SIMULATION OF RAM ACCELERATOR WITH PETN LAYER

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Summary The paper presents a new idea of ram accelerators with high explosive layer. The layer is an additional source of chemical energy which enhances trust generated by the device. In the paper there is described model of flow and two-phase combustion in ram accelerator. Results of numerical simulation show that it is possible to increase the trust about several percent.

INTRODUCTION

Ram accelerators are new type of hypersonic propulsion known since 1980's [4]. Basic idea of ram accelerator base on utilizing chemical energy released during combustion of gaseous mixture caused by high velocity projectile. In conventional ram accelerator high velocity projectile generates shock waves which ignite combustible gaseous mixture. Combustion of gas lead to increase of pressure in rare part of projectile and generates trust (Fig. 1 a). Modification depends on addition of high explosive layer. Combustion of gas causes ignition of the layer and releases of additional heat. It should give a rise of trust (Fig. 1 b).

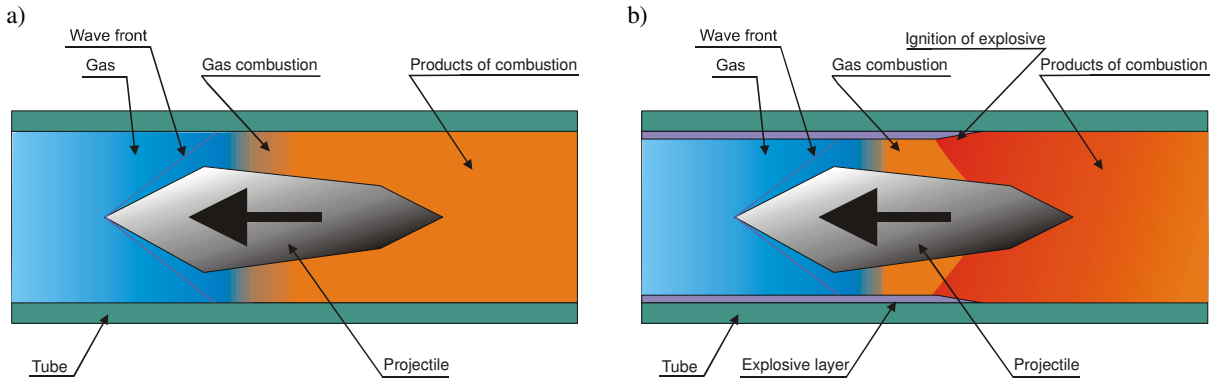

Fig. 1. a) Convetional ram accelerator, b) ram accelerator with high explosive layer.

Possibilities of enhancing of performances is studied in this work. A numerical simulation of the device is used in order to get information about increase of trust.

THEORETICAL MODEL

A two- dimensional model of the ram accelerator with PETN layer consist of two parts:

- flow and chemical reaction model of gas,
- heat conduction and chemical reaction model of high explosive.

First model is based on Euler equation of reactive gas with global reaction chemistry. Such model was successfully used in simulation of gaseous detonation and conventional ram accelerators.
Model of combustion of high explosive is based on equation of heat conduction with source term. Decomposition of high explosive is described by Arrhenius' law. Parameters of kinetics of high explosive decomposition were take from experimental data for PETN [1],[5]. Interconnection between gas flow model and model of PETN layer was realised by boundary condition. There is used Sichel's theory of heat exchange behind detonation front [2],[3]. This theory was chosen because physics of combustion in ram accelerators is very similar to detonation. The model was used in simulation of ignition of PETN layer by gaseous detonation and gave good qualitative agreement with experiments.

RESULTS

Described model was used to simulation of ram accelerator working with H_2-O_2 mixtures. The mixture composition was 40% H_2 and 60% O_2. Calculations were carried out in superdetonative mode for velocity ranging from 2300 to 4000 m/s. They proved that it is possible enhance performance of the device. Layer ignite enough quickly. Combustion of the PETN layer causes an increase of trust from 11% for V=2300m/s to ~0 for V=3250 m/s (Fig. 2). Comparison of pressure field around projectile shows that additional trust is generated mostly in rare part of projectile (Fig. 3). Next observation is that only very thin part of layer was burnt in neighbourhood of projectile.

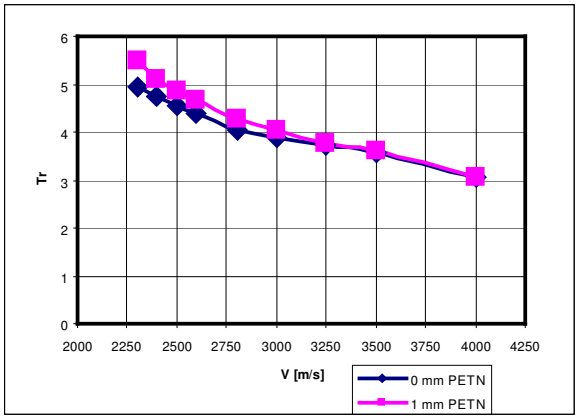

Fig. 2. Trust for ram accelerator without layer (0 mm PETN) and with layer (1 mm PETN).

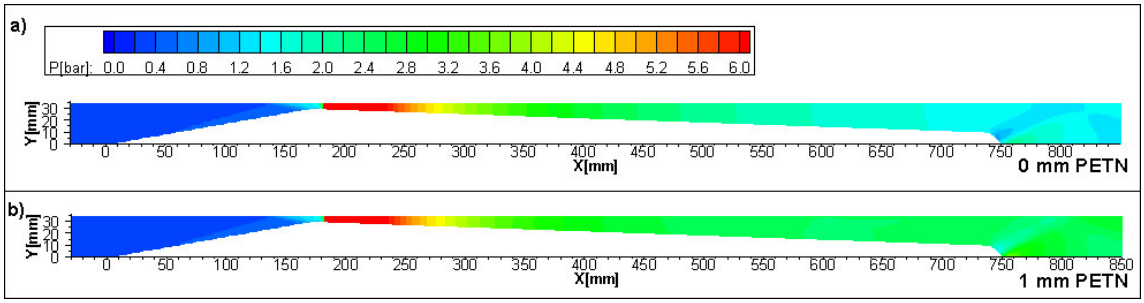

Fig. 3. Pressure fields around projectile in ram accelerator without layer (0 mm PETN) and with layer (1 mm PETN).

CONCLUSIONS

Simulation of modified ram accelerator shows that combustion of PETN layer is good way to improve its performance. Applied numerical model is sufficient and allows analysis of influence of different parameters of ram accelerators on trust e.g. geometry of projectile, kind of high explosive. Results of analysis also point out the ways of further improvements. Especially important may be increasing of rate of PETN burning e.g. by developing of layer surface.

References

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