Pergamon
J. Appl. Maths Mechs, Vol. 62, No. 6, pp. 981–983, 1998

PII: S0021–8928(98)00127-0
0021–8928/98/$—see front matter

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The death has been announced of A. A. Il'yushin—an outstanding Russian scientist whose ideas and achievements have made a substantial contribution to the development of mechanics of deformable media.

The main landmarks in Il'yushin's life are as follows. A. A. Il'yushin was born in Kazan, where he attended middle school. He was a student at the Physics and Mathematics faculty of Kazan University and in 1930 transferred to the Physics and Mathematics Faculty of Moscow University, where he specialized in aerodynamics, graduating in 1934. He then became a research student at the Institute of Mechanics at Moscow State University. In January 1937 he defended his candidate dissertation, and in October 1938 his doctoral thesis in physics and mathematics. In 1938 he was made a professor, and from 1942 to the last days of his life he as Head of the Department of Elasticity at Moscow State University. In 1943 he was appointed a corresponding member of the USSR Academy of Sciences and in 1947 he became a full member of the Academy of Artillery Sciences. From 1950 to 1952 he was Rector of Leningrad University, and between 1953 and 1960 he was Director of the Institute of Mechanics of the USSR Academy of Sciences. Il'yushin wrote about the important events of his career up to the 1960s in an article entitled "Dynamics" (Vestnik Mosk. Univ. Series 1. Mathematics. Mechanics. 1994, No. 3). This noteworthy essay is embued with the sadness and delicate humour of a man who has gained wisdom from his life and experiences.

Il'yushin's scientific legacy is large and multifaceted. His major contribution to mechanics, in his own view, was his research on plasticity, in the most general sense of that term. The main stages reached in that scientific quest were the theory of small elastoplastic deformations (in the 1940s), the general mathematical theory of plasticity (1950s and 1960s), the theory of elastoplastic processes and the thermodynamics of a continuum with measures of irreversibility and damage (1970s and 1980s).

His work on the theory of small elastoplastic deformations (the theory of plasticity under simple loading) was motivated by the dearth of shells available to the Red Army towards the end of 1941. The lack of high-quality, highly elastic steels resulted in an urgent need to replace them with low-elasticity materials. This major change demanded theoretical justification and engineering intuition. Il'yushin revised the calculation of the strength of artillery shells by the methods of the theory of elasticity, and of the standards that they had to meet with regard to residual plastic deformation, which were available

†*Prikl. Mat. Mekh.* Vol. 62, No. 6, pp. 1058–1060, 1998.

for high-quality steels only. His theory of small elastoplastic deformations was confirmed experimentally for simple loading, particularly under practical conditions of the use of shells and for those which produced a proportional change in all stresses. Once the calculations had confirmed that shells made of the available low-elasticity materials were strong enough, they were put into mass production. The theory involved no time parameters, was easy to apply in practice, and had been rigorously proved by the theorems on "simple loading" and "unloading", which established the sufficient conditions of simple loading at each point of a body and made it possible to find the residual strains.

The series of studies on plasticity under simple loading with application to the stability of plates and shells beyond the elastic limit was awarded a Stalin Prize of the First Class. That research was the basis of the monograph "Plasticity" (1948), a handbook for researchers and engineers that is still used today.

Developing the theory of plasticity for arbitrary complex loading processes involved generalizing existing concepts of the continuum mechanics. Il'yushin introduced special five-dimensional vector spaces of the deviator components of stresses and strains in which the complexity of the loading and deformation processes was represented by the internal geometry of the corresponding curves. The results of experimental studies were interpreted geometrically in terms of the connectedness of the internal structure of the curves, thus enabling the isotropy postulate and the delay principle to be formulated. The complicated functional relations were classified according to the values of the curvature of the deformation trajectories and the range of applicability of particular versions of the general theory of plasticity (the theories of flow and small elastoplastic deformations) were indicated.

The fundamentally new testing machine for complex loading (CL) designed under Il'yushin's direction, was widely used in various modifications. Later, Il'yushin was to fulfill his idea of a "CL-computer", which combined experimental and theoretical methods of determining the stresses and strains in structures in cases where the equations of state of the material were not known in advance. Il'yushin wrote about the work done during this period in his monograph "Plasticity" (1963) and in a number of papers.

