Wrocław University of Technology

Damping properties of magnetorheological composites. Tests, models, identification

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Outline

- Introduction, the aim of work
- MR materials and MR effect
- Magnetorheological composites (MRC)
- Experimental set-up\basic tests
- Model of magnetorheological composite material
- Example application of damper with MRC
- Summary

The aim of work

Identification of damping characteristics of magnetorheological composites constitutes were the main goal. Tests were carried out under cyclic shearing. Elastic porous matrix filled with magnetorheological fluid has been chosen for examinations.

INTRODUCTION
MAGNETORHEOLOGICAL MATERIALS

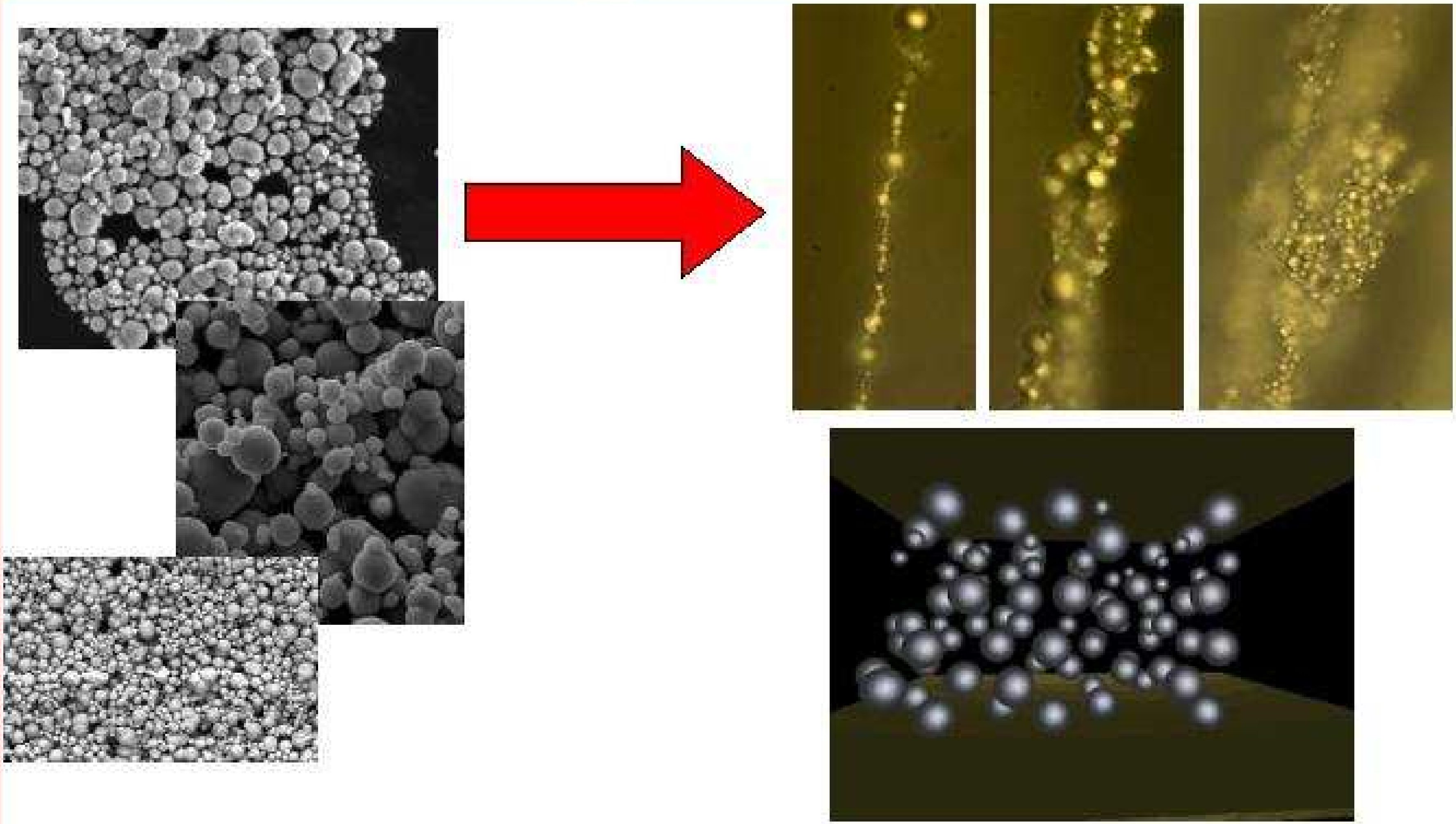
Magnetorheological Fluids as the reference point

- Main component of magnetorheological composites
- Small amount of information about MRC, big about MRF
- Similar area of applications - active damping construction

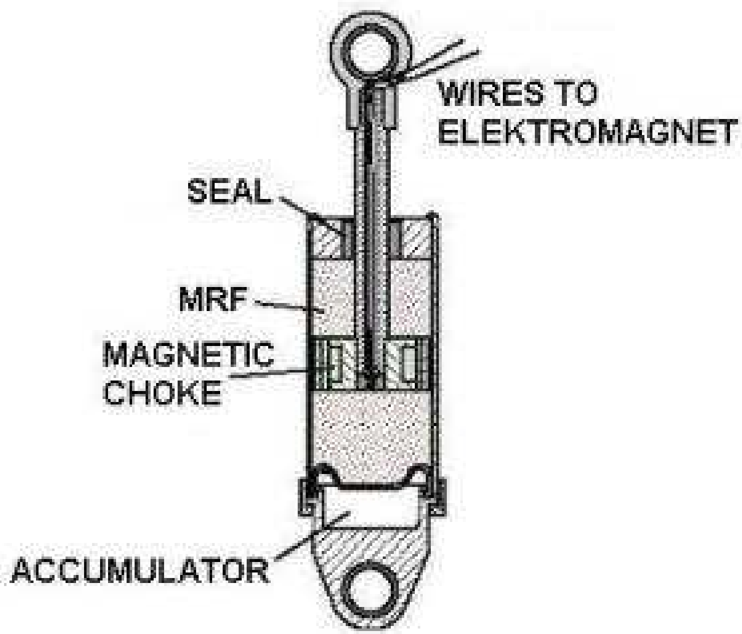
MR effect
Influence of magnetic field

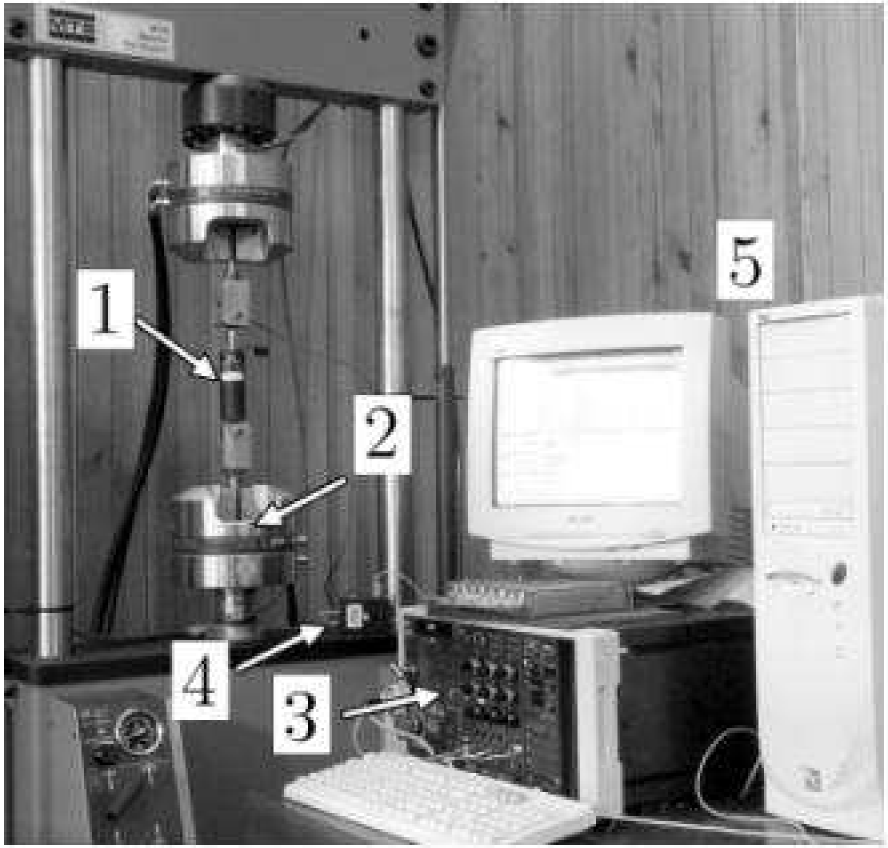
Source: LORD Corp.

