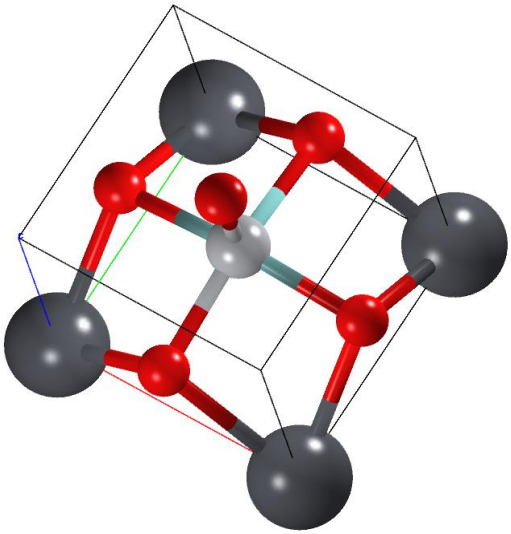
# IRWBM 2021

# 2nd International Research Workshop in Biomechanical Microsystems 2021

Program and Abstracts



October 22, 2021
Kaunas University of Technology
Lithuania

# IRWBM 2021

## 2nd International Research Workshop in Biomechanical Microsystems

**Organized by:**

**Faculty of Mechanical Engineering and Design**
**Kaunas University of Technology**

**Supported by:**

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# Location

Due to the COVID-19 situation the seminar will be held online via Zoom. Connection for the virtual room is here: https://liedm.zoom.us/j/94376197543?pwd=SGFRajVMbzhja0ZuWmczbVpFMXlEZz09.
Meeting ID: 943 7619 7543
Passcode: meeting

Please connect 5 minutes before the meeting and test your video and audio devices.

# International Organizing Committee

| | |
|---|---|
| Prof. Giedrius Janušas | Chairman, Kaunas University of Technology, Lithuania |
| Prof. Arvydas Palevičius | Scientific program supervisor, Kaunas University of Technology, Lithuania |
| Prof. Sergei Kruchinin | Member, Bogolyubov Institute for Theoretical Physics, National Ukrainian Academy of Science, Ukraine |
| Prof. Vytautas Ostaševičius | Member, Kaunas University of Technology, Lithuania |
| Dr. Petr Lepsik | Member, Technical University of Liberec, Czech Republic |
| Dr. Kęstutis Pilkauskas | Member, Kaunas University of Technology, Lithuania |
| Dr. Sigita Urbaitė | Coordinator, Kaunas University of Technology, Lithuania |

# Invited speakers

| | |
|---|---|
| Prof. Vytautas Ostaševičius | Head of Institute of Mechatronics, Kaunas University of Technology, Lithuania |
| Prof. Ahmad Monshi | Department of Materials Engineering, Isfahan University of Technology, Isfahan, Iran |
| Prof. Madhusudan Siddabathula | Professor & Head, Mechanical Engineering, Usha Rama College of Engineering, Telaprolu, India |
| Sohrab Nasiri | Department of Mechanical Engineering, Kaunas University of Technology, Lithuania |

# Program

Friday, October 22

| | |
|---|---|
| 09:30-10:00 | **Registration** |
| **Opening Ceremony** | |
| 10:00-10:10 | **Welcome by Prof. Giedrius Janušas**<br>*Chairman of International Research Workshop in Biomechanical Microsystems* |
| **Plenary session** | |
| 10:10-10:30 | *Invited speech*<br>**Biomechanical therapy research and innovations**<br>*Vytautas Ostaševičius*<br>Kaunas university of technology, Lithuania |
| 10:30-10:50 | *Invited speech*<br>**Comparing different methods with Monshi-Scherrer method for calculating nano crystal size using XRD**<br>*Ahmad Monshi*<br>Isfahan University of Technology, Iran |
| 10:50-11:10 | *Invited speech*<br>**Estimation of hygric strain - an experimental approach**<br>*Madhusudan Siddabathula*<br>Usha Rama College of Engineering, India |
| 11:10-11:30 | *Invited speech*<br>**New method for the investigation of mechanical properties by planar density**<br>*Sohrab Nasiri*<br>Kaunas University of Technology, Lithuania |

