ACTIVITIES AT IMID 2021-2025

Žáček Jiří, Ing.

Institute of Mechanical and Industrial Design
Faculty of Mechanical Engineering
Brno University of Technology

Brno, 7. 5. 2025

CONTENT

- Ph.D. Study
- Other Reasearch Acitivities
- Internships
- Future
- Hobbies

Ph.D. STUDY

DISSERTAION TOPIC:

Behaviour of MR Fluids in Non-Uniform Magnetic Fields

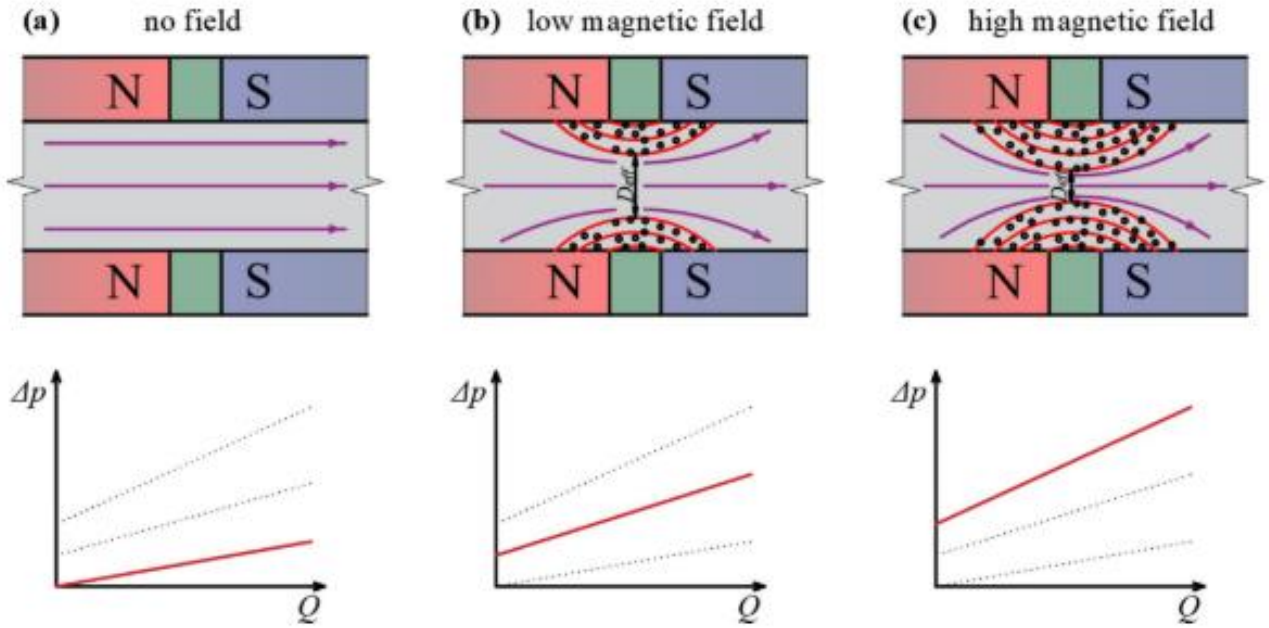
GAČR
GRANTOVÁ AGENTURA ČESKÉ REPUBLIKY

Supervisor:

doc. Ing. Michal Kubík, Ph.D.

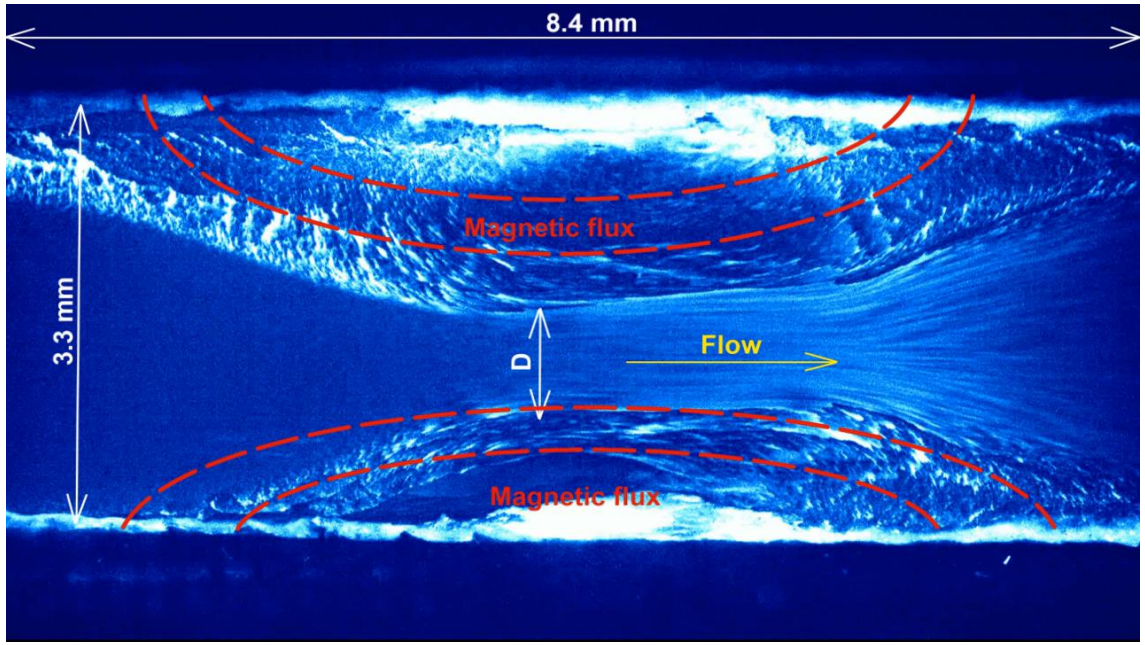
Objective of disertation:

