A THEORETICAL METHOD OF PROPELLANTS BALLISTIC PARAMETERS CALCULUS

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Abstract: *The present study aims at achieving a theoretical calculus instrument that helps the development of energetic materials synthesis by time and material resources reduction. Thus, firings in manometric bomb may be replaced with numerical simulations of the phenomena, using finite volume-based calculus software.*

Keywords: *energetic materials, FLUENT software, numerical simulation.*

1. Introduction

The ballistic parameters play an important role in the design of a new propellant. Thus, combustion heat, specific heat, force and covolume are mandatory parameters in choosing a new propellant recipe. This conducts to the necessity of achieving tests that imply firing in bomb calorimeter and manometric bomb. If in the first case, the energetic material is used in small amounts (a few grams), in case of the firing in the manometric bomb the materials consumption increases consistently (hundreds of grams), also

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considering that valid results are obtained following more firings at different loading densities.

If the newly synthesized energetic material is considered to accomplish the parameters desired in terms of ballistic parameters, the testing stage ends and the following development stage for the product begins. If the results of the testing stage are far from the imposed threshold values, the current stage is rolled again until the obtainment of the necessary results. This itterative process may be long and very costly.

The present study aims therefore at achieving a theoretical calculus instrument that helps the development of energetic materials synthesis by time and material resources reduction. Thus, manometric bomb firings may be replaced with numerical simulations of the phenomena, using finite volume-based calculus software.

In order to simulate the phenomena that take place during the deflagration in the manometric bomb, the following stages are mandatory to pursue:

- achievement of a physical model;
- discretization of the physical model achieved;
- introduction of the onset data;
- problem solving;
- presentation of the obtained results and conclusions.

2. The physical model

Starting from the dimensions of the manometric bomb used, the geometry of the propergol and the firing composition, a 2D or even a 3D physical model containing all the element details may be achieved or an equivalent physical model may be calculated. In Figure 1 is given such a 2D physical model.

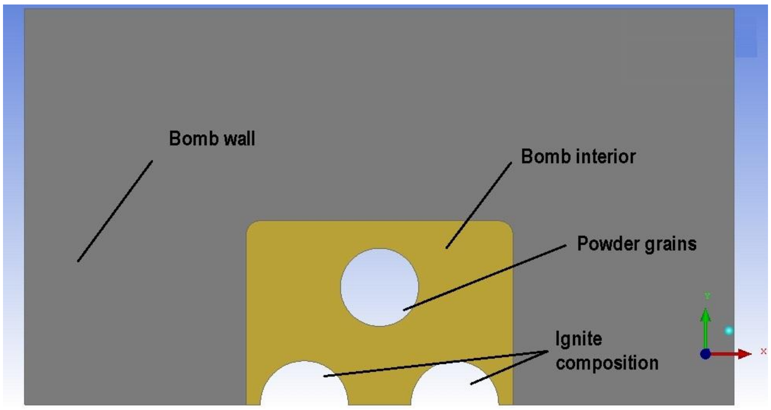

Figure 1. *The equivalent physical model for a 6/7 powder firing in the manometric bomb*

The physical model is characterized by the materials properties in solid state that are submitted to a phase transformation through combustion (powder elements), by the materials properties that are in compressible fluid state (combustion products and air), and by the solid materials that form the manometric bomb, which, even if they do not influence directly the gas-dynamic parameters, due to the fact that they allow the thermal transfer, they reduce the formed powder gases energy. All these aspects of the real phenomenon are taken into account during the numerical modeling.

3. Discretization of the physical model

In case of the achieved model, whose inner configuration is variable, a dynamic discretization network that allows the field transformation versus powder deflagration evolution was used, so that in every moment of the phenomenon analysis the field of the combustion products to be occupied by finite volumes with controlled dimensions.

For the field discretization of the manometric bomb-burning products, structured, unstructured or mixt finite volume networks may apply. A triangular network has been used during the numerical analysis (Figure 2) both for the manometric bomb interior and the solid field represented by the bomb wall. The network parameters for the onset time are given in Table 1.

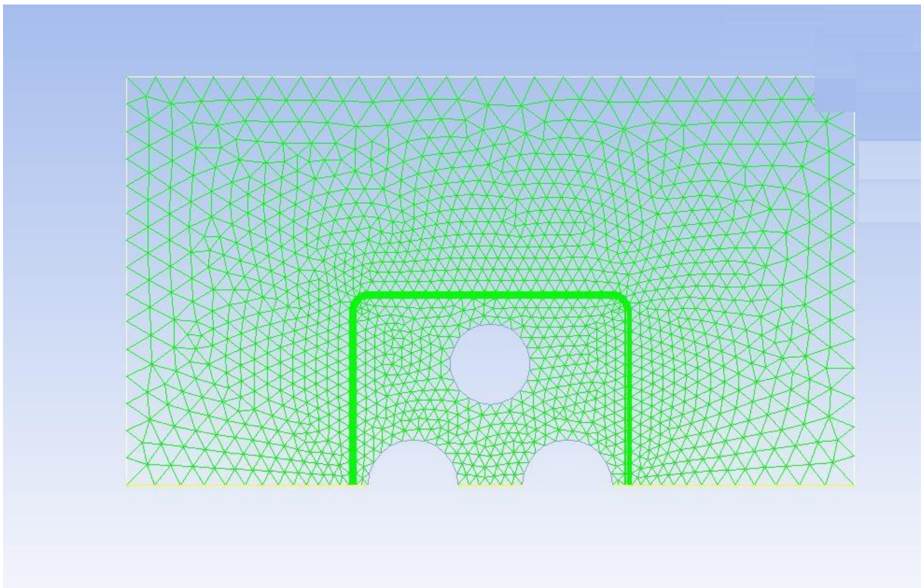

Figure 2. *Discretization of the physical model considered*

Table 1.
Network parameters for onset time

t = 0 s	Level	Cells	Faces	Nodes	Partitions
	0	130183	201985	69733	1
4 cell zones, 255 face zones					

The triangular network used has the advantage of a better control of the dynamic discretization. During the simulation, due to the permanent modification of the working field, a variation in the elements number has been noticed.

