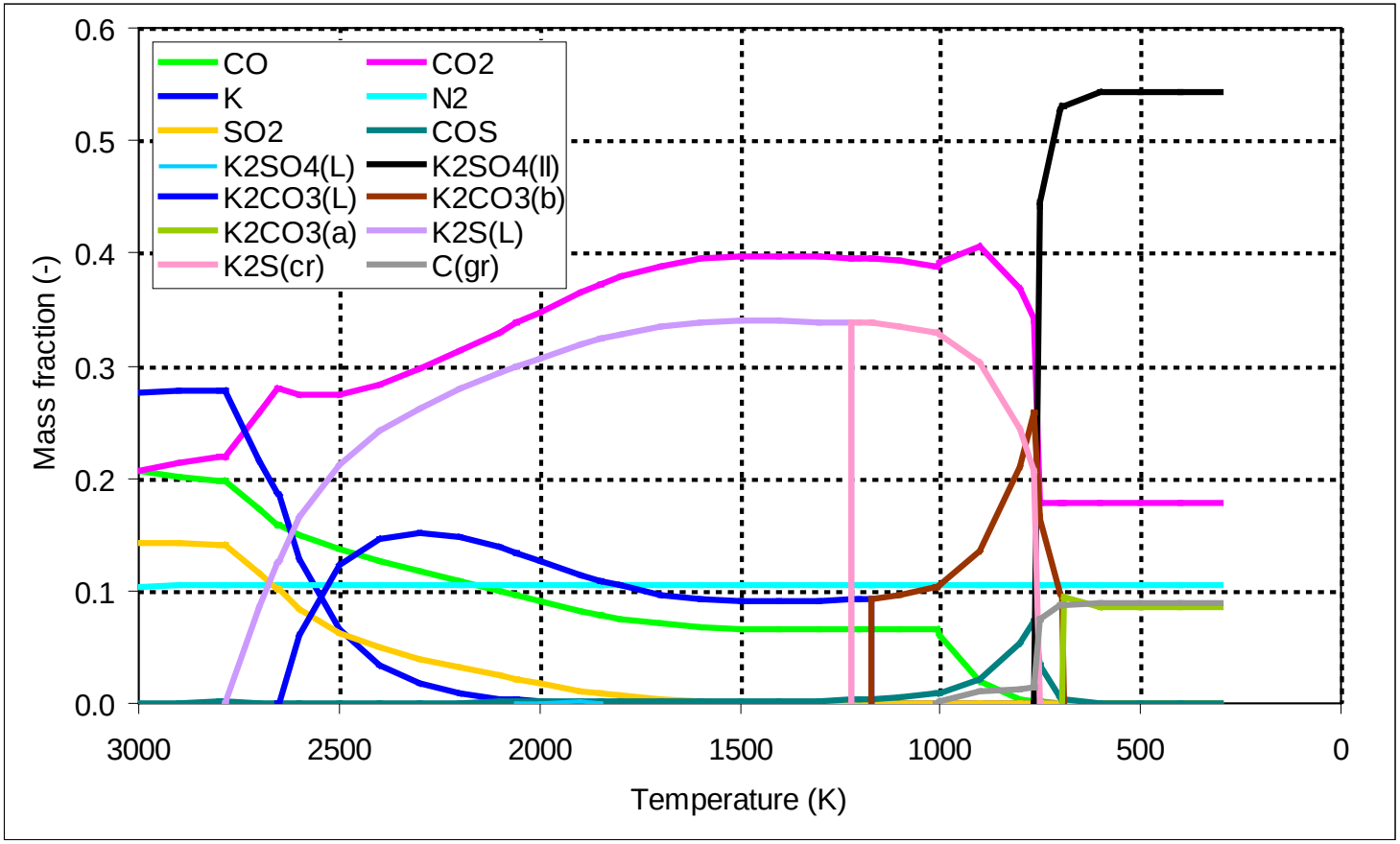
1 Background

Combustion products for black powder



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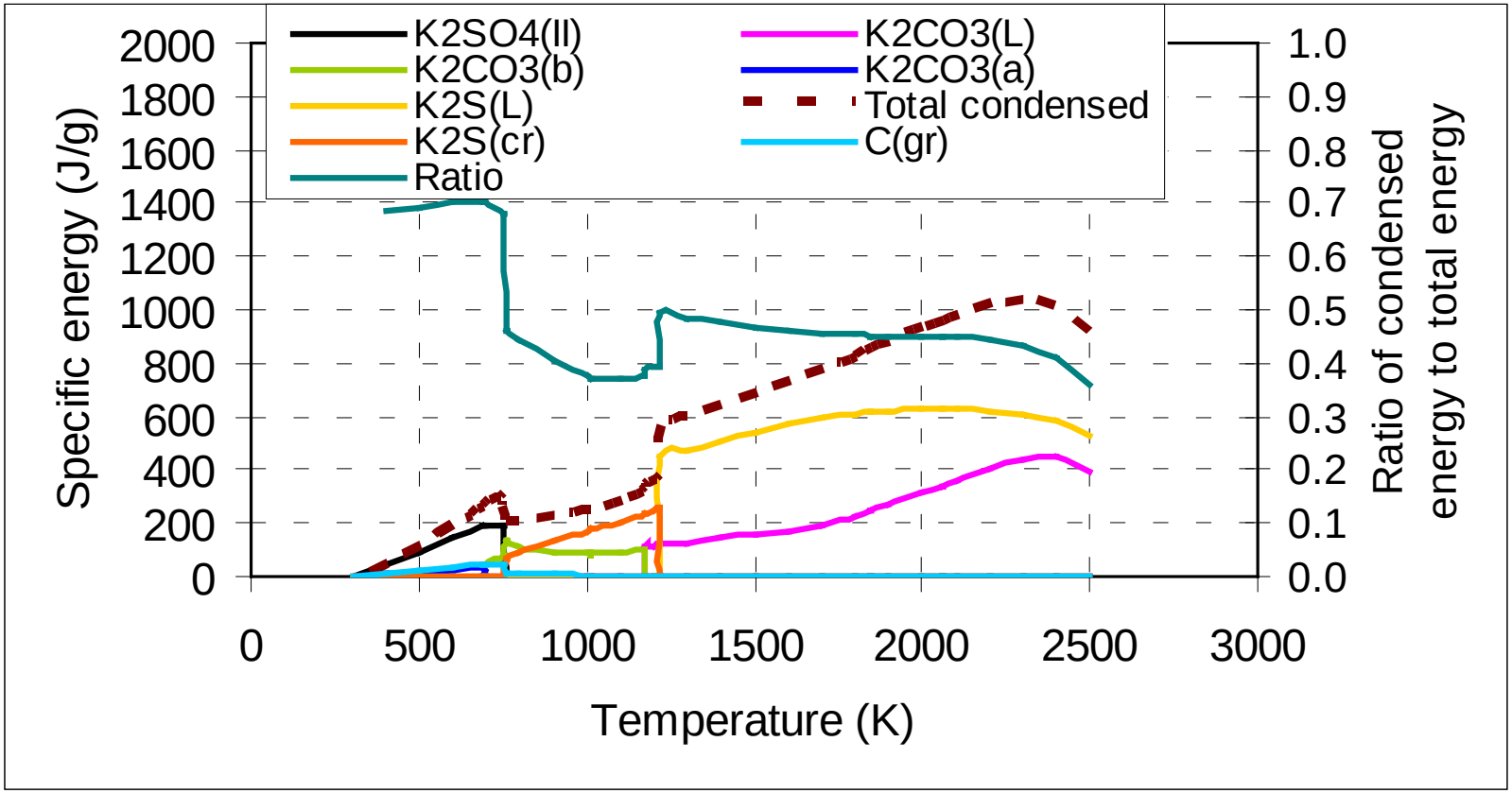
1 Background

Energy budget for black powder



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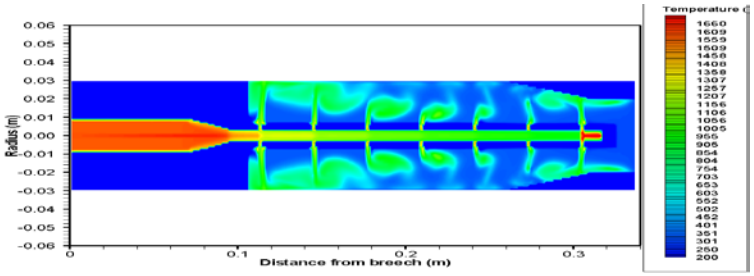
2
Details of model



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2 Details of model

Requirements of model

- Interactions between product species and unignited propellant species
- Account must be taken of the following:
  - Porosities of solid propellant and non-gaseous products of combustion
  - Particle sizes
  - Interphase slip velocity
  - Probability of collisions
  - Energy released following a collision.