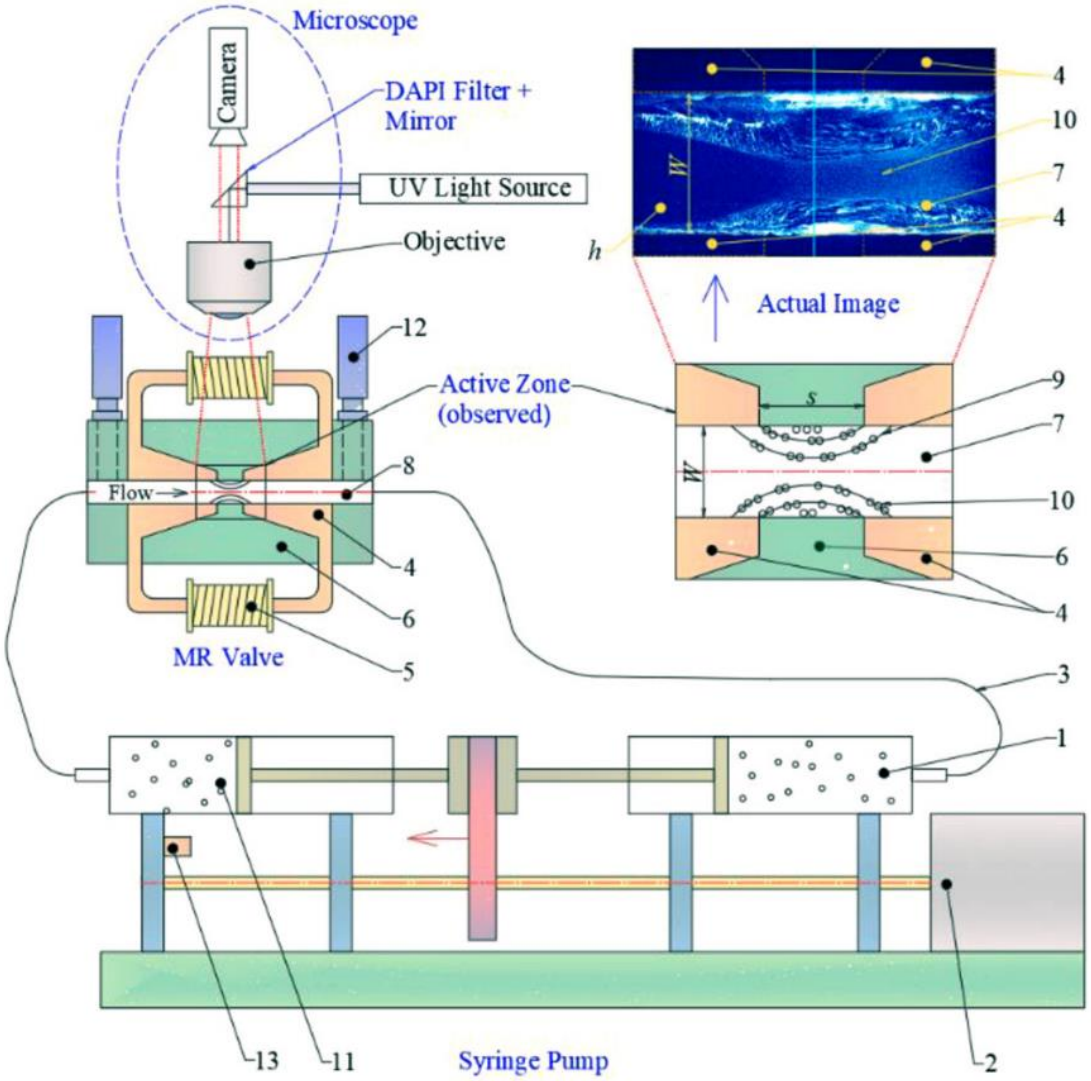
- Gradient Pinch mode – New opreating mode od MR Fluid
- Comprehending the mechanism of Gradient Pinch mode



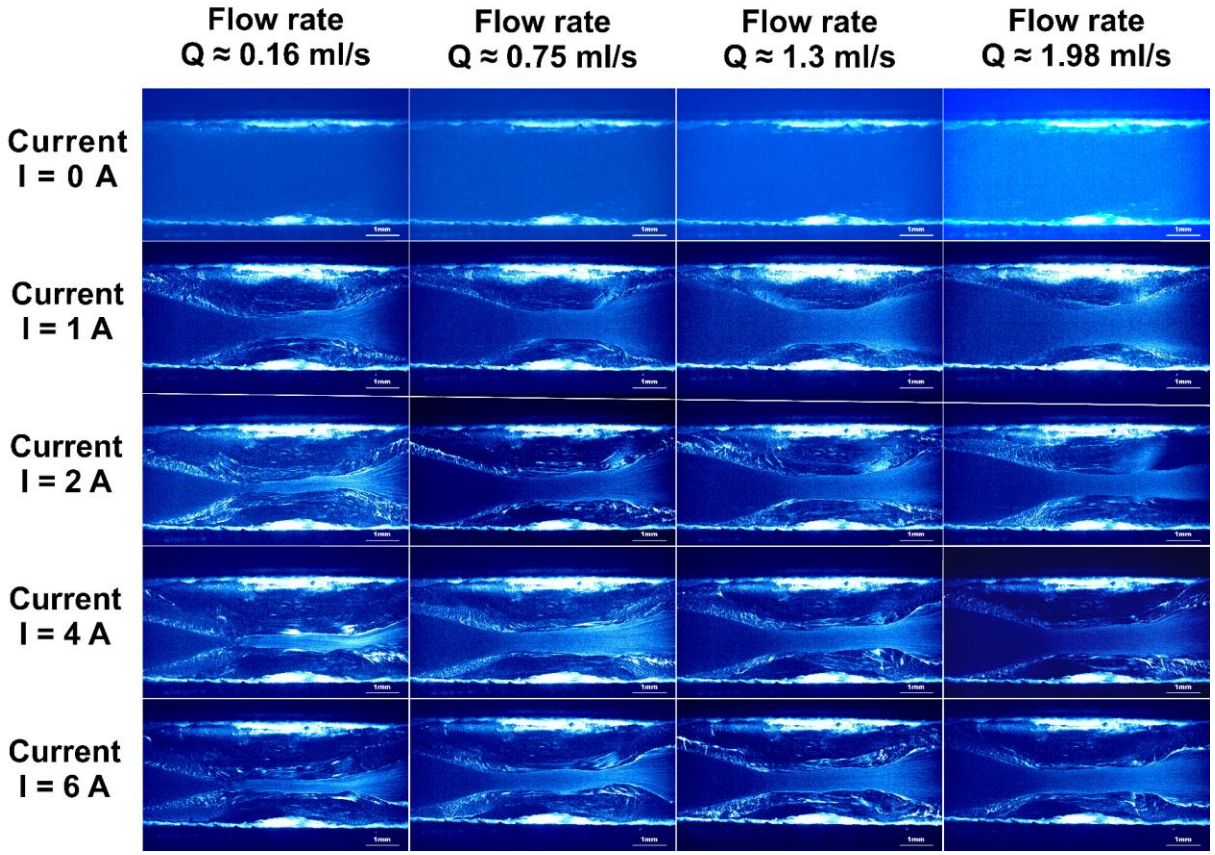
Ph.D. STUDY

- **Pinch mode principle was only estimated**
  - Only indirect evidence of its function
  - No Direct observation of the Pinch Mode valve
  - Venturi Contraction?





