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## Results of the XXII International Congress of Theoretical and Applied Mechanics<sup>☆</sup>

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At the end of summer of 2008, scientists and engineers from around the world gravitated towards Adelaide, the capital city of Southern Australia. Here, from 24 to 29 August 2008, the XXII International Congress of Theoretical and Applied Mechanics (ICTAM 2008) took place, and meetings of the General Assembly of the International Union of Theoretical and Applied Mechanics (IUTAM) were also held. The venue chosen for ICTAM 2008 was the Adelaide Convention Centre, a large modern complex in the centre of town. ICTAM is the largest and most impressive event in the engineering calendar and is held every four years. It was last held in Warsaw, Poland, in 2004.

At the XXII International Congress there were over 1500 applications, and about 1000 papers were presented by scientists from 70 countries. These were divided into plenary papers (two in all, at the opening and at the end of the Congress, each lasting 1 hour), section papers (each lasting 45 minutes), lecture papers (each lasting 20 minutes), and seminar papers (each lasting 3 minutes). The authors of the latter papers were also given the opportunity to present a poster report.

At the opening, the president of the Congress, E. Tuck, and other officials spoke. Representatives of the aboriginal community performed a short programme with musical accompaniment. The scientific programme began with a paper given by J. Hutchinson (USA), "The role of mechanics in advancing thermal barrier coatings", which was devoted to research on multilayer coatings used in the high-temperature parts of aviation and power-generation gas turbines. These coatings consist of a layer of a porous ceramic substance with low thermal diffusivity, a thin layer of aluminium, which serves as a barrier to oxidation processes, and a metal layer to bond the coating to the alloy. Theoretical and experimental results of investigations of the thermal and mechanical properties of coatings and of the influence of their microstructure on the macroscopic properties were presented.

We will mention some of the most interesting sections and lecture papers. On the opening day of the Congress, the meeting of the "Hydrodynamics of Swimming and Flight" section was extremely interesting. Here, three 40 minute review papers were presented. In the paper by J. Wang (USA), "How insects fly", the mechanism of lift during the flight of winged insects such as dragonflies, flies, etc., was analysed. The paper was illustrated with a large amount of video material (obtained by high-speed photography). The paper given by D. Weihs (Israel), "Fish swimming dynamics: knowns and unknowns", was devoted to a study of the kinematic and dynamic processes of the movement of fish in ideal and viscous liquids. The principal question here was: how are forces of thrust and resistance created during the swimming of fish, and how are they related? In the paper given by L. Fauci (USA), "Understanding swimming at low Reynolds numbers: successes and challenges", methods by which bacteria and microorganisms move in liquid media were examined. For these organisms the Reynolds numbers are very low, and the mechanism of their movement differs greatly from the mechanism of the swimming of fish and the flight of insects. The results of an analytical investigation and computer modelling were given, as well as data of observations. All three papers were very well prepared and were accompanied by a large number of video illustrations, and they combined clear mechanical models with the results of computer modelling; furthermore, well-thought-out reviews of results and problems in this field were given. Unfortunately, in Russia, inadequate attention has obviously been paid to work on biomechanics as a whole and on the avenue of research touched upon in particular.

A series of interesting papers was given in the "Control of Structures" section. In the paper by S. Krenk (Denmark), "Design of resonant vibration absorbers with filtered feedback", a procedure for selecting the optimal parameters of two types of filter for resonant vibration absorbers was proposed. It was shown that, with the recommended selection of parameters, a considerable improvement in system response is achieved. The paper given by H. Dankowicz (USA), "Controlled onset of low-velocity collisions in vibro-impacting systems with friction", was devoted to the dynamics of a system with a dry friction element. A theoretical analysis and the results of experiments were given. In the paper of Academician F. Chernous'ko (Russia), "Mobile systems controlled by internal moving masses", the results of recent work by the author on the dynamics of systems with internal moving masses were presented. In the paper given by F. Ashida (Japan), "Optimum control of thermal stress in a piezocomposite disc", a multilayer disc of composite material subjected to heating by electrodes was investigated. The problem was to find the optimal structure of the multilayer disc in order to lower the temperature stresses in the material. It proved possible to reduce the maximum stress by 34%. In the paper of H. Hu (China), "Equilibrium stabilization via position and delayed position

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feedback”, problems of stabilizing the unstable equilibrium of a linear system with many degrees of freedom by applying position feedback, including delayed position feedback, were considered. It was shown that applied feedbacks enable effective stabilization to be achieved. Examples of stabilizing a robot manipulator and an inverted pendulum were considered. Mention must also be made of the paper given by G. Kostin and V. Saurin (Russia), “A variational approach to 3D rod motion modelling and optimization”, where an interesting method for solving problems of the mechanics of elastic bodies was described.

