College of Polytechnics Jihlava

Department of technical studies

AFEM - Applied Finite Element Method

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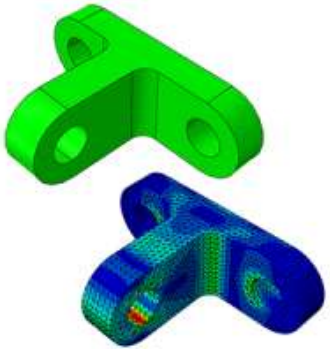
AFEM - Applied Finite Element Method

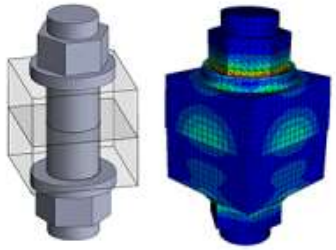
What is it?

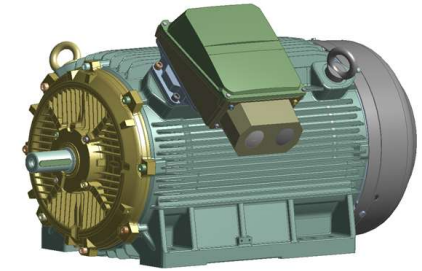
- Computational simulation method for solving various physical problems
- Nowadays an essential technical control and optimization tool

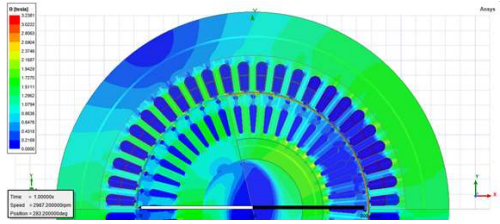
How does it works?

Real/model geometry -> areas with material properties - > mesh (computational network) - >
loads and boundary conditions - > calculation - > result (searched physical field on the given network)





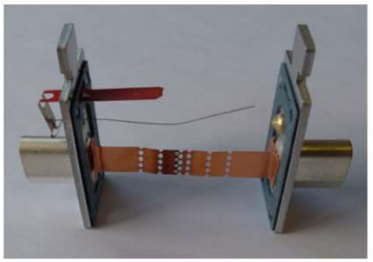




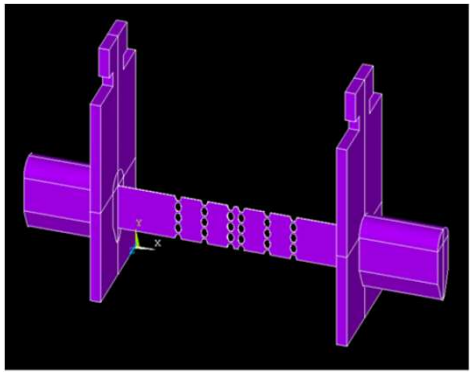
AFEM - Applied Finite Element Method directly concept…

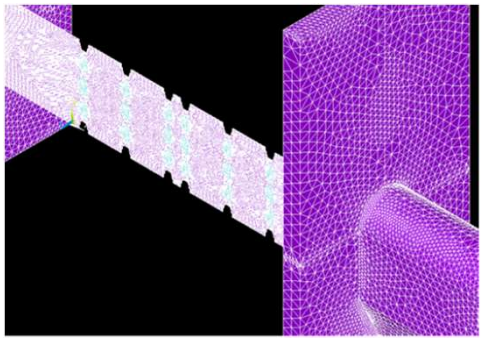
FEM basic concepts:

1) Creation of geometry
2) Setting the type of physical task
3) Setting material properties
4) Creation of a computing network (mesh)
5) Loads and boundary conditions
6) Calculation settings
7) Calculation
8) Rendering and processing of results



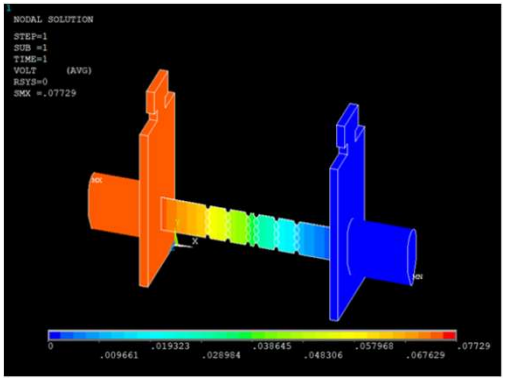
Example of a 100A fuse (electric field and current)

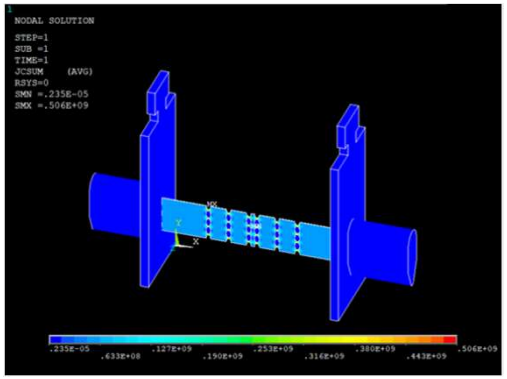




- Material data
- Computational load
- Calculation

- Solution





AFEM - Applied Finite Element Method

We divide FEM tasks in general:

According to the order of geometry:
1D tasks
2D tasks (planar or axisymmetric)
3D tasks

According to the type of physics being solved, it is a certain type of task:
Mechanical tasks
Thermal tasks
Flow
Electrical current conduction and electrostatics
Electromagnetic
Acoustics
Combined and otherwise connected tasks.

By time dependence or development:
Stationary
Harmonic
Generally transient

By type of material properties:
Linear
Non-linear

AFEM - Applied Finite Element Method

FEM professional software package:

- Simulia / ABAQUS
- ANSYS products - Clasic, Workbench, Maxwell, CFX...
- COMSOL Multiphysics (+ modules and add-ons)

- MSC
- OpenFoam

and more...

AFEM - Applied Finite Element Method

AFEM on the area Polytechnic College Jihlava

- one of the specialized ones subjects in subsequent study
- scientific activity in solving various technical projects, bachelor's and master's theses and other assignments

AFEM - Applied Finite Element Method

AFEM Subject conception on VSPJihlava

part A) Teoretical background – lectures

12 lessons about mathematical principles of the FEM methods.

part B) Practical background – exercises

12 lessons explaining the functionality and principle of model creation in the ABAQUS environment and several sample projects

… Detailed tutorials are prepared in the Moodle learning system for lectures and exercises.

… You can study this independently, but it is better to take a course.