| Session | |
|---|---|
| 12:00-12:10 | **Electrolytic plasma polishing of NiTi alloy**<br>*Algimantas Bubulis,*<br>Kaunas University of Technology, Lithuania<br>*Aleksandr Korolyov, Yury Aliakseyeu, Vladimir Minchenya, Vladimir Niss*<br>Belarusian National Technical University, Belarus<br>*D. Markin*<br>Polymedtech LLC |
| 12:10-12:20 | **Low-cost fabrication of nanoporous aluminium oxide membrane and its application in microfluidics**<br>*Yatinkumar Patel*<br>Kaunas University of Technology, Lithuania |
| 12:20-12:30 | **Development and characterization of bio-based fiber reinforced eco-friendly composite materials**<br>*Atmakuri Ayyappa*<br>Kaunas University of Technology, Lithuania |
| 12:30-12:40 | **Review of recent research on nanomembranes in bioengineering**<br>*Urtė Ciganė*<br>Kaunas University of Technology, Lithuania |
| 12:40-12:50 | **New approach for fabricating scaffold consisted of Ag-doped hydroxyapatite/polyvinyltrimethoxysilane**<br>*Marzieh Rabiei*<br>Kaunas University of Technology, Lithuania<br>*Reza Ebrahimi-Kahrizsangi*<br>Islamic Azad University of Najafabad, Iran |
| 12:50-13:00 | **Mathematical model of microstructure formation using magnetostriction process**<br>*Justas Ciganas*<br>Kaunas University of Technology, Lithuania |
| 13:00-13:10 | **Compliant structure with micro hydraulic actuation for biomechanical applications**<br>*Kęstutis Pilkauskas*<br>Kaunas University of Technology, Lithuania |
| 13:10-13:20 | **Engine vibration dampers**<br>*Vytenis Naginevičius, Skirmantas Adomavičius*<br>University of Applied Engineering Sciences, Lithuania |

# Biomechanical therapy research and innovations

Vytautas Ostaševičius[a]

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**Abstract**
Human vertebral and vascular systems are the most important complex structures for maintaining viability. Any changes in these structures could lead to discomfort, loss of function or death. The low back pain is a major problem throughout the world when the cardiovascular diseases are the number 1 cause of death globally. The fact that low back pain is the leading cause of disabilities in working age group means that it also has a significant negative socioeconomical impact not only on the individual but also on society. Due to this reason, mechanical measures may also be implemented in order to preserve or improve conditions of human health. The blood circulation conditions could be improved through dynamic activation of limb capillaries. The technique proposed for the re-use of the blood spilled as a result of surgical interventions or accidents may lead to the development of technologies for portable, low-cost biomedical procedures of energy-efficient separation/purification of microparticles in biological suspension. The benefits of a range of innovative therapeutic device layouts are demonstrated in solving circulatory, arthritis, diabetic foot ulcer, cardiac pacing, bioparticles separation, breathing and vestibular wireless recording and other human health issues.

**Keywords:** vertebral and vascular systems, capiliaries, blood circulation.

# Comparing different methods with Monshi-Scherrer method for calculating nano crystal size using XRD

Ahmad Monshi[a]

