

Strojírenství

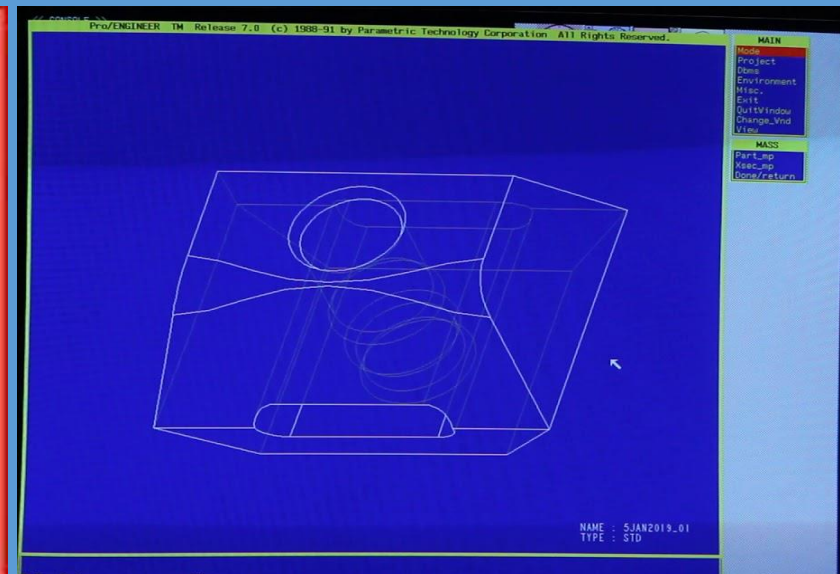
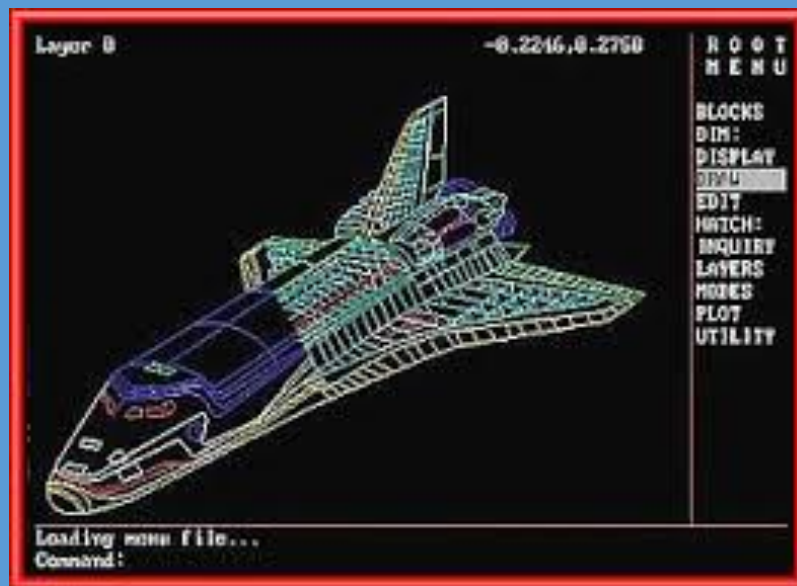
Ladislav Ševčík

ladislav.sevcik@tul.cz

Obsah přednášky obor konstrukce strojů

- Historie konstruování.
- Sériová a kusová výroba, praktické příklady, jednoúčelové linky.
- Výkresová dokumentace, výroba, montáž.
- Virtuální modely, výpočty FEM.
- Ověřování výpočtů v laboratoři KST.
- Nové způsoby konstrukce.
- Topologická optimalizace.