The following papers provoked great interest. The section paper given by H. Durrant-Whyte (Australia), “Maximal information systems”, was devoted to obtaining, measuring and processing data in tracking, navigation and search problems. The main applications were associated with software for robot-assisted military operations: detecting targets, following the movement of targets, coordinating pilotless observation craft and striking targets. The paper was illustrated by video films taken by pilotless aircraft. Among the section papers, those by H. Stone (USA), “Interfaces in fluid mechanics and across disciplines”, and M. Ortiz (USA), “Non convex plasticity and deformation of microstructures”, must also be cited.

In the paper given by G. Cheng (China), “Optimum material design of maximum structural seepage under compliance constraint”, the problem of the optimum design of a filter with the contradictory requirements of high permeability and fairly high stiffness was considered. A numerical solution was obtained using the finite element method and a numerical optimization procedure. The paper given by P. Eberhard (Germany), “Coupled simulation of dispersions in multibody systems”, dealt with the simulation of the dynamics of a track with a liquid or granular load. A feature of the work was estimating the behaviour of the granular medium or liquid in the lorry container on sudden braking or turning at high speed. The numerical results obtained enabled the possible consequences of such manoeuvres, including overturning of the lorry, to be assessed. It was shown that division of the container into sections considerably reduces the dangerous influence of the granular or liquid load on the dynamics of the vehicle. In the paper by I. Zeidis, K. Zimmermann, M. Pivovarov and N. Bolotnik (Germany and Russia), “Motion of an inertially excited two-mass oscillator along a rough plane”, mechanical systems capable of moving along a plane by internal vibrations of system elements were considered, and data of calculations and experiments were presented.

A fair number of interesting papers on urgent problems of the mechanics of deformable solids were presented at the Congress. Thus, in the plenary paper given by N. Gupta (India), “Plasto-mechanics of large deformation under impact loading”, a broad range of experimental results on the flow of metals under compression and tension was analysed. In addition, an impressive review was given of results concerning the loss of stability of thin-walled elements of structures under impact loading, for example, of tubes under end impact loading. In the paper presented by Academician I. Goryacheva and Yu. Makhovskaya (Russia), “Effect of adhesion in sliding contact of rough bodies”, a number of basic problems of considerable importance for modern engineering were considered. In the paper presented by Academician V. Matveyenko, T. Nakaryakova and N. Sevodina (Russia), “Numerical analysis of stress singularity in three-dimensional problems of elasticity theory”, problems of analyzing elastic bodies of complex shape were studied. The paper by H. Petryk and S. Stupkiewicz (Poland), “Multiscale modelling of stress-induced microstructures in shape memory alloys”, was devoted to an investigation of the properties of the latest smart materials. Corresponding member of the Russian Academy of Sciences Ye. Lomakin and T. Belyakova (Russia) read a paper entitled “Phenomenological approach to the description of deformation and fracture of damaged solids”, in which a number of important problems for engineering applications were solved. A. Tralli, E. Milani and G. Milani (Italy) devoted their paper, “A new curved FE approach for analysis of masonry vaults”, to an analysis of the numerical calculation of block-structure designs. The paper by A. Manzhirov (Russia), “Mathematical theory of accreted solids and its applications”, dealt with a mathematical model of a growing body and its application in studying various technological and natural processes.

Delegates showed great interest in reports on new problems encountered at points where different scientific disciplines meet. These included the plenary paper by N. Sottos (USA), “Self-healing materials systems: where mechanics meets chemistry”. Modern materials that respond automatically to small damage by self-healing were considered. The idea is that the onset of damage (microcracks) causes the release of special adhesive substances contained in capsules spread over the base material. Another example of problems where the interaction of different areas of physics is considered was the paper by L. Zhu and X. Zheng (China), “Elastic properties of nanostructures with charged surfaces”. It was shown that the effect of a charge on the elastic properties of a substance will be considerable in cases involving miniature bodies, where surface effects begin to play a key role (nanowire, for example). Note that there were relatively few papers on nanotechnologies.

