Introduction

Nowadays, the combustion science is more often considered as an applied discipline in spite of a number of unresolved fundamental issues. Combustion is the most wide-spread phenomenon of energy conversion used in propulsion and power plant engines and turbines. As a sophisticated chemical process, combustion is used in chemical technology and material science to produce new materials with desired properties. Historically the two fundamental modes of combustion, namely flame and detonation, have found a wide variety of applications in human activities. It is a slow flame that has been utilized in the applications mentioned above, while detonations were used basically for military purposes. As the knowledge in detonation physics and chemistry is continuously advancing, one inevitably arrives at the time when this knowledge is to be used for constructive rather than destructive purposes. Detonation is a very attractive phenomenon from the view-point of the thermodynamic efficiency of chemical energy conversion into thermal and kinetic energy. Once this advantage of detonation is capitalized properly, considerable benefits are expected to be achieved in terms of fuel consumption, manufacturing and operational costs, pollutant emissions, etc. It is our profound belief that the existing knowledge allows one to focus on solving this challenging problem.

The idea to organize an international meeting devoted specifically to ongoing research in control of detonations and high-speed deflagrations has evolved in 1998, during the International Colloquium on Advanced Experimentation and Computation of Detonations, held in St. Petersburg, Russia. It has been implied that the presentation would comprise all possible approaches to control deflagrations and detonations, including 'external forcing' by obstructions, focusing surfaces, jets, multipoint ignitions, electrical discharges, acoustic and electro-magnetic fields, laser beams, microwave irradiation, etc.; pre-conditioning of the explosive medium by partial pyrolysis, pre-excitation of reactive and/or inert species, fuel sensitization, fuel blending, nonuniform mixing and/or preheating, etc.; and by varying mixture composition, multiphase structure, pressure, and temperature. In the middle of 1999 we announced that the International Colloquium on Control of Detonation Processes will be held in Moscow, Russia, July 4–7, 2000, and solicited extended abstracts/condensed papers for an edited publication to be distributed at the Colloquium, followed by full papers for presentation at the Colloquim at a later date.

Due to the enthusiastic response, more than 60 contributions have been received from researchers from 13 countries: Belarus, Belgium, Canada, France, Germany, Israel, Japan, Norway, People's Republic of China, Poland, Russian Federation, United Kingdom, and the United States of America. The contributions have been extensively edited and grouped into sections corresponding to the topics of the Colloquium.

Section 1, **Control of Deflagration to Detonation Transition (DDT) in Gaseous Systems**, deals with various approaches to control transient explosion processes both passively and actively. *Smirnov et al.* report the results of their experimental and computational studies on control of pre-detonation distance and time by means of a series of turbulizing chambers inserted into the detonation tube. From the experimental studies of flame propagation in fuel–air mixtures of different reactivity in tubes of various lengths, *Kerampran et al.* have revealed the conditions required for progressive acoustics-enhanced flame acceleration. *Brailovsky et al.*, based on the mathematical modeling, put forward the idea of an important role of hydraulic drag in DDT. *Makeev et al.* report extensive experimental data on flame acceleration and pre-detonation distances in unconfined and partially confined clouds of fuel–air mixtures. *Higgins et al.* explore various methods of reducing the pre-detonation distance in fuel–air mixtures by introducing free radicals for their sensitization. Re-establishment of detonation after passing through a nozzle has been studied experimentally by *Sugimura and Yamada.* Active control of DDT by electric discharges is the objective of the experimental study by *Afanasyev et al.* Transmission of detonation from a tube to the unconfined space by applying various configurations (annular orifices, tube bundles, partitions, blocking plates) has been studied experimentally by *Murray et al. Baev* introduces the idea of staged combustion for attaining high efficiency of chemical energy conversion into mechanical energy of the flow.

Section 2, **Control of DDT in Heterogeneous Systems**, includes contributions on transient explosion processes in liquid fuel sprays, propellant suspensions and layered systems. *Borisov* reviews the available approaches to treating the kinetics of heat release in heterogeneous explosion processes. *Khasainov et al.* report the results of computational studies on the cellular structure of two-dimensional hybrid detonation waves propagating in fuel–air mixtures laden with fine aluminum particles. *Tsuboi et al.* present the results of a three-dimensional computational studies of two-phase cornstarch–oxygen detonations. Propagation of combustion and detonation waves in a mine gallery with coal dust deposit on the walls is the objective of the computational study reported by *Korobeinikov et al.* Detonability of liquid decane sprays is studied numerically by *Tao* within the frame of a one-dimensional mathematical model. *Fedorov and Khmel'* report the one- and two-dimensional computational studies of detonation initiation in a suspension of aluminum particles by means of incident and reflected shock waves. *Benkiewicz and Hayashi* present their numerical modeling of combustion and detonation waves in suspensions of aluminum particles in oxygen by assuming both phases to be compressible. The effect of fine magnesium particles on the parameters of gaseous detonations at elevated pressures relevant to conditions in RAM accelerators has been studied computationally by *Paintendre et al.* *Malinin et al.* suggest a mathematical model for ignition and burning of aluminum particles taking into account the finite rate of aluminum oxide accumulation. *Kuznetsov* develops a generalized mathematical model for detonation in media laden with heavy inert particles, and applies it to condensed explosives.

A series of contributions deals with transient explosion processes in porous energetic materials. *Ischenko et al.* report a mathematical model and the computational results on transition from the slow convection mode of combustion to the high-speed compression mode and detonation in porous condensed propellants. *Yermilov et al.* demonstrate experimentally a possibility of controlling the burning rate of propellants by means of microwave irradiation of samples. *Rybakov and Djachkin* use the porosity as a factor to control detonation initiation in solid energetic materials. *Radchenko et al.* study the effect of pulse loads on detonation initiation in solid propellants contained in shells with various properties.