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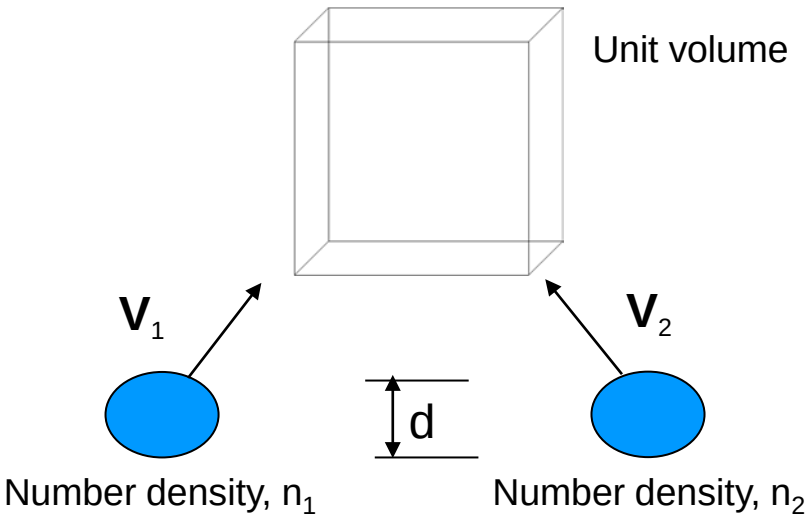
2 Details of model

Illustrative model

- An igniter product species and a solid propellant species are defined
- Species have different velocities and sizes and can collide (the example shows both species are spherical and have the same diameter)
- Collision rate per unit volume = $n_1 n_2 \pi d^2 |v_2 - v_1|$
- Igniter product species sticks (and stays stuck) to the solid propellant species, liberating energy
- Particle number conservation equation for the igniter product species is changed to allow for destruction.



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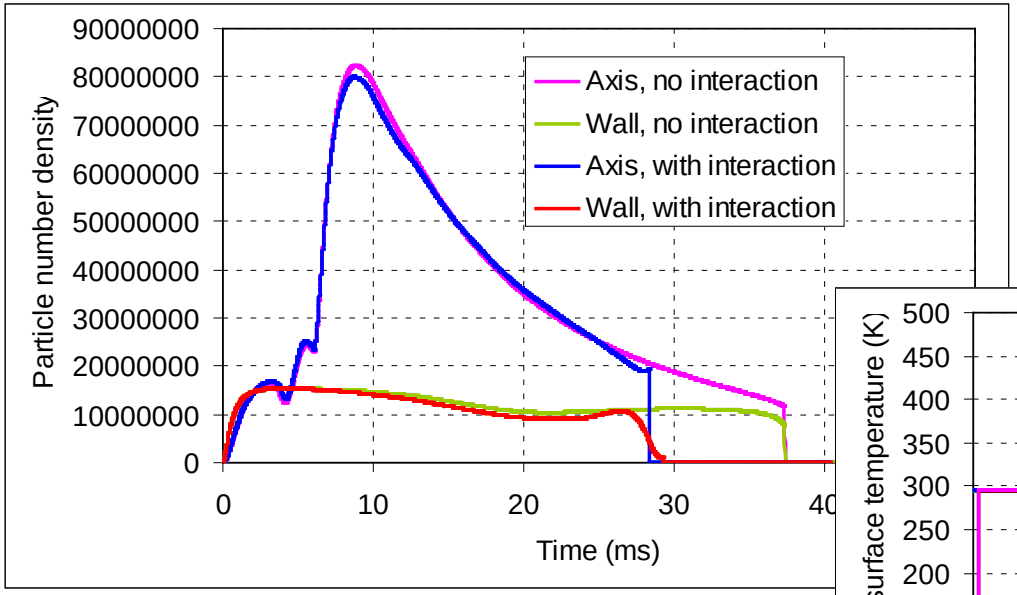
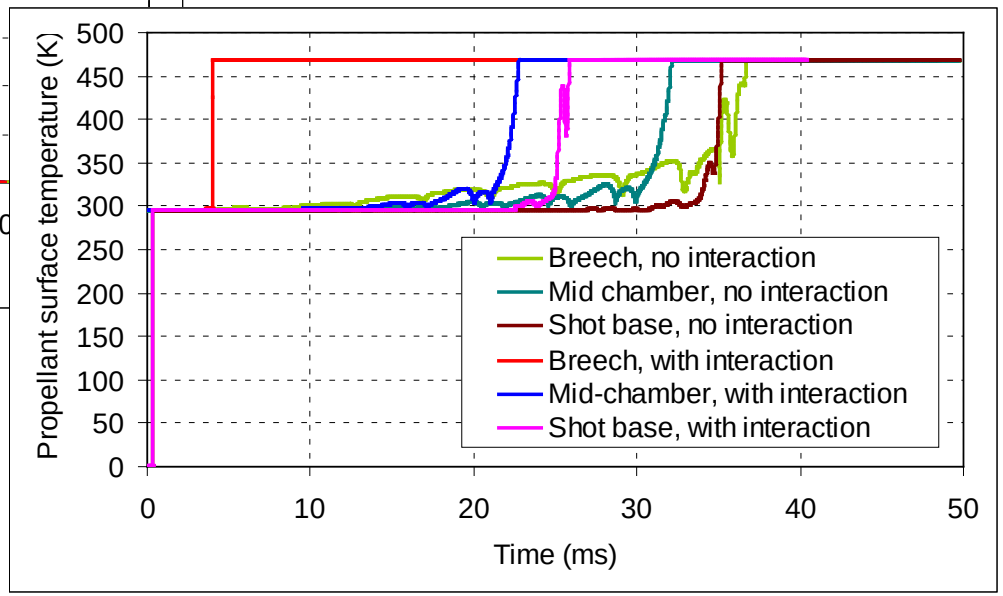
2 Details of model