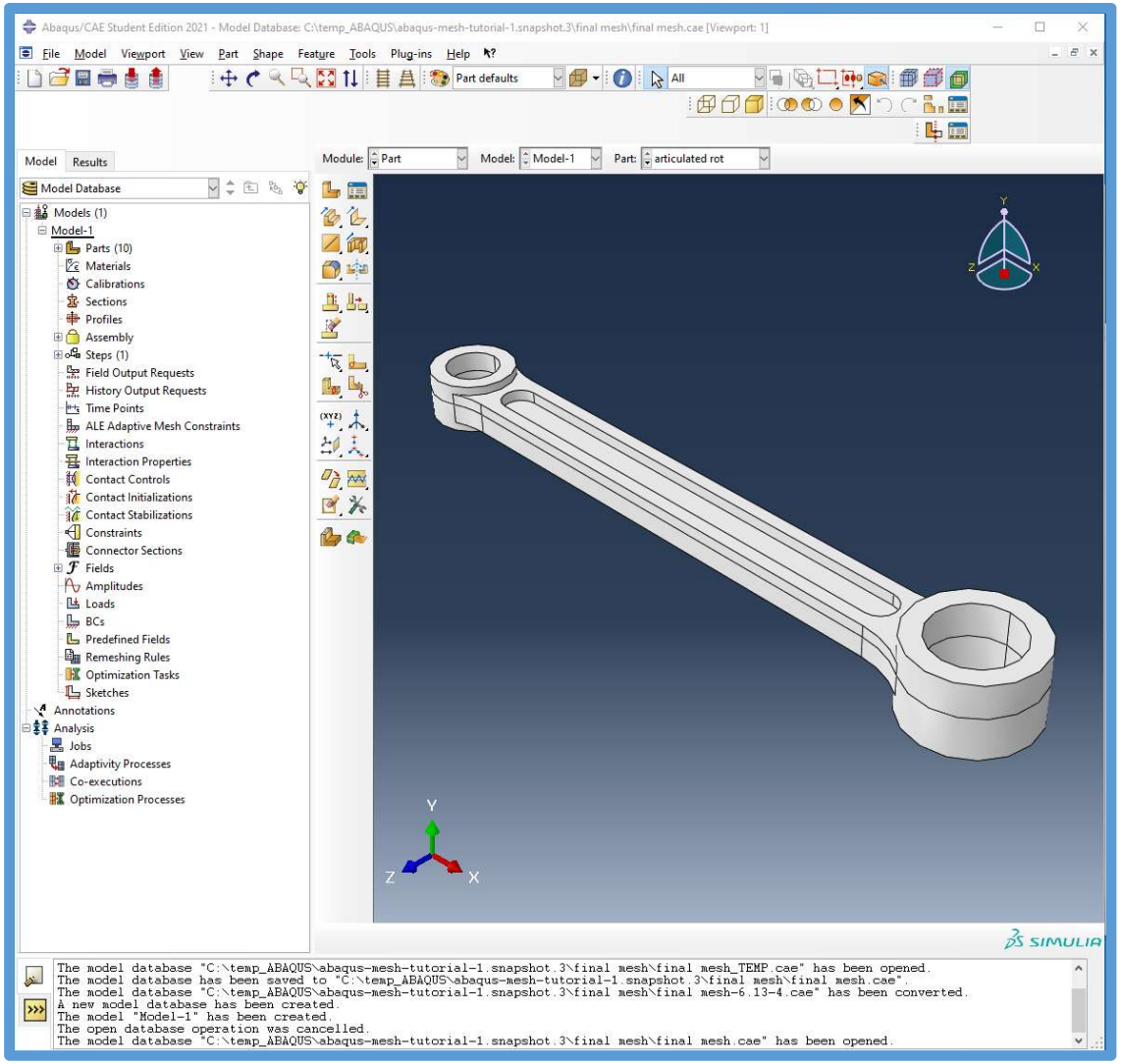
AFEM - Applied Finite Element Method

basic view of the program ABAQUS …

Student version is free … you can download it from:
https://edu.3ds.com/en/software/abaqus-learning-edition

user registration:
https://eu1-ds-iam.3dexperience.3ds.com/cas/login?service=https%3A//r1132100503382-eu1-3dswym.3dexperience.3ds.com/#register

If you are interested, you can learn the principles of FEM and software ABAQUS here at VSPJihlava.
☺ 😎



AFEM - Applied Finite Element Method

personal security of the subject

guarantor and lector: doc. Ing. Zdeněk Horák Ph.D. (rector VŠPJ)

Education:

2015	Ass. Professor, doc. , CTU Prague, Faculty of Mechanical Engineering Focus on Applied Mechanics
2001 – 2008	Doctoral studies, Ph.D., CTU Prague, Faculty of Mechanical Engineering Focus on Biomechanics
1996 – 2001	Master's degree, Ing., CTU Prague, Faculty of Mechanical Engineering Focus on applied mechanics

WORK EXPERIENCE:

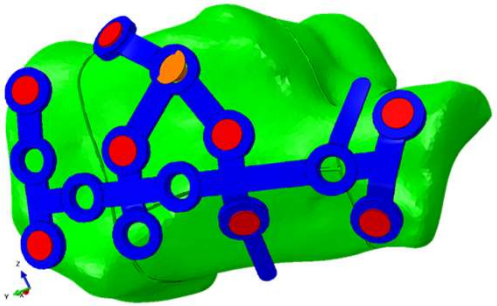
2022	Rector, College of Polytechnics Jihlava
2018 – 2022	Vice rector for Science and Research, College of Polytechnics Jihlava
2015	Academic Staff, College of Polytechnics Jihlava Applied mechanics, FEM modelling and simulation
2004 – 2015	Academic Staff, CTU Prague, Faculty of Mechanical Engineering Applied mechanics, FEM modelling and simulation

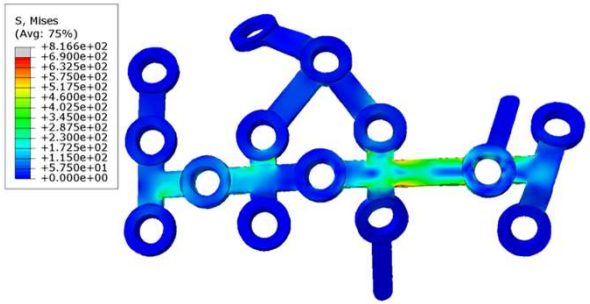
SPECIALISATION:

Structural analysis by finite element method (FEM); Materials research; Strength analysis and dimensioning of machine components; Design, construction and testing of machine components; Design, development and testing of medical devices; Design of 3D custom made skeletal defect implants

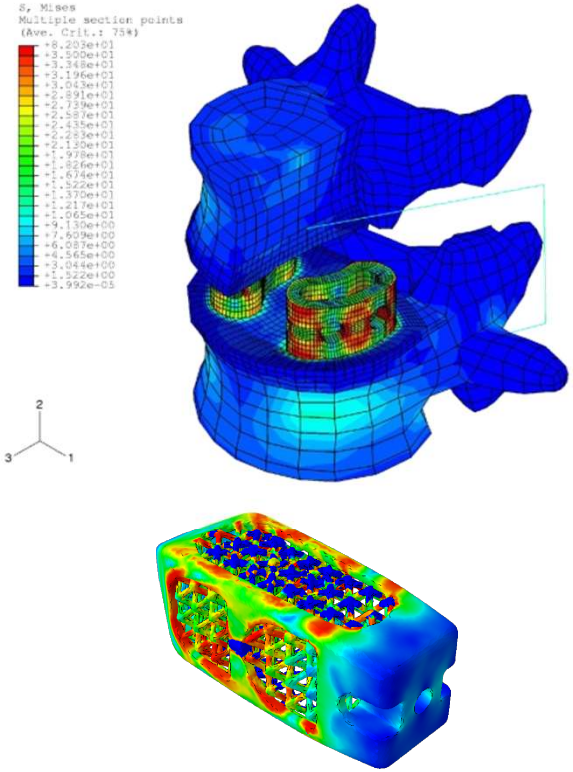
Example of the my interesting projects…

A) Simulation of the various mechanical problems …

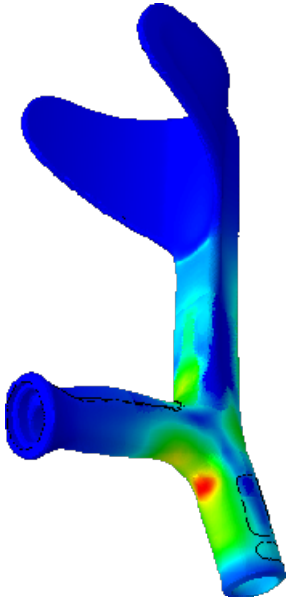




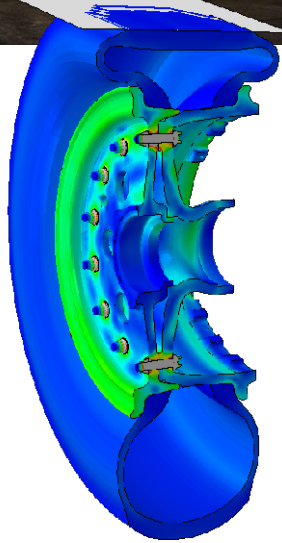
Ankle splint / heel fixator / titanium mesh
- checking the strength of computing



spine damage / herniated disc
titanium cage / spare filling
control of deformation ratios



crutch support
strength control



airplane AERO Vodochody new type L39MG
- control calculations for component manufacturer JIHLAVAN
- wheel stress for different landing conditions

AFEM - Applied Finite Element Method

personal security of the subject

professional assistant: Ing. Martin Marek Ph.D.

