TALLINNA TEHNIKAÜLIKOOL

MASINAEHITUSE INSTITUUT
Department of Machinery

TEADUS- JA ARENDUSTEGEVUSE AASTAARUANNE

2014

TALLINN
2015

1. INSTITUUDI STRUKTUUR

Instituudi direktor dots. Kristo Karjust

- Autotehnika õppetool, Chair of Automotive Engineering, prof. Jüri Lavrentjev
- Tootmissüsteemide õppetool, Chair of Manufacturing Systems, prof. Jüri Riives
- Tootearenduse õppetool, Chair of Product Development, prof. Martin Eerme
- Tootmistehnika õppetool, Chair of Production Engineering, prof. Tauno Otto
- Disaini õppetool, Chair of Design, prof. Martin Pärn

Tabel 1 – ME Instituudi töötajad 31.12.2013 seisuga

Jrk	Perekonnanimi	Eesnimi	nimetus	Hõive	**Õppetool**
1	**Auriemma**	Fabio	teadur	1	Autotehnika õppetool
2	**Eerme**	Martin	professor	1	Tootearenduse õppetool
3	**Hermaste**	Aigar	lektor	1	Tootmistehnika õppetool
4	**Herranen**	Henrik	nooremteadur	1	Tootearenduse õppetool
5	**Karaulova**	Tatjana	teadur	1	Tootmistehnika õppetool
6	**Karjust**	Kristo	dotsent, direktor	0,75	Tootmistehnika õppetool
7	**Kirs**	Maarjus	nooremteadur	0,5	Tootearenduse õppetool
8	**Kukuškin**	Merili	assistent	0,5	Tootmissüsteemide õppetool
9	**Kulbas**	Ruth	sekretär	1	Tehniline töötaja
10	**Kõiv**	Risto	lektor	0,5	Autotehnika õppetool
11	**Kõrgesaar**	Kristjan	insener	0,5	Tehniline töötaja
12	**Lavrentjev**	Jüri	professor	1	Autotehnika õppetool
13	**Lemmik**	Rivo	insener	0,5	Tehniline töötaja
14	**Lend**	Henri	nooremteadur	0,5	Tootearenduse õppetool
15	**Luppin**	Janek	lektor	0,75	Autotehnika õppetool
16	**Majak**	Jüri	juhtivteadur	1	Tootmistehnika õppetool
17	**McGroy**	Peter	külalisprofessor	0,5	Disaini õppetool
18	**Melioranski**	Ruth-Helene	teadur	0,25	Disaini õppetool
19	**Napp**	Andres	tehnik	1	Tehniline töötaja
20	**Otto**	Tauno	professor	1	Tootmistehnika õppetool
21	**Paavel**	Marko	insener	0,5	Tootmistehnika õppetool
22	**Ploompuu**	Triin	koolitusspetsialist	0,75	Tehniline töötaja
25	**Pohlak**	Meelis	vanemteadur	1	Tootearenduse õppetool
26	**Päev**	Erkki	insener	0,5	Tootmistehnika õppetool
27	**Pärn**	Martin	külalisprofessor	0,5	Disaini õppetool
28	**Riives**	Jüri	professor	0,5	Tootmissüsteemide õppetool
29	**Rämmal**	Hans	vanemteadur	1	Autotehnika õppetool
30	**Saar**	Eveliis	sekretär	0,5	Tehniline töötaja
31	**Sarkans**	Martinš	Dotsent	0,5	Tootmissüsteemide õppetool

32	**Semeniuk**	Mykola	insener	1	Tehniline töötaja
33	**Sonk**	Kaimo	lektor	0,75	Tootearenduse õppetool
34	**Ševtšenko**	Eduard	vamemteadur	0,5	Tootmistehnika õppetool
35	**Tiikoja**	Heiki	teadur	1,0	Autotehnika õppetool
36	**Tähemaa**	Toivo	dotsent	0,75	Tootearenduse õppetool
37	**Vene**	Karl-Kristo	insener	0,5	Tehniline töötaja

