ENERGODYNAMICS OF AUTOCYCLOMATA AND MODELING OF ELECTROCHEMICAL PULSE ENGINE

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General description of models for periodically regulated heat machines with minimized active moving parts is presented. The pulse engine as an important example of the machine is considered in the paper. New results on numerical study of electrochemical pulsejet operation are described. Small and large scales engine models are considered for the investigation. Hydrogen-oxidant and dust- hydrogen-oxidant mixtures are used in the calculations. Thrust and specific impulse are estimated.

Energodynamics of autocyclomata is mean theory of a class of models for self-aspirated and self-regulated heat machines (engines, heaters et. cetera) that are minimized of active moving parts. A continuous operation of the machine system is based on a feedback resulting from a closed chain of interactions of dynamics effects (well known example is human heart). The possibility of creation of fundamental energodynamics equations is briefly discussed in the paper. Conservation equations for fluid systems are used as a base for modeling.

As an example, electrochemical pulsejet with combustion, implosion and detonation are considered. The general scheme of combustion chamber operation is presented in Fig.1.

An electro discharge in the combustion chamber is used to improve efficiency for conversion of thermal energy into mechanical that. This electro discharge can convert combustion into detonation. The discharge appears in a combustion chamber when the flame front impinges on special electrodes that are attached to energy storage capacitor. A ring-shaped discharge creates converging shock waves in the combustible mixture, leading to detonation and increasing in the compression ratio (“double detonation mode”). The energy of combustion of one cycle is much higher than the electrical energy of the discharge. In Fig.2 the experimental data on the pressure variation in combustion chamber of electrochemical pulsejet correlated with electrical discharge are presented.

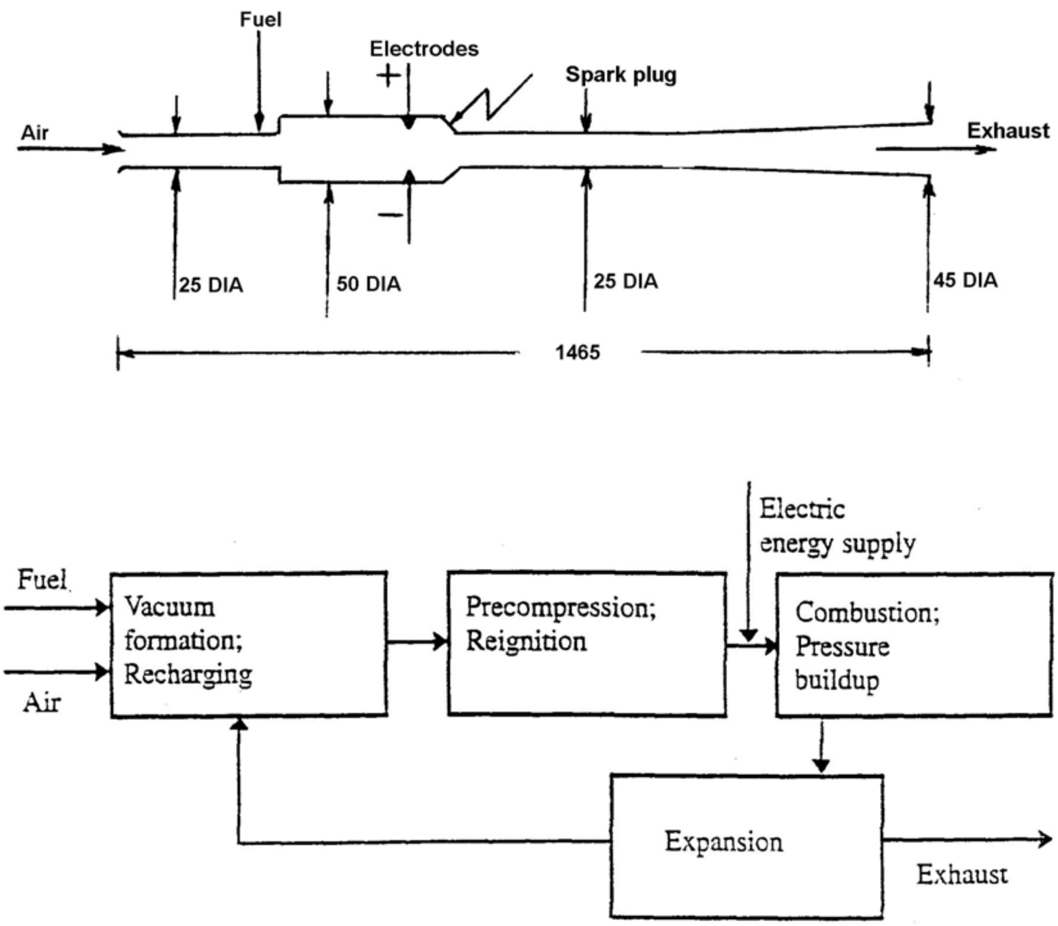

Figure 1. Operation of electrochemical pulsejet: schematic of the engine (dimensions are in mm) and block diagram of the operation