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**Abstract**
XRD peaks were extracted from natural hydroxyapatite obtained from cow, pig, and chicken bones, through the thermal treatment of natural bones at 950 °C. XRD patterns were selected by adjustment of X-Pert software and calculating the size of nano crystals. Methods consisted of Scherrer (three models), Monshi–Scherrer, three models of Williamson–Hall (namely the Uniform Deformation Model (UDM), the Uniform Stress Deformation Model (USDM), and the Uniform Deformation Energy Density Model (UDEDM)), Halder–Wanger (H-W), and the Size Strain Plot Method (SSP). These methods have been used and compared together. The sizes of crystallites obtained by the XRD patterns in each method for hydroxyapatite from cow, pig, and chicken were 1371, 457, and 196 nm in the Scherrer method when considering all of the available peaks together (straight line model). A new model (straight line passing the origin) gave 60, 60, and 53 nm, which shows much improvement. The average model gave 56, 58, and 52 nm, for each of the three approaches, respectively, for cow, pig, and chicken. The Monshi–Scherrer method gave 60, 60, and 57 nm. Values of 56, 62, and 65 nm were given by the UDM method. The values calculated by the USDM method were 60, 62, and 62 nm. The values of 62, 62, and 65 nm were given by the UDEDM method for cow, pig, and chicken, respectively. Furthermore, the crystal size value was 4 nm for all samples in the H-W method. Values were also calculated as 43, 62, and 57 nm in the SSP method for cow, pig, and chicken tandemly. According to the comparison of values in each method, the Scherrer method (straight line model) for considering all peaks led to unreasonable values. Nevertheless, other values were in the acceptable range, similar to the reported values in the literature. Experimental analyses, such as specific surface area by gas adsorption (Brunauer–Emmett–Teller (BET)) and Transmission Electron Microscopy (TEM), were utilized. In the final comparison, parameters of accuracy, ease of calculations, having a check point for the researcher, and difference between the obtained values and experimental analysis by BET and TEM were considered. The Monshi–Scherrer method provided ease of calculation and a decrease in errors by applying least squares to the linear plot. There is a check point for this line that the slope must not be far from one. Then, the intercept gives the most accurate crystal size. In this study, the setup of values for BET (56, 52, and 49 nm) was also similar to the Monshi–Scherrer method and the use of it in research studies of nanotechnology is advised.

**Keywords:** nanocrystal size; x-ray diffraction; Scherrer equation; hydroxyapatite; BET; TEM

# Estimation of hygric strain – an experimental approach

Siddabathula Madhusudan[a*], Ayyappa Atmakuri[b]

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**Abstract**
In general strain can be measured using strain gauges. If strain gauges are used in moisture environment, gauges will not read correct value and there is possibility of gauges getting damaged. Hence, an alternate testing approach is required. A separate test setup has been designed to determine hygric strain (β) in moisture environment. Polymer composite specimens when exposed to moisture will experience strain variations due to absorption of water. Composite specimens were fabricated according to ASTM standard (AS4/3501-6). The specimens were then bent into parabolic shape in order to accommodate into the set-up. Specimen deflections were measured periodically with respect to time. Specimens are also exposed to the moisture environment are removed periodically from the water bath and weighed on an analytical balance to determine the relative weight gain, M. The average moisture concentration 'C' representing the relative volume occupied by water is related to the weight gain. Coefficient of hygric strains are determined from moisture concentration (C) and hygric strains (β). The deflection changes i.e change in specimen length is measured and there by corresponding hygric strain is evaluated.

**Keywords:** natural fibers, PMCs, Manual layup, Deflection, Moisture concentration, Hygric strain

# New method for the investigation of mechanical properties by planar density

Sohrab Nasiri[a]

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**Abstract**
Young's modulus (E) is one of the most important parameters in the mechanical properties of solid materials. Young's modulus is proportional to the stress and strain values. There are several experimental and theoretical methods for gaining Young's modulus values, such as stress–strain curves in compression and tensile tests, electromagnetic-acoustic resonance, ultrasonic pulse echo and density functional theory (DFT) in different basis sets. Apparently, preparing specimens for measuring. Young's modulus through the experimental methods is not convenient and it is time-consuming. In addition, for calculating Young's modulus values by software, presumptions of data and structures are needed. Therefore, this new method for gaining the Young's modulus values of crystalline materials is presented. Herein, the new method for calculating Young's modulus of crystalline materials is extracted by X-ray diffraction. In this study, Young's modulus values were gained through the arbitrary planes such as random (hkl) in the research. In this study, calculation of Young's modulus through the relationship between elastic compliances, geometry of the crystal lattice and the planar density of each plane is obtained by X-ray diffraction.

