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Liquid-Fueled, Air-Breathing Pulse Detonation Engine Demonstrator: Operation Principles and Performance

S. M. Frolov*
N. N. Semenov Institute of Chemical Physics, 119991, Moscow, Russia

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A demonstrator of the liquid-fueled air-breathing pulse detonation engine with relatively low energy requirements for repeated detonation initiation, with no fuel preconditioning, no use of onboard oxygen, and reasonable geometrical dimensions has been designed and tested. The design of the demonstrator combined several new principles and technologies. One of the most important design principles is the use of the "detonation peninsular" in the tube comprising the Shchelkin spiral followed by the tube coil. For the cold startup of the demonstrator, a new method for detonation initiation by successive triggering of two igniters was applied. The demonstrator design was optimized for attaining stable operation in the detonation mode. The thrust was measured by the ballistic pendulum technique during the operation of the demonstrator at frequencies of 2.2, 3.1, and 3.9 Hz. The maximal measured thrust was about 30 N. Because of acceptable weight and size characteristics of the pulse detonation engine demonstrator, the proposed process design can be regarded as promising for practical applications.

Nomenclature

C_1, C_2	=	capacitances of the main discharge of the dischargers D_1 and D_2
C_1, C_2	=	capacitors of the igniters ED1 and ED2
E	=	discharge energy
ED1, ED2	=	igniters
PT1 to PT6	=	pressure transducers
U	=	discharge voltage
V	=	mean shock wave velocity
X	=	measuring segment length
ΔE	=	uncertainty in the discharge energy
Δt	=	uncertainty in measuring the time interval
ΔU	=	uncertainty in the discharge voltage
$\Delta \tau$	=	time delay

I. Introduction

DURING the last several decades there has been a growing interest in the development of a new type of jet propulsion engine, the pulse detonation engine (PDE) [1]. Such engines apply a new principle of fuel chemical energy conversion to thrust: fuel is supposed to be burned out in repeatedly initiated propagating detonation waves. As compared to the conventional schemes of the operation process in ramjet and rocket engines, fuel burning in the propagating detonation waves exhibits several principal advantages. First, the thermodynamic efficiency of the detonation cycle exceeds considerably the efficiency of other known cycles [2]. Second, PDE can potentially operate on both special fuels and conventional fuels used in aerospace applications. Third, in contrast to many existing concepts of jet engines, PDE has a simple design and does not require sophisticated and expensive compressors and turbopump machinery. Moreover, PDE is potentially robust because it contains no moving parts and is self-sufficient as a PDE-based vehicle requires no boosters for acceleration to cruise flight conditions. Fourth, the use of several identical PDE units in the assembly allows for the thrust magnitude and vector control.

There exist several concepts of PDE design reviewed recently in [1]. Most of the concepts imply fuel preconditioning (prevaporizing, preheating, partial decomposition, blending, etc.) before injection to a detonation chamber of a PDE, and the use of additional oxygen to facilitate detonation initiation. The reason for this kind of

Sergey M. Frolov graduated from the Moscow Power Engineering Institute in 1982 (with honors) as a research engineer in thermal and plasma physics (diploma work titled "Acoustic Conductance of Solid-Propellant Burning Surface"). He received his Ph.D. (thesis titled "Detonation in Systems with Mass, Momentum and Energy Loss") and D.Sc. degree (theses titled "Nonideal Effects at Explosion Origin and Propagation") in chemical physics in 1987 and 1992, respectively. Currently he is a Director of Laboratory of Explosion Processes in Gaseous and Heterogeneous Media at N. N. Semenov Institute of Chemical Physics, Russian Academy of Sciences, and a professor at the Moscow Physical Engineering Institute (Technical University). His major research and teaching interests include shock waves and detonations in gases and multiphase media; deflagration-to-detonation transition; laminar and turbulent combustion of gases, dusts, and liquid fuel sprays; combustion and detonation control; chemical thermodynamics of multicomponent systems; chemical kinetics of autoignition, combustion, and pollutant formation; and computational fluid dynamics. He has over 300 publications in journals, books, and conference proceedings and about 200 research seminars and presentations. He has been the editor of 18 books on combustion and detonation topics. Frolov's awards include The Prize of Leninski Komsomol in science and technology (1989) and The Prize of the European Academy of Sciences (1992). His professional service includes vice-chair, Russian Section of The Combustion Institute; National Councils on Combustion and Chemical Physics; Executive Secretary, *Russian Journal of Chemical Physics*; and the Editorial Advisory Boards of *Combustion, Explosion and Shock Waves*, *Archivum Combustionis*, and *Central European Journal of Energetic Materials*.

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*Director of Laboratory, Department of Combustion and Explosion, 4, Kosigin Street; smfrol@center.chph.ras.ru.