Education:

2000 – 2005	Doctoral studies, Ph.D., VSB-TU Ostrava, Faculty of Electrical engineering and computer science Focus on determining the magnetic properties of materials and measuring magnetic fields
1993 – 1999	Master's degree, Ing., VSB-TU Ostrava, Faculty of Electrical engineering and computer science Focus on magnetic measurements and materials

WORK EXPERIENCE:

2020 – 2024	Academic staff, College of Polytechnics Jihlava Specialization in FEM simulation and graphical programming
2020 – 2024	Scientific Researcher , VŠB-TU Ostrava, ENET centre Induction heating for pyrolysis unit, Unit for plasma gasification of waste
2013 - 2020	Scientific Researcher , VŠB-TU Ostrava, IT4Innovations National Supercomputing Centre Programming, virtual instrumentation, FEM modeling and simulation, magnetic measurements
2005 – 2012	Assistant Professor, VSB-TU Ostrava, Faculty of Electrical engineering and computer science Specialization of electrical machines and devices, magnetic measurements and materials, FEM simulations
2000 – 2005	Scientific Researcher, VSB-TU Ostrava, Faculty of Metallurgy and Materials Engineering Magnetic measurements and materials
2000 – 2005	Electrical equipment designer, Orgrez a.s. Development and implementation of plasma technology for heating and stabilization of coal power units

SPECIALISATION:

Measuring of the magnetic field and magnetic properties of the materials, Vilrtual instrumentation, Graphical programing with LabView,
FEM simulation – electromagnetic problems, electrostatic problems, thermal and flow problems, mechanical problems, coupled problems

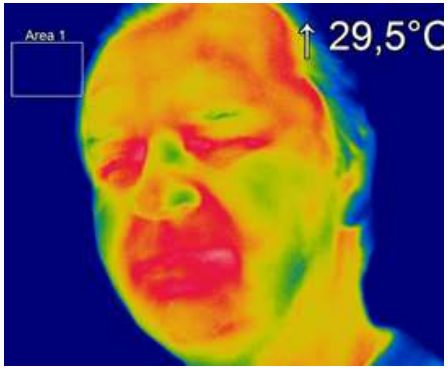
SMART Lab

- Development, measuring and analysis of Smart materials

- To day we solve PIEZZOMATERIALS and PIEZZOELEMENTS (Ceramic and PVDF materials prepared by 3D print, HV polarisation, Impedantion analysis, Force and flexible testing systems)

- Professional development termo vision system (-20 +1500 °C, high resolution 0,05 °C)

- Virtual instrumentation by NationalInstruments measuring elements and graphical programing with LabView studio.

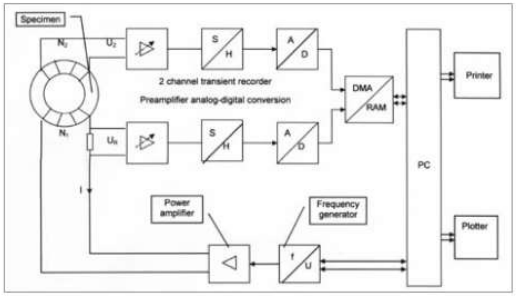


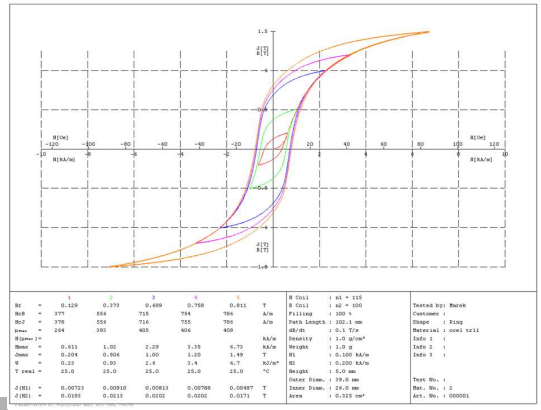
SMART Lab

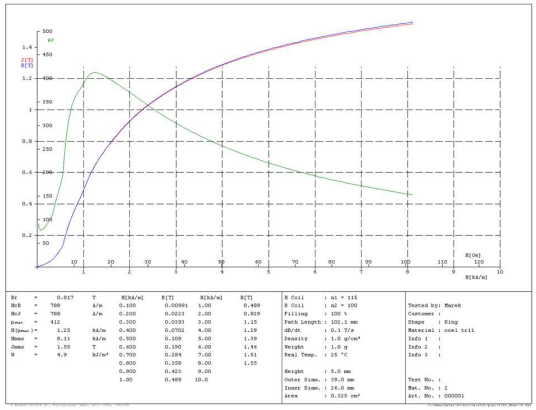
- Measuring magnetic field and magnetic properties of constructional materials

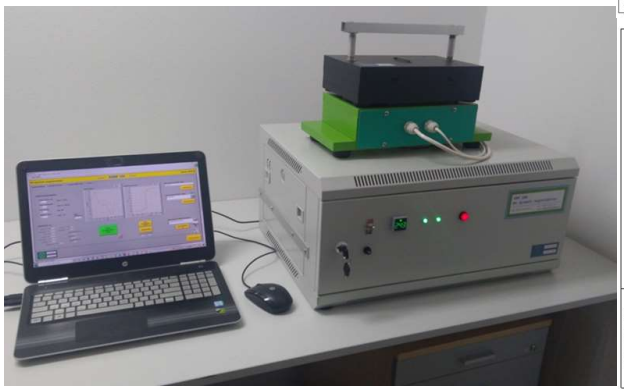
a) DC static BH hysteresis characteristics

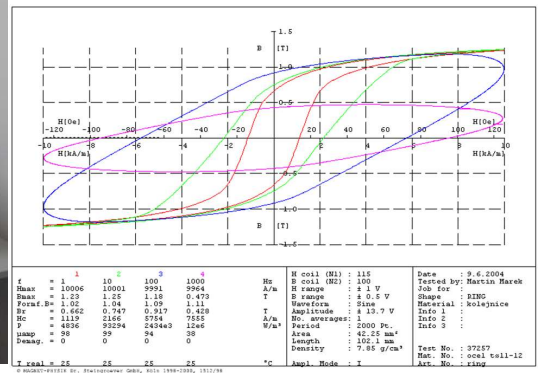
b) AC dynamic BH hysteresis characteristics for various frequency

