FAKULTA STROJNÍ TUL

Ph.D. Thesis Topics for academic year 2023/2024
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**	doc. Ing. Radomír	KSA

	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.	Mendřický, Ph.D.	
4.	**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
5.	**Research of thermo-acoustic cooling device** The aim of the study is theoretical description (on high level) of the thermo-acoustic device which could be possibly used for cooling of microelectronics, design of experimental arrangement with possibility of changing basic parameters, suggestion of experimental approaches and preparation of experiments, implementation and evaluation of experiments and analyses of results with numerical calculations.	prof. Ing. Tomáš Vít, Ph.D.	KEZ
6.	**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	doc. Ing. Vlastimil Hotař, Ph.D.	KSR

	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 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.		
7.	**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.	doc. Ing. Marcel Horák, Ph.D.	KSR

	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.		
8.	**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 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.	doc. Ing. Marcel Horák, Ph.D.	KSR
9.	**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-	doc. Ing. Vlastimil Hotař, Ph.D.	KSR

	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.		
10.	**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 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.	doc. Ing. Vlastimil Hotař, Ph.D.	KSR

	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.		
11.	**Development and optimization of 3D printing from glass using cured suspension materials** **Abstract:** The potential of 3D printing from materials such as glass is very extensive. From industrial applications, through optics, artwork printing, to healthcare. The current state of knowledge and research of 3D printing from glass does not yet allow for application deployment on a large scale. Currently, there are several research directions for obtaining glass products using additive technologies (3D printing). One of them is the use of suspension materials and the technologies of stereolithography (SLA) and digital light processing (DLP). Based on an in-depth search of the current state of knowledge in this area, the aim of the dissertation will be to perform research activities aimed at identifying, specifying, and optimizing the conditions of additive technologies for curing suspension materials (SLA, DLP), which will enable glass products. The theoretical part of the work will focus on the study of the properties of suspension materials (polymers, composition and particle size of glass impurities and other components) and printing conditions. The aim will also be to study the principles and describe the mechanisms applied in the removal of	doc. Ing. Vlastimil Hotař, Ph.D.	KSR

	the polymer part (de-binding) and the process of sintering the material. In the experimental part of the work, the theoretical assumptions will be verified and possibly modified based on the results. The practical part will focus on the optimization of technological parameters of printing and the transfer of knowledge into industrial practice.		
12.	**Research of cooling of microelectronics systems** Increase of cooling intensity of microelectronics becomes one of the most important topics in the field of design of portable consumer electronics devices Usage of conventional cooling systems as standard fans in microelectronics is extremely disadvantageous. It is therefore necessary to find new physical principles to design miniaturized air mover systems. Most promising are cooling systems based on Ion Wind Synthetic Jets technologies. The aim of this work is to summarize current knowledge and modern techniques in the field of cooling of microelectronic systems, develop appropriate physical models, and design an algorithm for the numerical simulation of cooling processes in microelectronics.	doc. Ing. Petra Dančová, Ph.D.	KEZ
13.	**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 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	doc. Ing. Radomír Mendřický, Ph.D.	KSA

	dimensional and shape characteristics of the layer in real time and ensure higher safety and quality of 3D printed constructions.		