Preface to the special issue on material instabilities and micromechanics – Energy methods, instabilities, microstructures and thermodynamics of dissipative solids

In honour of Professor Henryk Petryk on the occasion of his 70th Birthday

Henryk Petryk

In July 2020, Professor Henryk Petryk was celebrating his 70th birthday. Our intention was to honour him by organizing a special session within the 42nd Solid Mechanics Conference (SolMech 2020) that was organized for September 2020. Unfortunately, the conference was cancelled due to the COVID pandemic. Selected papers planned for this session appear now in this Special Issue of the International Journal of Solids and Structures to celebrate the scientific achievements of Henryk Petryk. These contributions address fundamental aspects of material instabilities and micromechanics.

Henryk graduated from the Warsaw University of Technology (Politechnika Warszawska), Department of Mechanics and Technology in 1974. He then decided to pursue a scientific career and enrolled to the PhD school at the Institute of Fundamental Technological Research (IPPT), Polish Academy of Sciences in Warsaw. Since 1974 till now, he

has been associated with that institution. It is also since 1974 that Henryk has been married to Ewa, with whom he has three children.

From a young age, Henryk has always been a brilliant thinker and two facts from an early stage of his life perfectly match our image of Henryk as a scientist. First, as a student of a secondary school, he received a bronze medal at the International Mathematical Olympiad in 1968 in Moscow. Second, he was a chess player, reaching the category of national master in 1980 and the FIDE rating of 2370.

In 1978 Henryk defended his PhD thesis supervised by Wojciech Szczepiński. Henryk's PhD thesis and his early research activity were concerned with the problem of a steady-state flow of a rigid–perfectly plastic material with a free boundary, a problem encountered in oblique indentation of a wedge or rolling over a rigid–plastic half-space. Slip-line field analysis was carried out to solve these problems, however, this classical approach turned to deliver a non-trivial result, namely that infinitely many solutions exist for given boundary conditions. The problem of non-uniqueness of solutions in plasticity and related problems became and remained one of his leading research interests in the following years.

After the PhD period, Henryk started to work on the problems of stability and bifurcation in rate-independent elastoplastic solids. This is the topic where he gave several fundamental results that contributed to his wide recognition in the scientific community. Following this line of research, Henryk published a number of cornerstone contributions where he examined stability conditions and the corresponding energy criteria, as well as post-critical deformation of elastoplastic solids, in particular, considering incrementally nonlinear response and material heterogeneity. The general and powerful approach of incremental energy minimization developed by him has become very popular during the last three decades in the communities of mechanicians and applied mathematicians working on the mechanics of dissipative solids. The most recent related contribution by Henryk is that published in 2020 in JMPS. In this paper, he formulated a quasi-extremal energy principle that is valid for a general class of rate-independent elastoplastic solids

without assuming the normality flow rule or symmetry of the tangent stiffness matrix, thus removing the inherent requirement of symmetry of the original incremental energy minimization framework.

The mentioned series of publications on plastic instability comprises more than 30 papers, most of them single-authored. The series includes also several joint papers with Klaus Thermann, as a result of a collaboration that started when Henryk received a Humboldt Research Fellowship and spent two years at the Dortmund University, with Klaus Thermann as his academic host. A three-month stay at Ecole Polytechnique in 1990 resulted in a joint work with late Nguyen Quoc Son. Let us note that Nguyen Quoc Son kindly agreed to contribute to this Special Issue and, sadly, passed away soon after his paper was published.

In a natural way, Henryk's early results on plastic instability formed the basis of his habilitation thesis which he defended in 1988. He became full professor in 1995.

In addition to those mentioned above, Henryk's scientific activity involved collaborations with Z. Mróz, F.D. Fischer, A. Bertram, D. Bigoni, and S. Forest, as well as with his younger colleagues and students at IPPT, including K. Kowalczyk-Gajewska, R. Kiryk, M. Kursa, M. Ryś, and S. Stupkiewicz. These contributions include a generalization of time differentiation and spatial averaging rules for materials with moving boundaries and interfaces, analysis of divergence and flutter instabilities in elastoplastic materials, extremal principles in non-equilibrium thermodynamics, modelling of laminated microstructures in shape memory alloys, and micromechanical modelling of elastoplastic and viscoelastic heterogeneous materials. The concepts of incremental energy minimization were employed in a novel approach to the long-standing problem of selection of active slip systems and deformation banding in rate-independent crystal plasticity. An extension of the incremental energy minimization approach was also developed to model evolution of martensitic microstructures with account for the energy of interfaces and thus to predict the corresponding size effects. Size effects in plasticity were a motivation of the recent research concerned with development of a new class of gradient-enhanced crystal plasticity models with a natural length scale.

As a confirmation of his high reputation in the Polish and international mechanics community, Henryk has received a number of honours and awards. He was awarded the Mercator Professor fellowship in Germany (2001) and was elected a member of EUROMECH Council (2007–2012), a corresponding member of the Polish Academy of Sciences (2010), and the Secretary-General of IUTAM (2016–2020, 2020–2024), to mention just a few. Since 1999, he serves as the Editor-in-Chief of Archives of Mechanics, an international journal published since 1949.

Throughout the years of his scientific career, Henryk proved to be an exceptional scientist able to combine mathematical rigour with deep mechanical insight, all supplemented by a passion for science and dedication to hard work. All colleagues and friends who have the privilege of collaborating and interacting with him, consider Henryk a source of inspiration and a shining example of scientific integrity. They look forward to continue collaborations for many years to come.

On the occasion of the 70th birthday of Professor Henryk Petryk, this Special Issue of IJSS gathers 16 articles written by his friends and colleagues. The topics of the papers are centred around his research interests and scientific achievements, specifically, energy methods, instabilities, microstructures, and thermodynamics of dissipative solids.

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