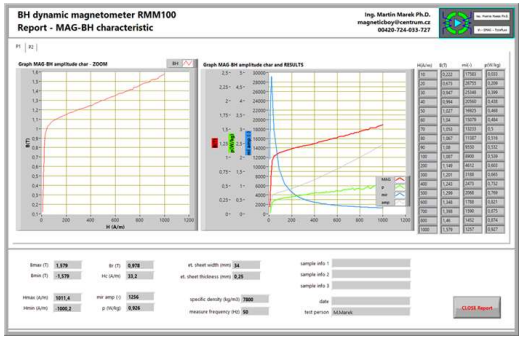








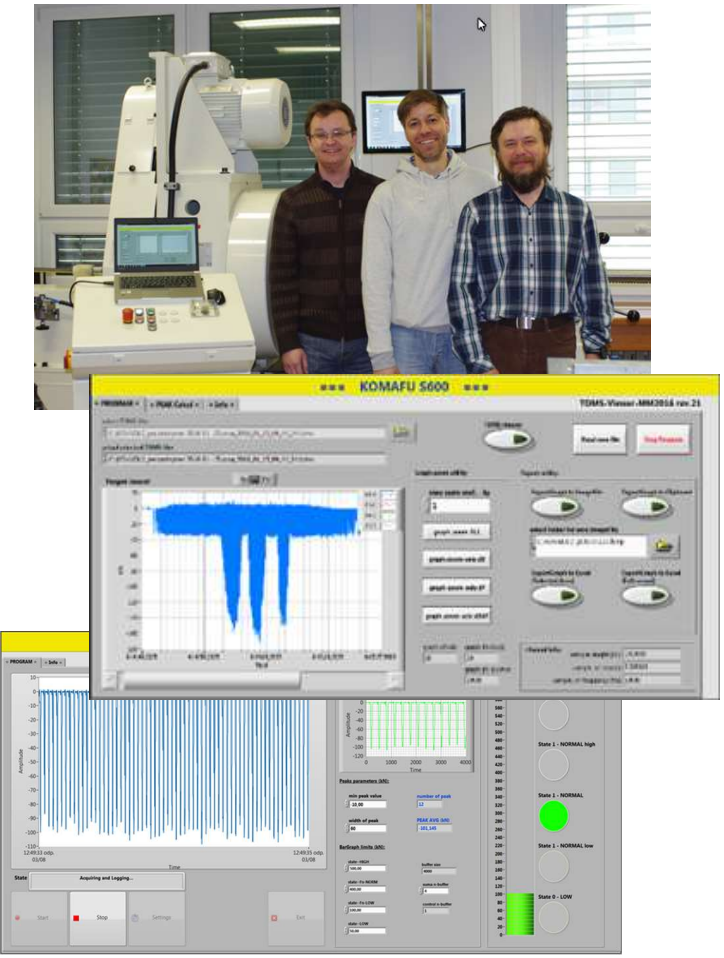




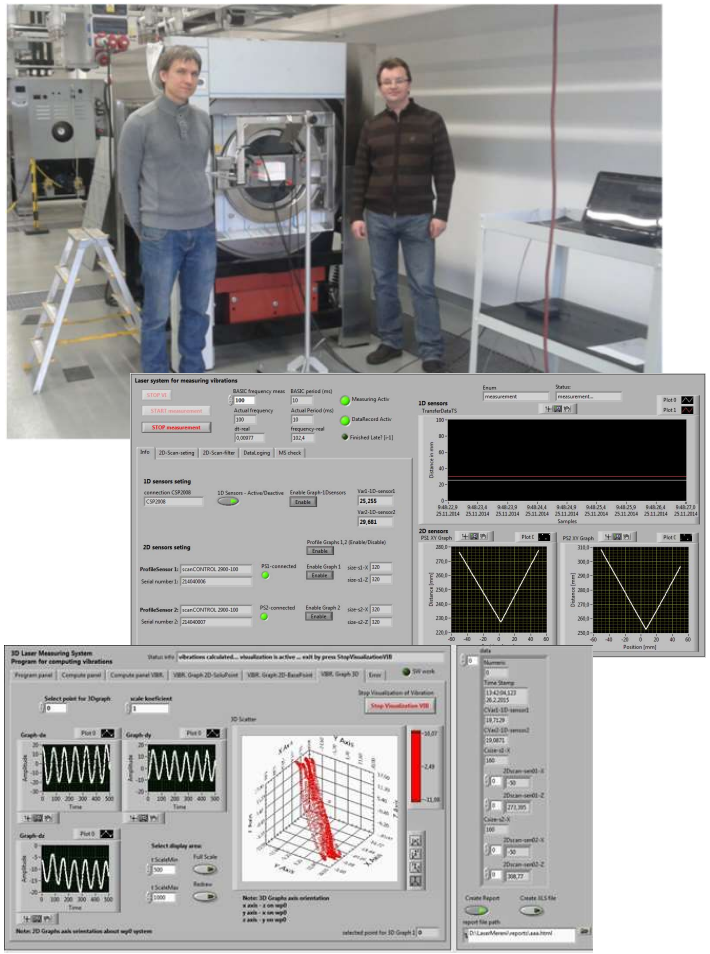
SMART Lab

Virtual Instrumentation …

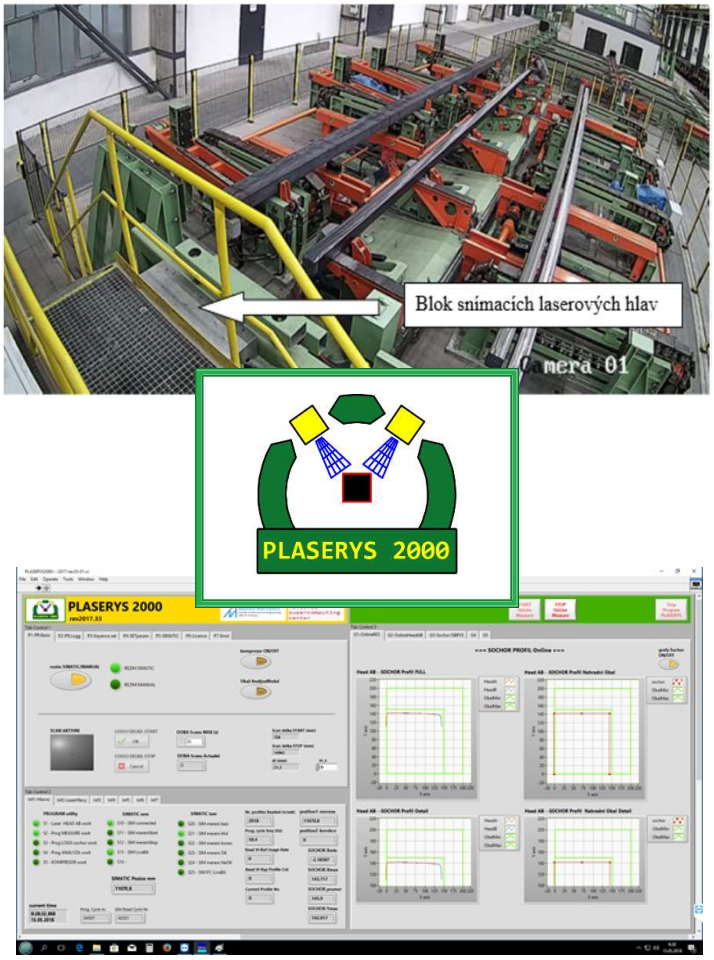
A) System for measuring swaging forces rotary swaging machines



B) System for measuring 3D spatial movement of the objects by laser scanners



C) 3D scanner for automatic long billet grinder

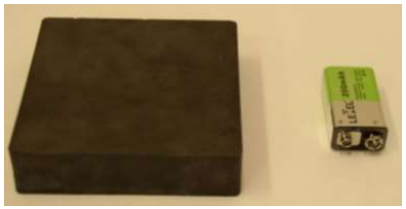


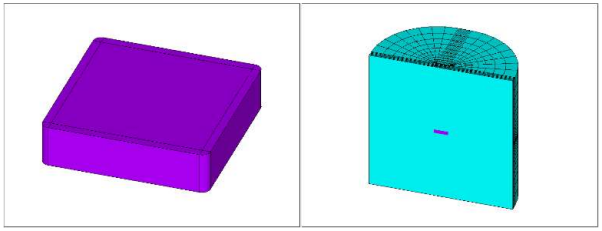
SMART Lab

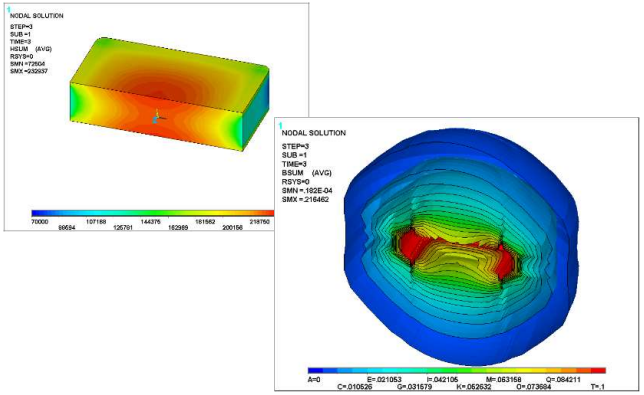
FEM Simulation…(Ansys/Comsol/Abaqus)

A) Electromagnetic simulation

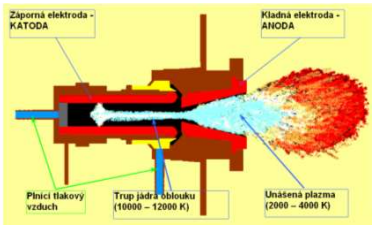
A1) magnetic field of the permanent magnets…

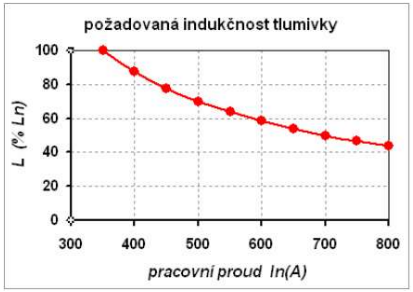


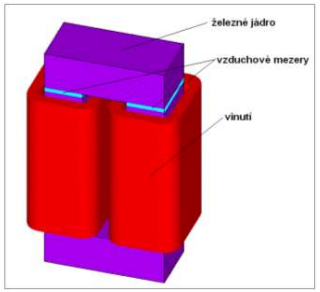


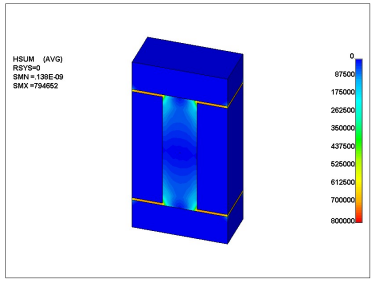


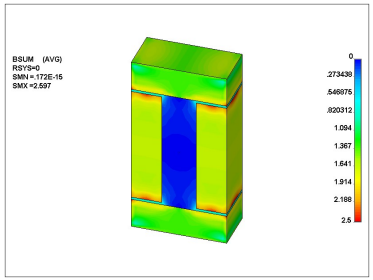
A2) magnetic field of the power inductor for plasma generator 320kW