Section 3, **Control of Detonation Initiation and Propagation**, combines contributions on detonation initiation and control of developed detonations. *Hayashi* reviews the investigations on detonability of hydrogen–air mixtures. *Lefebvre and Van Tiggelen* report the results of detailed two-dimensional simulations of decaying detonations during transmission from reactive to nonreactive medium. *Achasov and Penyazkov* demonstrate an experimental feasibility of controlling detonation initiation and propagation by shock wave focusing, supersonic jets, and hot jets of combustion products. *Fujiwara and Fukiba* report a computational study of the effect of transport processes on the structure of propagating detonation waves. A possibility to control reactivity of hydrogen–oxygen mixture by pre-excitation of electronic states of oxygen molecules is proved theoretically by *Starik and Titova*. *Ishii et al.* report the results of extensive experimental investigation of hydrogen–oxygen detonations in narrow gaps. Initiation of detonation by hot jets is studied numerically by *Borisov et al.* *Levin et al.* present an interesting example of detonation initiation as a result of collapse of a low-pressure domain. *Koren'kov and Obukhov* study the effect of location of an explosion initiator in the torroidal cloud of fuel–air mixture on the arising overpressure field. New efficient algorithms for simulating detonation-induced flows is the topic of contribution by *Yu.* *Kozlov* demonstrates experimentally a possibility to generate and control a detonation wave by a laser beam. *Trotsyuk* reports a detailed computational study of the unsteady reflection of a propagating detonation wave on a wedge. *Rybanin* suggests a classification of detonation waves exhibiting momentum and heat losses. *Buzukov* presents the results of experimental investigations of detonation suppression by water sprays. *Azatyan et al.* report experimental data on inhibiting accelerating hydrogen–air flames by chemical additives. *Fomin* suggests a mathematical model of heterogeneous detonation in liquid fuels with bubbles. *Sinkevich* proposes a mathematical model of combustion- and detonation-like phenomena in charged fractal structures (fractal aggregates, fractal tangles, and aerogels).

A series of papers is devoted to control of oblique detonations in view of possible applications in scramjets and RAM accelerators. *Bezgin et al.* demonstrate computationally the approaches to control shock-induced combustion in scramjets. *Berland et al.* report the results of computational studies of an unstable structure of oblique detonation waves. *Terioshin* suggests a new concept of a scramjet with a stepwise detonation process. *Zaslonko* analyzes the concept of discharge-synchronized heterogeneous RAM accelerator.

Section 4, **Transient Heat Transfer and Diagnostics of Explosion Processes**, includes several contributions on advanced diagnostics of explosions. *Sarofim et al.* present the results on heat transfer to cylinders containing high-energy materials and review the studies on heat transfer in pulse detonating systems. *Sanders et al.* demonstrate the capabilities of new diode laser-based sensors for diagnostics of transient explosion processes. *Woiki et al.* present the results on the application of laser-induced incandescence technique to soot diagnostics behind shock waves. *Abrukov et al.* report the methodology of processing the images of combustion and detonation fronts to obtain additional data on their topology, dimensions and statistics.

Section 5, **Pulsed Detonation Engines**, is devoted to the application of various techniques of explosion control to pulsed detonation engines (PDE) — power plants operating on propagating detonations. *Desbordes* reviews the key issues in pulsed detonation propulsion. *Kailasanath et al.* present the results of computational studies of the effect of various factors (such as tailoring the pressure relaxation process and degree of fuel fill in the chamber) on PDE performance. *Frolov et al.* present the results of thermodynamic and chemical kinetic calculations illustrating a potential of fuel blends in PDE applications. *Ivanov et al.* describe the test detonation chamber and the results of flow simulations in it. *Brophy et al.* demonstrate a feasibility of detonating liquid JP-10 – air mixtures in a repetitive manner for PDE applications. *Segal and Mullagiri* addresses an important issue of the stability of the PDE inlet flowfield under variable, partially applied back-pressure. *Daniau et al.* study experimentally the effect of straight and diverging nozzles on the PDE performance. The effect of nozzles attached to a PDE is studied computationally by *Fujiwara and Fukiba*. *Levin et al.* suggest a PDE concept based on fuel pre-conditioning with further detonation in a gas-dynamic resonator. *Jermishin et al.* present an analysis of different PDE concepts, in particular those operating in a closed-type cycle. *Korobeinikov et al.* discuss a concept of a PDE based on the repetitive detonation initiation by an electrochemical pulsed jet. *Vasil'ev* suggests a mathematical model of a jet engine with the detonation wave moving continuously around a body of revolution through the semi-confined ring-shaped layer of reactive mixture. *Bykovskii and*

Mitrofanov demonstrate a feasibility of continuous detonation of fuel sprays in annular chambers. *Smirnov et al.* describe the pulse detonation device operating with a conventional liquid fuel and provide the mathematical model of the phenomena encountered. A mathematical model of a new PDE concept and comparison of the predicted performance with that of alternative engines operating in a continuous combustion mode are presented by *Alexandrov et al.* *Furlong et al.* present the results of testing a small-scale PDE operating on JP–8 fuel – air mixture.

The above are possibly best research efforts going on worldwide, and the authors have provided up-to-date results. It is planned to publish, at a later date, a volume entitled, "Detonation and High-Speed Deflagration: Fundamentals to Control," which will contain edited version of a selection of full papers presented at the Colloquium.

Editors