Ph.D. STUDY



Physics of Fluids ARTICLE pubs.aip.org/aip/pof

Grasping the behavior of magnetorheological fluids in gradient pinch mode via microscopic imaging

Cite as: Phys. Fluids **36**, 042004 (2024); doi: 10.1063/5.0203804
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Michal Kubík,[1,a)] Jiří Žáček,[1] Janusz Gołdasz,[2] David Nečas,[1] Michal Sedlačík,[3,4] Jiří Blahuta,[1] Wojciech Bańkosz,[2] and Bogdan Sapiński[5]

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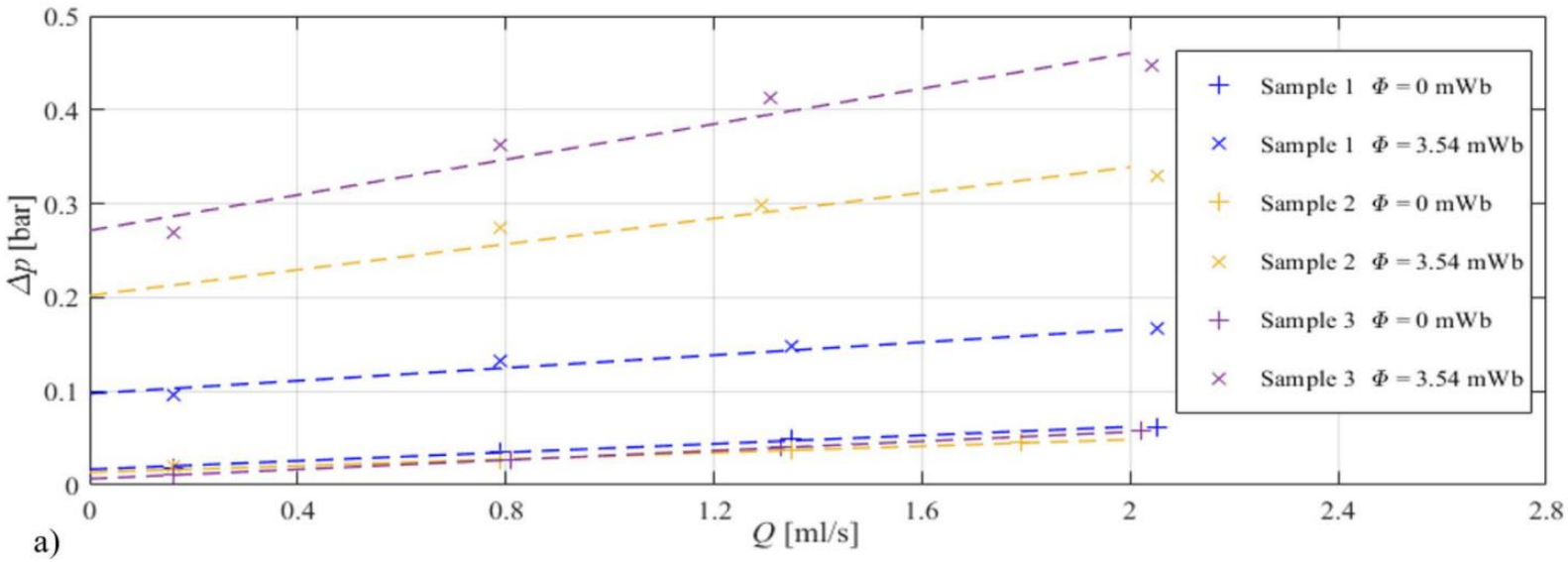
ABSTRACT

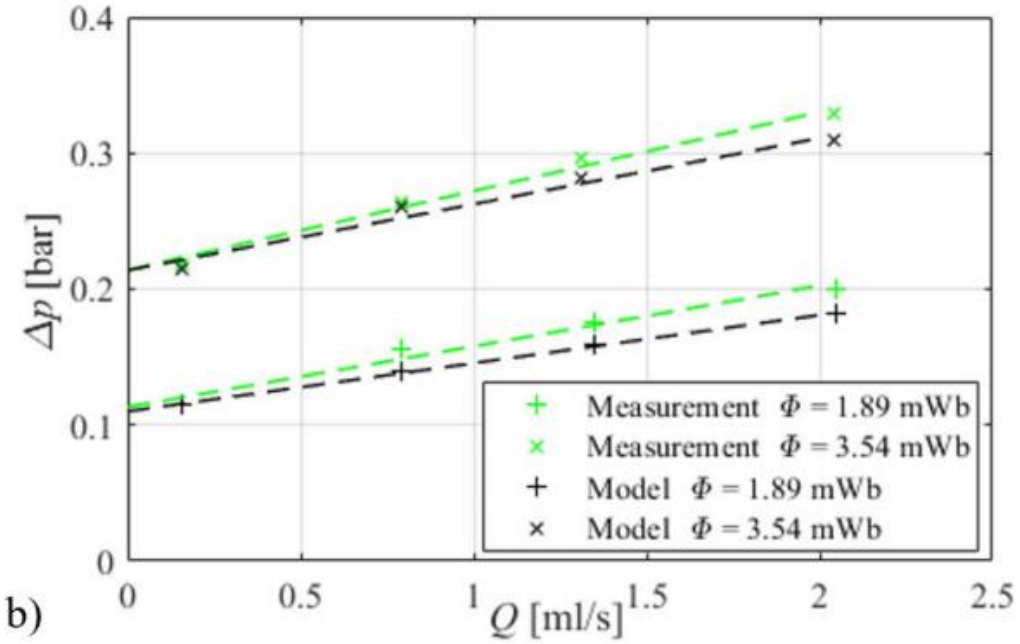
Magnetorheological (MR) fluids are suspensions of micrometer-sized ferromagnetic particles in a carrier fluid, which react to magnetic fields. The fluids can be operated in several fundamental modes. Contrary to the other modes, the rheology and microstructure formation of the MR fluid in the gradient pinch mode have been studied to a far lesser extent. The magnetic field distribution in the flow channel is intentionally made non-uniform. It is hypothesized that the Venturi-like contraction is achieved via fluid property changes, leading to a unique behavior and the presence of a pseudo-orifice. The main goal is to investigate the presence of the Venturi-like contraction effect in the fluid by means of optical imaging and hydraulic measurements. To accomplish the goal, a unique test rig has been developed including a fluorescence microscope and MR valve prototype. The Venturi-like contraction hypothesis was confirmed. The results indicate that the effective flow channel size decreases by 92% at the maximum magnetic flux applied. This has a direct impact on the flow characteristics of the MR valve. The variation of the pressure–flow rate curve slope with magnetic field was demonstrated. The results provide valuable information for understanding the rheology and microstructure formation mechanism in MR fluids in the pinch mode.