MR effect
Influence of magnetic field

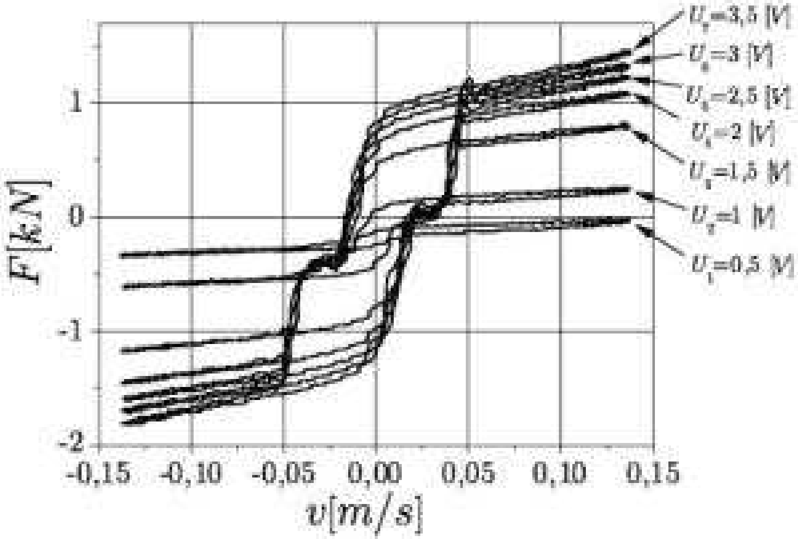


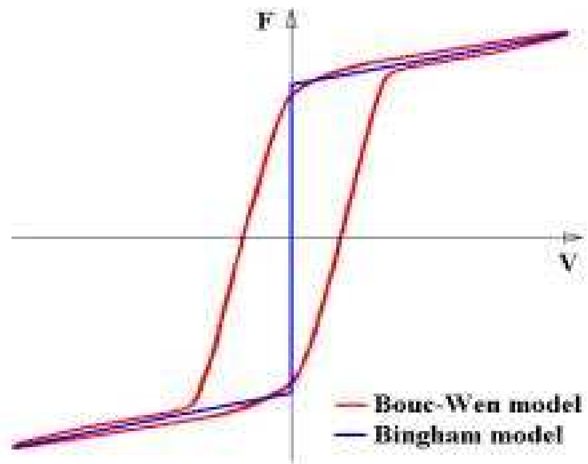
Active damper with MR fluid

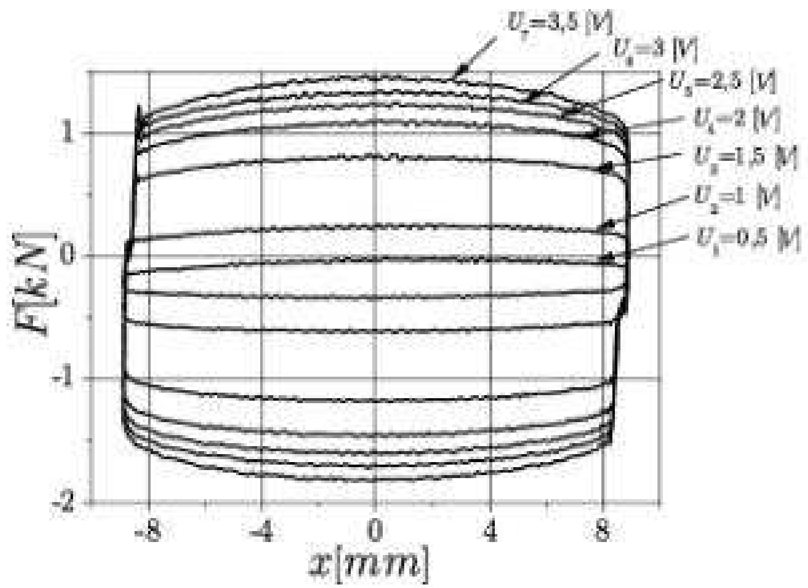




Experiment, basic models

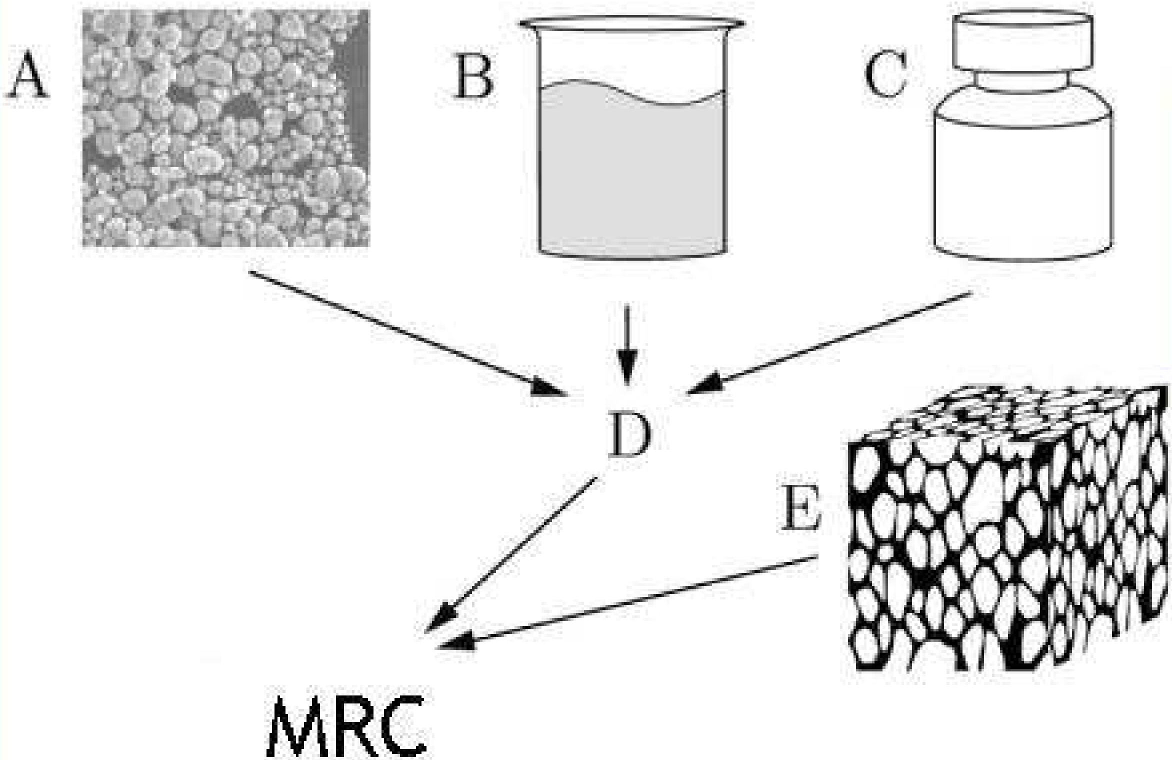






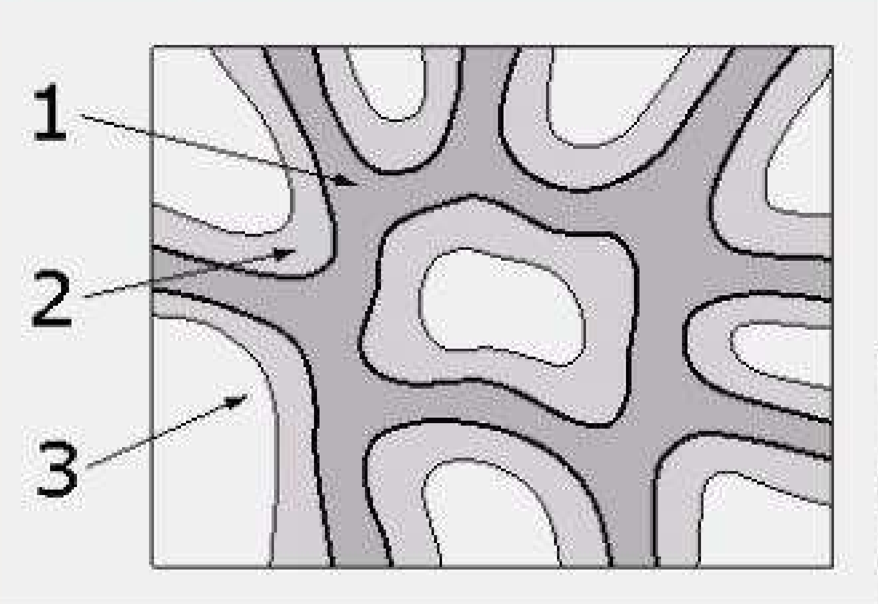
Magnetorheological Composites

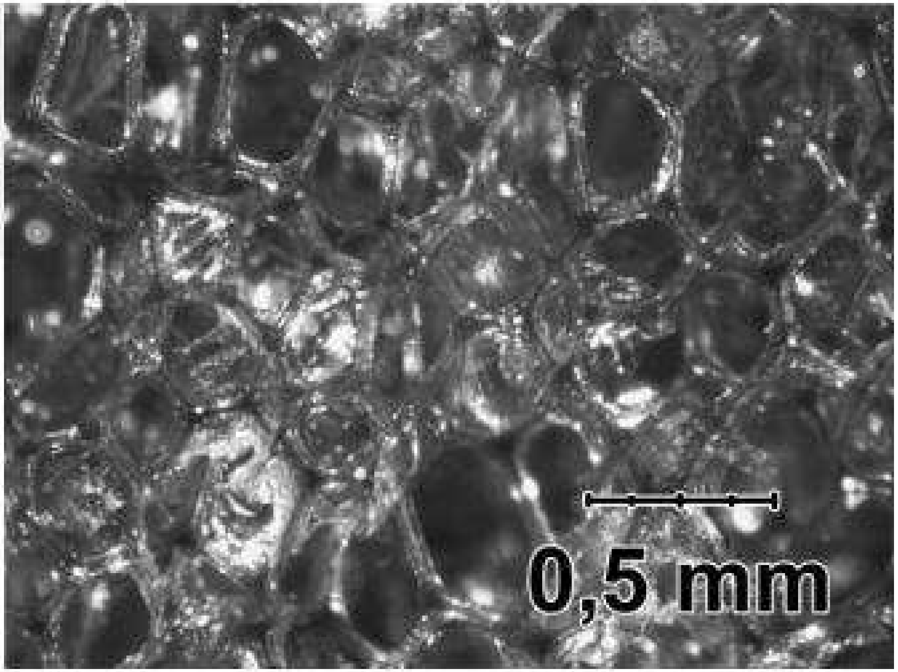
Margnetorheological composites preparation



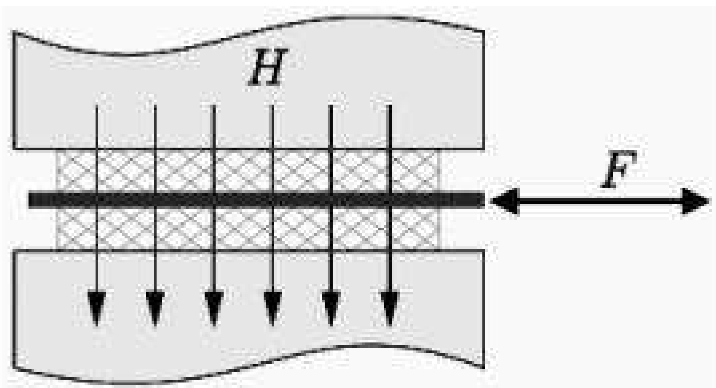
A – carbonyl iron powder,
B – carrier fluid,
C – additives,
D – MR Fluid
E – porus material – matrix.