Testing of model





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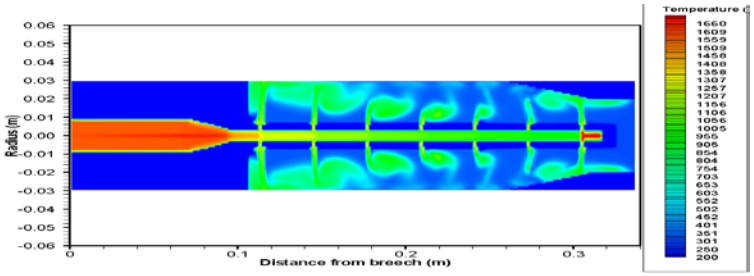
3
Application of model



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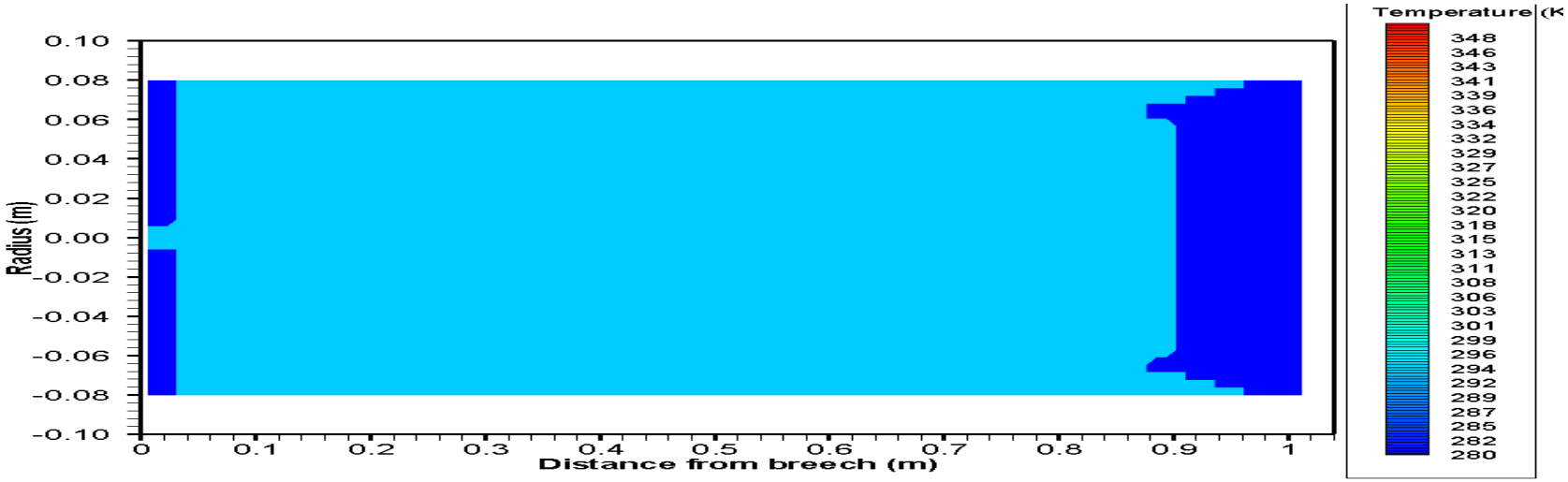
3 Application of model