Tootearenduse-, tootmistehnika- ja tootmissüsteemide õppetoolide juurde kuuluvad järgmised laborid:

1. RapidLAB (Prototüüpide kiirvalmistamise labor)
2. Toodete modelleerimise ja materjalide dünaamilise- ning vibrokatsetuste labor
3. Tootmise automatiseerimise labor
4. Hüdro- ja pneumoseadmete labor

Olulisemad seadmed:

- CNC freespink Dyna 3116;
- Kiirprototüüpimise masinad - Zprinter 310 ja Formiga P 100;
- Optiline 3D skänner ATOS II, GOM;
- Optiline 3D deformatsioonide mõõteseade ARAMIS 2M, GOM;
- Optiline 3D lehtmaterjali vormitavuse mõõtmisseade ARGUS, GOM;
- Optiline 3D mõõtesüsteem TRITOP, GOM;
- Optiline 3D kiirete deformatsioonide mõõtesüsteem PONTOS 4M, GOM;
- Materjali tõmbe-surve seade Tinius Olsen H10KT;
- Kolmeteljeline jõudude mõõtmise süsteem Kistler;
- Koordinaatmõõtemasin Tesa Micro-Hite 3D;
- Robotsüsteem ABB (180 kg, 2,55 m);
- Vibrostend TIRA TV 5220-120;
- Ultraheli defektoskoop Imperium i600.

Olulisemad tarkvarad:
ANSYS Professional V12.1. Ansys on LEM programmipakett, mis võimaldab sooritada erinevaid toodete simulatsioone (tugevusarvutus, voolamise ülesanded jne). On olemas programmi kommerts- litsents tööstusprojektide tegemiseks. Varem kasutati programmi vaid õppetöös.

Autotehnika õppetooli laborid:

1. Sisepõlemismootorite labor
2. Akustikalabor

Mootorilabori kõige kaasaaegsemateks seadmeteks on:

- väljaheitegaaside 4-komponendiline analüsaator (Bosch),
- endoskoop (Karl Storz),
- 2-kanaline digitaaltermomeeter,
- 8-kanaliline analoog-digitaal andmeloger (NI)
- mootorite tehnilise diagnostika seade Automotive Kit.

Akustikalabori olulisemateks seadmeteks on:

- dünaamiline kuumade gaaside mõõtestend (kiirus kuni 100 m/s, temperatuur kuni 200 C)
- 2-kanaliline pieso-elektriline mõõteseade koos vedelikjahutusega dünaamiliste rõhuanduritega (Kistler),
- 4-kanaliline D/A andmeloger (National Instruments) kiirete protsesside mõõtmiseks arvuti abil,
- 4 mõõtemikrofoni koos eelvõimenditega (PCB).

Instituudi liikmed osalevad aktiivselt Innovatiivsete Masinaehituslike Tootmissüsteemide Tehnoloogia Arenduskeskuse (IMECC) töödes.

2. INSTITUUDI TEADUS- JA ARENDUSTEGEVUSE ISELOOMUSTUS

Masinaehituse instituudi põhilised teadussuunad 2014 aastal:

- Komposiit- ja funktsionaalsetest materjalidest konstruktsioonide, toodete ja tootmisprotsesside optimaalne projekteerimine (Juhtivteadur Jüri Majak)
- Mehhatroonika- ja tootmissüsteemide proaktiivsus ja käitumismudelid (Prof. Tauno Otto)
- Tootmissüsteemide ja protsesside optimeerimine läbi monitooringu ja ennustusmudelite (Dotsent Kristo Karjust)
- Digitaalsete otsetootmisprotsesside analüüs ja arendus (Vanemteadur Meelis Pohlak)
- Tootmisettevõtete jätkusuutlikkuse parendamine töökindla tehnoloogia abil (Teadur Eduard Ševtšenko)
- Kõrgtemperatuursete gaaside voolu akustika eksperimentaalsed uurimismeetodid (Prof. Jüri Lavrentjev).

