UNIVERSITY OF LATVIA
2021 REVIEW/ 2022 KICK-OFF MEETING WPPRD-LMD

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TASKS AND MAIN ACTIVITIES IN 2021

- P3-D001: Study microchannel/CPS flow in high magnetic field

- Numerical simulation
- Analysis of MHD flow in packed sphere system
- 3D printed CPS experiments in 5 T superconducting magnet
- Experiment series with various field strength and orientations
- SiC material long-time behaviour in MHD flow

CAPILLARY POROUS SYSTEM (CPS) AS SOLUTION FOR DIVERTOR

Darcy law and various models describing CPS flows
Only few works on CPS MHD flow

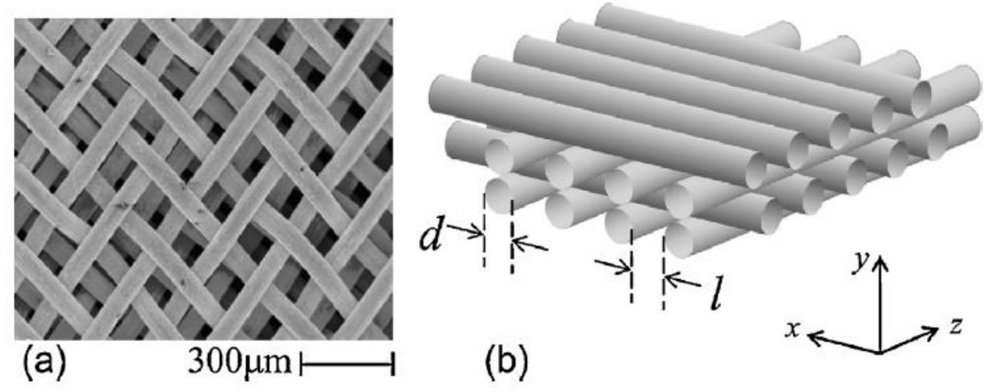


Fig. 1. View of a 100 µm CPS [5] (a) and a model geometry (b).

L. Bühler et al. / Fusion Engineering and Design 98–99 (2015) 1239–1243. Evitkin 2001

Proposed expriment geometry

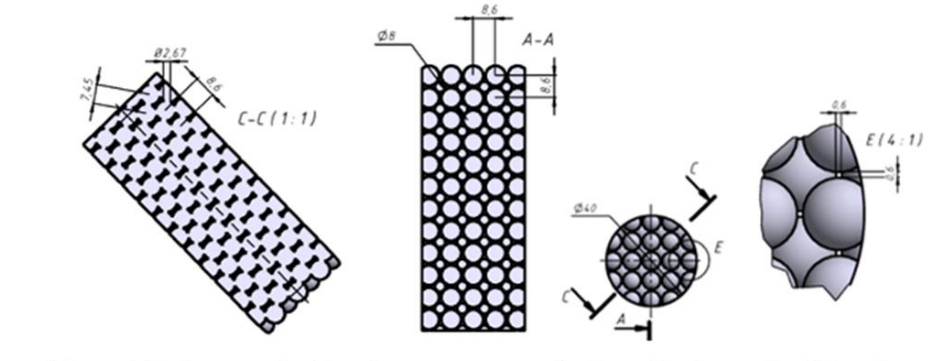


Figure 1. Body centred cubic sphere arrangement (b=8mm, D=40 mm, L=100 mm)

