FAKULTA STROJNÍ TUL

Ph.D. Thesis Topics for academic year 2025/2026
Study programme: Machines and Equipment Design

	Ph.D. Thesis Topic	Supervisor	Department
1.	**Vibroinsulation systems of transported objects** **Abstract:** Vibroinsulation systems of the transported objects concern the problem of minimizing the vibrations transmitted to the transported objects or persons in the means of transport. The solution is centered on the structure of the support device, which allows to control the stiffness and damping of the connection of the transported object to the vehicle frame. This requirement is necessary for optimal tuning of the system solved with regard to instantaneous kinematic excitation caused by uneven road. The doctoral thesis will design guiding mechanisms of vibroinsulation system, elastic and damping elements. Simulation of their behavior under operating conditions will be performed and dynamic parameters optimized. The dissertation will also solve the design of the selected vibroinsulation system and the production of its functional sample.	prof. Ing. Lubomír Pešík, CSc.	KST
2.	**Using methods of detection and localization of damage on rolling parts of machinery** Abstract: The Ph.D. thesis will focus on research and study the possibility of using the methods of detection and localization of damage on rolling parts of machinery. These methods are as a tool for more accurate identification of the origin and development of damage on rolling parts leading to the design of appropriate structural modifications. Experimental measurements will be carried out to obtain information describing the emergence and spread of defect and the influence of operating conditions on the identification of wear damage detected in the character of the sensed signal. During your work, you can use software and measurement analysers that are available at the Department of Vehicles and Engines.	doc. Dr. Ing. Elias Tomeh	KVM

3.	**Research and development of an application head** **Abstract:** Research and development of the application head, which will be placed at the end of a robotic arm (or other positioning mechanism). This head's task rests in the application of concrete (or other) building material in the individual layers to create an object. The head's functions and parameters will be based on material needs (a need for additives to be supplied directly into the head, mixing the mixture in the head, temperature control, etc.) and the needs of the construction process itself (flow rate control, flow closing, smoothing and forming of the applied layer, etc.). It will result in a tested functional prototype and a patented solution for the application head. New methods of product design or innovation (e.g. TRIZ, additive technology, etc.) will be applied to design development.	doc. Ing. Radomír Mendřický, Ph.D.	KSA
4.	**Development of a system for contactless digitization of large objects** Abstract: This dissertation aims to develop and implement an advanced system for the non-contact digitization of large-sized objects, with emphasis on the speed and dynamics of 3D point cloud generation. In line with current trends in the field of photogrammetry, the thesis will investigate appropriate strategies for data collection, efficient processing and subsequent evaluation, in addition to research and development of the device in question. One of the key applications will be the ability of the device to perform non-contact deformation analysis of objects that have been fabricated through 3D printing from concrete mixtures.	doc. Ing. Radomír Mendřický, Ph.D.	KSA
5.	**Automation of 3D digitization process of machine parts** Abstract: The subject of the dissertation will be to perform a feasibility study and design of a device for automatic scanning using a contactless 3D scanner or a coordinate measuring machine. The aim will be the design and implementation of a system for automatic manipulation and positioning of the 3D scanner (or work piece) and the method of communication between this device and the software for controlling the scanner. It will also be appropriate to integrate the formed structure of automatic inspection into the autonomous production system of the workplace, which is created in accordance with the Industry 4.0 concept at the KSA department.	doc. Ing. Radomír Mendřický, Ph.D.	KSA
6.	**Development of a 3D scanner for automatic non-contact inspection of the applied layer of concrete mixture** Abstract: Currently, non-contact measurement methods are increasingly used to	doc. Ing. Radomír Mendřický, Ph.D.	KSA