Ph.D. STUDY

- **What affects the pinch mode valve effiecncy?**
  - Effect of MR fluid composition
    - Particle Size
    - Particle Concentration
    - Carrier Fluid viscosity
- **Regression model?**
  - Wuest equations?



Ph.D. STUDY



scientific reports

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OPEN

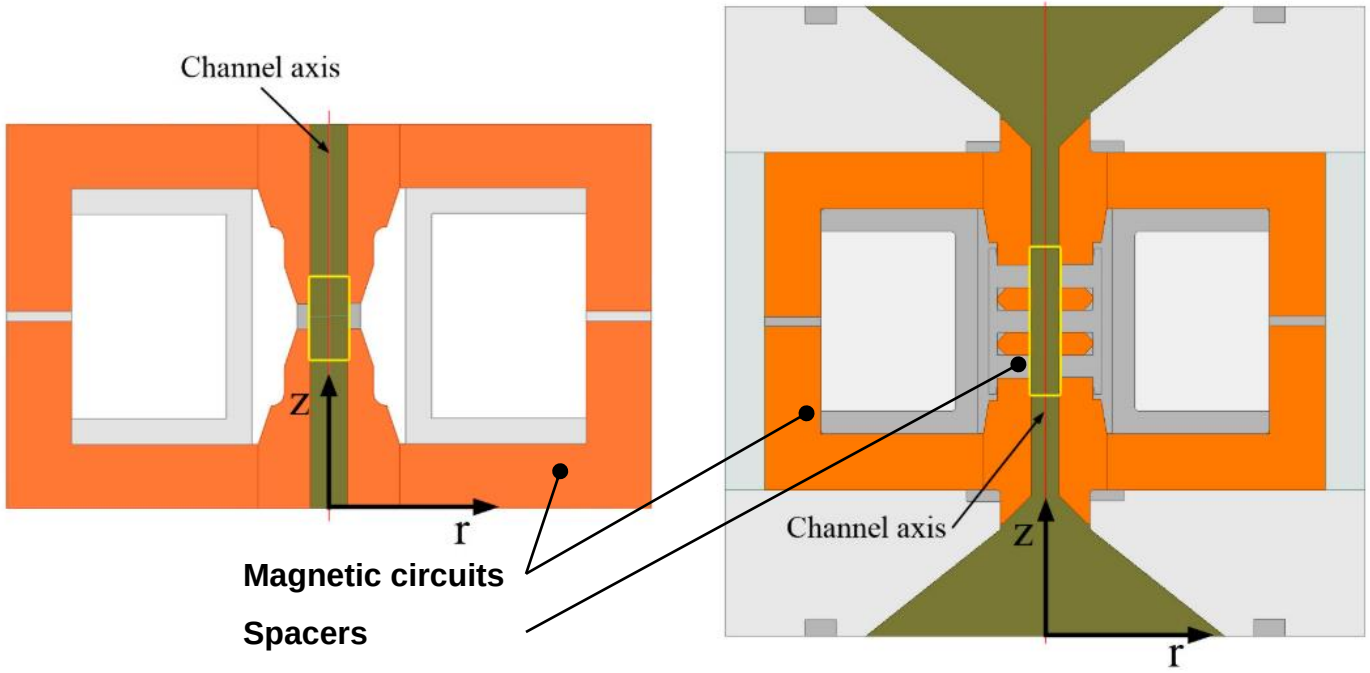
Impact of magnetorheological fluid composition on their behaviour in gradient pinch mode

Jiří Žáček[1], Zbyněk Strecker[1], Filip Jeniš[1], Ondřej Macháček[1], Janusz Goldasz[2], Bogdan Sapinski[3], Martin Vrbka[1] & Michal Kubík[1]✉

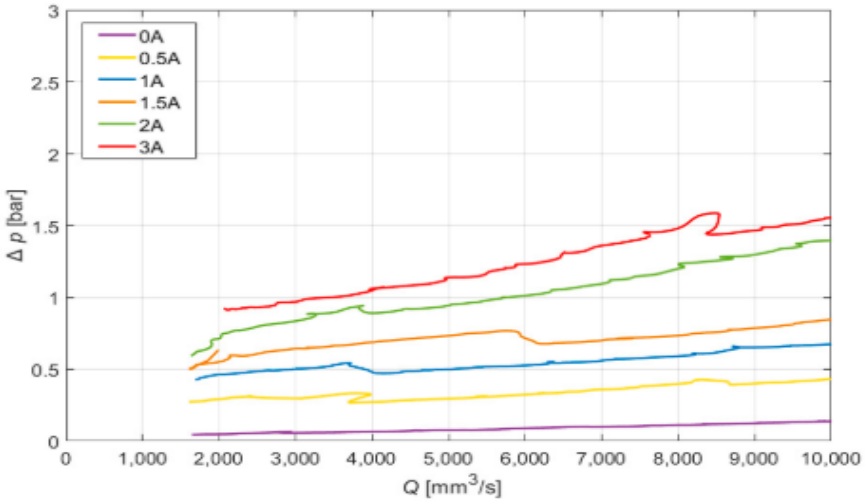
Magnetorheological (MR) fluids can be utilized in one of the fundamental operating modes of which the gradient pinch mode has been the least explored. In this unique mode non-uniform magnetic field distributions are taken advantage of to develop a so-called Venturi-like contraction in MR fluids. By adequately directing magnetic flux the material can be made solidified in the regions near the flow channel wall, thus creating a passage in the middle of the channel for the fluid to pass through. This leads to unique variations of the slope in the pressure-flow rate characteristics. It can be stated that the effect of the MR fluid composition on the behaviour of the MR fluid in gradient pinch mode has not been thoroughly investigated yet. In this study, the behaviour of MR fluids was assessed with a dedicated pinch mode MR valve that provided a valuable insight into the contraction mechanism using fluorescence microscopy. Briefly, seven MR fluid samples were prepared with different particle concentrations (10%, 22% and 32 vol%) and mean particle sizes (2, 4.5 and 8.2 µm). It was found that the MR fluid sample with the larger particle size exhibits a significantly larger slope change observed in the pressure-flow rate characteristics. Increasing the particle size from 2 µm (base) to 8 µm resulted in the slope increase by a factor of 2.6 compared to the base sample. Increasing the particle concentration has a negligible effect on the pinch mode effect. Finally, these results were analysed using the modified Wuest equation, which is commonly used for characterizing sharp-edged orifices in low Reynolds number flow regimes. The simple equation was determined to describe the behaviour of MR fluids in gradient pinch mode with adequate accuracy.