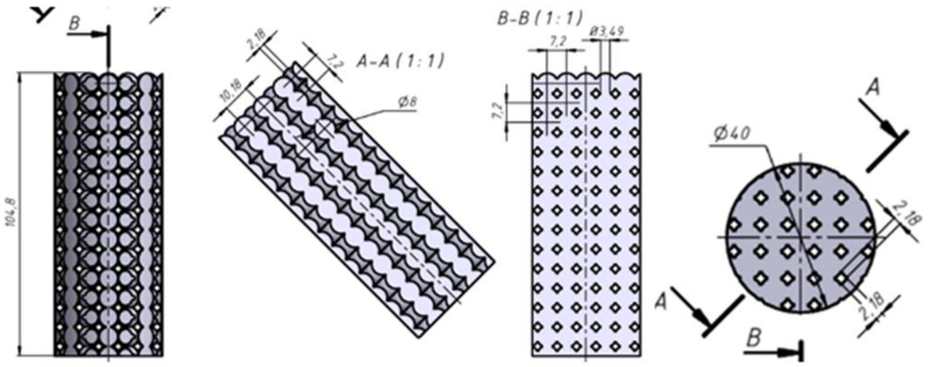
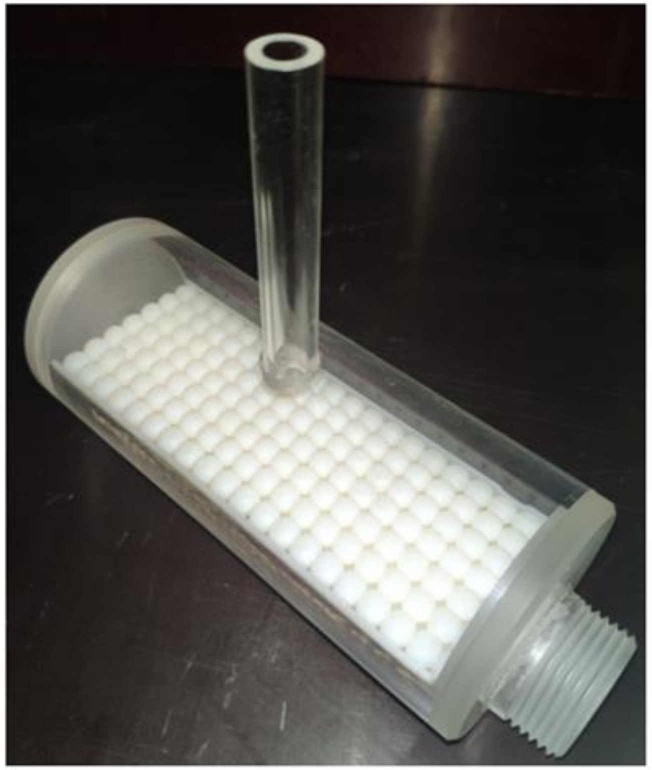
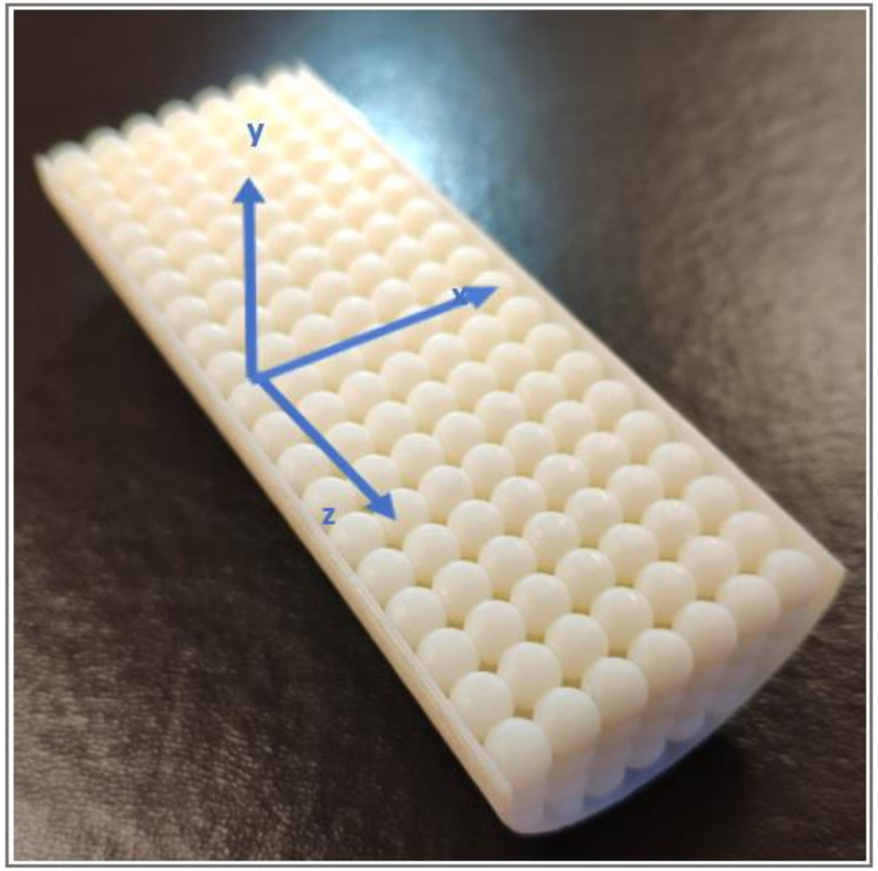