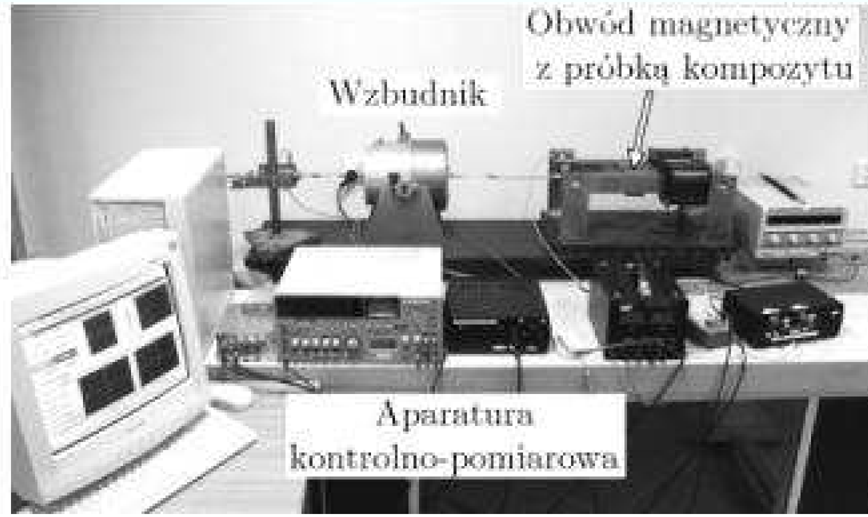
Margnetorheological composites preparation