Historie konstruování na TUL

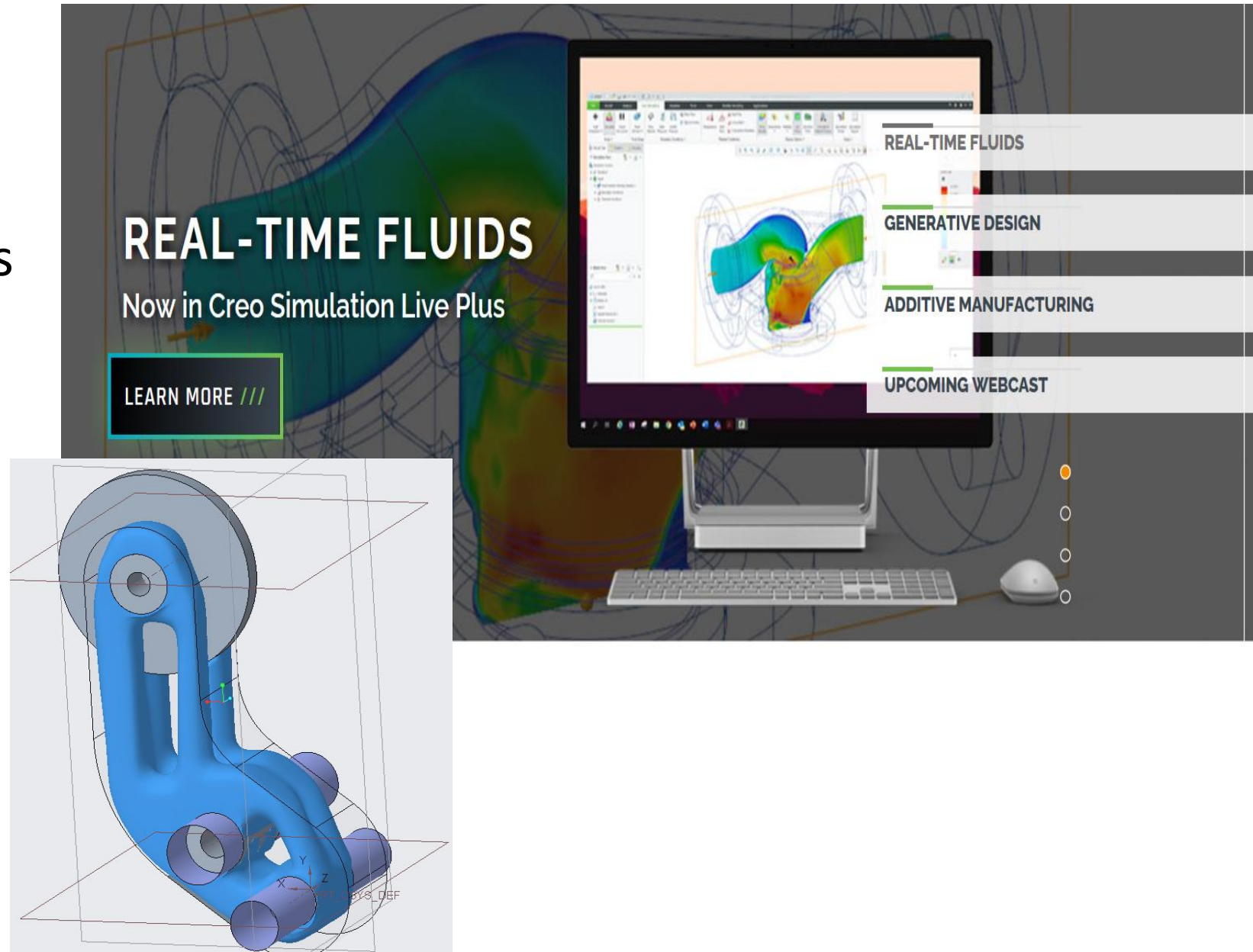


Vývoj 2D systémů byl prakticky ukončen v roce 1987,
Vývoj 3D systémů byl prakticky ukončen v roce 1996.

Co se změnilo od té doby?