2.1 Struktuuriüksuse koosseisu kuuluvate uurimisgruppide kirjeldus ja tulemused

2.1.1 Teadustöö kirjeldus (inglise keeles)

a) Optimal design of composite and functional material structures, products and manufacturing processes (T035)

Persons: Research Professor Jüri Majak, senior researcher Meelis Pohlak, professor Martin Eerme, professor Jüri Lavrentjev, senior researcher Hans Rämmal, researcher Tatjana Karaulova, associate professor Kristo Karjust, associate professor Toivo Tähemaa, junior researcher Henrik Herranen, junior researcher Henri Lend.

The present application focuses on scientific/engineering aspects of manufacturing engineering including the development of novel methods and tools for optimal product development and manufacturing planning in industry. The goal of the research project is to develop methods and

techniques for optimal design of products and manufacturing processes. Main sub-goals can be outlined as: 1. Optimal design of composite and functional material structures, products and manufacturing processes, 2. Exploiting advanced materials and structures in design, 3. Development of sustainable manufacturing technologies. The objectives of the current research project draw on needs of European and Estonian technology platforms for manufacturing industry and are formulated in accordance of the General roadmap of EU programme FACTORIES OF THE FUTURE - BEYOND 2013

b) Smart Composites – Design and Manufacturing (AR12139)

Persons: Research Professor Jüri Majak, senior researcher Meelis Pohlak, professor Martin Eerme, professor Jüri Lavrentjev, professor Rein Küttner, Professor Tauno Otto, researcher Heiki Tiikoja, associate professor Kristo Karjust, associate professor Toivo Tähemaa, junior researcher Henrik Herranen, junior researcher Henri Lend, engineer Maarjus Kirs, persons from different institutions like: Department of Materials Engineering, Institute of Cybernetics, Laboratory of Proactive Technologies at Department of Computer Control, Thomas Johann Seebeck Institute of Electronics, Small Craft Competence Centre, OÜ Eliko Tehnoloogia Arenduskeskus, Defendec OÜ, Goliath Wind OÜ, Kasse Paadid OÜ, Lindvart OÜ, Luksusjaht AS, MMG Taastusravi OÜ.

The general goal of the project is to develop smart composite materials and structures according to the needs of Estonian industry TOPICS: Design of smart composite materials and structures Development of computational modeling capabilities and manufacturing techniques for the design of smart materials and structures Validation and evaluation of the smart composites.

c) EmerEEG - A portable device for Early detection and treatment of Traumatic Brain Injury based on advanced qEEG and HD-TES to prevent major Health problems and specially for use in emergencies and telemedicine (FP7-SME-2013-605103)

Persons: Associate professor Kristo Karjust, Research Professor Jüri Majak, senior researcher Meelis Pohlak, junior researcher Henrik Herranen, junior researcher Henri Lend, engineer Maarjus Kirs.

Traumatic Brain Injury (TBI) is recognized as a major public health concern, especially for teenagers and young adults, since it can lead to significant disruption in education, working ability, and quality-of-life in general. It is one of the leading causes of death and disability worldwide. 1.2 million EU citizens are hospitalized with TBI each year and of which 50.000 die. The total economic burden in Europe for TBI of all known severities is estimated EUR 33 billion annually. Currently, there is no objective method for diagnosing TBI in an early stage or in emergency, which is a premise to prevent serious health impact. Our idea is to develop a portable medical device for objective and reliable emergency diagnosis of TBI and a monitored personalized treatment based on qEEG (quantitative electroencephalography) and HD-TES (High-Definition Transcranial Electric Stimulation).