Figure 2. Simple cubic sphere arrangement (b=8mm, D=40 mm, L=100 mm)

3D PRINTED TEST SECTIONS
(SPHERE PACKING WITH 10% OVERLAP)

Test sections without and with free surface





ANALYTHICAL DESCRIPTION

$Re = \frac{Inertial\ \ forces}{Viscous\ \ forces} = \frac{U_0 L}{\upsilon}$ - Reynolds number

$Ha = \left(\frac{Electromagnetic\ \ for ces}{Viscous\ \ forces}\right)^{1/2} = B_0 L \sqrt{\frac{\sigma}{\upsilon\rho}}$ - Hartmann number

$N = \frac{Electromagnetic\ \ forces}{Inertia\ \ forces} = \frac{Ha^2}{Re} = \frac{\sigma B_0^2 L}{\rho U_0}$ - Stuart number (interaction parameter)

$Ca = \frac{Viscous\ \ forces}{Capilla\ ry\ forces} = \frac{\upsilon\rho U_0}{\gamma}$ – Capillary number

$$\nabla p = -(\vec{v}\nabla)\vec{v} + \frac{1}{Re}\nabla^2\vec{v} + \frac{Ha^2}{Re}\vec{j}\times\vec{B}$$

Inertia dominated regime, $\nabla P \sim Q^2$

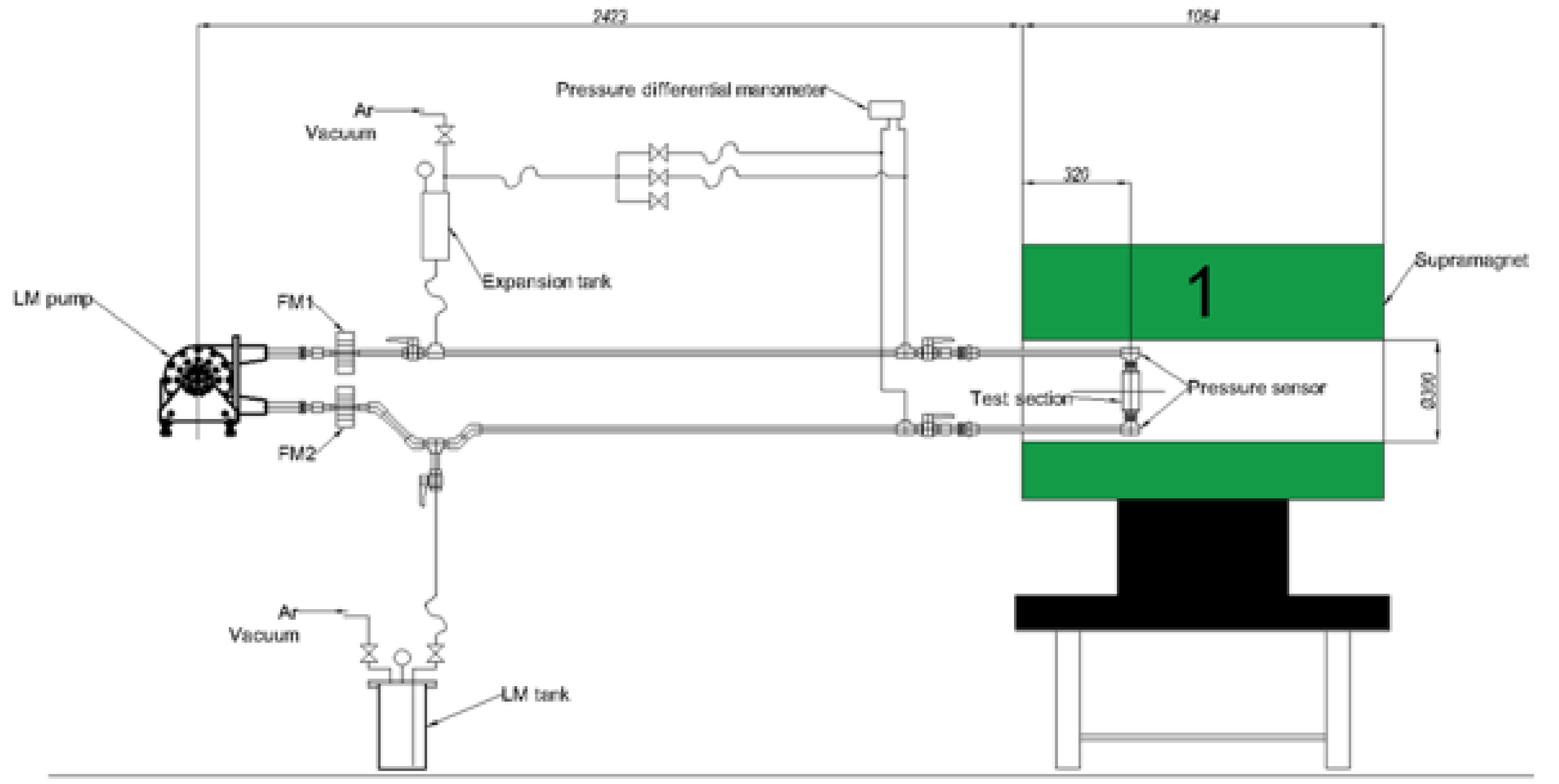
Viscosity dominated regime, $\nabla P \sim Q^1$

EM forces dominated regime, $\nabla P \sim Q^1$

$Q\left(\frac{mL}{s}\right)$	$Re = \frac{U_0 L}{\upsilon}$	$Ca \cdot Re = \frac{\rho U_0^2 L}{\gamma}$	$N = \frac{Ha^2}{Re}$				
			$B_0 = 1\,T$ $Ha = 18$	$B_0 = 2\,T$ $Ha = 36$	$B_0 = 3\,T$ $Ha = 54$	$B_0 = 4\,T$ $Ha = 72$	$B_0 = 5\,T$ $Ha = 90$
1	23	0.001	14.0	56.0	126.0	223.9	349.84
10	230	0.07	1.4	5.6	12.6	22.39	34.98
50	1160	1.64	0.28	1.12	2.52	4.48	7.0