4. Entry data

The powder gases generated during the propellant combustion represent a complex mixture of chemical substances, which, due to temperature and pressure variations, are submitted to dissociations, recombinations, condensations, etc. In the simulated model, it was assumed that a nonreactive gas is generated during combustion, whose properties were determined theoretically through thermodynamic calculus at various pressures versus temperatures. More, the following parameters are defined as entry data: flame temperature, law of burning rate.

5. The problem resolution

The numerical simulation model of the deflagration in the manometric bomb has been achieved using FLUENT software, based on the general equations of the fluid mechanics and the real gas equation of state, together with the equation of the burning rate for the description on the mobile borders of the powder elements.

6. Results obtained

Using numerical simulation, the pressure and temperature fields were obtained versus time during the entire phenomenon development. The two fields at a certain moment are presented in Figure 3 (t = 0.22 s). Also, using a virtual transducer installed into the bomb, the pressure variation of the studied powder versus time was captured. The graph is presented in Figure 4.

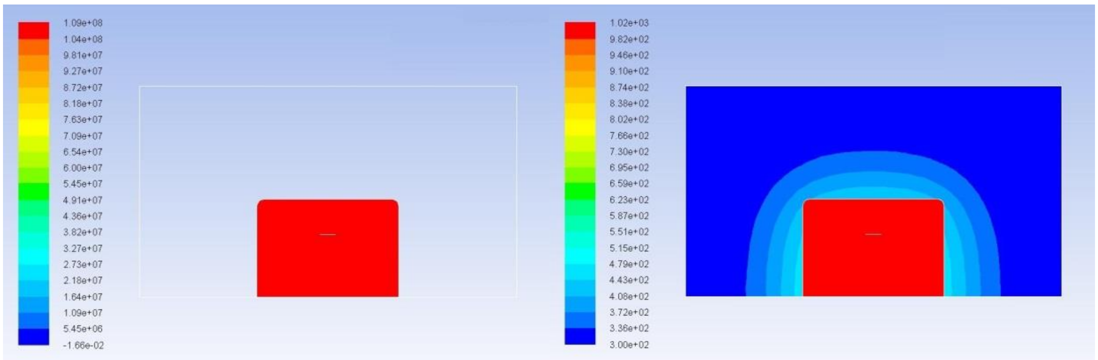

Figure 3. *The pressure and temperature fields at t=0.22 s*

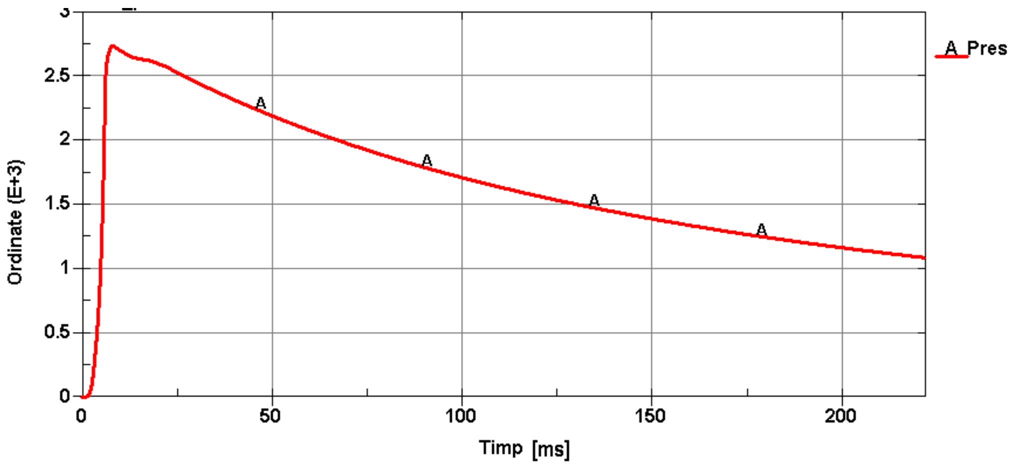

Figure 4. *The pressure versus time graph with data from the manometric bomb*

7. Conclusions

The firings in the manometric bomb may be simulated using dedicated calculus software, such as FLUENT, reducing the time and the allocated materials resources for the tests development, thus reducing the energetic material achievement cycle.

Acknowledgements

This paper has been financially supported within the project entitled ***"Horizon 2020 - Doctoral and Postdoctoral Studies: Promoting the National Interest through Excellence, Competitiveness and Responsibility in the Field of Romanian Fundamental and Applied Scientific Research",*** contract number POSDRU/159/1.5/S/140106. This project is co-financed by European Social Fund through Sectoral Operational Programme for Human Resources Development 2007-2013. **Investing in people!** (fellowship of dr. Matache Liviu).