	check the dimensions of 3D objects, e.g. using photogrammetry, laser or optical 3D digitization. In terms of direct on-line monitoring of the 3D printing process of the concrete mixture, no specific application solutions are currently available worldwide. During 3D printing, various serious defects can occur, such as deflection of the printed wall or total collapse of the wall. Not only for this reason, it is necessary to monitor printing, ideally in real time, so that technological and printing parameters can be adjusted in case of deviations from the desired shape. The dissertation will be focused on research in the area of systems for measuring the profile of the printed layer in real time. The main goal will be the development and implementation of a device for automatic non-contact control of a layer of concrete mixture applied by the 3D printing method. The system should be able to monitor and evaluate the dimensional and shape characteristics of the layer in real time and ensure higher safety and quality of 3D printed constructions.		
7.	**Research and development of light constructions made of composite materials** **Abstract:** The aim of the dissertation is to develop knowledge in the design of light constructions made of composite materials consist long prepregged carbon fibers. The aim will be to develop a comprehensive methodology for designing light constructions of more complex shapes in order to achieve the required mechanical properties. In addition to the methodology, a functional sample of a lightweight construction replacing the selected construction of conventional materials will be made. The research will be based on literary review, design, implementation and evaluation of experiments and numerical modeling.	doc. Ing. Petr Lepšík, Ph.D.	KST
8.	**Vision systems for wide range of optical electromagnetic spectrum** A proved methodology currently exists for visible spectrum image acquisition and processing. However, the situation is different when talking about the detection of transparent materials, or environments highly loaded by interfering effects (e.g., parasitic reflections) and noise. There is no comprehensive methodology that includes hardware and software solutions for these problems. There is a strong potential for the development of such a methodology using a wider range of optical spectra - from ultraviolet to infrared electromagnetic radiation. The theoretical part of the course will focus on the issue of image acquisition in a wider range of optical radiation, image analysis, technological scene evaluation and generation of 3D models. The task will also be to implement the vision systems into control systems with the use of industrial buses. During the course, it will be necessary to master the physical principals of acquisition techniques, the methodology and software requirements of image analysis and the basics of wireless	doc. Ing. Vlastimil Hotař, Ph.D.	KSR

	communication. In the practical part, particular tasks of image acquisition and analysis will be addressed for complex imaging and object definition. It will also include the connection with control systems and implementation to robot control. The student's work will focus on the expansion of the application possibilities of machine and robot vision in industrial practice. The student's creativity is expected through the practical solution of a particular task, programming, and the evaluation of experimental results.		
9.	**Collaborative robots for medical rehabilitation application** Interactive robotics is a new trend in mechatronics, providing the possibility of direct contact between robotic effectors and humans. This provides a wide range of new activities in medical applications. The use of robots for medical rehabilitation is one of the main applications. In this context, the use of interactive robots for optimizing the movements and trajectories of rehabilitation devices with respect to patients' biomechanical parameters, is of great interest. It is assumed, that students will gain an overview of safe human-robot interaction systems with respect to biomechanical parameters (limb mobility). In the theoretical part of the course, thorough background research and an analysis of biomechanical parameters with the possibility of 3D trajectory planning will be performed. In the practical part, the possibility of applying IIWA robots, which are available in a laboratory of interactive robotics, will be monitored. IIWA robots will be applied in supporting the rehabilitation of upper limb movement. A special adjustable effector with an elastic contact for gripping the selected arm part will be designed. The whole system will be verified under laboratory conditions. An understanding of the physiological issues and systematical studies will be required from the student. Procedures and results will be consulted with professional medical personnel. A creative and innovative approach to testing and designing the engineered device will be mandatory.	doc. Ing. Marcel Horák, Ph.D.	KSR
10.	**Flexible Robot Effectors for Gripping of Sensitive and Rheological Objects** **Abstract:** The field of interactive robotics is a new phenomenon based on direct contact between robot effectors and humans. In relation to the supporting themes of the Industry 4.0 initiative, HRI robotics is supplemented by appropriate safety parameters in critical system structures. This means that autonomous interactive robots with safe flexible grippers for interactive communication with humans are being implemented. This opens a wide range of themes in effector robotics. One of the main themes is	doc. Ing. Marcel Horák, Ph.D.	KSR

	electric servo-drives for effectors with force, position, and combined control of the gripper – object interaction. Another important theme includes new design principles and materials with controlled toughness for gripper applications. A sperate issue is gripper (effector) flexibility, based on ability to configure the gripping element space. Understanding the mechatronic aspects of drives, sensors, effector design principles and control system communications, as well as systematic studies will be required from the student. The gained theoretical knowledge will be used during the design process of an experimental robotics workplace with flexible effectors for a concrete application.		
11.	**Research of the principle of micro-melting of glass for additive technologies (3D printing from glass)** **Abstract:** The potential of 3D printing from inorganic silica material (glass-type) is very extensive. From industrial applications, through optics, artwork printing, to healthcare. The current state of knowledge of 3D printing from glass does not yet allow extensive research or application deployment. Currently, there are several research directions for obtaining glass products using additive technologies (3D printing). The principle of micro-melting, i.e., obtaining small batches of glass is examined within basic research. As the basic research conducted at the department to-date has shown, the principle of micro-melting is potentially applicable for the creation of objects from glass using additive technologies. The theoretical part of the work will be devoted to the processes of micro-melting using a laser (or other local heat sources) at high speeds. Changes in the properties, composition and volume of the resulting glass, the amounts of gaseous inclusions depending on the composition of the molten substrate, the supplied thermal energy and other melting conditions will be studied. In this part, it will also be necessary to address the possibilities of creating 2D and 3D objects, including performing the necessary experiments. In the experimental part of the work, the theoretical knowledge and proposed possibilities of additive technologies will be verified and modified where required. It will be necessary to design a methodology for the experimental work, build an experimental workplace and perform the experiments. The practical part will focus on the specification of the conditions of the 3D printing technology with the relevant laboratory verification of the selected concept.	doc. Ing. Vlastimil Hotař, Ph.D.	KSR
12.	**Research of glass micro-melting with the formation of sub-microfibers and nanofibers from glass** **Abstract:** The production of sub-microfibers and nanofibers from glass is currently	doc. Ing. Vlastimil Hotař, Ph.D.	KSR