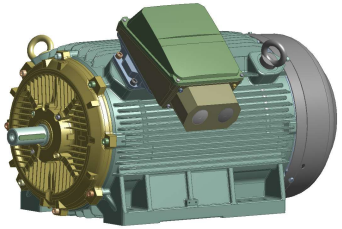


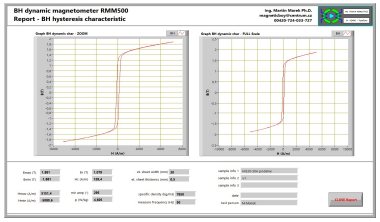


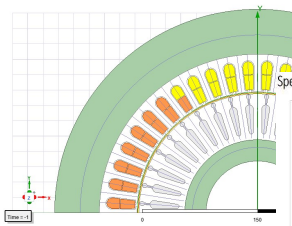


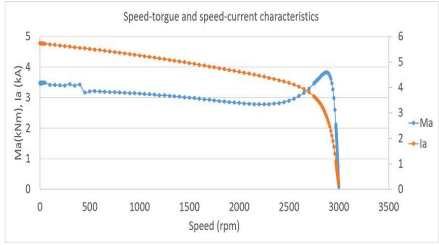


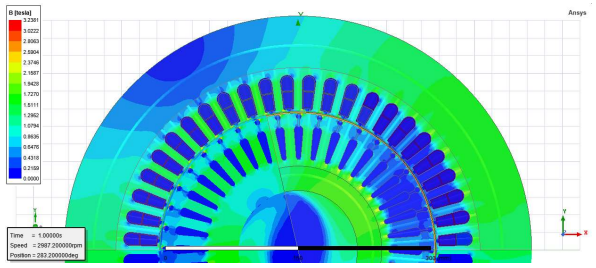
A3) magnetic field of the asynchronnous motors 315 kW





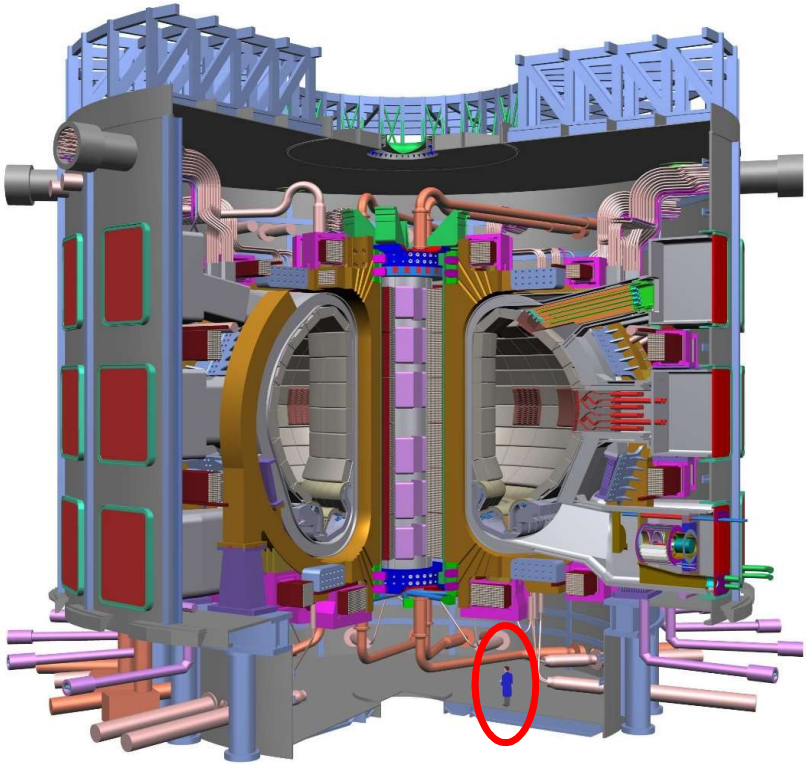






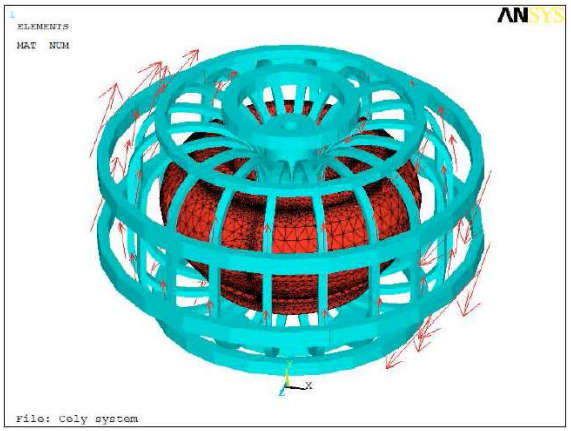
Magnetic field of types coils systems of the Tokamak ITER (solved at year 2009)

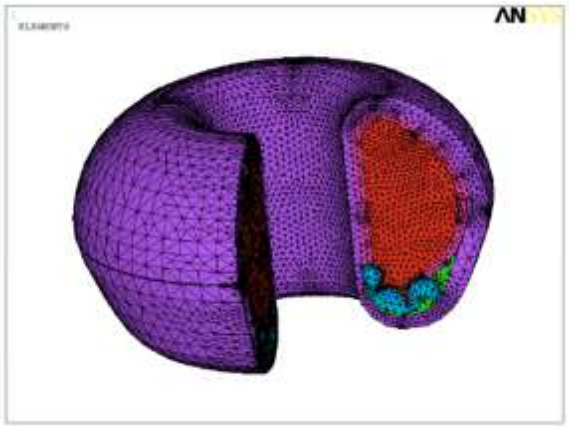
Tokamak ITER old conception



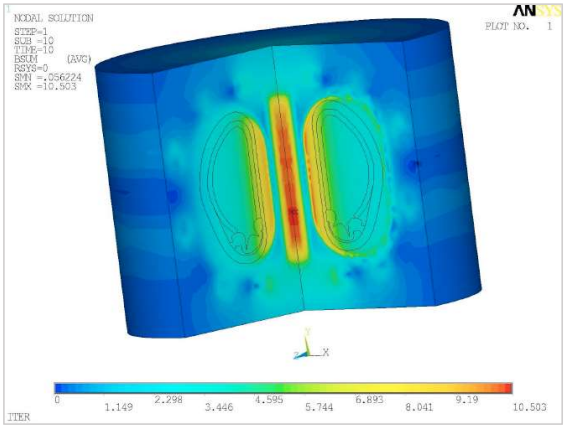
France / Cadarache
https://www.iter.org

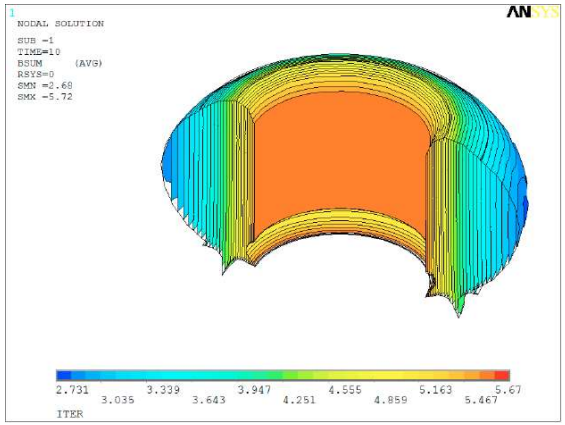
FEM Model of the tokamak (model torus and coils)





Computed magnetic field
Magnetic induction B(T)