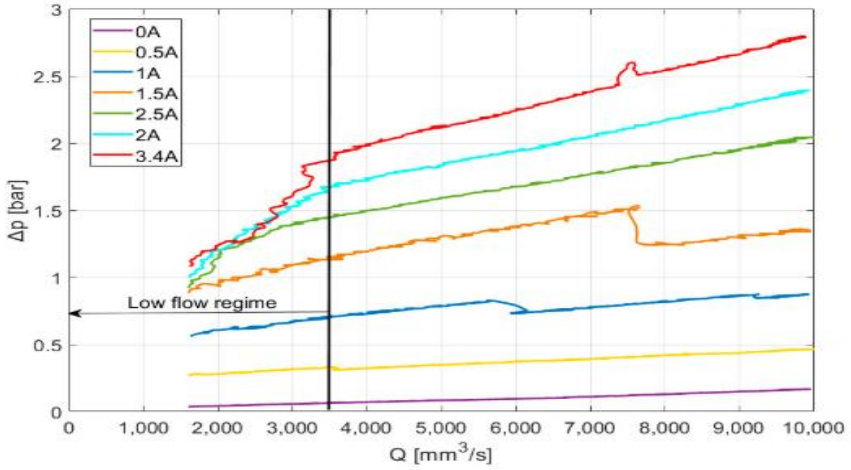
Ph.D. STUDY

- **Can geometry of the valve impact its performance?**
  - Multistage valve



Ph.D. STUDY





actuators

MDPI

Article

Assessment of the Dynamic Range of Magnetorheological Gradient Pinch-Mode Prototype Valves

Jiří Žáček [1], Janusz Goldasz [2], Bogdan Sapinski [3], Michal Sedlačík [4,5], Zbyněk Strecker [1] and Michal Kubík [1,*]

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2 Faculty of Electrical and Computer Engineering, Cracow University of Technology, 31-155 Cracow, Poland; janusz.goldasz@pk.edu.pl
3 Department of Process Control, AGH University of Krakow, 30-059 Cracow, Poland; deep@agh.edu.pl
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5 Department of Production Engineering, Faculty of Technology, Tomas Bata University in Zlín, 760 01 Zlín, Czech Republic
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Abstract: Magnetorheological (MR) fluids have been known to react to magnetic fields of sufficient magnitudes. While in the presence of the field, the material develops a yield stress. The tunable property has made it attractive in, e.g., semi-active damper applications in the vibration control domain in particular. Within the context of a given application, MR fluids can be exploited in at least one of the fundamental operating modes (flow, shear, squeeze, or gradient pinch mode) of which the gradient pinch mode has been the least explored. Contrary to the other operating modes, the MR fluid volume in the flow channel is exposed to a non-uniform magnetic field in such a way that a Venturi-like contraction is developed in a flow channel solely by means of a solidified material in the regions near the walls rather than the mechanically driven changes in the channel's geometry. The pinch-mode rheology of the material has made it a potential candidate for developing a new category of MR valves. By convention, a pinch-mode valve features a single flow channel with poles over which a non-uniform magnetic field is induced. In this study, the authors examine ways of extending the dynamic range of pinch-mode valves by employing a number of such arrangements (stages) in series. To accomplish this, the authors developed a prototype of a multi-stage (three-stage) valve, and then compared its performance against that of a single-stage valve across a wide range of hydraulic and magnetic stimuli. To summarize, improvements of the pinch-mode valve dynamic range are evident; however, at the same time, it is hampered by the presence of serial air gaps in the flow channel.