Effect of % gaseous products & angle of venting of primer vent tube

- Black powder primer
  - Parallel primer, 0-100% gaseous products
  - Parallel primer, 0-100% condensed products
  - Diverging primer, 100% condensed products



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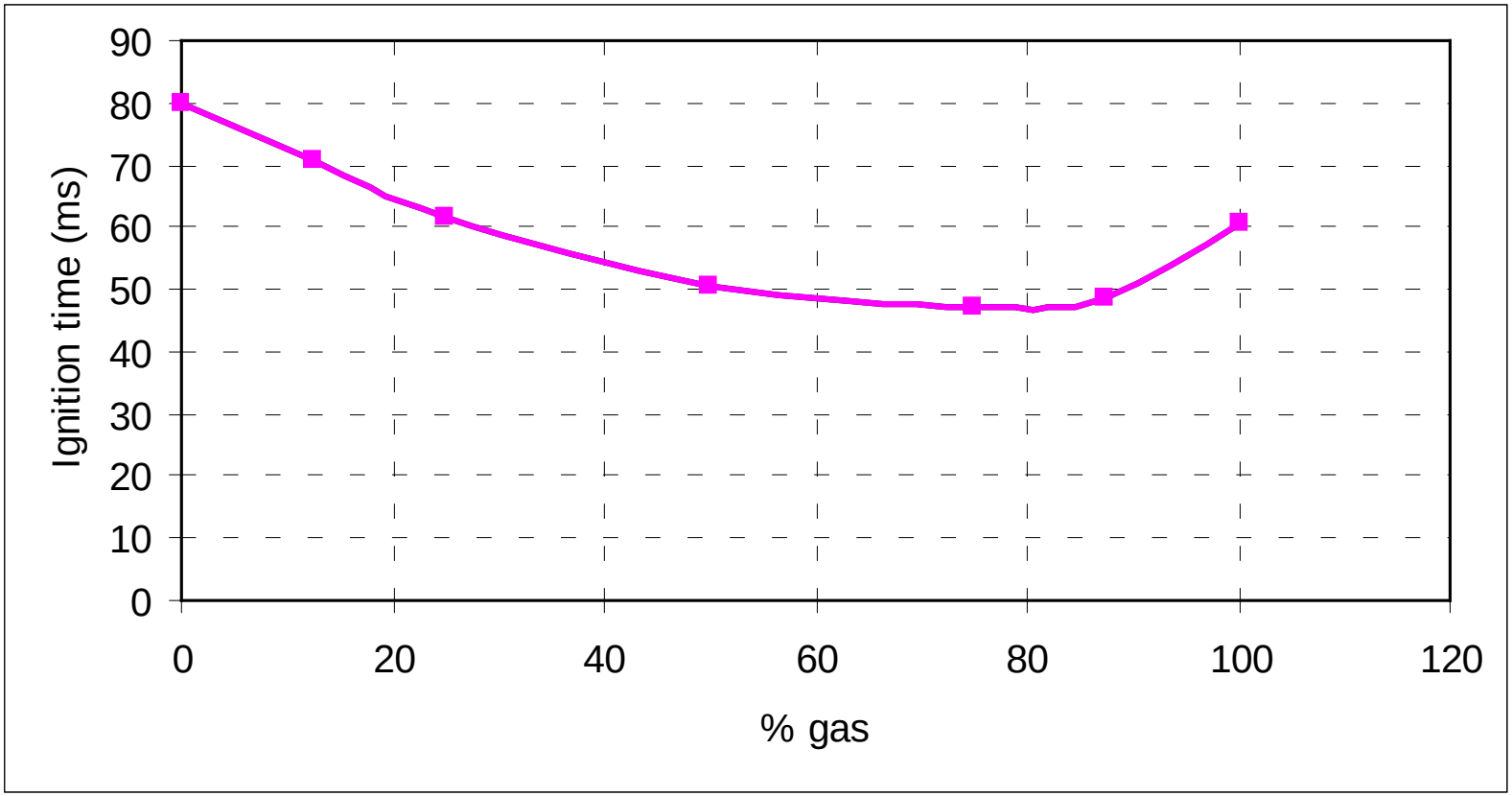
3 Application of model