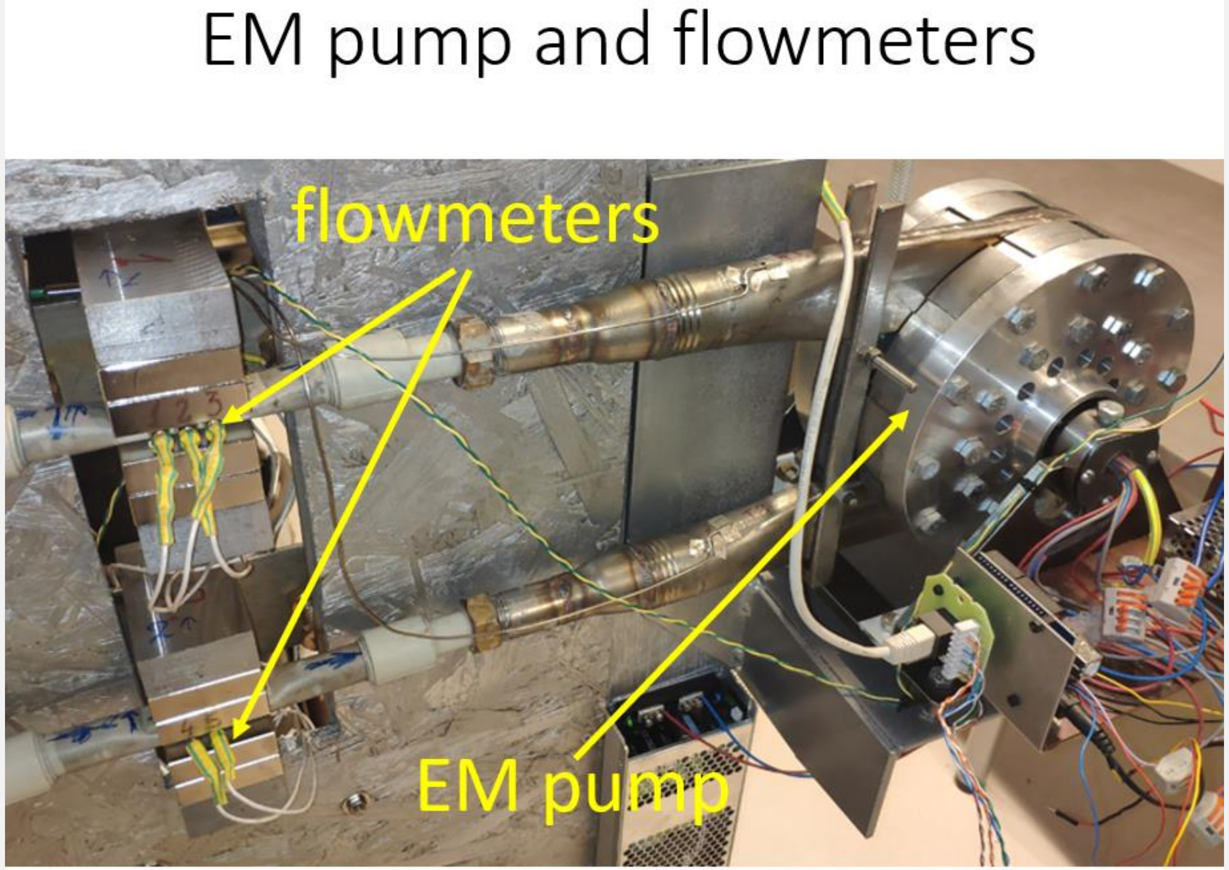
SUPERCONDUCTING MAGNET EXPERIMENT

Drawing of experimental setup and test section position for B_x and B_{xy} orientation of magnetic field