At the end of the 1930s, Il'yushin became interested in the processes of forming (viscoplastic flows, the technology of pressure treatment and creep). He developed a general theory of "stress-strain" relations, devised some problem-solving techniques, investigated heat liberation, formulated and proved the principle of the minimum power of the work of viscoplastic forces, and introduced the concept of the stability of viscoplastic flow used in the creep theory. The creation of "rigid zones" during the flow of viscoplastic fluids was predicted theoretically and confirmed by experiment. These results were used in the oil industry to calculate and predict the behaviour of ground masses and mortars.

During the 1950s he formulated in a general form the problem of the plastic flow at metal forming. This allowed for the influence of the rate and degree of deformation, variable temperature fields and the possibility of "rigid zones" occurring. He introduced a special variational principle. He investigated the conditions of similarity of plastic flows and formulated modelling laws. He established an analogy with the theory of small elastoplastic deformations. He developed the theory of the flow of thin layers of a metal over the tool surfaces which was applied to the analysis and choice of the technology of thin-sheet rolling, punching and pressing of ribbed panels.

He made an important contribution to the study of the dynamic interaction of deformable bodies and media. During the 1950s he studied the interaction of waves generated by an explosion and of elastoplastic structures and massifs, developed methods of modelling these phenomena, and designed a linear accelerator to investigate the effect of powerful explosions on obstacles as well as the ejection parameters. It was at this time that Il'yushin also applied the law of plane sections to the flow past bodies at high supersonic velocities. One consequence of this was the affine model method, by means of which it was possible to obtain an information on the flow past bodies at high velocities in experiments at considerably lower velocities. Another consequence was the formulation of the problem of aeroelastic oscillations of plates, and the construction of the theory of panel flutter in particular. Il'yushin extended the theory of plane sections to plastic media, opening up new possibilities in the study of the high-speed injection and penetration of solids.

Much of his work concerned the mechanics of viscoelastic materials. For thirty years, starting in 1964, he was the scientific director and consultant for experimental and theoretical research on the strength of solid propellant grains. He constructed non-linear versions of the theory of thermo-viscoelaticity, developed mathematical models of he long-term strength and failure of solid propellant charges and jet-engine cases, introduced the damage tensor and damage measures, and explored the role of couple stresses. He devised effective methods of calculating the strength of charges on the basis of the "simple loading and heating" theorems, using the "method of approximations" to calculate inverse Laplace–Carson transformations. These results were included in the publication, under his direction, of the strength code for solid propellants and reference manuals for designers.

During the latter years of his life Il'yushin spent a great deal of time on the thermodynamics of irreversible processes, studying the closure of the system of equations of a continuum, based on an analysis of the general functional form of the equation of state and a general formulation of elasticity problems in distortions.

The depth and breadth of his talents were noted in 1943, by Academician Leibenzon: "He is a happy combination of the acute theoretician, elegant designer and skilful experimenter, which permeates the very essence of the technical problems that he investigates. He has the art of expressing the phenomena of nature in mathematical symbols."

In additional to the researches already mentioned, Il'yushin carried out many specific investigations in various spheres of industry, including tank construction and nuclear-power and space engineering, in particular. He advised on ways of strengthening steam-generator collectors in nuclear power plants, thereby improving their lifetime. Many of his suggestions have been taken up by design offices and industrial enterprises. For his service to the development of science and technology, he was awarded the Order of Lenin, the Order of the Red Banner of Labour (three times), the Order of the Red Star, two "Badges of Honour" and the Order of the October Revolution, as well as many medals.

He was the Head of the Department of Elasticity of Moscow University for 56 years. His unusual and interesting lectures were distinguished by a depth of thought and wealth of ideas, were clear and emotional in execution, and left an indelible impression on his audience. He wrote outstanding courses on the strength of materials (published in 1958 and translated in the USA, China and Poland), the theory of elasticity and plasticity, and the mechanics of continuum (the last edition appeared in 1990). Many new ideas crystallized out of the seminars of the department that he directed as reader, in the best and most noble sense of the word, and the generations of researchers that emerged now form a remarkable school of strength mechanics.

A. A. Il'yushin's creative career and his life as a citizen offer a shining example of service to science in the name of truth and for the good of one's country. His memory will endure in the minds and hearts of his colleagues, students and successors.

Translated by R.L.