**Keywords:** Young's modulus; X-ray diffraction; planar density; crystalline materials; elastic compliances; modified W–H

# Electrolytic plasma polishing of NiTi alloy

Aleksandr Korolyov[a], Algimantas Bubulis[b*] ,Yury Aliakseyeu[a], Vladimir Minchenya[a], Vladimir Niss[a], Dmitry Markin[c]

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*[b]Kaunas University of Technology, Kaunas, Lithuania*
*[c] «Polymedtech» LLC*
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**Abstract**
Nitinol is widely used in the production of medical devices, especially the ones that are designed for minimally invasive treatment, such as stents to restore vascular patency, stent grafts to eliminate aneurysms, and cava filters to trap blood clots. One of the most important characteristics that determines the reliability of the functioning of such products in the human body is the state of the surface layer. The higher the surface quality, the less negative impact is on the circulatory system, the walls of blood vessels and the higher the biological compatibility of the product. Electrochemical polishing methods are mainly used to improve the surface quality of nitinol products. The disadvantage of the applied electrochemical methods is the need to use aggressive electrolytes that contain toxic components, such as hydrofluoric acid, sulfuric acid, perchloric acid, nitric acid, methanol. As an alternative to the existing methods of electrochemical polishing, we have developed electrolytic-plasma polishing (EPP), a new highly efficient process for improving the surface quality of nitinol products. The most important advantage of the method over traditional electrochemical polishing is the use of aqueous salt solutions with a concentration of 4 % as electrolytes. Based on the results of the studies performed, the most rational EPP mode was established, the use of which during polishing of nitinol provides surface cleaning from scale, polishing with a decrease in the roughness parameter Ra by 0.344 µm and an increase in pitting potential by 33%.

**Keywords:** nitinol, stent, electrolytic plasma polishing, roughness, corrosion.

# Low-cost Fabrication of nanoporous aluminium oxide membrane and its application in microfluidics

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**Abstract**

Over past few decades nano technology has gained tremendous attention in terms of research and industrial innovation in variety of field. Aluminum is abundant metal on earth which is easily available everywhere. Due to unique electrochemical, optical, and tunable geometrical properties and high thermal stability by customizing the electrochemical anodization process, nanoporous anodic aluminum oxide membrane has become a most popular material with large potential to develop emerging application in various areas, including biosensors, wastewater treatment, desalination, pollutant detection, cell devises, photo crystals, templet nano structure fabrication, nanofiltration, and so on.

Fabrication of low-cost nanoporous aluminum oxide membrane was done using two step anodization method using 0.3M Oxalic acid ($C_2H_2O_4$) at constant voltage 60V. Entire anodization process was conducted under maintained temperature 8-10°C. Scanning electron microscopy (SEM) was done to analyze the formation of nano pores on the surface of nanoporous membrane. SEM images reveals that the fabricated nanoporous membrane has hexagonal array with pore size of 80-100 nm, 120-150 nm interpore distance and 65.02% porosity. The hydrophobic behavior of fabricated nanoporous aluminum was done using water contact angle (WCA) measurement and it shows the hydrophilic behavior towards distilled water. Further, simulation was performed using COMSOL Multiphysics 5.4 to determine the functionality of fabricated nanoporous aluminum oxide membrane for filtration and separation in the filed of microfluidics using piezo-acoustic to understand the deformation of nanoporous aluminum oxide membrane at different frequencies. Result of the simulation shows that elevation in the driving frequency allows to achieve different acoustic wave distribution over the surface of nanoporous aluminum oxide membrane and it enables to control the inner surface of the nanotube and allows the nanoparticle in the center of the tube. This phenomenon enables variety of application of fabricated nanoporous alumina in the field of microfluidics for particle separation and filtration.

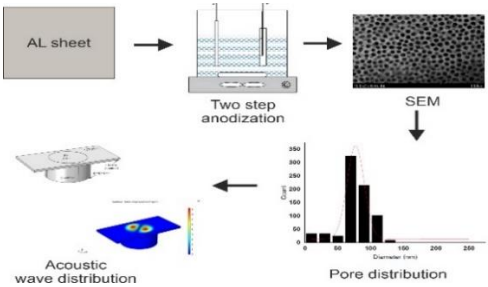


Fig. 1 Graphical illustration of abstract

**Keywords:** Nanoporous alumina, two-step anodization, microfluidics, nanofiltration

This research was funded by a grant S-MIP-19-43 from the Research Council of Lithuania.