Keywords: magnetorheological fluid; gradient pinch mode; valve; dynamic range

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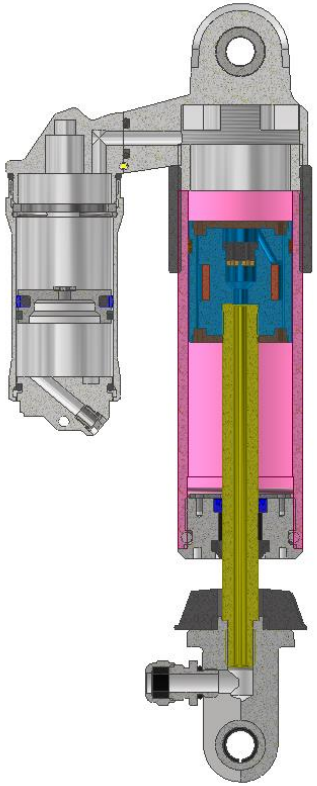
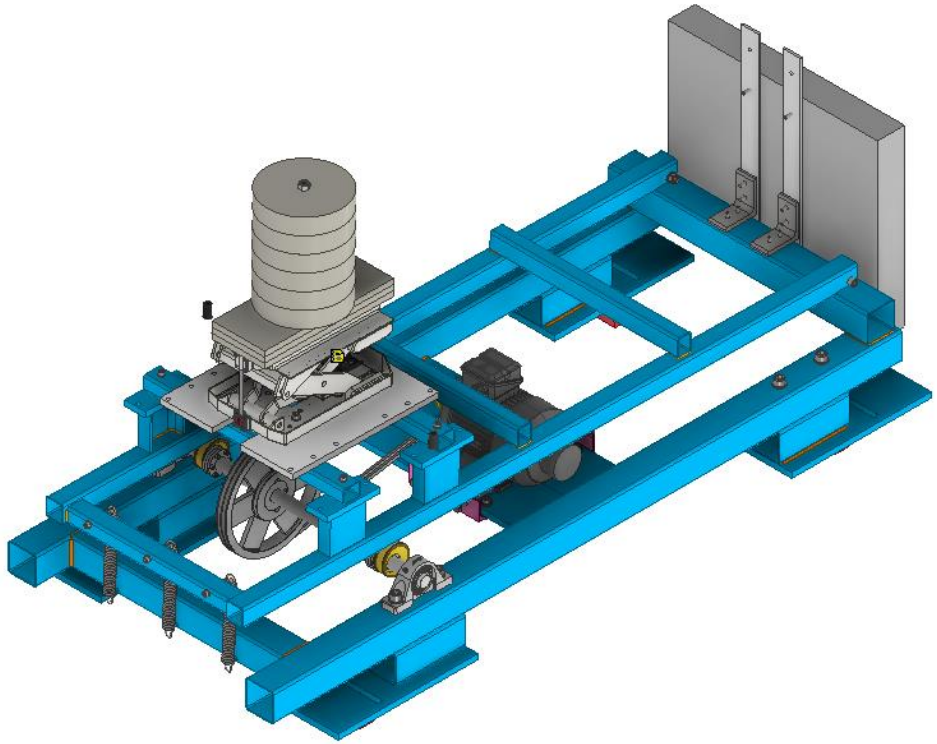
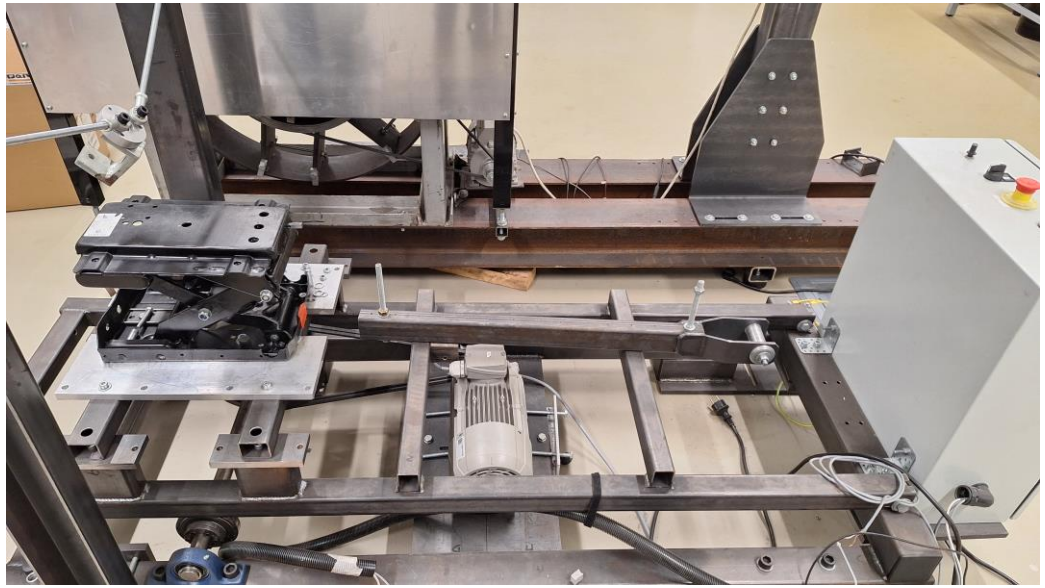
Citation: Žáček, J.; Goldasz, J.; Sapinski, B.; Sedlačík, M.; Strecker, Z.; Kubík, M. Assessment of the Dynamic Range of Magnetorheological Gradient Pinch-Mode Prototype Valves. *Actuators* **2023**, *12*, 449. https://doi.org/10.3390/act12120449

OTHER RESEARCH

KInG - Demonstrátor Semi-aktivního tlumení s využitím Magnetoreologického tlumiče







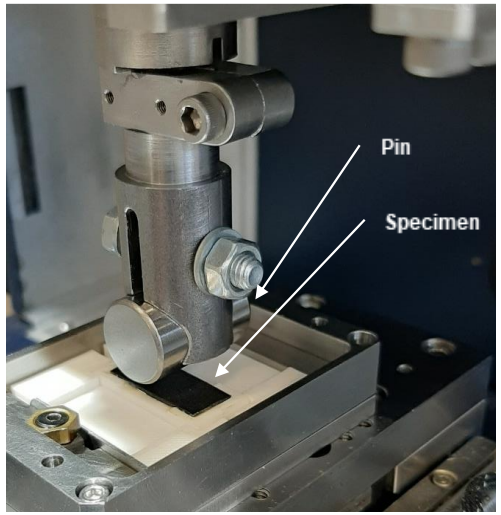
OTHER RESEARCH

KInG - Demonstrátor Semi-aktivního tlumení s využitím Magnetoreologického tlumiče

OTHER RESEARCH

EDA – Common Link

- Development of a new MR fluid for military aplication
- Tribological and Rheological tests



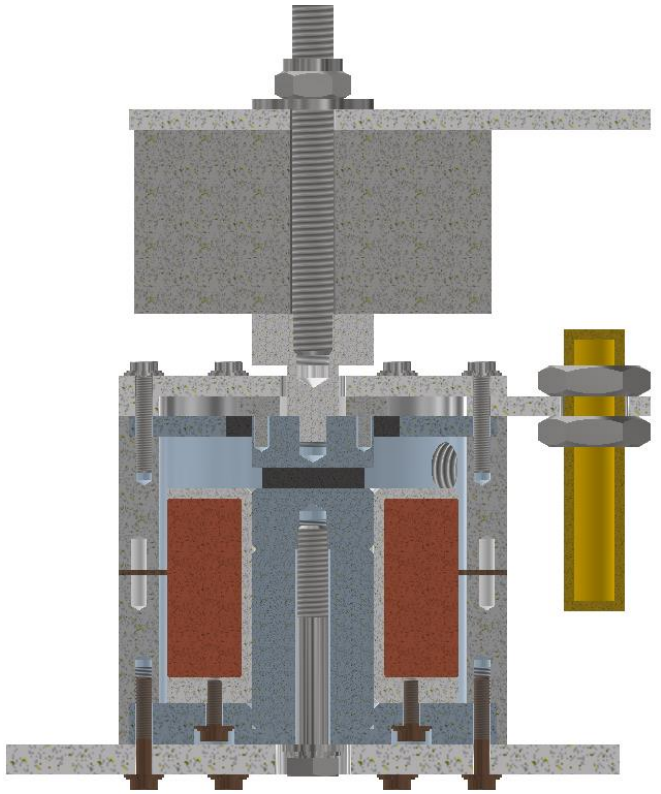
TAČR Doprava/Proof of Concept

- Development of MR based semi-acitve damping systems for trains
- Various work on the project

OTHER RESEARCH

GAČR - Durable Magnetorheological Elastomers for Vibration Control Devices

- From 2025
- Cooperation with UTB
- BUT Team
  - Design of Test Bench for Elastomers
    - ZIP project
  - Durability tests of MR Elastomers