In the field of dynamic problems, several non-trivial formulations and solutions were presented. One instance was the problem of a circular crack at the interface between two linearly elastic materials under the action of a periodic external load (Yu. Guz', A. Men'shikov and M. Kashtalyan, UK). A specific feature of this problem is the presence of an unknown variable boundary separating the region of contact of the crack surfaces from the zone of opening (conditions with unilateral constraints, as in the Signorini problem). This makes the response aperiodic, and the problem reduces to solving a system of integral equations based on dynamic Somigliana identities. Another example is the problem of the high-speed penetration of bodies of different shape into the ground (I. Simonov, Russia). To check the goodness-of-fit of the penetration model proposed, complex experimental investigations were carried out. The stability of motion of bodies in an elastoplastic medium was also studied on the small and large scales.

As regards experimental methods in mechanics, laser interferometry has been developed (an accuracy of  $\pm 3$  nm has been achieved in measuring displacement amplitudes in the vibration frequency range 0– $10^8$  Hz), as well as the acoustic emission method as applied to recording the evolution of damage to thin objects under the action of cyclic loads and waves. Relatively new methods include Ravi-Chandar's electromagnetic method of dynamic loading of an annular specimen of metal at deformation rates of the order of  $10^4$  s<sup>-1</sup> in order to study the effect of fragmentation. The method makes it possible, with greater accuracy than with known dynamic methods, to determine the loading conditions and to model the process, which promotes a deeper understanding of the laws governing fragmentation effects. Papers given by St Petersburg scientists must be noted. In these papers, a structurally kinetic approach was developed to problems of the dynamics of a solid continuum (fracture, cavitation and fragmentation under electrical action). The Morozov–Petrov quantum-mechanical approach proposed explained a number of effects found in experiments on the loading of solids by different rapidly changing physical fields.

In a number of papers, as is traditional, problems of the fatigue failure of media with complicated properties, and different problems of the localization of strains in plastic materials were considered. A number of new problems concerning cracks in anisotropic elastic media or media with complex properties were solved. Calculations of the evolution of three-dimensional cracks were given. Comparatively new theories of so-called gradient models of materials, which describe more accurately bodies with dislocations concentrated along lines on surfaces, were also developed.

**Table 1**  
Statistical data from the XXII International Congress of Theoretical and Applied Mechanics

Country	Proportion of representation (in %) according to number of papers			
	total	on solid mechanics	on fluid mechanics	on points where different scientific disciplines meet
USA	14.0	9.9	12.7	21.9
Australia	11.1	5.6	16.4	13.1
China	10.4	16.6	7.3	6.6
France	8.5	7.0	10.2	10.2
Japan	7.6	7.0	8.5	6.6
Germany	6.6	6.4	7.1	5.1
UK	5.8	3.8	8.2	4.4
<b>Russia</b>	<b>4.3</b>	<b>6.4</b>	<b>3.7</b>	<b>2.9</b>
Poland	3.2	2.9	2.0	3.6
Taiwan	2.5	3.2	1.7	1.5
India	2.4	3.5	0.8	2.9
The Netherlands	2.3	1.6	3.7	2.2
Denmark	2.2	3.2	<0.5	2.2
Italy	1.9	2.4	0.8	2.9

At the closing of the International Congress, a paper was presented by J. Imberger (Australia), “Physical limnology: advances and future challenges”, which was devoted principally to the hydrodynamics of lakes. The effect of wind on the surface of a lake, surface and internal waves in lakes, the turbulent flows and seiches in lakes and problems of the stratification and analysis of flows were examined. Three-dimensional modelling of the hydrodynamics of lakes was carried out.