# Development and characterization of bio-based fiber reinforced eco-friendly composite materials

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**Abstract**
The modern-day industries are vastly focusing on the development of bio-based fiber composite materials for lightweight, biomedical, automobile, and microfluidic applications. In the current research work, the morphological and mechanical properties of hemp and flax fiber- reinforced ecopoxy matrix composites were investigated. The composites were fabricated by using the compression molding technique followed by a hand layup process. To draw the contrast between processed and unprocessed fiber composites, two sets of composites were fabricated by using flax, hemp, noil flax, and noil hemp fibers. The fabricated composites were allowed for testing the mechanical properties and the morphological studies were investigated by using the scanning electron microscope. It was observed from the results that the alkaline treatment enhances the fiber properties and also presence of bioactive resin material improves the composite properties. In both sets, hybrid composites showed superior properties to individual fiber composites. Also, hemp/flax fiber composites showed improved properties than noil fiber composites.

**Keywords:** Hemp/flax and noil hemp/noil flax fibers; Alkaline treatment; Ecopoxy; Mechanical properties; SEM.

# Review of recent research on nanomembranes in bioengineering

Urtė Ciganė[a]

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**Abstract**
This article provides an overview of recent research on nanomembranes used in bioengineering. Bioengineering is an area where nanomembranes drive rapid progress. Nanomembranes can be used in tissue engineering as well as in drug delivery systems and this allows for more effective treatment of patients with various diseases. Nanoporous membranes must have the required mechanical strength and porosity, as these are very important parameters. An overview of the latest types of nanomembranes has been performed. The pore size of nanomembranes is one of the most important criteria, as many of the functions of nanomembranes depend on the geometry of the pores. Nanoporous membranes can be classified according to pore size, shape, and distribution. According to the size, nanopores are divided into micro- (<2 nm), meso- (2-50 nm), and macro- (> 50 nm). Depending on the shape of the pores, the pores can be divided into channels, regular shapes (cylinders, balls, cones), irregular shapes, and complementary. Rare forms of nanomembranes, such as curved pores, are also possible. The distribution of the pores can be ordered or disordered. A disordered structure is less predictable and harder to control, so an ordered distribution of pores is important. Moreover, an overview of the latest materials used in the production of nanomembranes has also been performed. Nanomembranes can be classified according to the materials used in their manufacture. According to materials, nanomembranes are generally divided into three categories: inorganic (metals, alloys, semiconductors), organic (carbon compounds), hybrid (composite). Also, a review of the latest nanomembrane manufacturing technologies has been performed.

**Keywords:** Nanoporous membranes; Porosity; Manufacturing technologies; Materials; Bioengineering

# New approach for fabricating scaffold consisted of Ag-doped hydroxyapatite/polyvinyltrimethoxysilane

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**Abstract:**

Recently, researchers have focused on the biocompatibility and mechanical properties of highly porous structures of biomaterials products. Porous composites are a new category of bioengineering that possess excellent functional and structural properties. In this study, the physical and mechanical properties of prepared doped silver (Ag)-hydroxyapatite (HA) by the mechanochemical and spark plasma sintering (SPS) methods were investigated. The influence of dopant on phase formation, structural properties, mechanical properties and morphological characteristics was investigated. Furthermore, in this case, as a new approach to produce a porous scaffold with an average size of >100 μm, the hair band was used as a mold. According to the Monshi-Scherrer method, the crystal size of scaffold was calculated 38.09±2 nm and this value was in the good agreement with average value form TEM analysis. In addition, the stress-strain compression test of scaffold was considered and the maximum value of compressive strength was recorded ~ 15.71 MPa. Taking into account the XRD, TEM, FTIR, SEM and EDAX analysis the prepared scaffold was bioactive and the effects of doped Ag-HA and the use of *polyvinyltrimethoxysilane* (PVTMS) as an additive were desirable. The results showed that the effect of thermal treatment on composed of Ag and HA were impressive while no change in transformation was observed at 850 °C. In addition, PVTMS plays an important role as an additive for preventing the decomposition and creating open-microporous in the scaffold that these porosities can be helpful for increasing bioactivity.