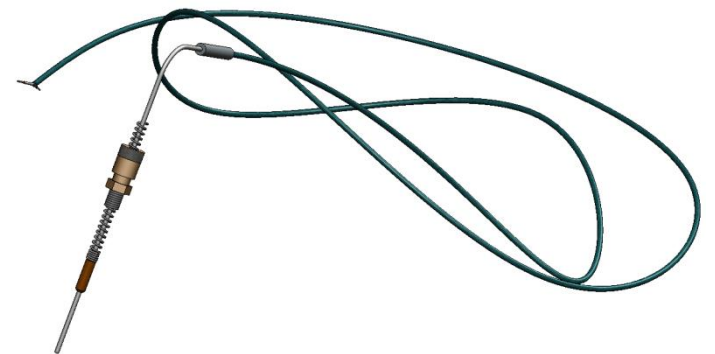
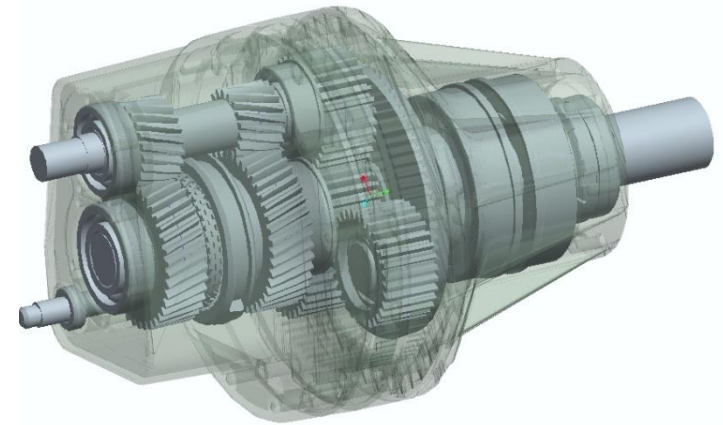
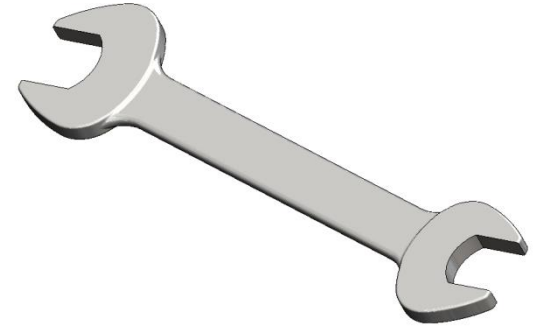
Standardně nainstalovaný – požadovaný software