We propose to create innovative technology for the early detection and treatment of one of the most severe cognitive diseases for the use in emergency, telemedicine, hospitals, and rehabilitation centres. We will achieve this by 1) developing a novel vacuum based helmet device that will enable an accurate positioning system of up to 32 electrodes, 2) developing an instrumentation system that will combine qEEG recording and HD -TES treatment, 3) developing a data processing system that will control all measurements and data analysis including the algorithm for early detection and treatment of TBI.

d) Enhancing Sustainability of Manufacturing Enterprises through reliability engineering (ETF9460)

Persons: researcher Eduard Ševtšenko, researcher Tatjana Karaulova.

The purpose of this grant is to redesign the manufacturing processes in reliable way. The focus is to increase the internal effectiveness of production processes. Objectivities of the work have 3 main directions, because they are connected with doctoral theses (during this grant implementation must be done 3 doctoral works). Its main directions are: 1. Intelligent module elaboration for optimal allocation of resources and elimination of the production processes faults. 2. Reducing waste by changing the patterns of production, using Green initiatives. 3. Development the maintenance plan: maintenance activities on operational level. Optimization quality inspection process Hypothesis 1. Sustainability can make businesses more profitable. 2. The integration of technological processes with reliability analysis enables to increase the production process efficiency. 3. The planning and scheduling of preventive maintenance activities is often crucial for the cost-effectiveness of many large industrial organizations. 4. Production waste realisation gives economic and ecological effect. Significance of the project for science and national economy • The new world of sustainable technologies and work practices is undoubtedly a challenging and exciting emerging reality for the manufacturing industries. Manufacturers of all sizes are turning to lean manufacturing techniques to reduce waste and save money. As a result of the project implementation, enterprises receive a set of recommendations that, when implemented, result in production efficiencies, environmental improvements, and cost savings. • Green manufacturing, a process for production that bolsters sustainable consumption and production by minimising waste and pollution, has become an increasingly important corporate strategy in the global business arena. Green manufacturing, despite higher incurred costs, offers a distinct competitive advantage over the laggards • Supports and diversifies masters/doctoral studies of researchers. • Links university and industry to develop patents and implement innovations.

e) Analysis and Development of Additive Manufacturing Processes (ETF 9460)

Persons: senior researcher Meelis Pohlak, Research Professor Jüri Majak, associate professor Kristo Karjust, researcher Heiki Tiikoja, lector Kaimo Sonk, junior researcher Henri Lend.

The objective of the current research project is to analyse the processes involved in Additive Manufacturing (AM) technologies and find ways to improve them. It is planned to study methods

and procedures to improve AM processes, especially those that are based on SLS approach. The main tasks of the study are: to develop new simulation models of SLS process by implementing more accurate material models and simulation procedures; to improve accuracy of SLS; to improve SLS process by developing method to apply composite particles/fibers into model in controlled way so that parts with FGM could be produced and to develop multidisciplinary topology optimization procedures for parts made with AM. For achieving the objectives, it is planned to use extensively numerical modelling methods (e.g. FEA) and experimental procedures. Flexibility is an important property of manufacturing processes. One feature of traditional mass production technologies is complicated and time consuming readjustment for production of new products. The capability of fast adaptation to new products assures significant competitive advantage. The technologies providing such capability are Additive Manufacturing technologies, also known as Direct Digital Manufacturing or Rapid Manufacturing. In case of these technologies, parts are manufactured directly from three dimensional digital models without significant manual work. The parts are built automatically in layer wise manner by adding material, not removing like in most traditional processes. As the process is additive, it complies with modern environment friendly mentality. No special tooling is required – the process is very flexible and highly automated. One of the most promising AM technologies is Selective Laser Sintering (SLS). In this process, objects are made of powder material by fusing particles together layer by layer with a laser. Parts can be made of metals, polymers, ceramics and composites. Although AM technologies are in industrial use already for several decades, there exist some serious limitations that prevent wider industrial implementation. The main limitations are associated with quality (mechanical properties, surface quality, accuracy of geometry, etc.) of parts produced by AM; only limited number of materials can be used; the productivity is low and the technology is expensive. The wider use of AM technologies depends on removing such limitations, and the current research project addresses this issue.

