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Journal of Applied Mathematics and Mechanics 70 (2006) 1–3
Journal of APPLIED MATHEMATICS AND MECHANICS
www.elsevier.com/locate/jappmathmech

Editorial

Vasilii Zakharovich Vlasov On the Centenary of his Birth☆

Vasilii Zakharovich Vlasov, the eminent scientist, has passed into the history of science as the originator of new scientific specializations in the mechanics of deformable media and in structural mechanics. He founded a unique international scientific school of structural mechanics, shell mechanics and the mechanics of thin-walled structures and systems, attended by his numerous students and followers – scientists and engineers from various countries throughout the world. He and his school obtained classic results that, over half a century later, remain the focus of attention of researchers and founders of new technology – in the building industry, in the aircraft industry, in rocket design, in surface and submarine shipbuilding, in the nuclear power industry, etc.

☆ *Prikl. Mat. Mekh.* Vol. 70, No. 1, pp. 3–5, 2006.

doi:10.1016/j.jappmathmech.2006.03.016

V. Z. Vlasov was born on 24 February 1906 in the village of Kareyevo in the Tarusskii district of Kaluga Province. In 1930, having graduated from the Higher Construction Engineering School (later renamed the Moscow Construction Engineering Institute), he began to teach Construction Engineering there and in the V. V. Kuibyshev Military Engineering Academy. Then he began research work at the All-Union Institute of Constructions, and from 1946 he headed the Department of Structural Mechanics of the USSR Academy of Sciences Institute of Mechanics. In 1953 he was elected a Corresponding Member of the USSR Academy of Sciences.

In 1937, for his work on the structural mechanics of shells, which he presented as a first postgraduate degree dissertation, he gained a doctorate in technical sciences. At the same time, the Committee on Matters of Higher Education at the Council of People's Commissars of the USSR made him a professor.

In his brilliant dissertation work, by combining very effectively methods of the mathematical theory of elasticity and structural mechanics, and introducing certain geometrical and mechanical hypotheses, he developed several versions of applied theories for analysing cylindrical shells of arbitrary cross-section. Here, for the first time, along with the classic hypothesis of undeformable normals, in various combinations, longitudinal bending moments, torques, transverse elongation strains, and middle surface shear strains were neglected. This opened up ways of constructing various mechanical models that were convenient for simple analytical study. He modelled an isotropic cylindrical shell as an orthotropic shell with prescribed properties, ensuring momentlessness in the longitudinal direction and moment stiffness in the transverse direction; thus, for the first time, the semi-momentless theory of cylindrical shells or the theory of cylindrical smooth and folded shells and systems of medium length was formulated. The proposed theory was used on a wide scale and formed the basis of numerous engineering developments.

In the spirit of this research, he developed a theory, unique in its completeness and elegance, for analysing thin-walled rods of open profile taking into account the effect of cross-sectional warping, which made it possible correctly to determine the stress–strain state of a rod under complex loading, and to find the critical loads in the case of a flexural-torsional form of stability loss, and also values of the frequencies of flexural and torsional vibrations of the rod. The results obtained were extended to the case of thin-walled curvilinear rods (plane and three-dimensional), the theory of rods/shells of closed profile was constructed, making allowance for shear strains, and the problems of dynamic stability and the determination of temperature stresses were examined. The results obtained in this area were included in Vlasov's classic monograph *Thin-Walled Elastic Rods*, which was translated into many languages and in 1941 was awarded the first-degree Stalin Prize.

He obtained important and fine results in the momentless theory of shells of revolution, traced along arbitrarily prescribed second-order surfaces. He was the first to demonstrate that shells of revolution of positive and negative Gaussian curvature differ fundamentally in their mechanical behaviour. In the case of shells of positive Gaussian curvature, the solution of the problem by the momentless theory reduces to elliptic equations, and for any boundary-value problem a unique solution is obtained. For shells of negative Gaussian curvature, the main differential equation will be a hyperbolic equation, which is known to have a non-unique solution. Essentially, from the viewpoint of the momentless theory of shells, on the one hand we have here a geometrically unalterable system, and on the other hand we have a thin-walled instantly changing three-dimensional system. Thus, he demonstrated that the momentless theory of shells can be used unconditionally only to analyse shells of positive Gaussian curvature, and in the case of shells of negative Gaussian curvature it is acceptable only in exceptional cases.

The results obtained, which have become classic in the general shell theory, are very important for a correct estimation of the limits of applicability of the momentless theory of shells of revolution and certain types of shell of a different class.

Problems of the general thin shell theory undoubtedly occupy an important place in his research. The results obtained in this area were set out in his well-known monograph *The General Shell Theory*, which, together with his other monograph *The Structural Mechanics of Thin-walled Three-Dimensional Systems*, was awarded the Stalin Prize in 1950.

A version of the shell theory that he proposed, called the technical shell theory, and occasionally the shallow shell theory, based both on well-known assumptions concerning the approximate representation of changes in curvature of the middle surface and on simplifications of the first two equilibrium equations, was supplemented with the original suggestion of the possibility of neglecting, in the principal equations, small terms with factors of Gaussian curvature of the middle surface of the shell. In this formulation, the analysis of a shell of arbitrary shape reduces to solving a very compact and clear system of two differential equations in the required functions of stresses and normal displacement, which, in the special case where the curvatures of the middle surface of the shells are zero, are harmonic equations of the plane problem and the problem of transverse bending of a plate.

This version of the shell theory has been widely employed due to its compactness, clarity, and universality. In particular, such an approach can be used correctly and effectively to solve problems of shallow shells of arbitrary shape, open and closed cylindrical shells of certain length, the simple edge effect, local stability, etc. The theory became irreplaceable when considering non-linear problems of the shell theory, in the study of the supercritical behaviour of shells and in the analysis of linear and non-linear vibrations and the dynamic stability of a certain class of shells.

In the technical shell theory that he proposed, very shallow shells occupy a special place. Assuming that the internal geometry of the middle surface differs little from the Euclidean geometry, i.e. assuming roughly that the coefficients of quadratic form and curvature of the middle surface of the shell behave as constants during differentiation, he constructed a very compact and extremely simplified shell theory that has been widely used in almost all areas of engineering – from instrument making to rocket design. This theory, nominally called the theory of very shallow shells, can also be used to design shells with a high variability index, to construct a simple edge effect, to solve problems of local stability, etc.

He obtained extremely important results in the applied theory of elasticity. The variational method he proposed for the correct solution of a number of problems of elasticity theory, termed the method of reduction to ordinary differential equations, differs from existing variational methods in that, instead of the required coefficients, sought functions are introduced that are determined by linear differential equations. The new method was applied successfully to solve a wide range of problems of elasticity theory. The method of initial functions that he proposed had something in common with his variational method. This is well known to comprise a generalization of the method of initial parameters and provides new scope for solving three-dimensional problems of elasticity theory.

The above account does not even begin to cover the enormous contribution he made to science – to structural mechanics, to elasticity theory, to the strength of materials, and to mechanical engineering as a whole. His ideas and methods for investigating the most complex problems of the mechanics of deformable bodies and the elements of structures are unique and can be characterized as a symbiosis of mathematics, elasticity theory, and structural mechanics. His clear and transparent engineering intuition and his rigorous mathematical brain, which were flawless, led him to outstanding results.

Vasilii Zakharovich Vlasov died on 7 August 1958. He was 52 years old, and left a vast scientific legacy in world science. His talent was not superficial. This native of Russia, who brought glory to Russian science, had a God-given talent. Many generations of scientists and engineers will use his results in their work.

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Translated by P.S.C.