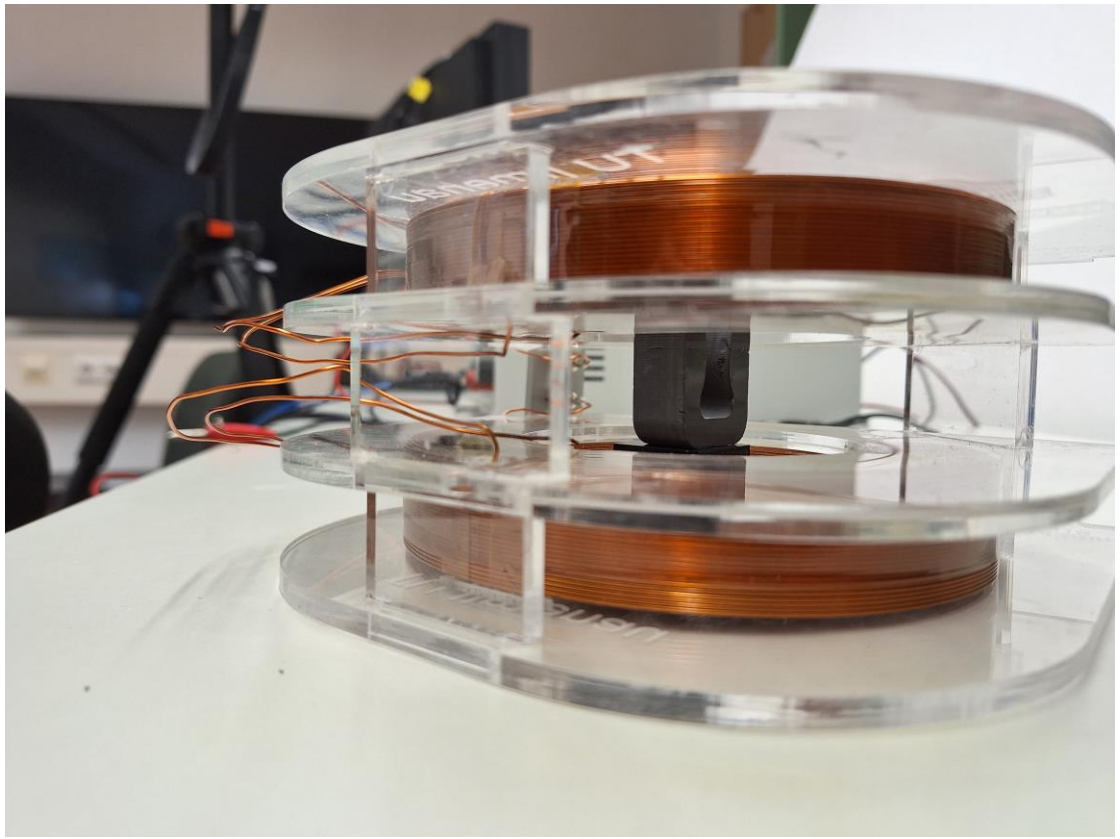


IINTERNSHIPS

Technische Univesität Ilmenau

- November 2023
- Supervisor: dr. Tatiana Becker

IINTERNSHIPS



IINTERNSHIPS

IINTERNSHIPS

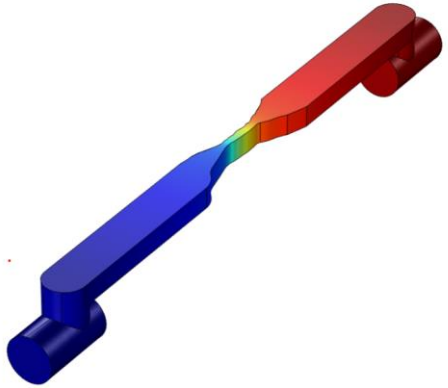
Universidad de Granada

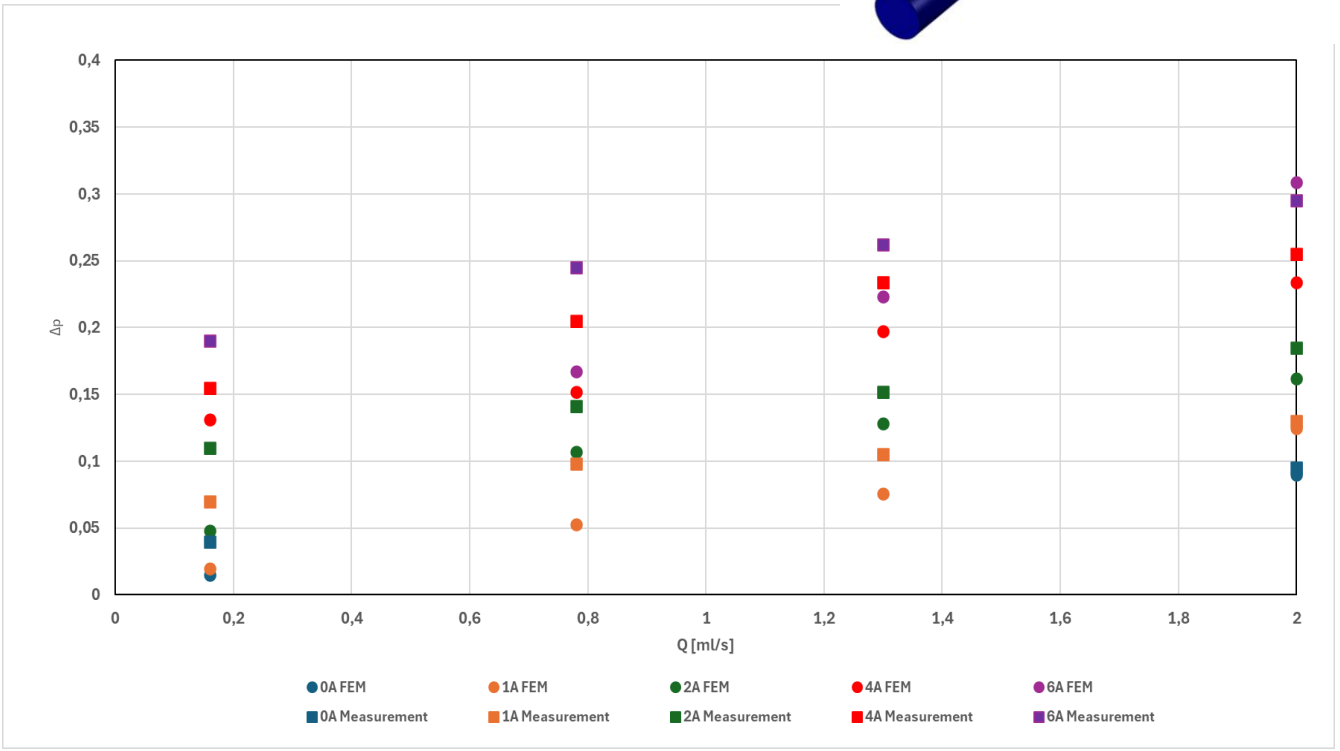
- September 2024 - November 2024
- Supervisor: prof. Juan de Vicente