f) Micro-perforated locally resonant acoustic metamaterials: a combined approach for noise control (Project SS346)

Persons: Researcher Fabio Auriemma, researcher Heiki Tiikoja

The objective of this research project is the enhancement of the acoustic properties of thin-membrane locally-resonant acoustic meta-materials (LoRAMs) by including properly designed micro-apertures or microperforated masses on the element surface. A number of samples exhibiting unique impedance and absorptive characteristics, while being cost effective and ready-to-use in a wide range of engineering applications, will be designed, engineered, modelled and tested. Modal, energy and fluid-structure FEM analyses will be performed, aiming to characterize the behaviour of the acoustic elements. Genetic Algorithm and Simulated Annealing techniques will be utilized to optimize the design. Laser-Doppler vibrometry will be employed to describe the punctual surface velocity and to validate the numerical results. Finally, the sound absorption, transmission and reflection coefficients of the samples will be experimentally determined by using the 2-port method.

2.1.2 Aruandeaastal saadud tähtsamad teadustulemused

a) Optimal design of composite and functional material structures, products and manufacturing processes (T035)

The characterization of acoustic performance of a novel type of advanced acoustic materials micro grooved element (MGE) has been provided. A novel technology proposed is patented by workgroup in 2013.

The convergence theorem for Haar wavelet discretization method (HWDM) has been proved analytically for general n-th order ordinal differential equations. The rate of convergence has been validated numerically in a number of examples provided by workgroup and found in literature.

The methodology for design optimization of graphene/nanostructures has been proposed.

It has been shown that the results and also some design rules are principally different in the case of macro and nanostructures. The necessary optimality conditions for multilayer graphene sheets are derived by applying averaged and multilayer plate theory. It has been shown that the necessary optimality conditions corresponding to these two theories are equivalent (results the same optimal design).

The optimization procedures for design of smart/advanced composite structures have been improved. ALT technology was adopted for design of defensive housings for electronic components embedded in composite. The procedure for price performance optimization of the sandwich structure is proposed. A Pareto concept is employed to estimate the price performance behaviour of a structural material composed of discrete component materials.

Publication: The results are published in four 1.1 category papers and eight 3.1 category publications.

b) Smart composites: design and manufacturing (AR12139)

Electronics design:

Development of sensor node for multi-sensor measurement system (strain, vibration, humidity and temperature) has done. Experimental vibration analysis of small wind turbine blade for damage detection has developed. Development of carbon fibre yarn base strain sensor has done.

Smart materials design:

The methodology for the design of smart composites with structural health and performance monitoring capabilities has been developed and validated in laboratory tests and real world applications (Goliath wind OÜ). The proposed methodology includes formulation of the multicriteria and multilevel optimization problem, development of solution procedure and concepts. The impact of embedded electronics on the mechanical properties has been minimized by employing design optimization.

A microscale finite element model has been developed in order to investigate stress distribution inside the specimens.

The integration of embedded electronics has been improved by introducing ALT technology. A novel concept of using additive layer technology to produce optimized encapsulation for the foreign object is proposed. Asymmetric ellipse cross-section is found to be the most optimal shape for NCF fabric material.
The characterization of acoustic performance of a novel type of advanced acoustic materials micro grooved element (MGE) has been provided.
The results are published in one 1.1 category paper and three 3.1 category publications. One PhD thesis has been defended in this research area (H. Herranen).

c) EmerEEG - A portable device for Early detection and treatment of Traumatic Brain Injury based on advanced qEEG and HD-TES to prevent major Health problems and specially for use in emergencies and telemedicine (FP7-SME-2013-605103)

System requirements, of portable device for early detection and treatment of traumatic brain injuries, and concept analyses have done. Vacuum based head device is under the development, but first stage is finished and tested; In head device instrumentation system electrode and electrode gel technology is selected and first experiments have done. Instrument architecture and electrode node positioning is under development; in data processing system architecture Early prototype system Methods and tools for EEG processing and TBI diagnosis and analysed and under development.
Key achievements for the end of the 2014: A shared target system understanding has been reached among the partners; overarching system requirements have been defined and approved by all partners; Initial investigations on various key technologies and concepts have been carried out.