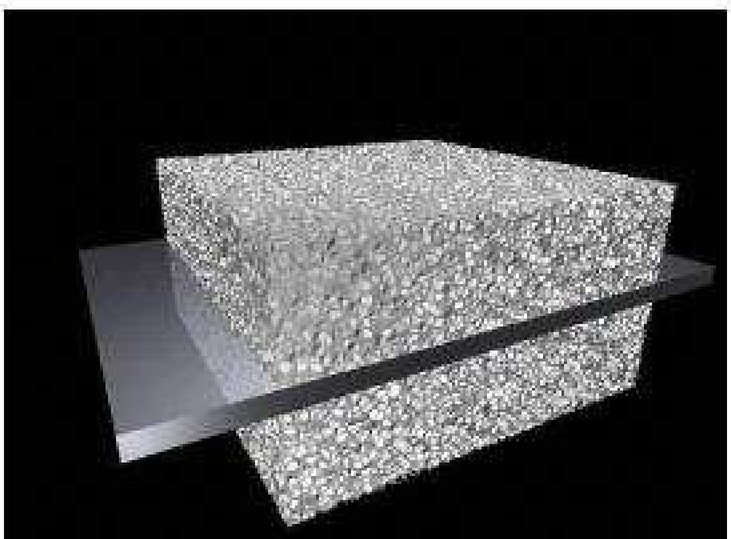


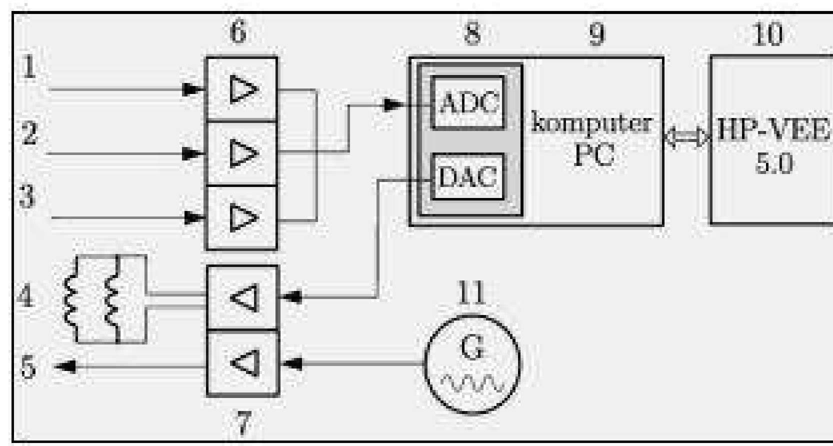


Samples, test stand

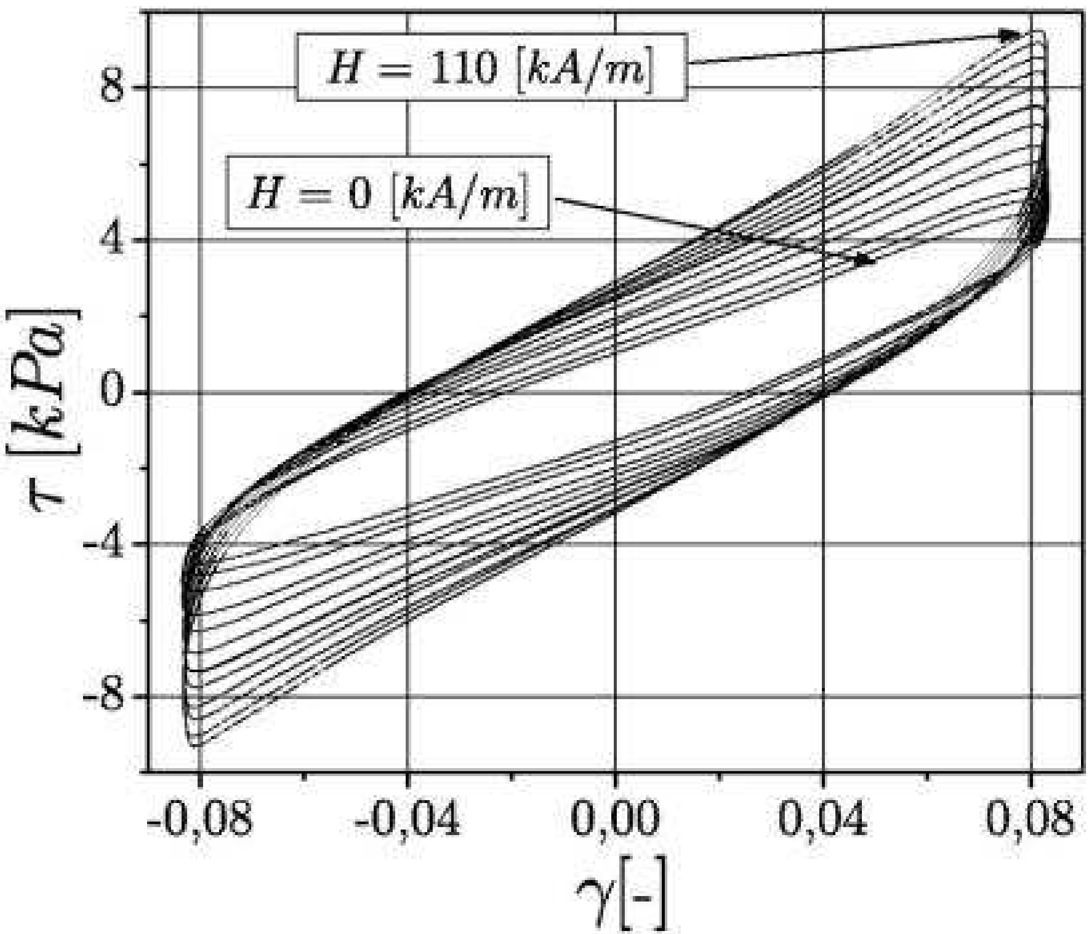






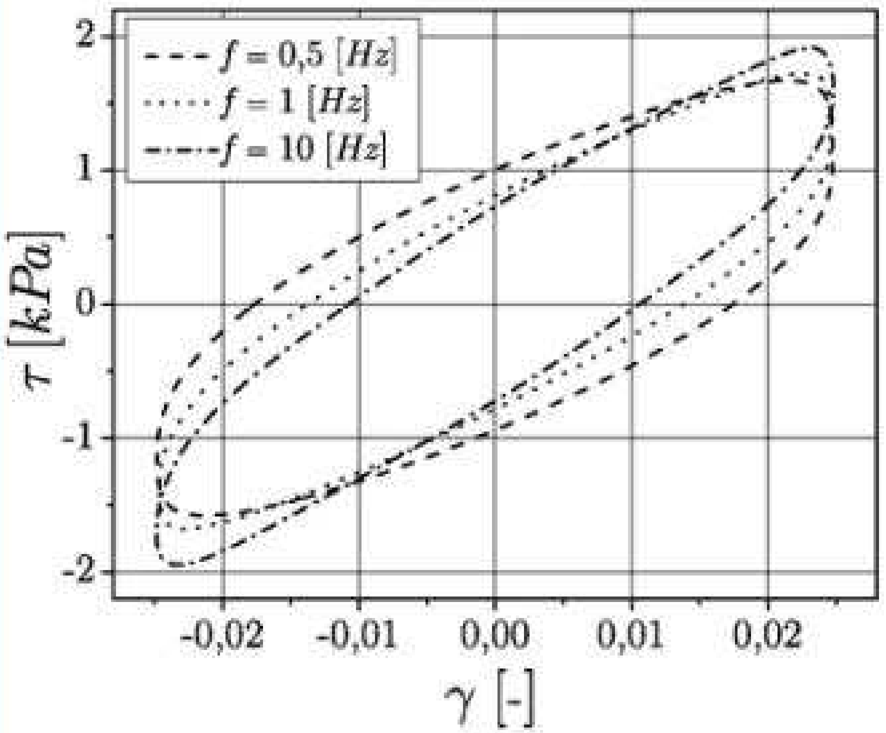


Basic results

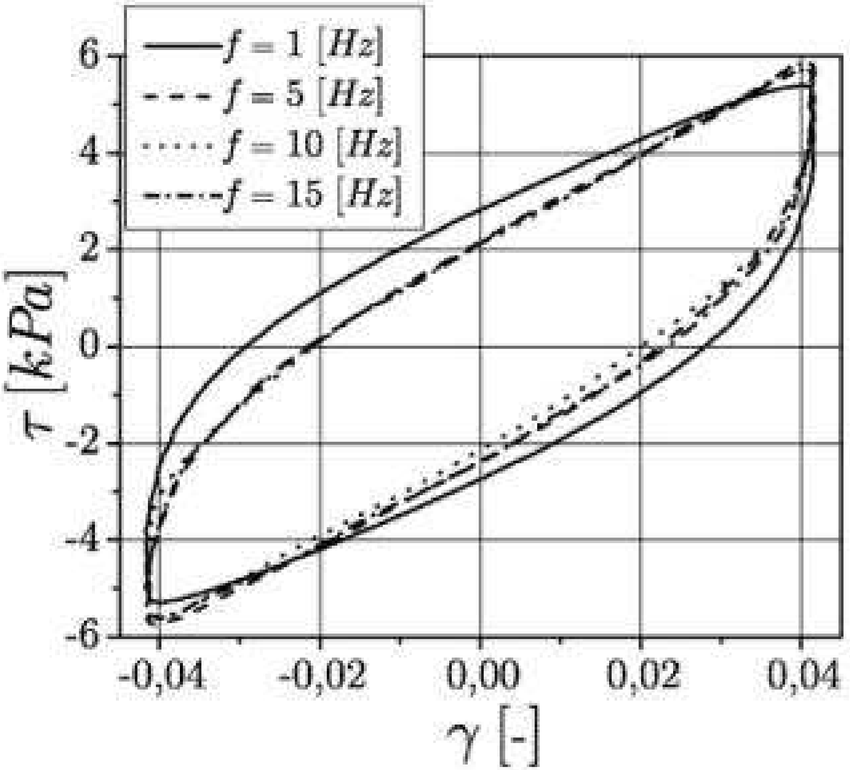


Basic results - frequency influence

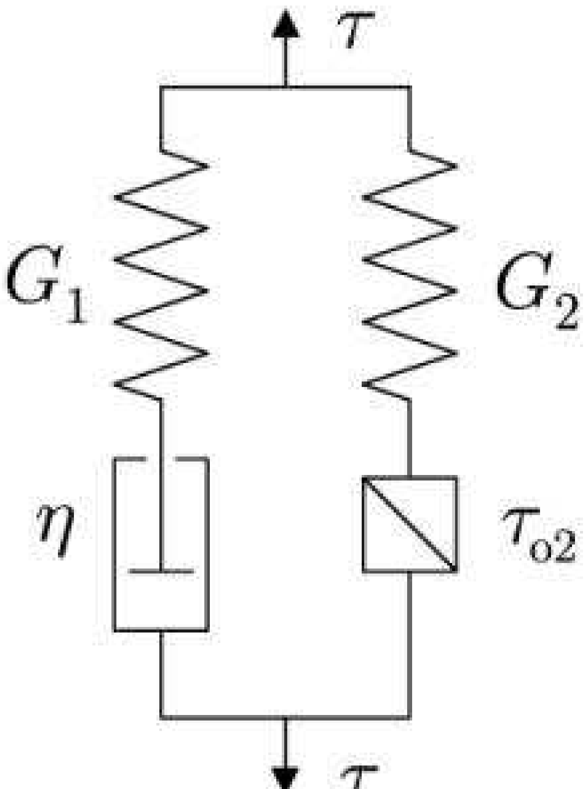
H* = 30 *kA/m



H* = 110 *kA/m



Material model



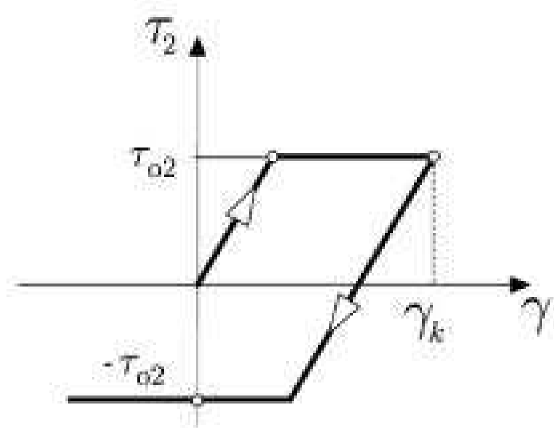
$$\tau = \tau_1 + \tau_2, \qquad \text{i} \qquad \gamma = \gamma_1 = \gamma_2 \, ,$$

$$\dot{\gamma}_1 = \dot{\gamma} = \frac{\dot{\tau}_1}{G_1} + \frac{\tau_1}{\eta} \, ,$$

$$\tau_2 = G_2(\gamma - \gamma_k) \pm \tau_{o2} \qquad \text{dla} \qquad |\tau_2| \leqslant \tau_{o2}$$

$$\tau + \frac{\eta}{G_1}\dot{\tau} = G_2\left(\gamma + \eta\dot{\gamma}\frac{G_1 + G_2}{G_1 G_2}\right) - G_2\gamma_k + \tau_{o2}\text{sign}\dot{\tau}$$

$$\tau + \frac{\eta}{G_1}\dot{\tau} = \eta\dot{\gamma} + \tau_{o2}\text{sign}\dot{\tau} \qquad \text{gdy} \qquad \tau_2 = \tau_{o2}\text{sign}\dot{\tau}$$



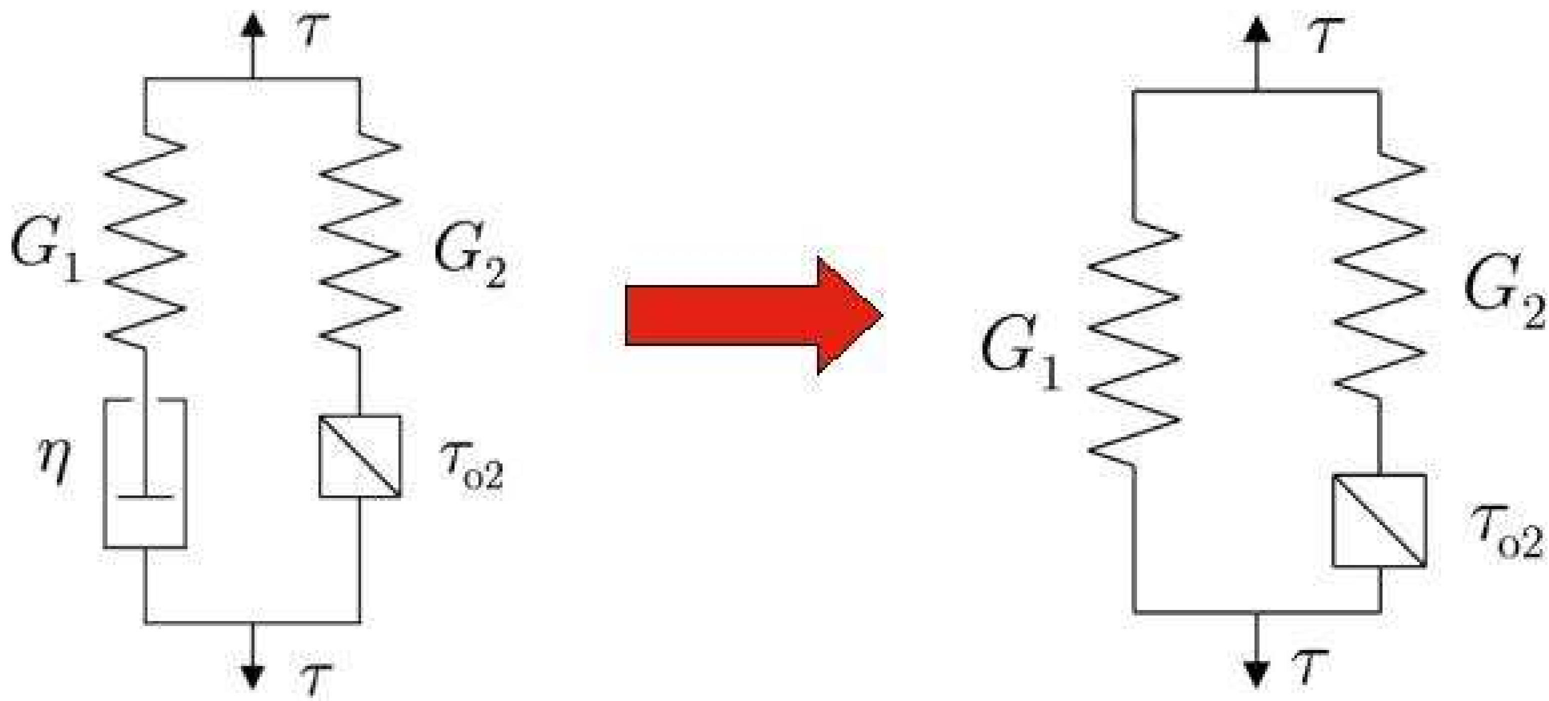
Damping properties
Visco and plastic parts

$$\Delta W = \int_0^{\frac{2\pi}{\omega}} \tau(t)\dot{\gamma}(t)dt$$

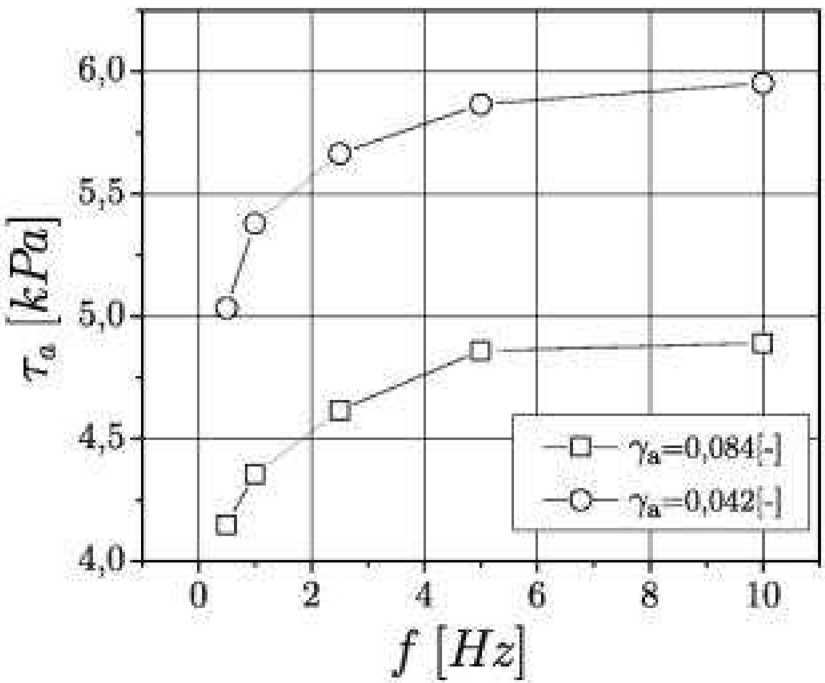
$$\Delta W = \underbrace{\frac{G_1^2 \pi \eta \omega \gamma_a^2}{G_1^2 + \eta^2 \omega^2}} + \underbrace{4\left(\tau_{o2}\gamma_a - \frac{\tau_{o2}^2}{G_2}\right)}$$

