Proposals for cooperation
of Theoretical Mechanics department of NTU «KhPI»

Theoretical mechanics

Head of the department:

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Research directions:

- Continuum mechanics
- Electromechanics
- Computational mechanics and nonlinear dynamics of rigid body systems
- Plates and shell theories
- Temperature and radiation induced creep
- Anisotropic creep and damage

Research group

Prof. Morachkovsky O.K.

Ph.d. Lavinsky D.V.

Ph.d. Lvov I.G.

Major scientific results

Researchers of the theoretical mechanics department took part in the following projects:

- Innovative nondestructive testing and advanced composite repair of pipelines with volumetric surface defects (“Innopipes”), 7th Framework Program Marie Curie Actions

Software development:

During the educational process as well as for research needs scientific co-workers use self made software complex KiDym, designed as multitask tool for solving kinematics, statics and dynamics problems.

Major scientific results

Various scientific results of the department have been published in multiple rated journals. Published work include:

Altenbach, H.,Morachkovsky, O.,Naumenko, K.,Lavinsky, D. Inelastic deformation of conductive bodies in electromagnetic fields., Continuum Mechanics and Thermodynamics (2016)

Breslavskii, D.V., Metelev, V.A., Morachkovskii, O.K. Anisotropic creep and damage in structural elements under cyclic loading ., Strength of Materials (2015)

Lvov, I., Altenbach, H., Naumenko, K. Homogenization approach in analysis of creep behavior in multipass weld., Materials Science and Technology (2014)

Breslavsky, D., Morachkovsky, O., Tatarinova O. Creep and damage in shells of revolution under cyclic loading and heating., International Journal of Non-Linear Mechanics (2014)

Bondar, S., Lavinsky, D. Study of thermoelastoplastic contact deformation of production tooling mixed structures., Strength of Materials (2011)

Altenbach, H., Kolarow, G., Morachkovsky, O., Naumenko, K., On the accuracy of creep-damage predictions in thin-walled structures using the finite element method., Computational Mechanics (2000)

Proposal for cooperation:

The creation of theories, analysis methods and software to study inelastic deformation of systems of bodies under the action of fields of different physical nature

There is a practical need for the mathematical formulation of problems of non-isothermal elastic-plastic deformation of bodies under the influence of external electromagnetic fields, taking into account the mutual influence of fields of different nature in a wide ranges of temperature, and taking into account the nonlinearity of electromagnetic, thermal, and mechanical properties o f materials.

Electromagnetic field is an integral part of work for many elements of structures and machines. They include elements of power equipment, power conversion system (transformers, generators), devices designed to protect against lightning and electromechanical energy converters. High-intensity electromagnetic-fields cause substantial energy levels in electro-conductive bodies, which can lead to failure. Therefore, approaches to determine stress–strain states of electro-conductive bodies are required to estimate the strength.

Practical significance

The developed facilities can be used:

- in the creation of devices for electromagnetic metal forming of conductive materials.

- in the creation of devices for the electromagnetic compacting of powder materials

Electromagnetic metal forming is a dynamic, high-strain-rate forming method. In this process, deformation of the workpiece is driven by the interaction of a current generated in the workpiece with a magnetic field generated by an inductor adjacent to the workpiece. In particular, the interaction of these two fields results in a material body force, i.e., the electromagnetic force, representing an additional supply of momentum to the material resulting in deformation. Electromagnetic metal forming is one of a number of high-deformation-rate forming methods which offer certain advantages over other forming methods such as increase in formability for certain kinds of materials, reduction in wrinkling, and the ability to combine forming and assembly operations.

Proposal for cooperation

- **Anisotropic creep damage in composite materials**

Because of its microscopic nature damage has, in general, an anisotropic character even if the material is originally isotropic. The orientation of fissures and their length result in an anisotropic macroscopic behavior. It is well known that the creep process of a metal in its tertiary stage and the ensuring creep rupture is accompanied by the formation of microscopic cracks on the grain boundaries and that damage accumulation occurs. In some cases voids are caused by a given stress history and, therefore, they are distributed anisotropically among the grain boundaries. Thus, the mechanical behavior will be anisotropic and it is necessary to consider this kind of anisotropy by introducing appropriately defined anisotropic damage tensors into constitutive equations.

- Describing the creep damage behavior of the composite materials can be done using micro-macro approach.
- Homogenization procedure can be applied to reflect the influence of the microstructure of the composite material to the lifetime prediction of the components.

Proposal for cooperation

- **Structural optimization of composites**

Thanks to the exponential increase of computing resources, the development of numerical tools oriented to structural optimization has been outstanding, reaching now a practical use widespread in industry. Setting the optimization tasks for composite structures can have significant variety. The methods of statistical tests has been used successfully in solving various problems of optimization of composite structures. Such methods are suitable in cases where the determination of the value of the objective function requires the creation of new geometric patterns and solving complicated boundary value problems of mechanics of composites.

- Lifetime of the composite structure can be predicted using a parametric optimization, where the shape of construction is described a priori using a limited number of parameters. Such control variables can be for example the thickness distribution of the structure or the size of structural members.