- PTC CREO
- AV Standards
- Ansys
- CATIA
- AutoCAD
- Inventor



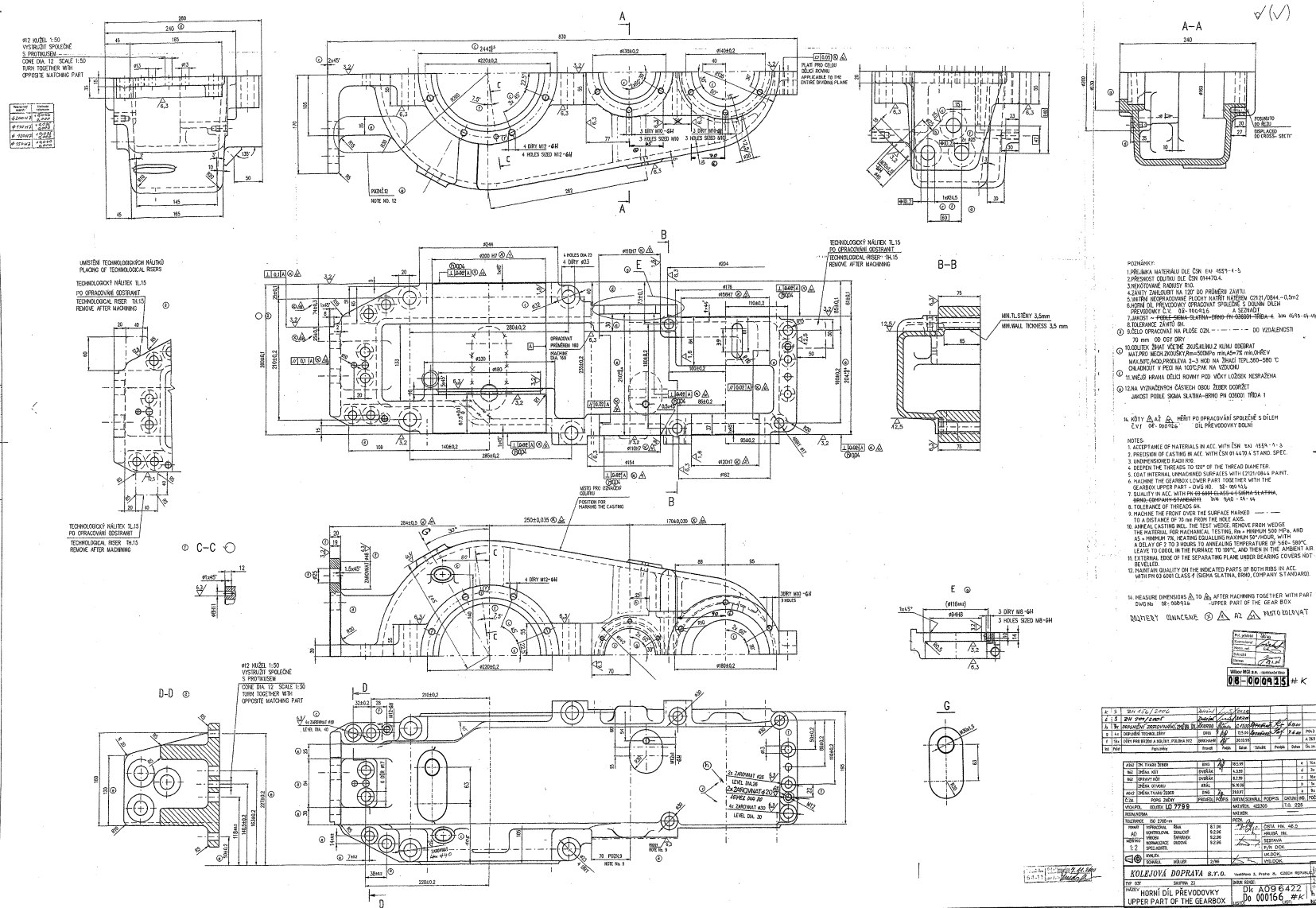
Katedra částí a mechanismů strojů

- Konstruování 1 a 2
- CAD 1 a 2
- Části a mechanismy strojů 1 a 2
- Konstrukční cvičení
- BP např. implementace převodovky
- NMSP Inovační inženýrství

