Proposed topics for research projects 2024/2025 in the *mechanical engineering discipline*

dr hab. inż. Grzegorz Domek, prof. uczelni

1. *Modeling the properties of cleats on timing belts, made in 3D printing technology*

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dr hab. inż. Jacek Jackiewicz

1. *Multi-scale modeling of thermo-mechanical damage development in structural materials with particular emphasis on the micromechanical approach based on the solid mechanics continuum theory*

Methodologies of multiscale modeling, such as concurrent and hierarchical, will be considered. They will constitute the basis for building different bridging methods, such as concurrent and hierarchical.
The (assumed) initial goal of the work is to develop a programming environment based on the already existing computational algorithms for carrying out computer simulations of damage growth and fracture processes in a selected material affected by variable external and internal interactions (inter alia: force and temperature loads, phase-conversions, and reconstruction of the crystal structure).

2. *Design of the leak-before-break protection in industrial pipelines and tanks*

Leak-before-break (LBB) is a term that has been used for decades in a methodology that means that a leak will be discovered before a catastrophic break occurs in service. LBB has been applied to missile casings, gas, and oil pipelines, pressure vessels, nuclear piping, etc.
Piping design codes are based on fatigue design resistance. They have performed relatively well in avoiding fatigue failures. Unfortunately, these design codes have not evolved to require the designer to use methods to prevent stress corrosion cracking, which is the dominant pipe degradation mechanism.
Piping design codes do not traditionally deal with water chemistry influenced by used additives. The impact of weld residual stresses and fabrication procedures on protection against new degradation mechanisms that may develop should also be included during the piping and tank design. The intended goal of the work is to develop Level 2 and Level 3 LBB procedures, which require using a detailed leak-rate code for estimating the postulated leakage size crack and finite element analyses for calculating the allowable moments or stresses. Procedures of the Level 2 and Level 3 LBB are a more advanced form of the Level 1 LBB procedure, which employs a series of simple algebraic equations to predict:

• leakage area for a prescribed leak rate,
• crack-opening displacement,
• crack length, and
• allowable moment, or stress.

3. *Semi-active and active mechanical vibration protection systems*

Semi-active and active systems in torsional vibration damping for crankshafts will be considered. Engine models will be built to analyze the possibility of balancing inertia forces and torques.
Vibration isolation systems deliver the versatility and adaptability of fully-active systems by expending a small amount of energy to change system parameters such as stiffness and damping.

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dr hab. inż. Wiesław Urbaniak, prof. uczelni

1. *Development of a new formula of biodegradable lubricating oil containing layered nanomaterials for the needs of the machinery industry*

The aim: Preparation of a new formula of biodegradable lubricating oil and determining the possibilities of its use. Subject of the dissertation: Replacing lubricants and hydraulic fluids of mineral origin with fluids of biological origin, characterized by similarly good tribological properties, but with a significantly higher level of biodegradability.

2. *The influence of repeated processing on the mechanical characteristics of a new polymer composite containing hexagonal boron nitride*

The aim of the work: Development of a new formula of a biodegradable polymer material containing hexagonal boron nitride and determining its possible applications. *Subject of the dissertation:* Development of a technology for producing an innovative biodegradable material based on a polymer containing selected layered materials. The material produced in this way will have unique properties combining the advantages of polymer materials, such as a simple method of producing products and unique mechanical properties resulting from the use of layered materials. Ultimately, the material developed in this way can be used to produce a filament for 3D printing technology, thus providing wide possibilities of its application.

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