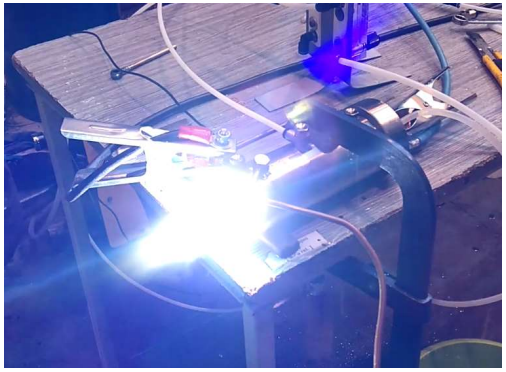


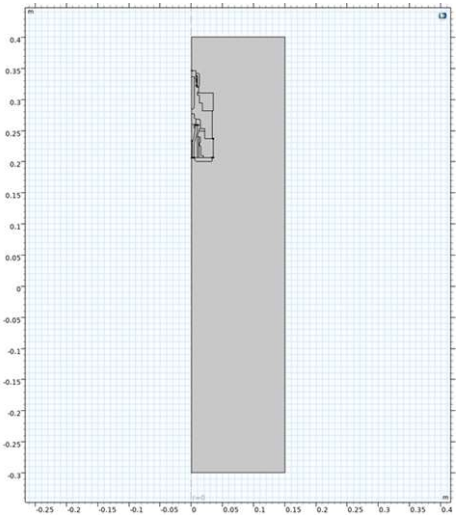


SMART Lab

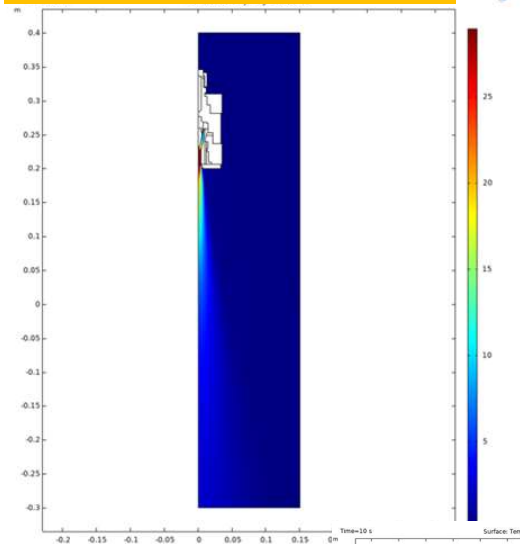
FEM Simulation…(Ansys/Comsol/Abaqus)

B) Coupled analysis (electro/flow/heat analysis) - Plasmatorch 50kW

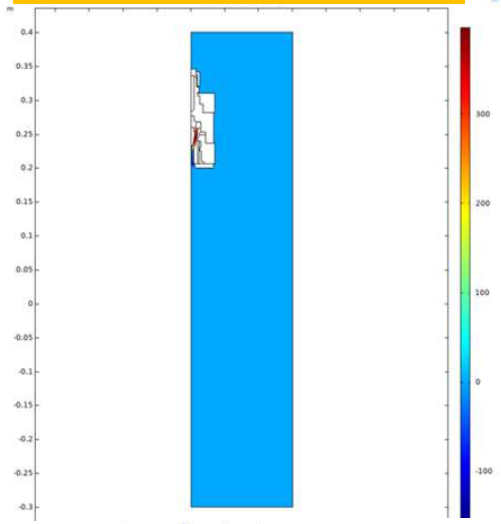




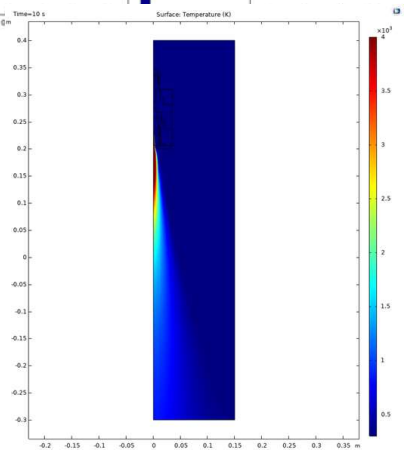
Velocity field

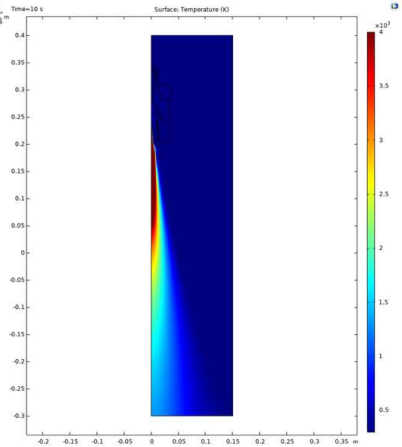


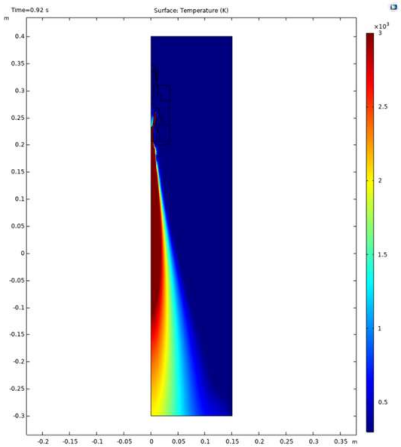
Pressure field



Temperature field for various power (10,20,30 kW)



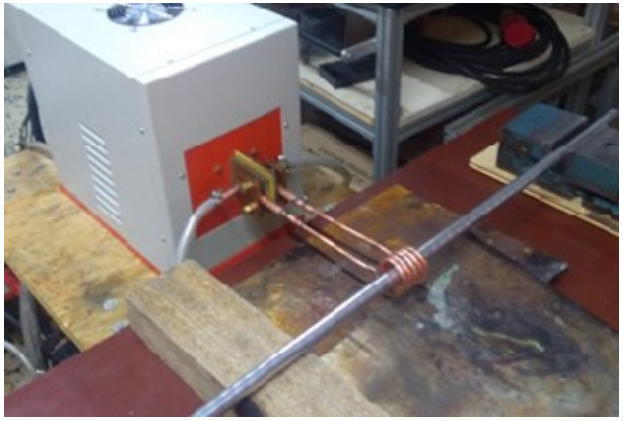




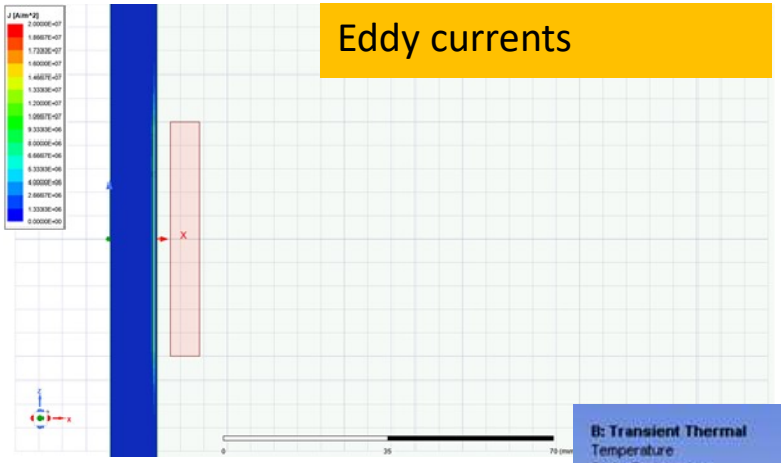
SMART Lab

FEM Simulation…(Ansys/Comsol/Abaqus)

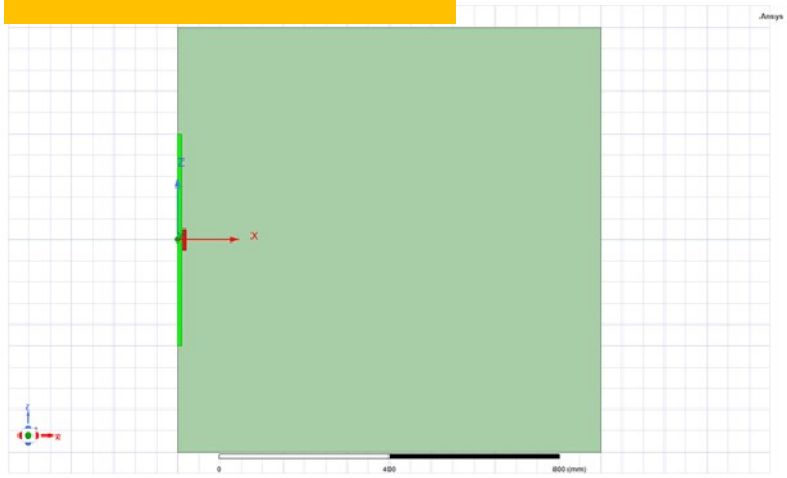
C) Coupled analysis (electromagnetic/heat analysis) – Inducting heating 25kW