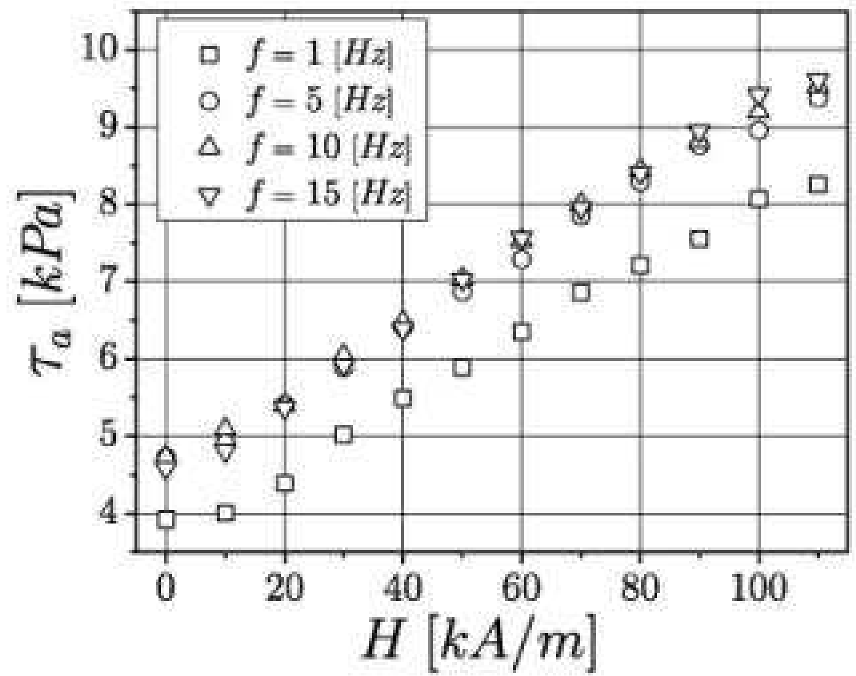
$$\Delta W = \Delta W_1 + \Delta W_2$$

Identification part I
Simplification

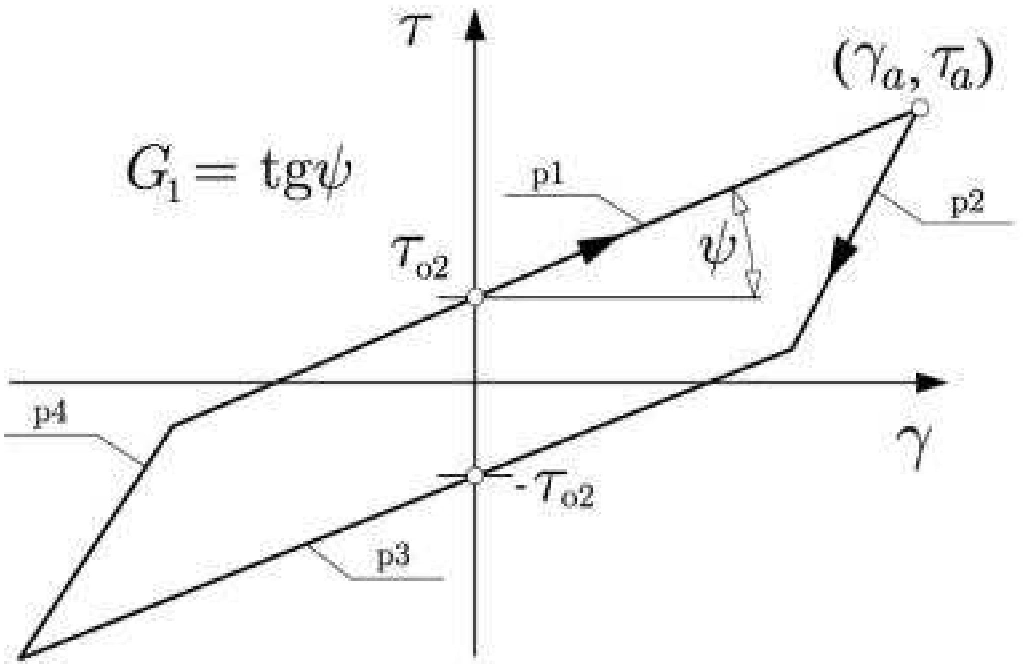


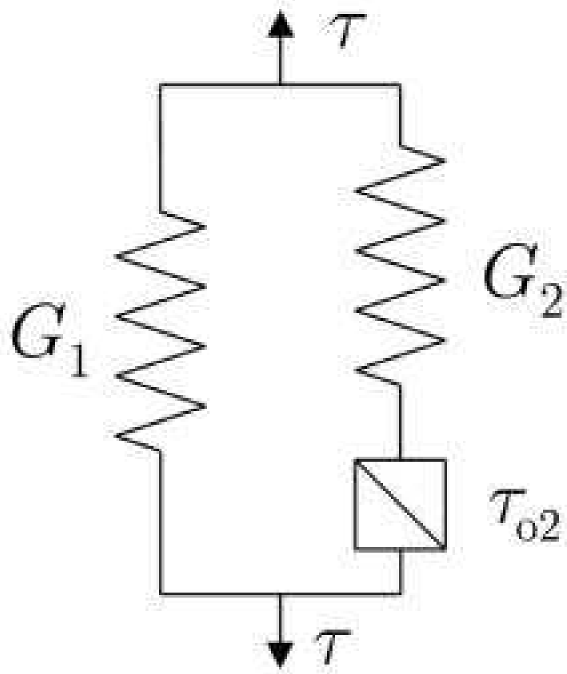
Basic results - frequency influence



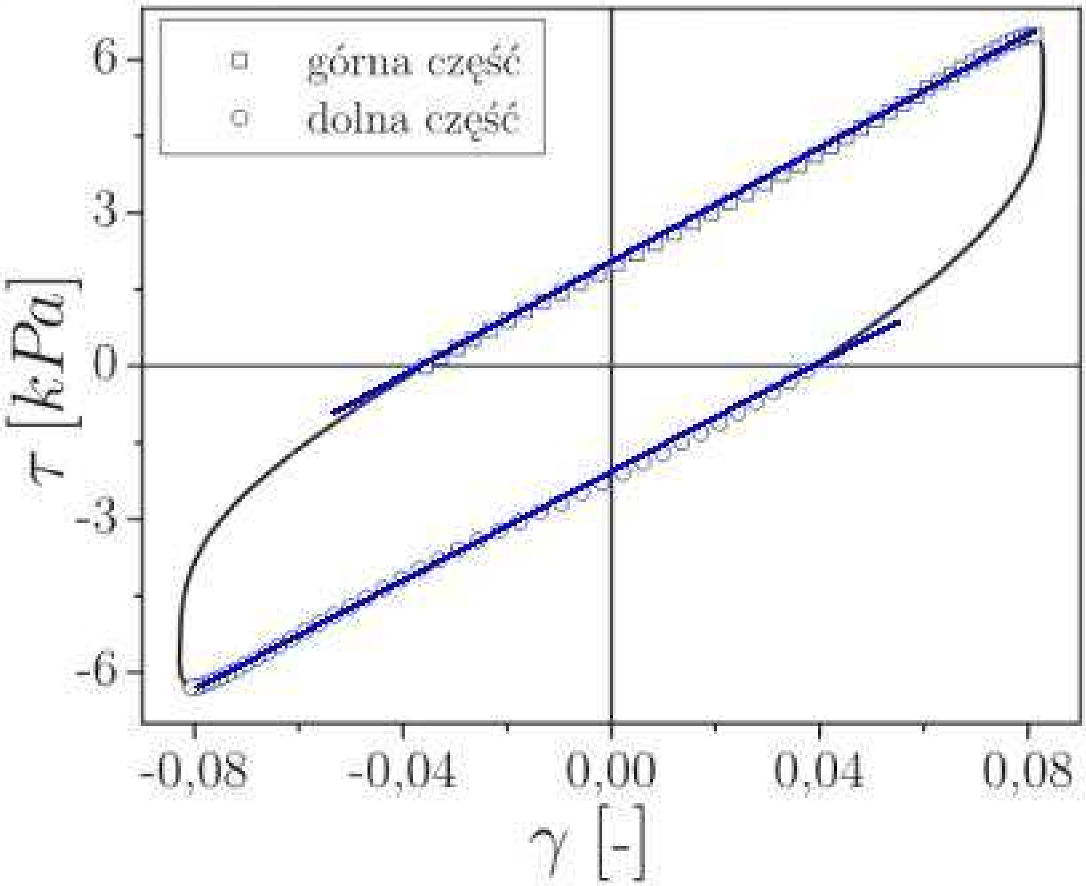


Identification part I Simplification





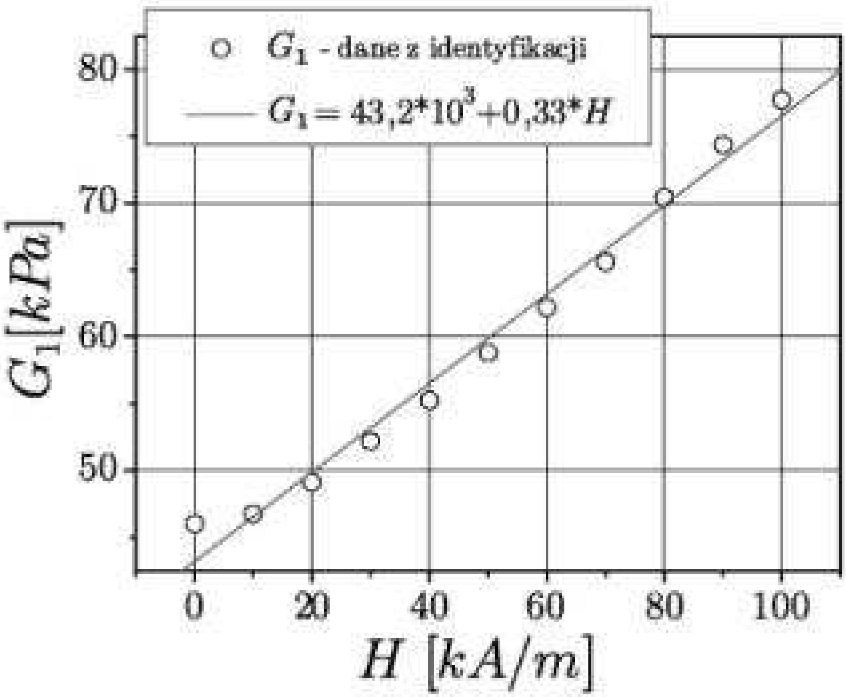
Identification part I
Parameters - Γ_1, ↵$_{o2}$