The Table 1 gives interesting statistical data. The representation of the countries of those taking part in the International Congress, in terms of the total number of papers given, is shown in the second column of the table. The USA was best represented, followed by Australia, the host country. The fact that China is in third place indicates that the extremely rapid growth of China's economy is being sustained by wide-ranging basic research. And, as developments in China show, this has been extremely successful. The distribution of papers between countries on problems of rigid bodies and deformable solids is shown in the third column of the table. China and the USA clearly come out on top, and Russia is in a comparatively poor position. In fluid mechanics (the fourth column of the table), the leaders are the USA, France and Australia (the fact that Australia is in a leading position is possibly due to the “home fixture” factor). Japan, the UK, China and Germany form a tight group, and then comes Russia, with almost half the number of papers, clearly lagging behind. The distribution of papers between countries on problems encountered at points where different scientific disciplines meet is given in the fifth column of the table. The number of papers in this most complex area, demanded by applications, can serve as an indirect indicator of the use of high-tech methods by various countries. The USA far outstripped the other countries in this respect. Australia and France had half as many papers. Japan and China had almost a third as many papers, and Germany a quarter. Russia had 7 times fewer papers.

The statistical data presented obviously cannot provide a complete picture, given that it is impossible to take into account all the factors unrelated to science. For Russia, the long distance from Australia and the high cost of travel are among these factors. At this point it would be appropriate to express gratitude to the Russian Foundation for Basic Research, whose financial backing enabled most of the Russian participants to attend the Congress.

And a few more words about the representation of Russia. For a developed country occupying one of the leading positions in the world, its representation was clearly inadequate. However, the undoubted progress compared with previous periods gives room for optimism that the situation is improving.

During the Congress, a number of attendant events took place. Thus, on 26 and 27 August, meetings of the General Assembly of the International Union of Theoretical and Applied Mechanics (IUTAM) were held, at which about 80 members of the General Assembly were present. Russia was represented by F. Chernous'ko. At the meetings, a wide range of questions were considered: reports by agencies of IUTAM, problems encountered in its interaction with other international scientific unions, etc. The most important topics, giving rise to lively discussion and debate and then voting (by secret ballot), were questions concerning the holding of IUTAM symposia in 2010–2011 and the composition of the IUTAM agencies.

It was confirmed that over ten symposia on different divisions of mechanics would be held in various countries: the USA, China, the UK, Japan, Canada, etc. Unfortunately, not a single proposal that a IUTAM symposium be held in Russia in this period was made. New members of the IUTAM Symposia Panels were elected. There are two such panels: the Panel for Fluid Mechanics and the Panel for Solid Mechanics. Russia is not represented on either. Academician I. Goryacheva represents Russia on the Congress Committee.

Elections of IUTAM officials were held. Russia had not previously been represented, but F. Chernous'ko was elected as a member of the IUTAM Bureau. T. Pedley (UK) was elected president, L. Freund (USA) was elected vice-president, F. Dia (France) was elected Secretary-General of IUTAM and N. Olhoff (Denmark) was elected treasurer.

The Congress was well organized and successful. The participation of Russian scientists in the International Congress was significant, especially if the considerable distance to Australia is considered. However, no Russian scientist presented a plenary or section paper.

The subject-matter of the International Congress covered all areas of mechanics. Special attention was paid to specializations associated with new industrial technologies, new materials, information technologies, nanotechnologies and computer methods. There were comparatively few purely theoretical papers. A deep impression was left by papers on biomechanics, where clear physicomachanical ideas were combined with computer modelling and rich experimental data.

It is no secret that the degree of economic development and, ultimately, the independence of a country are determined by its level of provision for the latest technical developments and up-to-date technologies. Mechanics is essentially the principal science providing engineering and technology with a basic, model and theoretical base. In this context, the results of the International Congress present Russian mechanical engineers with a number of problems, including the following. Firstly, the development of basic and applied research in areas of new biological, chemical, nano- and other technologies, and also mechatronics. Secondly, the improvement of calculation methods and

the need to calculate motion in different media and the stability and strength of complex technical objects and their elements. Thirdly, the study and description of various animate and inanimate phenomena. The solution of these problems will undoubtedly require the development of basic research at points where two or more scientific disciplines meet.

As regards the International Union of Theoretical and Applied Mechanics itself, we must be seen to be very active within its management agencies and in its events. In particular, in the coming years, a number of IUTAM symposia on various problems must be organized in Russia, and the international community must be shown the varied and quite unique advances made by Russian scientists in the field of mechanics. This will undoubtedly raise the profile of Russian science and strengthen its influence at the international level.

*Translated by P.S.C.*