	being intensively investigated. Their properties are of interest in terms of their chemical inertness, relatively high utilization temperatures, but also due to their beneficial optical properties and mechanical strength. As part of the basic research conducted at the department, the principles of obtaining small batches of glass by the micro-melting method are investigated. The micro-melting principle seems to be potentially applicable for the production of sub-microfibers and nanofibers. The theoretical part of the work will be devoted to studying the conditions for obtaining sub-micron and nanostructures in the form of glass fibers. The influence of the composition of the substrate on the micro-melting process and the physical conditions for the formation of the mentioned structures will be studied. The shapes and defects of the resulting structures will also be studied. The main part of the work will be experimental research focused on the design and construction of equipment for performing experiments based on the theoretical knowledge. The development of laboratory equipment will enable the specification of technical conditions and help stabilize the process of generating sub-microfibers and nanofibers through the performed experiments. The practical part will focus on the design of equipment for the production of sub-microfibers and nanofibers, including verification of the functionality of key parts of the equipment.		
13.	**Diagnostics and modelling of cyclically loaded machine parts from hybrid composite structure** The failure-free operation of machines is based on the reliability of their individual components. Monitoring their condition can predict the necessary maintenance and their residual life. The monitoring process can ensure design safety and cost-effectiveness in preventive maintenance and planning of larger-scale repairs. Many components are exposed to cyclic stress and thus to the possible formation of fatigue cracks in the material. The problem at present is diagnostics and modelling of dynamically stressed machine components, which are made of lightweight materials mainly from composite structures and especially hybrid structures (combinations of two or more reinforcement elements, e.g. carbon and glass fibres, glass and basalt fibres, aramid and waste fibres, inorganic and organic). Dimensioning of composite machine components in the field of time strength and study of crack development are typical examples, where monitoring of their loads and exceeding of limit loads play a key role for their safe function. The aim of the thesis is to describe and study fatigue fracture monitoring of selected composite machine parts in cyclic stress. As part of	doc. Ing.Michal Petrů, Ph.D.	KST

	the dissertation solution, functional samples of machine parts from hybrid composite structure will be manufactured for study and testing. Furthermore, testing equipment with individual sensors will be designed and assembled for the study of mechanical properties within cyclic stress in the Laboratory of Applied Mechanics of KST. Another aim will be to create a mathematical model describing the cyclic stress and fatigue fracture of the tested machine part from a hybrid composite structure for verification of measured data. Most of the practical part of the work will be realized in laboratories of KST, which are well equipped for performing fatigue tests and measurements of mechanical quantities and in computer classrooms where there are adequate software for design and mathematical modeling.		
14.	**Development of light components from composites from refractory polymer matrices for design applications** Lightweight structures and parts made of polymeric composites are designed with low weight for the corresponding mechanical and physical properties. The dissertation will mathematically model and study selected lightweight parts made of polymeric fibre reinforced composites, which have advanced fire-fighting properties and together with selected types of matrices will form a complex composite system. Most polymeric composites are not primarily designed for heat and fire management, which creates a lot of toxic smoke and promotes the spread of fire. This phenomenon can be overcome by introducing additives and an appropriate choice of flame-retardant fibres. Numerous flame-retardant additives such as aluminium trihydrate (Al (OH)3), magnesium hydroxide (Mg (OH)2), ammonium polyphosphate and phosphorus-based additives can be used together with polymers to reduce the spread of fire. The issue of designing and testing fire-retardant components for structural fire-retardant applications is very complex. This is due to the complexity of the physical nature of the process of loading the structure with flame. The problem lies in the combination of multiple heat transfer mechanisms. While heat transfer is mainly conducted in structures at normal temperatures, at high temperatures there is also a significant influence on the radiation transfer side. Another problem is the non-stationary behaviour of materials, because the thermal-insulation properties of materials and the parameters determining these properties are usually reported by manufacturers as temperature-independent constants or at low temperatures, usually at 20 °C. Therefore, it is necessary that these facts are taken into account when designing models by introducing constants more in line with reality and based on experimental measurements. The description and study of such composite lightweight parts in the	doc. Ing.Michal Petrů, Ph.D.	KST