d) Enhancing Sustainability of Manufacturing Enterprises through reliability engineering (ETF 9460)

The grant was divided into several sub-topics:
1. Intelligent module elaboration for optimal allocation of resources and elimination of the production processes faults.
This research introduced the new framework for continuous improvement of reliability of production process and Key Performance Indicators (KPIs) (Quality, Cost and Throughput). Here was integrated various tools and methods into five steps of Six Sigma DMAIC (Define, Measure, Analyse, Improve, Control) methodology (the basic accent of this research is presented in Measure and Analyse step). The main target of this framework was to improve production process reliability by decreasing the number of defects/failures in the process, thus decreasing their real Risk Priority Number (RPNReal) value that in turn increases the required indicators such as, Process/Product Sigma Performance Level (PSPL), Cost Weighted Factor for RPN (CWFRPN) and Process Constraint (PC) and influence on KPIs.
The presented new framework was adapted into the database - Data Mart, which will play the role of a source for“dashboard” that allows monitoring production processes (collect data about

production problems, failures) measure and analyse them in real time. In addition, the new Data Mart will be applied into Information Systems (IS) environment with various tools (Product Data Management (PDM), Extract Transfer Load (ETL), Enterprise Resource Planning (ERP) system) that enables to process different data from one system to another and derive new knowledge that are useful for business processes improvement. The developed framework is used as input for theoretical and practical part of PhD thesis of Jevgeni Sahno which is planned to defence in 2015.

2. Reducing waste by changing the patterns of production, using Green initiatives.

TRIZ (Theory of Inventive Problem Solving) was used as an innovation mechanism for decision-making in the current research. The Green Matrix from the general TRIZ Contradiction Matrix was elaborated to resolve environmental conflicts by using GE (Green Engineering) principles. The innovation part is solved by using various TRIZ tools in terms of the implementation perspective of the GM (Green Manufacturing) projects. The Green Matrix can be used as part of the general decision-making framework as was proposed in this thesis and also as the absolutely independent tool to resolve environmental contradictions.

3. Development the maintenance plan: maintenance activities on operational level. Optimization quality inspection process

The green framework is the basis for the general systematized CAIS approach for used industrial equipment LCA and its prolonging with general GM principles inside. In the study the integrated method for evaluating the remanufacturability of the used equipment was also adopted and extended. Remanufacturability of the used equipment is the basis of the decision to determine whether it can be remanufactured or not. An integrated methodology for evaluating the remanufacturability in terms of technological, economic and environmental benefits was used for this purpose. On the basis of technological, economic and environmental assessment parameters of remanufacturability, the necessity of the GM (Innovation part of the decision-making framework) use was defined. One of the main achievements of this work is that the three independent modules were united under one mechanism and all of them can be implemented separately. It is very important to mention that it allows finding standard and non-standard solutions through innovation-oriented module by directing it, not just following the world's best practices.

Scientific Novelty

- The decision-making green framework was developed to evaluate the current state of the used industrial equipment and the most suitable EOL strategy was proposed.
  - Lean technique implementation for current technical state analysis of used industrial products.
  - Adaptation of the re-manufacturability module by improving the economic assessment part and risk analysis.
  - Independent Green Matrix derivation from the general TRIZ Matrix to resolve environmental contradictions by using GE principles.

- The new innovation-oriented approach was proposed for SME industrial equipment controllability and utilization on a daily, monthly or yearly basis.
- Developed Waste Matrix was derived as an evaluation tool of Lean and GM techniques integration into each other.
- TRIZ was implemented for the extension of used industrial products life cycle.