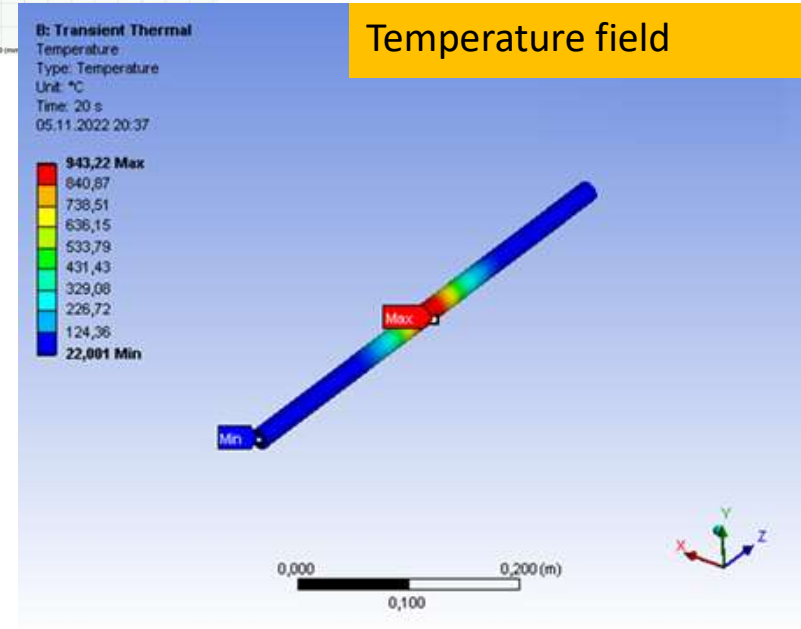
Eddy currents



2D model



Temperature field

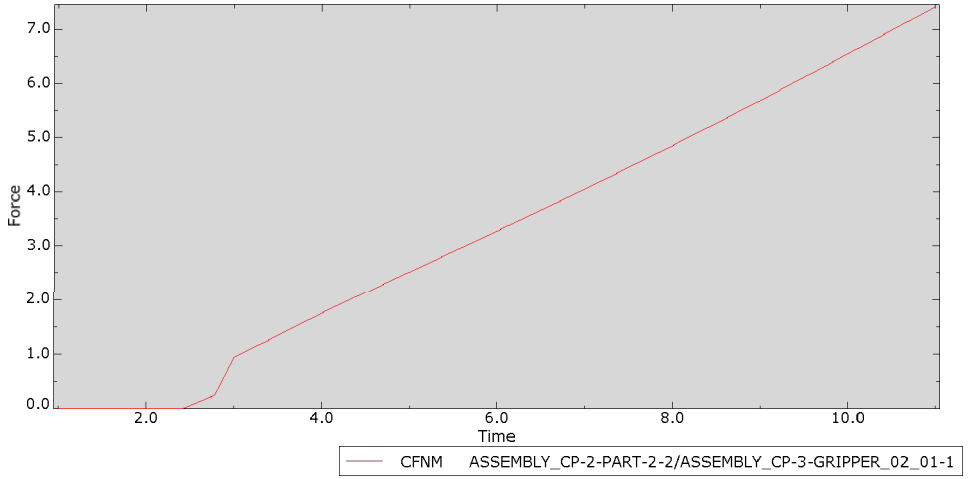


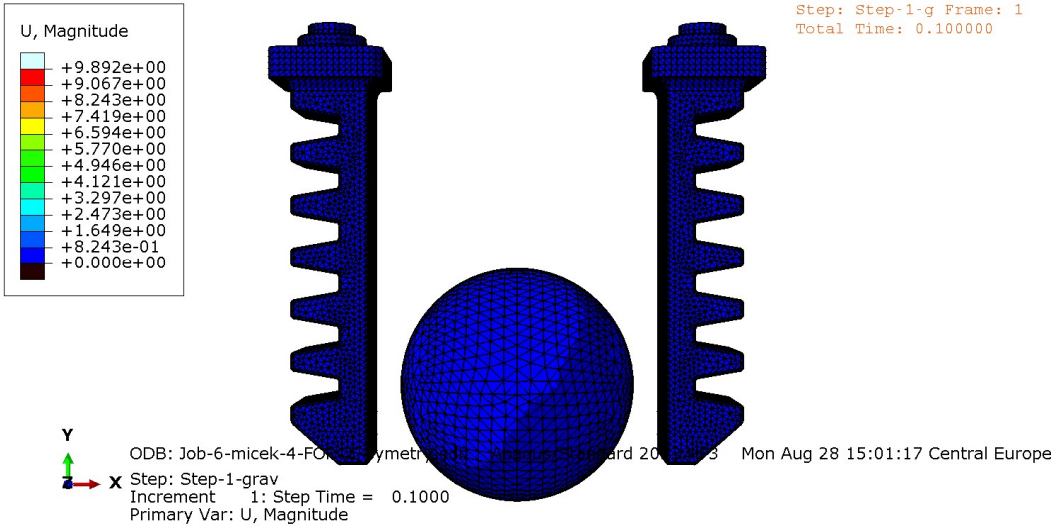
SMART Lab

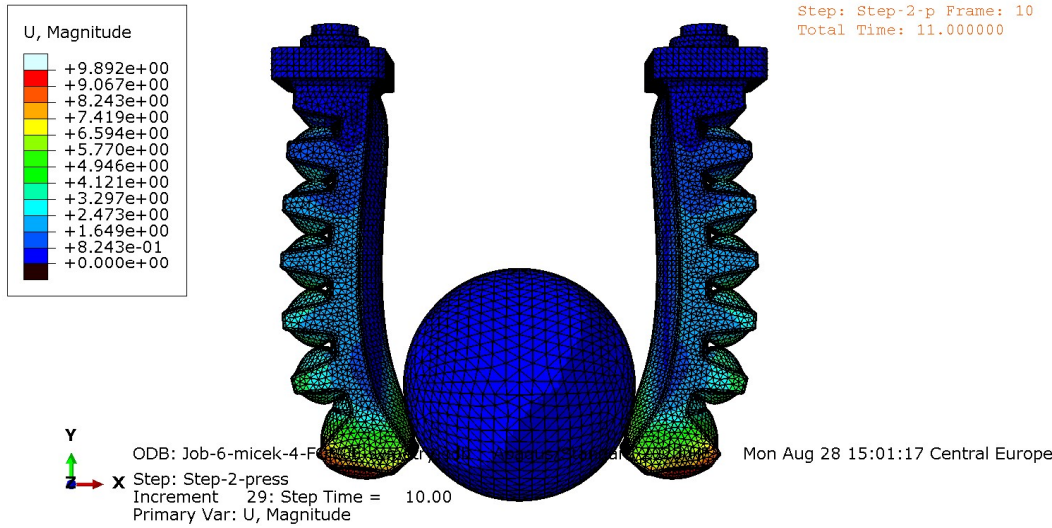
FEM Simulation…(Ansys/Comsol/Abaqus)

D) Mechanical – hyperelastic model of the pneumatic gripper

Contact force by pressure





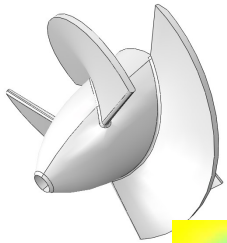


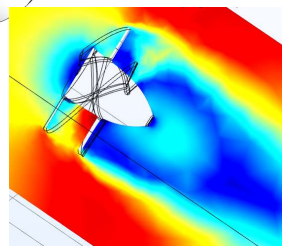
SMART Lab

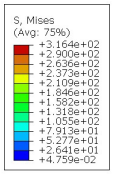
FEM Simulation…(Ansys/Comsol/Abaqus)