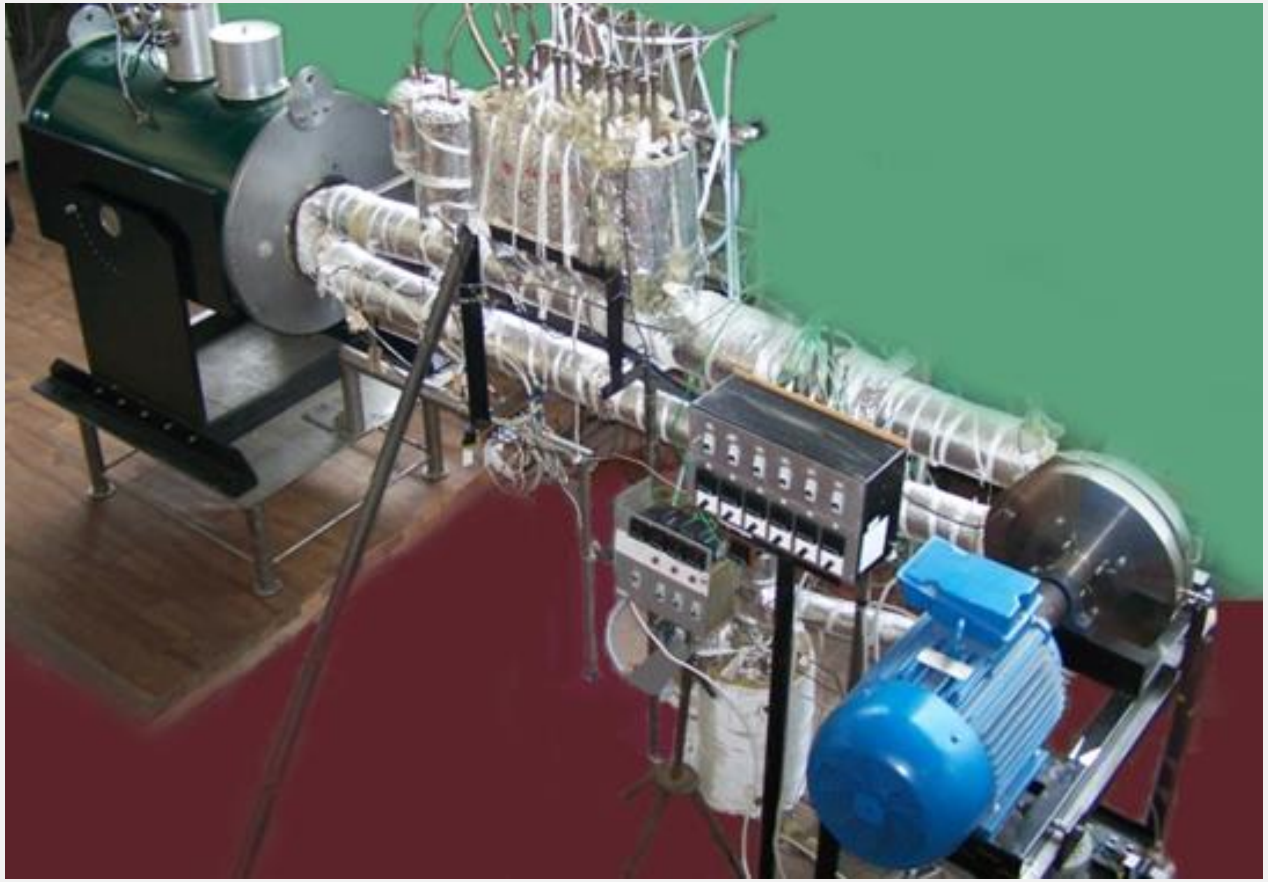


Test section position for B_z orientation of magnetic field and free surface test section

