

Mechanics revisited

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Traditionally mechanics is considered to be a cornerstone for engineering. It is still true, but mechanics in contemporary sense is much wider, being closely related to material science and oceanography, to biology and climatology and so on. Inquiries on stability of three bodies about a century ago have led to non-linear dynamics and chaos theory, developments in biomedical engineering have practical applications in surgery, the dynamics of galaxies is based on computational mechanics, better understanding of the mechanism of earthquakes and freak waves has probably saved many lives, etc. The recent International Congress on Theoretical and Applied Mechanics (ICTAM) in Adelaide (August 2008) has clearly demonstrated how wide the possible applications of mechanics are. However, the basis for applications must be strong and in this sense mechanics is also progressing extremely well. The multiscale modelling, the notion of internal variables, the specific theories for describing the behaviour of complex materials, the enhanced theories for understanding turbulent and diffusive processes, etc – this is just a short list of important new results.

Estonia is a small country, but during the last century mechanics and related fields have progressed well thanks to founding fathers O. Maddisson, H. Laul, N. Alumäe and to their contemporary followers. One of the traditions in this field is to call every three years the Estonian Days of Mechanics, where experienced researchers meet younger generation and recent results are discussed. In 2008, the XIII Estonian Days of Mechanics were organized (September 15–16) at the Estonian Academy of Sciences. Altogether 24 talks were given with more than one third from the younger generation, most of research centres from Tallinn and Tartu were represented. Below a brief summary of talks and discussions is given.

Marine research is an important field in Estonia. The mechanics of floods and of emergence of extreme waves were described by T. Soomere. In recent years

much has been done for remote sensing, which explicitly shows the quality of our waters (T. Kutser). The mathematical modelling of eco-systems over many scales has resulted in a series of program packages that can be used for the prediction of the life-span and intensity of several species in the sea (R. Tamsalu). The problems on the sea were illustrated by V. Mäss, who gave an overview of sunken ships in the Baltic. Leaving aside wars, the reason for such disasters is often related to ignoring simple rules of mechanics. The best example from our neighbourhood is the famous battleship *Vasa*, which was built following the orders of an ignorant ruler and sunk immediately on her maiden voyage.

In solid mechanics, the problems of residual stresses and machine design were discussed. The experimental technique designed in the Institute of Cybernetics at TUT for determining the residual stresses in glass plates using scattered light is an excellent example of applications (A. Errapart). J. Majak described several optimized machine elements, which have led to direct applications. From the theoretical side, J. Lellep and his young co-workers presented several optimized projects of shells and plates with and without cracks. Residual stresses in galvanized thin layers were studied by A. Lille. M. Heinloo has analysed virtually the working processes of agricultural machines and I. Talvik described dynamical models of cable structures and their possible limit situations.

An important new field in solid mechanics is the proper modelling of microstructured materials. Several new results, related to the analysis of wave motion in such materials, were presented (M. Randrüüt, L. Ilison, K. Tamm, T. Peets). An interesting and very practical problem is the dynamics of piano hammers (made of felt) and their interaction with strings (D. Kartofelev). Dealing with such materials, the determination of their material properties is a prerequisite to proper modelling and optimal design of complex materials. The algorithms for the non-destructive evaluation of materials were described by A. Ravasoo while J. Janno has solved several inverse problems with the needed mathematical correctness.

The focal point of the Days of Mechanics over the last decade is the Alumäe lecture. This lecture bears the name of N. Alumäe, “the Grand Old Man” of mechanics in Estonia and the initiator of the Days of Mechanics. The lecturers are selected by the Estonian National Committee for Mechanics and this year the choice was J. Kalda, who has intensively studied turbulence over many years. His talk “Turbulent mixing as a generator of complexity” can be summarized as follows. The progress in understanding the turbulent mixing has been slow, because of the geometrical complexity of the emerging structures and because the behaviour of the flow is very sensitive with respect to specific conditions. Three most important mixing regimes are mixing in compressible velocity fields, mixing in smooth velocity fields and mixing in fully developed turbulent flows. In the latter case, tracer density field becomes everywhere discontinuous and is characterized by anomalous scaling of structure functions. A simple one-dimensional model, reproducing such a behaviour, is described. Based on that model, it is concluded that the very strong intermittency of the tracer fields is

created by stochastic synchronization of dynamical processes at different scales. These results are without any doubt at the frontier of science.

To sum up, the talks explicitly demonstrated our strength in solid and fluid mechanics: hydrodynamics, mechanics of microstructured materials, experimental mechanics, design of machine elements and optimization. Characteristically, sound theoretical basis is a prerequisite to applications. This was explained by J. Engelbrecht who compared the talks at ICTAM 2008 in Adelaide and our results. Beside the papers in leading journals many results are reflected also in special issues of Estonian journals [¹⁻⁶]. In addition, two monographs [^{7,8}] were recently published.

In three years we would like to make the Days of Mechanics more visible and invite also more engineers to participate and talk about their ideas and applications.

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Järjekordne ülevaade Eesti mehaanikast

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On antud ülevaade Tallinnas 15.–16. septembrini toimunud 13. Eesti mehaanika päevadel esitatud ettekannetest. Akadeemik Nikolai Alumäe mälestusloengu teemal “Turbulentse segunemise keerukuse generaator” pidas TTÜ Küberneetika Instituudi juhtivteadur Jaan Kalda. Kirjanduse loetelus on ära toodud Eesti Teaduste Akadeemia Toimetiste seerias *Engineering* ja ajakirjas *Estonian Journal of Engineering* viimastel aastatel ilmunud mehaanikale pühendatud erinumbrite loetelu.