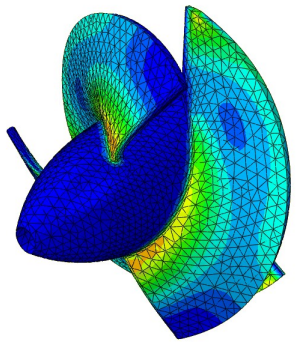
E) Mechanical and other simulation

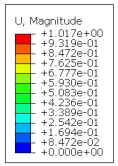
E1) JetSurf turbine/propeller analysis

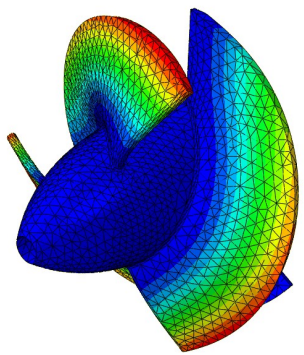




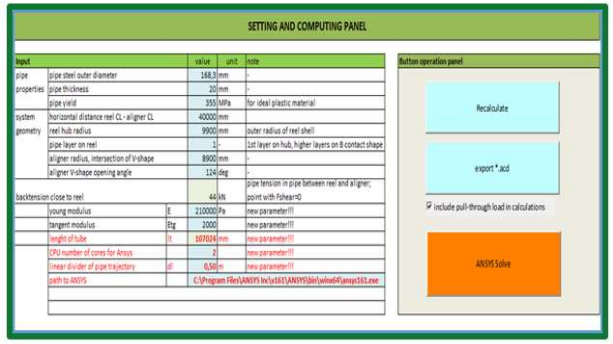


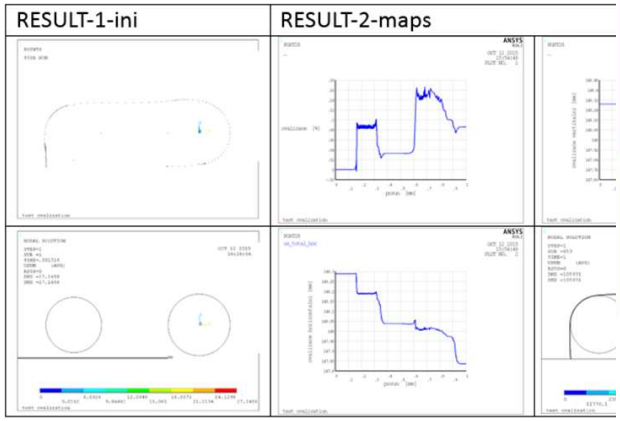


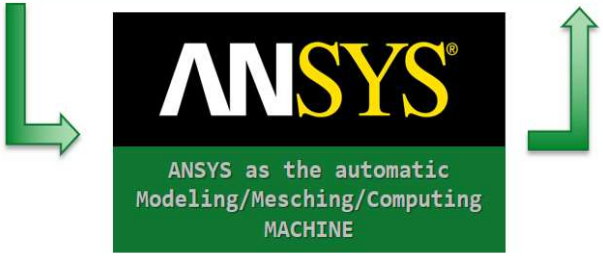




E2) Simulation of Pipe deflection and ovalization, automatic computing machine XLSM







… and many other interesting examples

My collaboration in professional branch

College of Polytechnics Jihlava

VŠB TU Ostrava:

- Department of Applied Mechanics
- Department of Metallurgical Technologies
- CEET Centre
- IT4 Innovations – National supercomputing centre

https://www.it4i.cz/

… several large HPC systems

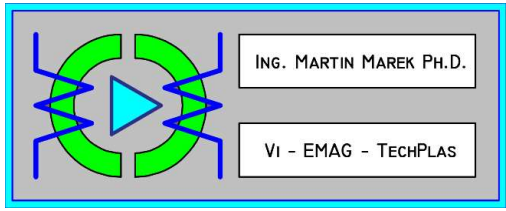
- Ecorem Energo s.r.o, dr. Podhrázky (inducting heating)

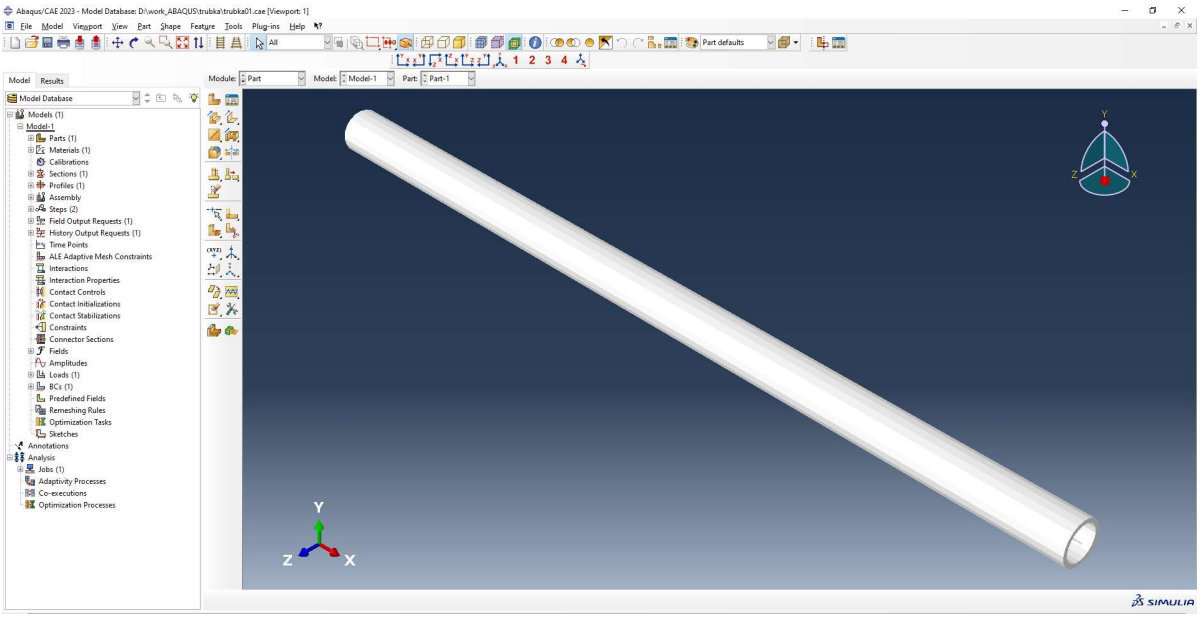
Thank you for your attention

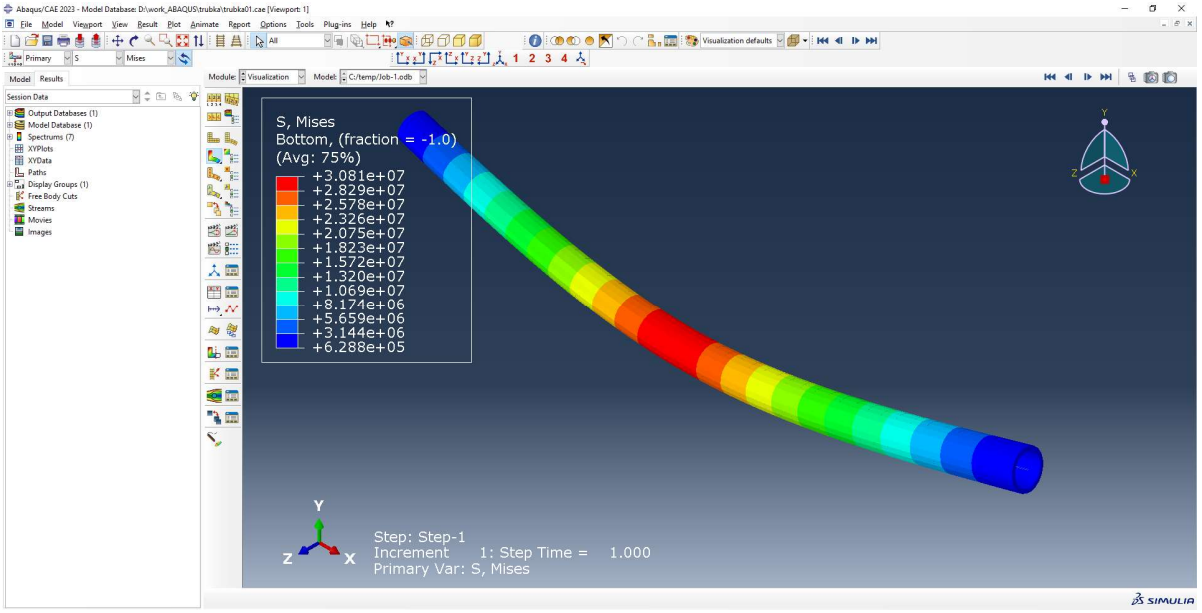
and now short example of the works in ABAQUS …

Ing. Martin Marek Ph.D.

martin.marek@vspj.cz; magneticboy@centrum.cz







Homework:

what is this characteristic?

describe the individual sections of the curve!

what law and equation describes this curve!