	field of thermal and heat resistance, burn-through studies and breaks in the composite structure are typical examples where monitoring their loads and exceeding the limits from temperature and fire play a key role for their safe functioning. The aim of the work is to build advanced numerical models using mathematical theories for modelling the combustion of lightweight composite parts for the design and construction of parts and components for structural fire-fighting applications. The doctoral student will use advanced mathematical tools and programs such as PyroSim (Fire Dynamics Simulator developed at NIST) or ANSYS, where it can be used to solve the thermal and heat resistance of the Navier-Stokes equation using the Large Eddy Simulation method. The input values will also be based on semi-empirical correlations, Moody diagrams or more sophisticated methods involving the use of Reynolds averaging of the Navier-Stokes equation (RANS) describing the evolution of midpoints.		
15.	**Development of a battery box for electric-powered vehicles from composites reinforced with graphene-filled carbon fibres** It is expected that in 2024 approximately 28% of the total new vehicle market will be electric or hybrid vehicles. The design of powerful and multifunctional battery boxes for storing electric batteries will be one of the important tasks for increasing the efficiency, functionality and lifetime of electric batteries in electric vehicles. The aim of the thesis will be the development of a new concept of lightweight battery box design for storing electric batteries, which should meet the following objectives: low weight, high specific mechanical properties including shock toughness and vibration resistance, effective thermal ratio management, longer life, fire safety, no static charging, corrosion resistance, electromagnetic compatibility, high resistance to penetration of water vapour and water. It is known that most Li-Ion batteries cannot be charged quickly enough below 5 ° C and are inactive at temperatures below 0 ° C. This requires e.g. the possibility of a design solution within the battery box using added heating for heating at low ambient temperatures e.g. Joule with resistive electric heating. High temperatures in Li-Ion batteries can increase thermal ageing and shorten the life of the box structure. Therefore, the aim will be first to carry out a thorough research of existing solutions, to propose various concepts of battery box construction from composites reinforced with graphene-filled carbon fibres, to study graphene particles and to search for possibilities of enhancement of epoxy phase while allowing Joule heating, Comparison with epoxy composites based on graphene and selection of the best variants with regard to composition, size of particle systems and their concentrations, to carry out laboratory preparation and testing of composite structures with experimental evaluation of their electrical conductivity and mechanical	doc. Ing.Michal Petrů, Ph.D.	KST

	properties and to build a numerical model for innovation of battery box design. The result will be a functional sample of the battery box design, which will be tested in TUL laboratories.		
16.	**Research and Development of AC electrospinning device for the production of nanofiber membrane** The topic focuses on the development of a spinning device enabling the continuous production of a flat nanofibrous structure without using a supporting textile. The central part of the work is the development of spinning electrodes with controlled orientation of nanofiber formation and transport of nanofiber material. The design of the electrodes and related elements of the spinning device are derived from the results of the electric field analyses. Part of the work will be the analysis of optimal technological conditions for achieving high production productivity and uniformity of the produced nanofibrous material.	doc. Ing. Jan Valtera, Ph.D.	KTS
17.	**Research and development of a spinning machine for the continuous production of coir yarn** The topic focuses on the development of spinning equipment for the continuous production of yarn from coir fibres as a natural fibre material. Attention will be paid mainly to the development of a high-production spinning unit based on the analysis of events in imparting a twist to the coir fibre material. The work will also include the optimisation of technological parameters to ensure the required productivity and uniformity of the produced yarn.	doc. Ing. Jan Valtera, Ph.D.	KTS
18.	**Integration of artificial intelligence into the TRIZ method in product design** The TRIZ method is a recognized tool for solving innovative tasks. The method is based on the search for successful solving procedures, their generalization and application to one's own specific tasks in the generation of the product concept. With the advent of artificial intelligence (AI), the possibilities of integrating AI into the TRIZ method and achieving a synergistic effect in the search for suitable conceptual solutions for a new or innovative product are expanding. The goal of the work will be to create a methodology based on the integration of AI tools into the TRIZ method. The methodology will be applied to its own complex solution, which will be a faster and more effective solution than with the isolated use of the TRIZ method.	doc. Ing. Petr Lepšík, Ph.D.	KST