What is optimum ratio of condensed to gaseous energy?



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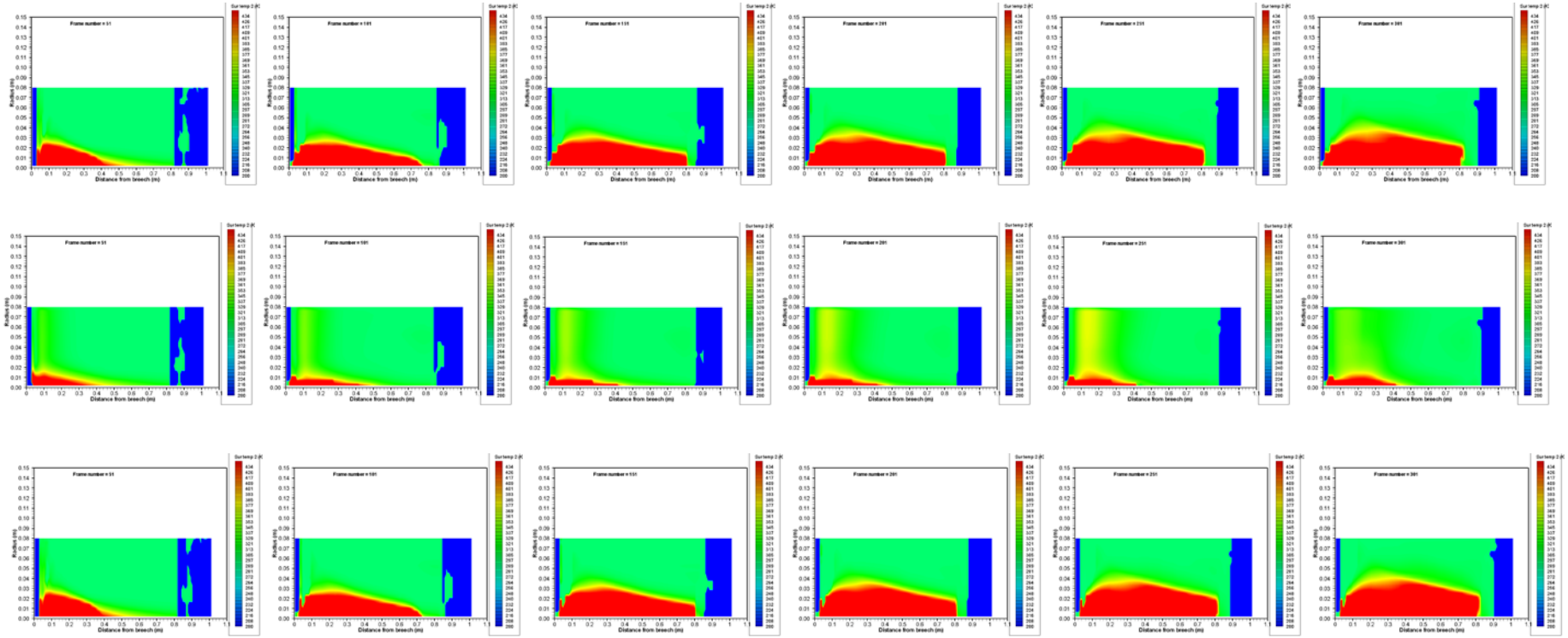
3 Application of model

Effect of angle of venting of primer vent tube

- Series below are for 100% gaseous energy, 0% gaseous energy and 0% gaseous energy but divergent primer vent hole