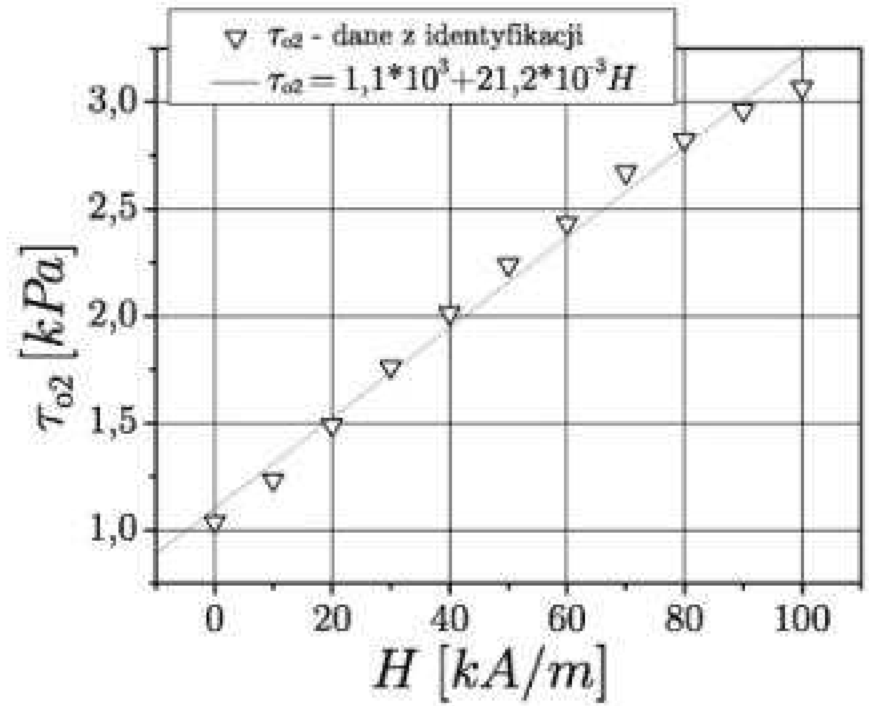


Linear regression :

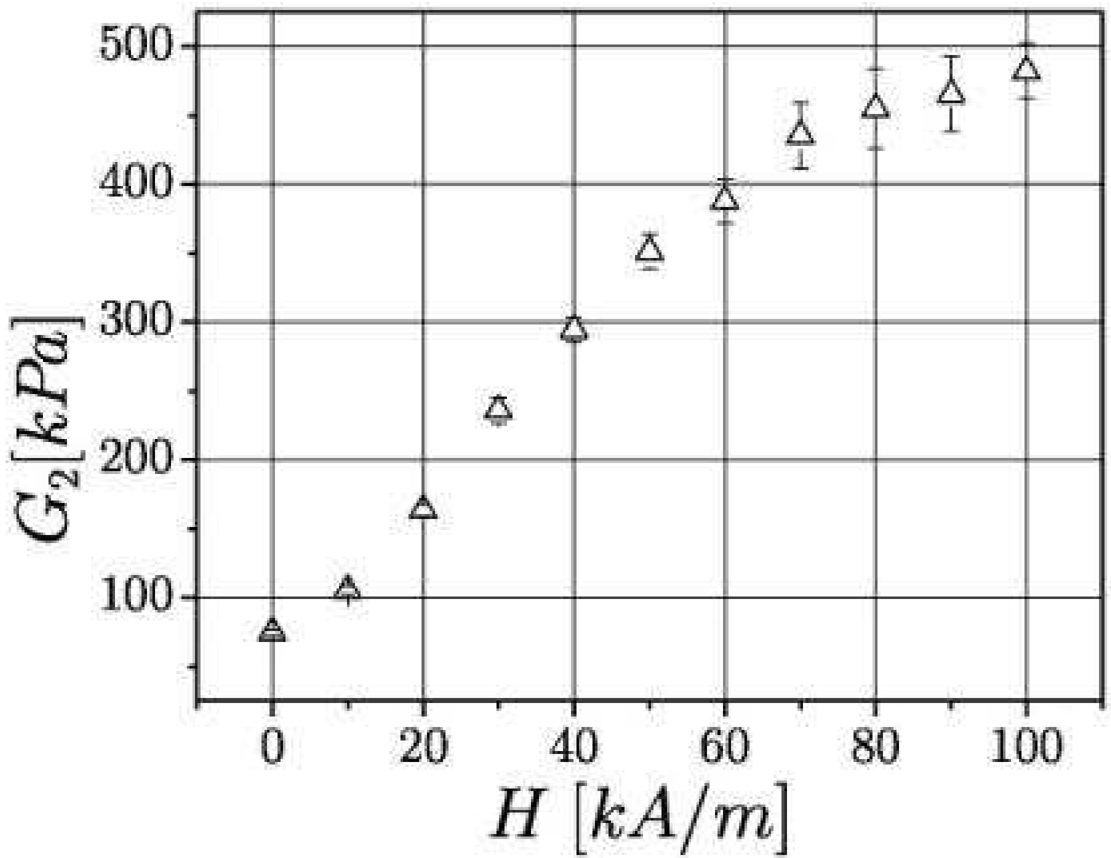
$$\tau = \gamma G_1 + \tau_{o2}$$

Identification part I
Parameters - Γ_1, ↵$_{o2}$





Identification part I
Parameter - Γ_2



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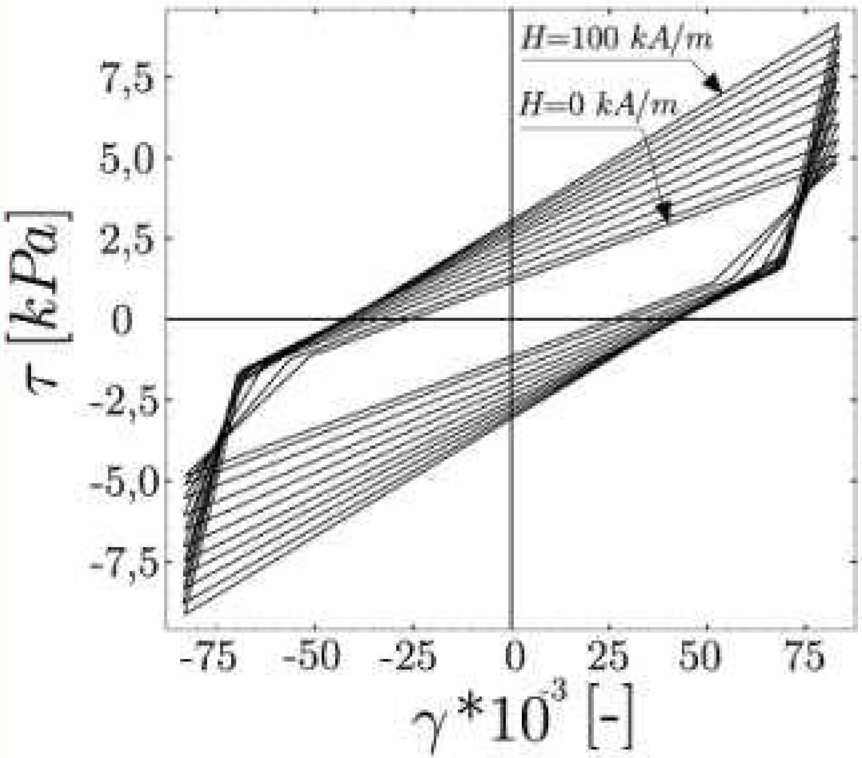
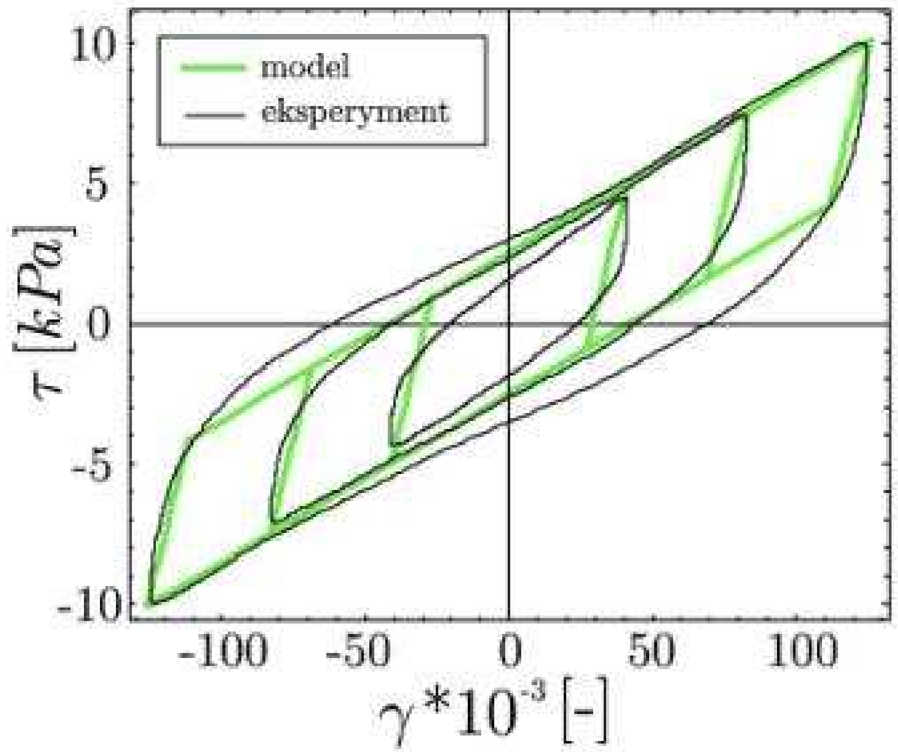
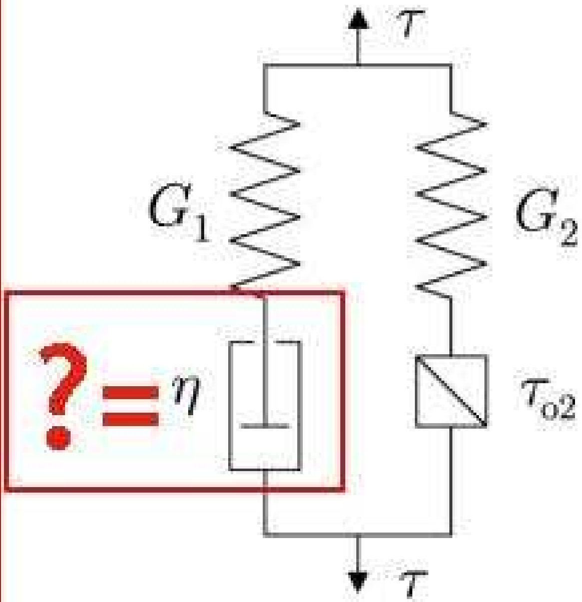
Identification part I
Model and experimental data comp.