**Keywords:** Ag-doped HA; Mechanochemical process; Spark plasma sintering; Open porosities; Simulated *body fluid; Bioactivity*

# Mathematical model of microstructure formation using magnetostriction process

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**Abstract**
This paper is intended for introduce new microstructure formation technology. This new technology is based on a hot stamping process. Moreover, additional vibration is also used during the formation of microstructures. The magnetostriction process is used simultaneously with the heating process. One coil of the device creates a magnetostriction process. One coil in the device is created by a magnetostriction process. Another coil uses an induction field that creates the heating process. Such technology has the potential to create microstructures with high quality surface morphological. Magnetostriction and induction processes were analyzed by the finite element method by using the Joule effect. The model consisted of two rods wrapped in wire, a cooling container, and a forming tool. The rods were immersed in a cooling agent. The temperature of the pressure tool depended on the induction efficiency and the cooling intensity. Target operating temperature was up to 180 degrees.

**Keywords:** Magnetostriction; Microstructure; Vibration; Heating process

This research was funded by a grant No. 0.1.2.2-CPVA-K-703-03-0015 “Development of new technology for the formation of microstructures in functional materials” from the European Regional Development Fund.

# Compliant structure with micro hydraulic actuation for biomechanical applications

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**Abstract**
Compliant structure actuated by micro fluidic principle is described in the paper. Advances in design of novel actuators and their integration into elastic structure for obtaining active fabric for biomechanical systems are presented. Plastic tubular element less than one millimeter in cross-section dimension is embedded into the micro system of elastically hinged links for obtaining the main functional component of active fabric. The processes of the micro-tube interaction with link in contact when pressurized researched.
Materials with increasing levels of functionality play a critical role in developing medical and life-support devices of new standards. Developments that integrate sensors and actuators, together with the principles of biomimetics and nanotechnology are especially promising. The structure under investigation consists of a number of periodically arranged U-shaped rigid elements (Fig. 1) rigidly fixed on a foil and micro tube inserted in between them acting as a fluidic actuator when inflated. Piezoelectric sensing elements as the ones with minimal influence on mechanical characteristics are selected.

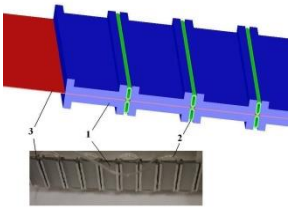


Fig. 1 Compliant structure with micro hydraulic actuation: 1 – rigid spacer, 2 – fluidic actuator (micro tube) , 3 – elastic foil;

The dependences of angular displacements on supplied pressure at different geometrical parameters of the structural elements are analysed. The proposed structure which features mechanical simplicity and is compliant in its nature when elastically pre-stressed is able to function in actuation and sensing modes.

**Keywords:** micro tuber, compliant, fluidic actuator

# Engine vibration dampers

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**Abstract**

When attaching a gearbox to the body, not only reliable anchorage but also damping of vibrations transmitted to the body sought. There is an abundance of both passive and adaptive fastening systems, which briefly reviewed in the paper to present application possibilities, advantages and disadvantages. This work presents the original construction of the mounting unit and its dynamic scheme. The equation of motion of the fastening system made and the theoretical assumptions confirmed experimentally.

The engine mounted in motor vehicles using elastic design schemes, which also perform vibration damping. Sources of vibration are motor-induced high-frequency oscillations (20 - 500 Hz) as well as low frequency (~ 10 Hz) motor's own oscillations. These are difficult to reconcile tasks using traditional passive damping systems. In this work, a passive version of the engine mount to the body proposed to increase the system's speed.

The aim of this study is to research the original structure damper for mounting the engine to the body.

The following task solved to achieve this goal:

- Overview of automotive engine mount to body schemes;
- To present the dynamic scheme of the original structure damping system and the design of the damping system;
- To make a differential equation of the damping system;
- Provide experimental research.

The hydraulic damping scheme proposed in this work is passive and it’s damping characteristics provided by the primary principle of rapid fluid permeability from one valve cavity to another.

# Notes