IINTERNSHIPS

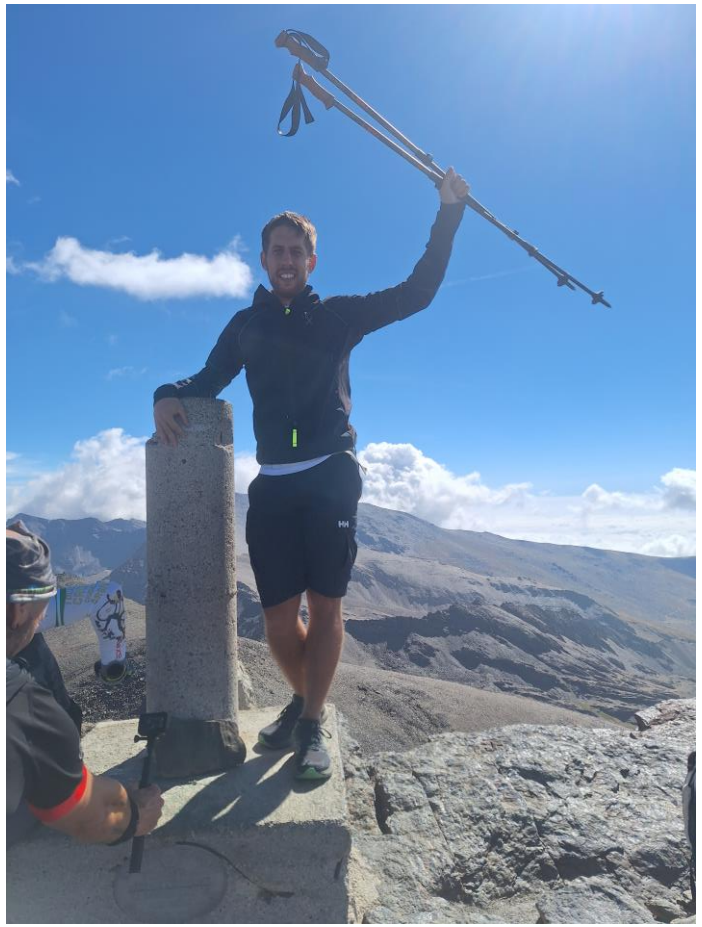
- Particle simulation of pinch valve mode - prediction
- More than 1000 rows of code

- FEM simulation of venturi contaction
- Not suitable for prediction!!!

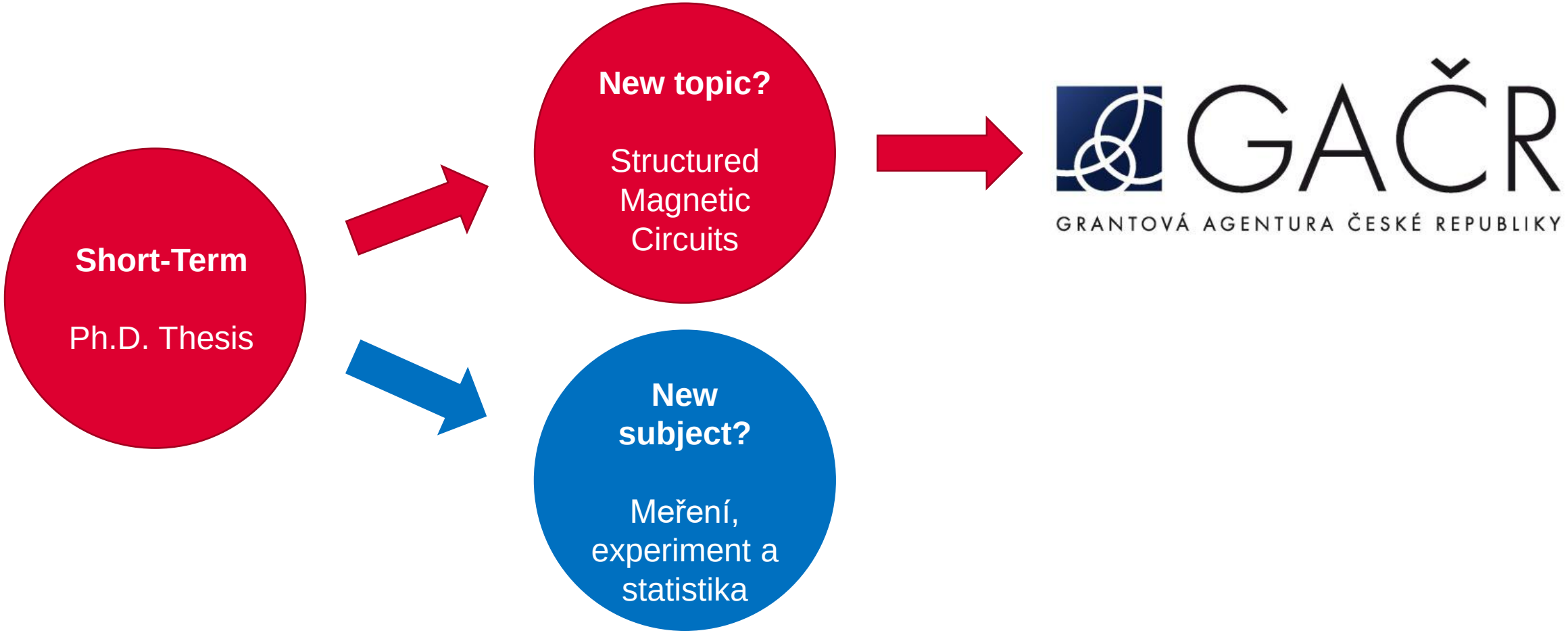




IINTERNSHIPS



FUTURE RESEARCH AND ACTIVITIES



SAILING

- … not only racing (my 21st season)

SAILING

- But also
  - Coach
  - Referee/Umpire
  - Measurer
  - Czech Sailing Associoation official

ČESKÝ SVAZ JACHTINGU

THANK YOU FOR ATTENTION

Žáček Jiří

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KONSTRUOVÁNÍ

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