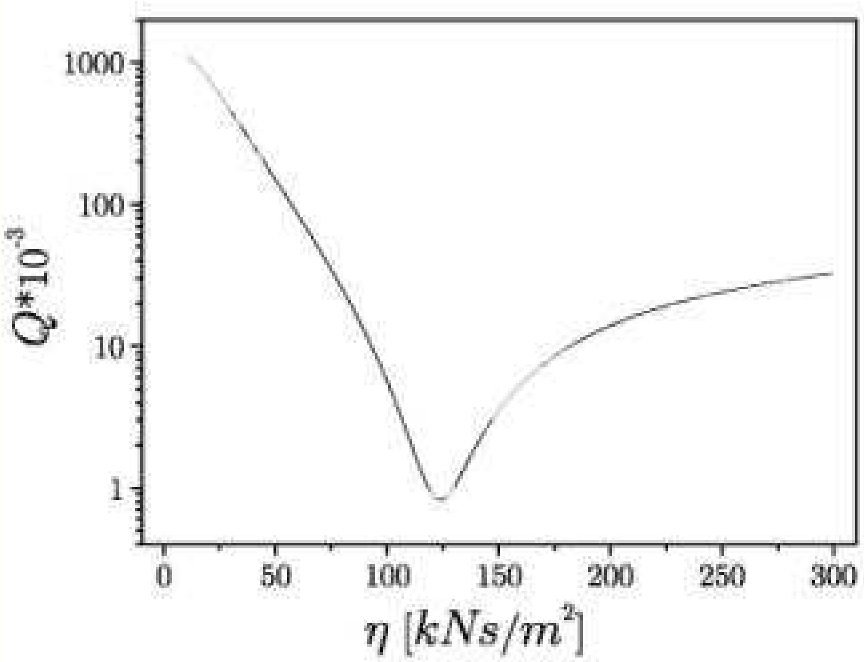
Identification part II
Parameter ×



$$Q = \sum_{j=1}^{N} \left(\Delta W_j^{(\mathrm{eks})} - \Delta W_j^{(\mathrm{mod})} \right)^2$$

H kA/m	G_1 kPa	τ_{o2} Pa	G_2 kPa	γ_a $-$
60	62,2	2434	388	0,084

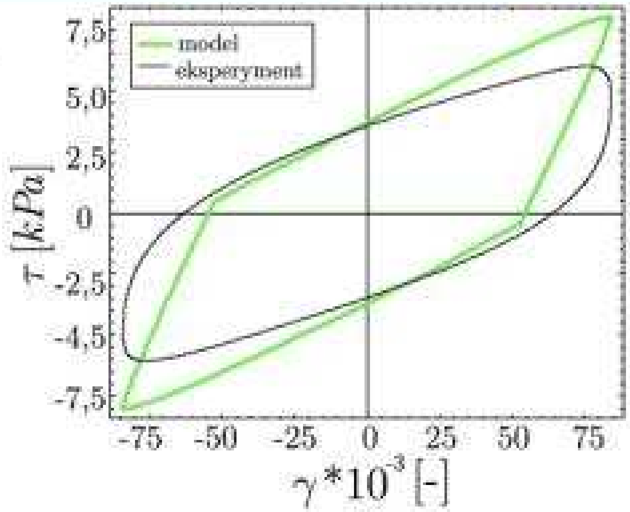
Identification part II
Results of calculation Θ(×)



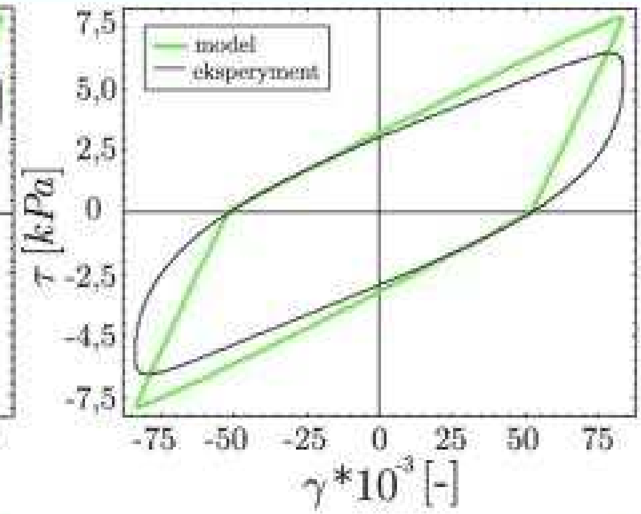
$$\min Q \rightarrow \eta = 124\ kN\ s/m^2$$

Identification part II
Model and experimental data comp.