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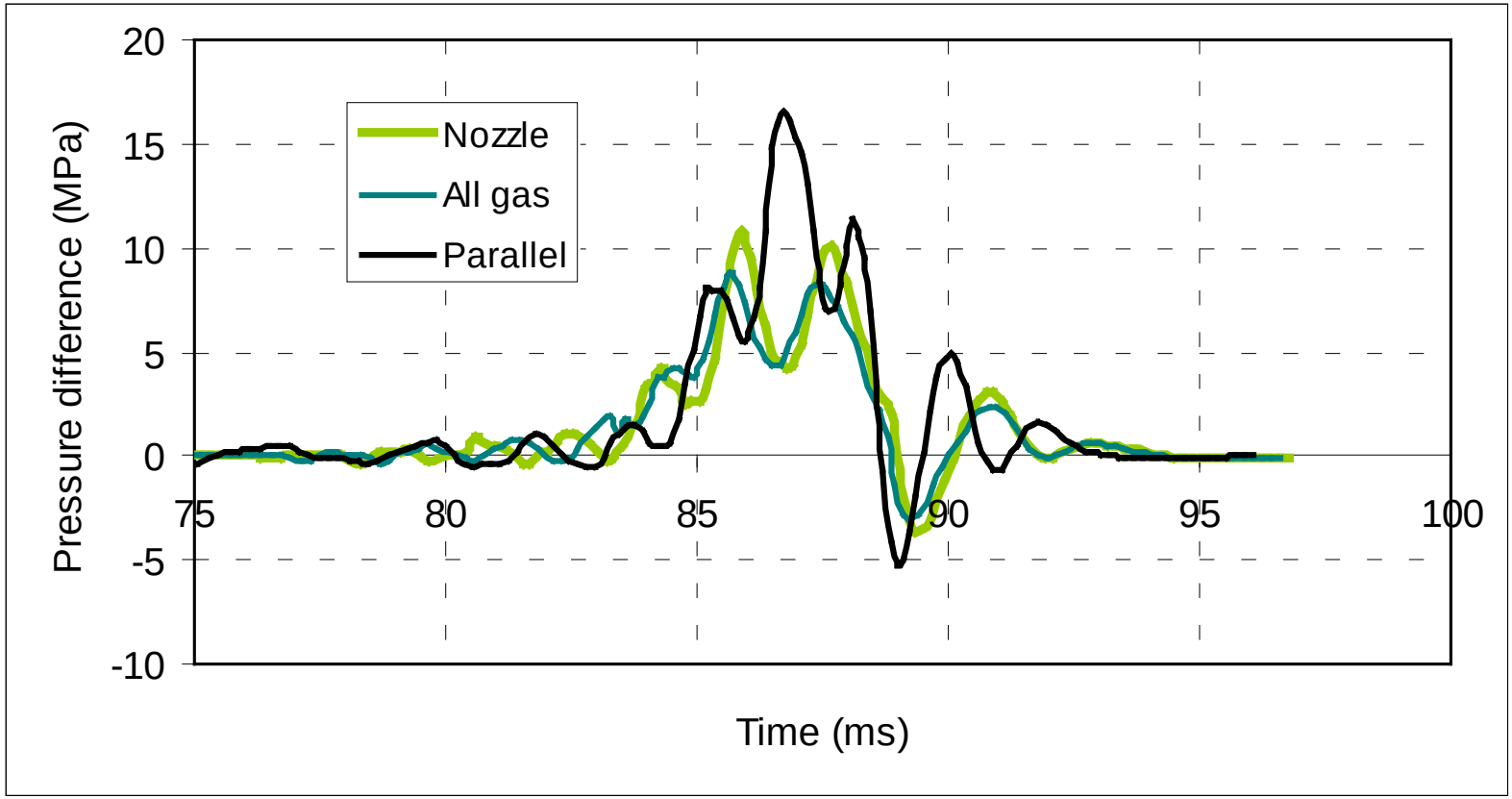
3 Application of model

Effect on predicted pressure difference



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4 Conclusions

The enhanced energy transfer model allows for convective, radiative and conductive/condensative heating

- Modelling shows the igniter materials, ignition train and igniter geometry/design are all critical factors in the ignition of charge systems
- Small changes in the igniter design may lead to a significant reduction in the ignition delay, and hence safer charges due to a reduction or elimination of pressure waves
- The latest ignition model enhancements implemented in QIMIBS gives a significant computational capability that can be used in the assessment of any charge system for any gun calibre
- Conductive/condensative model being validated in work on pyrotechnic countermeasure decoy flares

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