EXPERIMENTAL INVESTIOGATION OF MHD FLOW IN CPS

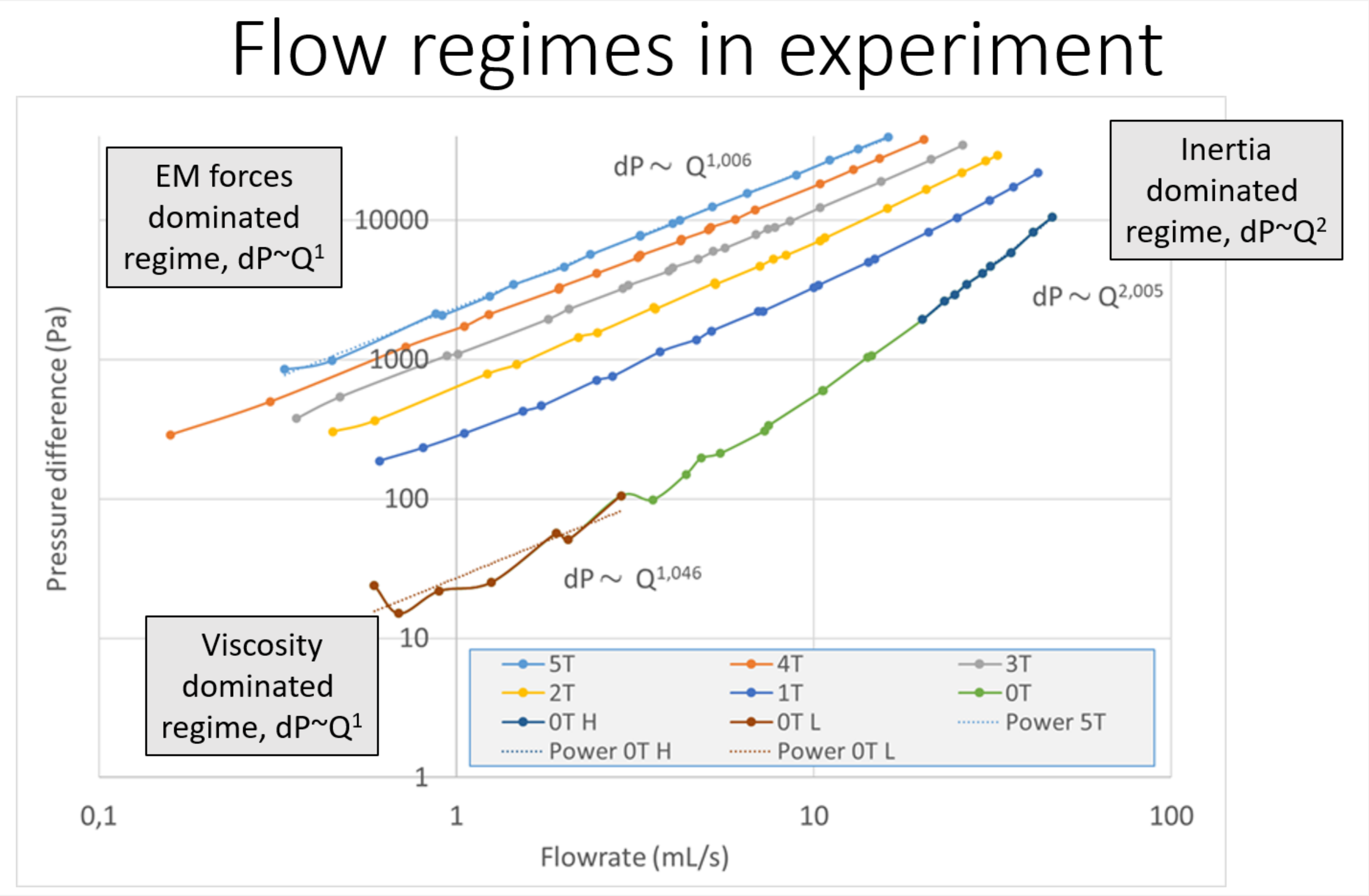


Permanent magnet pump and flowmeters used in experiment

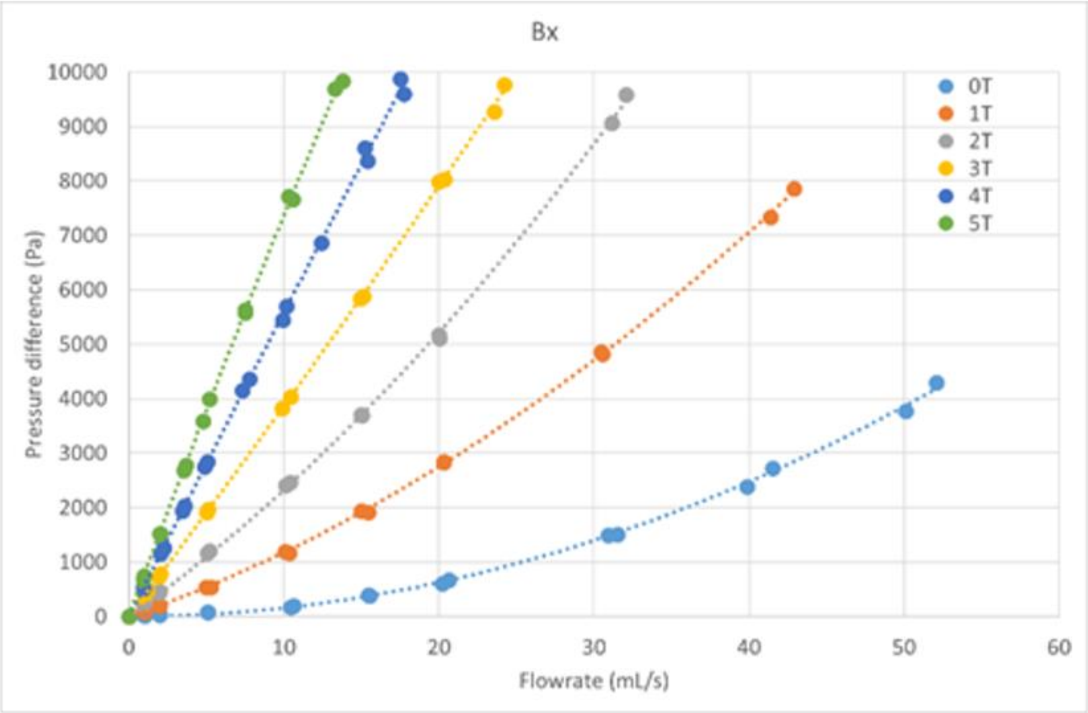


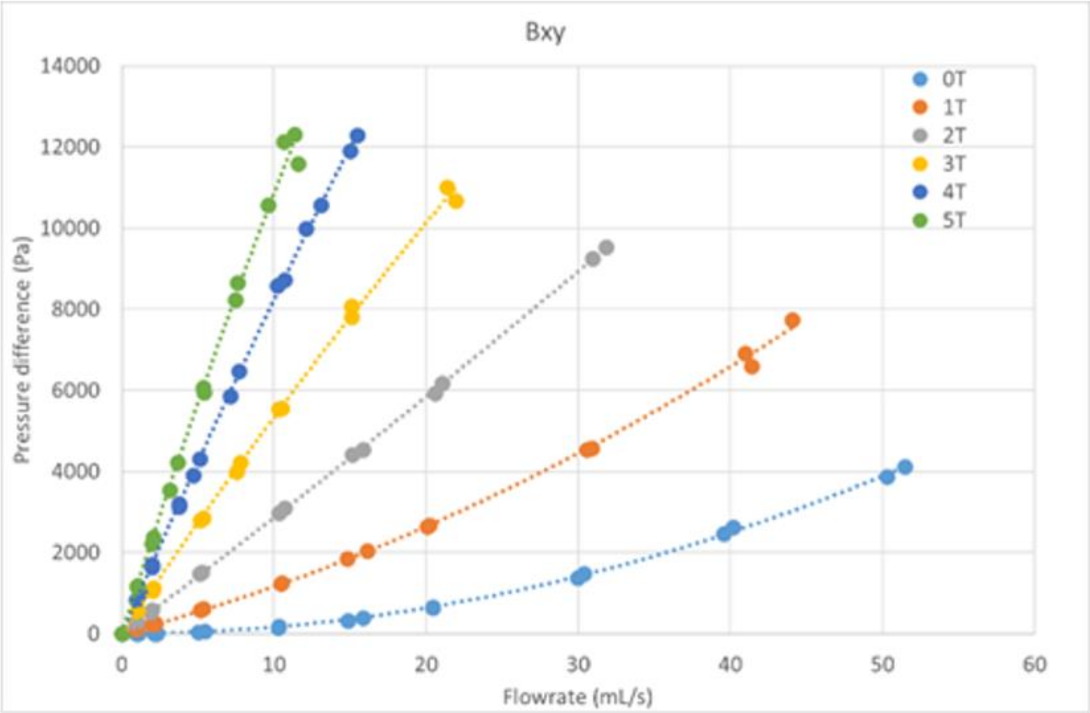
Liquid metal loop with permanent magnet pump and test section in 5 T superconducting magnet

EXPERIMENTAL RESULTS



dP-Q curves for B_x and B_{xy} orientation of magnetic field





FUTURE WORK

- In next part of the project it is planned to continue experiments with liquid metal flow through the CPS. Several possible experiments are foreseen in the future.
- Experimental investigation of thermoelectromagnetic effects (Constantan/GaInSn system)

- Test liquid GaInSn flow using various CPS in high magnetic field.
- Quantification of MHD on the flow and P-Q curves, development of analythical model.
- Develop numerical models to include MHD effects.
- Divertor surface model to investigate thermoelectromagnetic effects on liquid metal flow/film