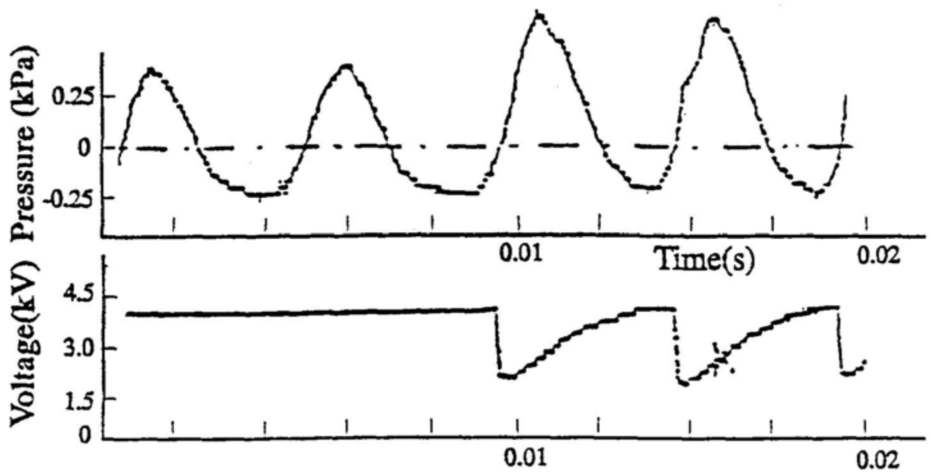

Figure 2. Pressure variation in combustion chamber of electrochemical pulsejet correlated with electrical discharge

Modeling of these processes includes the converging shocks and detonation waves. Different modes of the pulse engine are studying to get good thrust and impulse. Numerical simulation of gas flow in the chamber and in connecting intake and exhaust tubes has been implemented. Chemical kinetics, wall friction, heat losses as well as two-phase combustible mixture (dusty gas) burning are included. The calculations are made for a number of initial conditions, types of combustible mixtures and implosion modes. Previous results were published in papers [1-5].

In Fig.3 the results of numerical modeling of the engine shown schematically in Fig.1 are presented. This picture illustrates the pressure variation on axis of symmetry in the center of combustion chamber in the case of the hydrogen-oxygen stoichiometrical mixture when frequency of fuel injection and of electrical discharges is 200 Hz and the value of the electrical energy per one discharge is 30J.

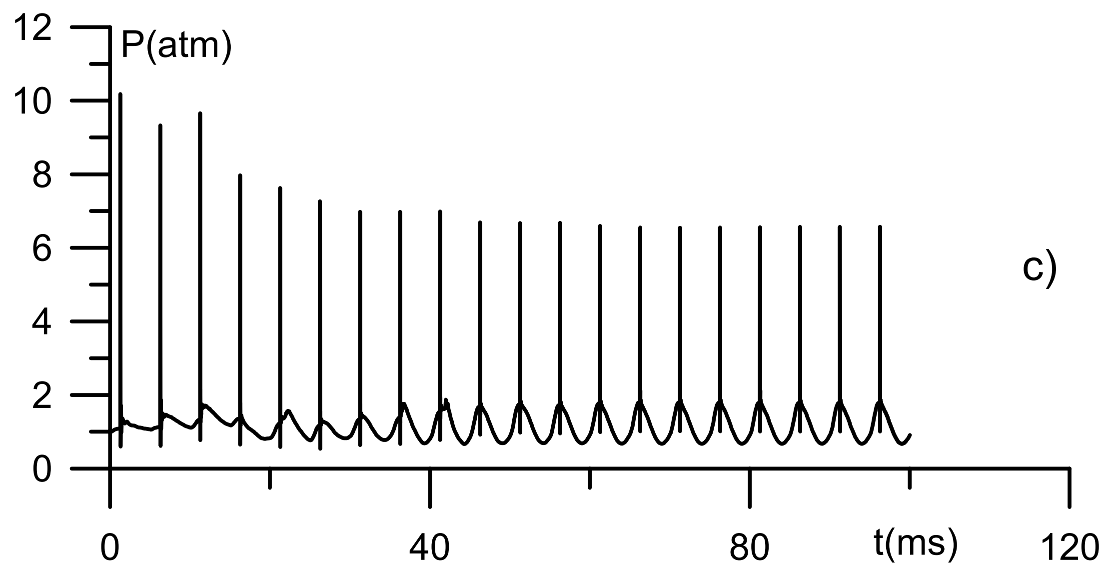

Figure 3. Pressure variation on axis of symmetry in the center of combustion chamber in the case of the hydrogen-oxygen stoichiometrical mixture (frequency of fuel injection and of electrical discharges is 200 Hz and the value of the electrical energy per one discharge is 30J)

Small-scale laboratory models and large-scale installation are taken for the consideration. Output data from the model calculations includes impulse, thrust values and engine efficiency. Results of small-scale experiments and scaling rules have been used for comparison with the theory. The experimental device was modified and applied to create intense spark channels which initiate the implosion in the combustion chamber as well as twin engine configuration is briefly discussed. Pictures and diagrams demonstrate the results. The application of implosion schemes to RAM Accelerators is also discussed in brief.

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