The new framework was introduced that allows continuously improving the reliability of business process and KPIs (Quality, Cost and Throughput) with less expenditures. In addition, the new framework was applied into Data Mart and IS environment that enables to perform the following actions:

- Perform daily monitoring of production processes (based on data for the previous day).
- Calculate indicators (PSPL, CWFRPN and PC) that influence on specific KPI by registering and assessing the failures of production process.
- Identify what KPI is more important for improvement from company and/or customer point of view using AHP approach.
- Determine what failure is the most harmful in the process from product quality, cost and throughput point of view.
- Perform continuous improvement of production processes and their indicators that affect the KPIs, this in turn helps to improve customer satisfaction and financial performance of the company.

Publications:

The results of reporting year 2014 were presented at the conferences and published in Scientific Papers: 1.1 - 2 papers (1 published 1 is in the second round review); 3.1 - 9 papers (6 published 3 is under review); 3.2 - 1 paper (published)

e) Analysis and Development of Additive Manufacturing Processes (ETF 9441)

During the period thorough literature analysis of the material modelling was made. The approaches of other researchers have been analysed, limitations and features have been extracted. Material properties, modelling techniques and procedures how to implement the models were studied. The most promising approaches have been selected, the process of implementing the models is in progress.

For studying the recycling issues of the SLS leftover material experimental analysis have been made. The material samples were produced, different approaches of changing physical properties were tested. Samples of new material with improved properties for Fused Deposition Modelling process have been produced. The work is in progress.

The results will be published in several journal papers and conferences within the next period.

2.1.3 Uurimisgrupi kuni 5 olulisemat publikatsiooni 2014 aastal

- Tiikoja, H.; Lavrentjev, J.; Rämmal, H.; Åbom, M. (2014). Experimental Investigations of Sound Reflection from Hot and Subsonic Flow Duct Termination . Journal of Sound and Vibration, 333(3), 788 - 800.
- Auriemma, F.; Rammal, H.; Lavrentiev, J. (2014). Extended Investigations on Micro-Grooved Elements - A Novel Solution for Noise Control. SAE International Journal of Materials and Manufacturing, 1(1), 600 - 611.
- Karaulova, T. ;Poljantshikov, I.; Shevtshenko, E.; Kramarenko, S. (2014). Fractal approach for manufacturing project management. Mechanika, 20(3), 352 - 359.
- Herranen, H.; Kuusik, A.; Saar, T.; Reidla, M.; Land, R.; Märtens, O.; Majak, J. (2014). Acceleration Data Acquisition and Processing System for Structural Health Monitoring. In: Proceedings of the 2014 IEEE International Workshop On Metrology For Aerospace: IEEE International Workshop On Metrology For Aerospace, Benevento, Italy, May 29 - 30, 2014,. Benevento, Italy: IEEE, 2014, 244 - 249.
- Aruväli, T.; Otto, T. (2014). Digital object memory integration into indirect surface roughness measurement in turning. In: Applied Mechanics and Materials: 4th International Conference on Mechanical and Manufacturing Engineering "Innovative Solutions for Sustainable Engineering", Putrajaya, Malaysia, 17-18.12.2013. Switzerland: Trans Tech Publications Ltd, 2014, 764 - 768.

2.2 Loetelu struktuuriüksuse töötajate rahvusvahelistest tunnustustest

Kangilaski T., Norta A. "Collaborative Project Management Framework for Parner Network Initiation" "International DAAAM symposium on Intelligent Manufacturing & Automation" Best Poster Award. Shevtshenko E.,Polyanchikov I.,Mahmood K.,Kangilaski T., Norta A. "Collaborative Project Management Framework for Parner Network Initiation"

Tauno Otto; Internaional Academy of Engineering - Central European Branch - corresponding member

2.3 Loetelu struktuuriüksuse töötajatest, kes on välisakadeemiate või muude oluliste T&A-ga seotud välisorganisatsioonide liikmed.

Jüri Lavrentjev – Society of Automotive Engineers (SAE)

Jüri Lavrentjev – International Institute of Acoustics and Vibration (IIAV)

Tauno Otto - European Higher Education and Research Standing Committee (HERSC)