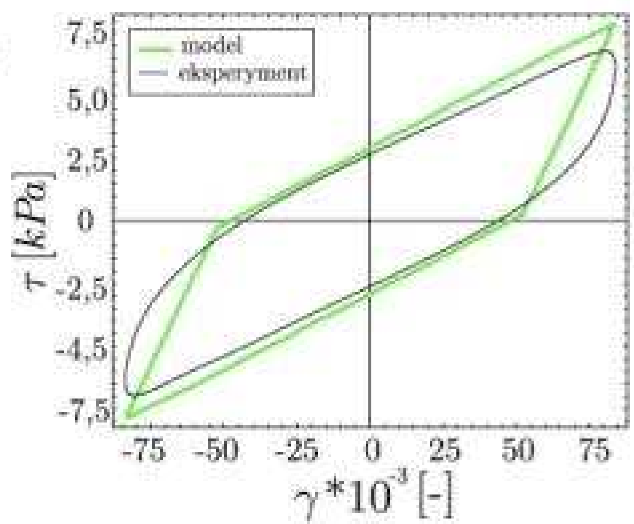
$f = 0{,}5\ Hz$



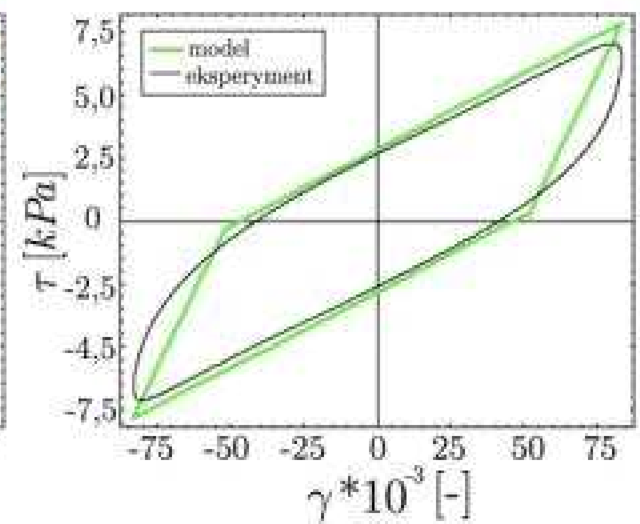
$f = 1\ Hz$



$f = 2{,}5\ Hz$

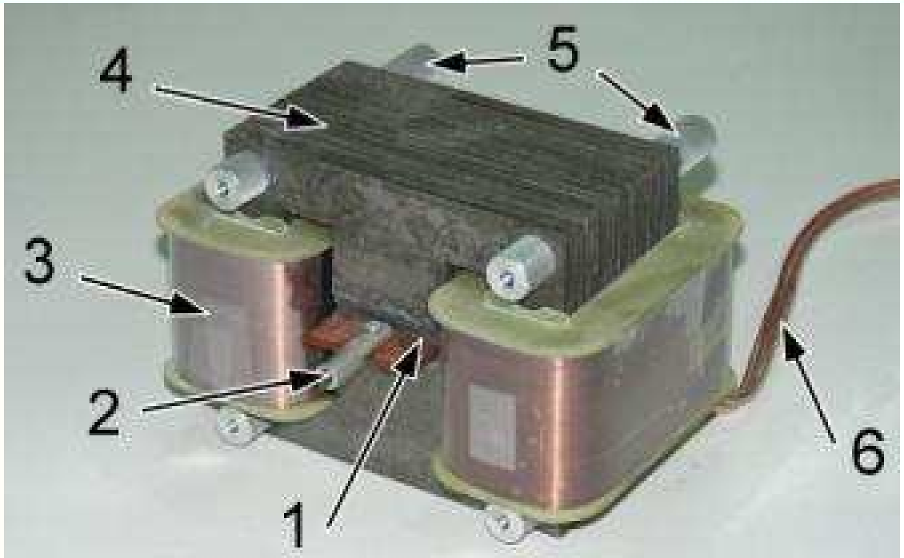


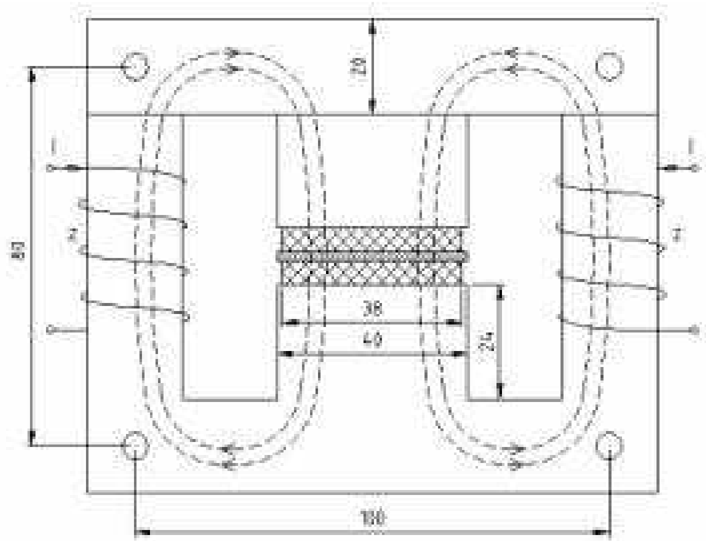
$f = 5\ Hz$

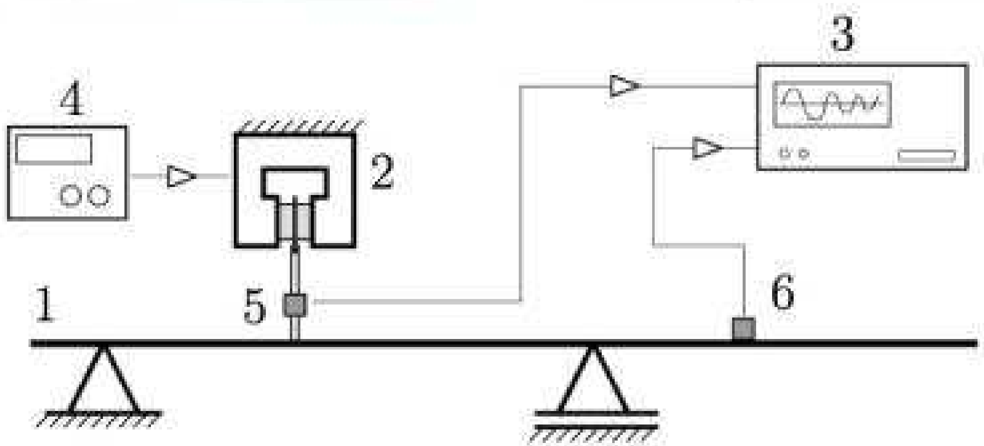


Example of application for magnetorhoelogical composites

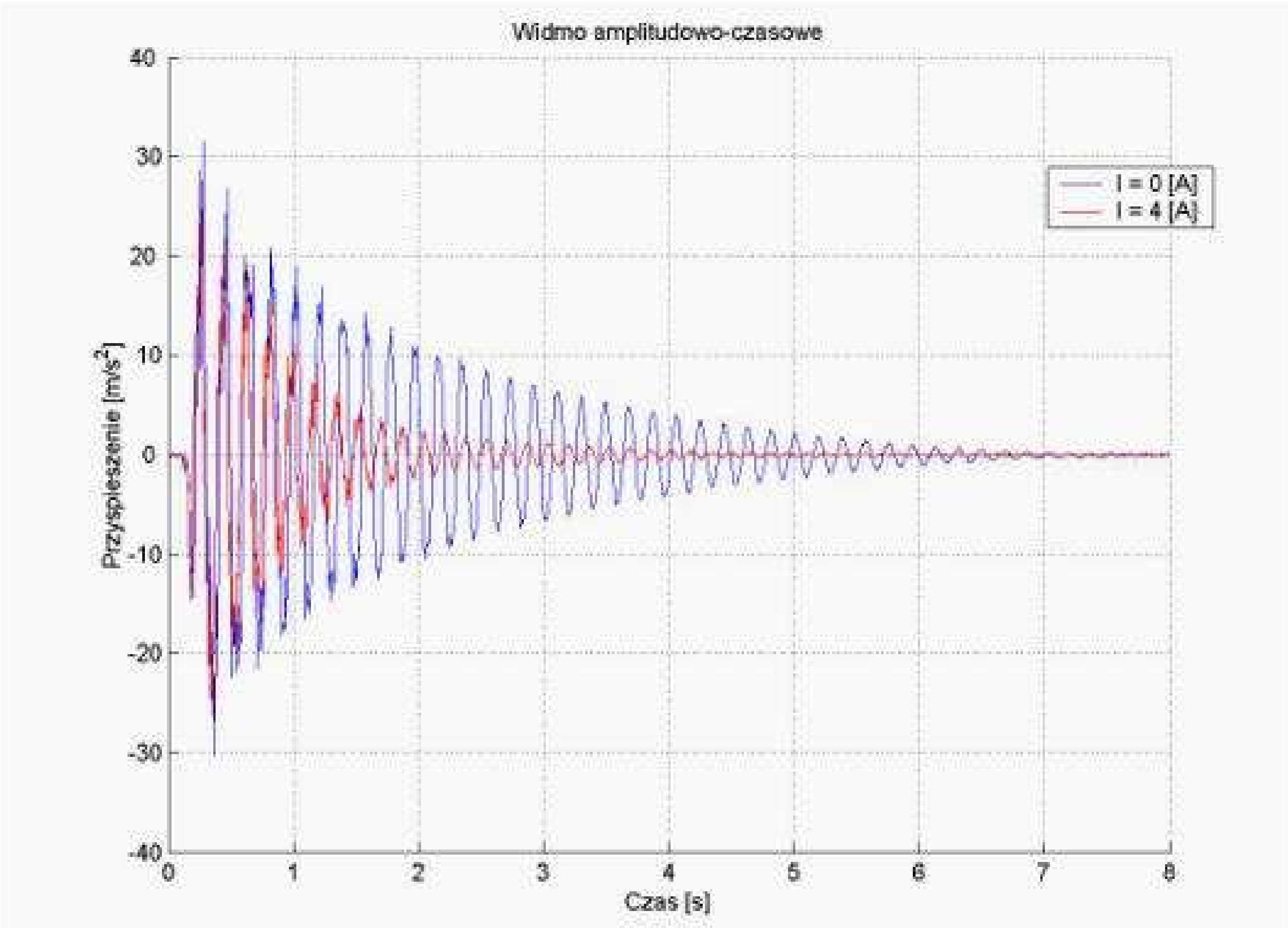
Test stand
Beam - vibration analysis



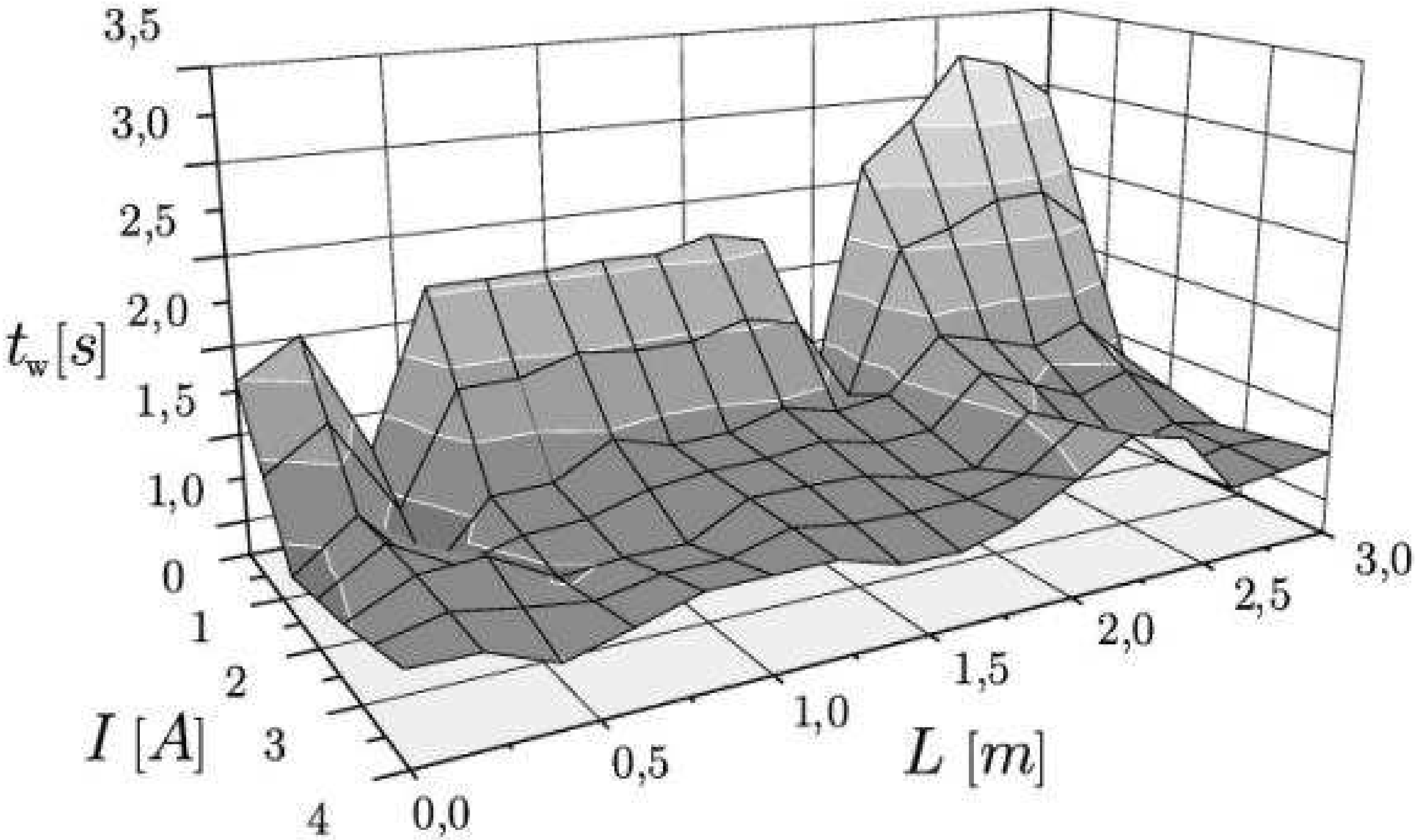




Free vibrations



Free vibrations



Thank you for your attention