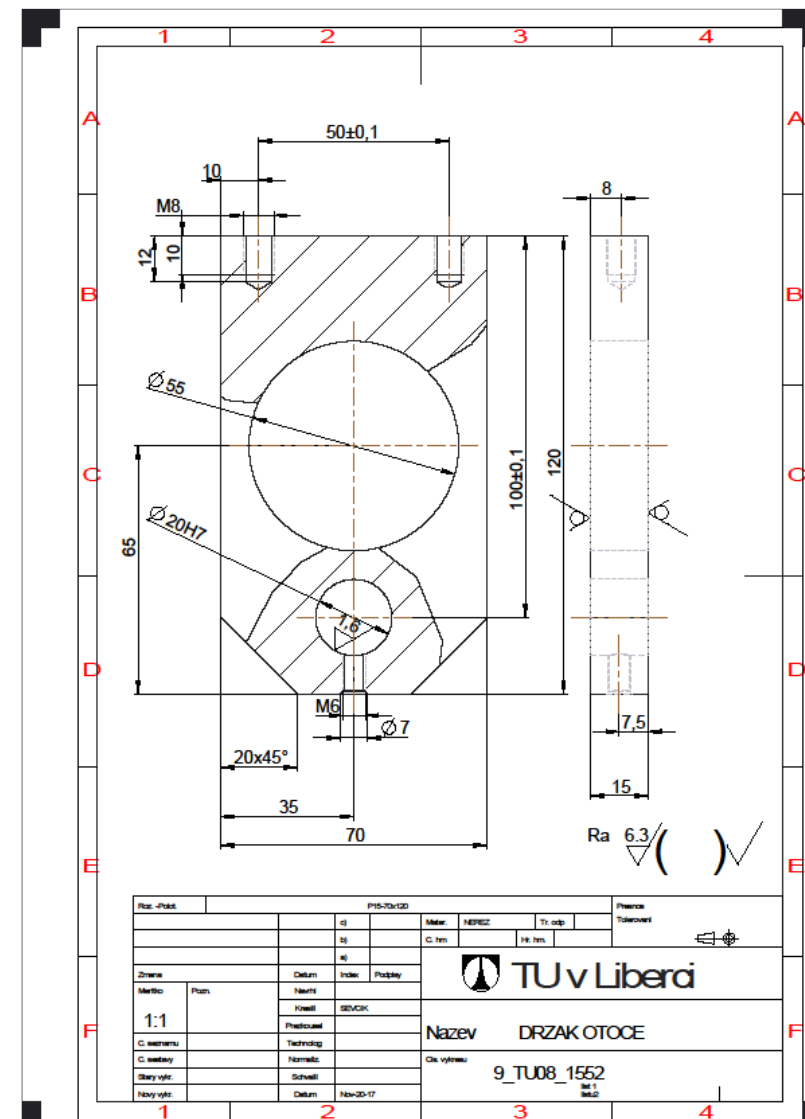
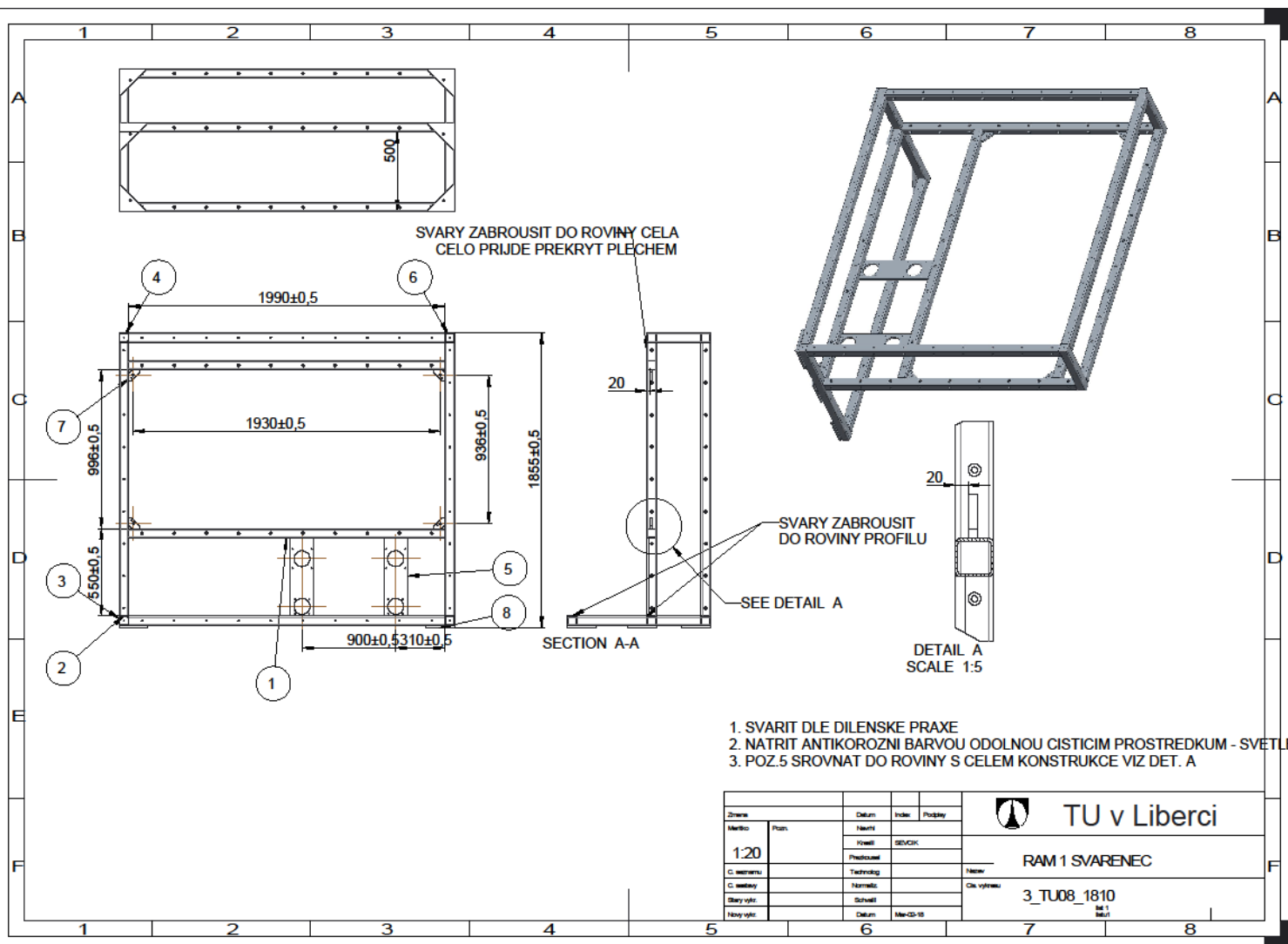


Sériová výroba, dokumentace skříň litina

Konstrukce, technologie,
materiály – vznikne
model, výkres



Výrobní výkresy kusové výroby



Layout a Skeleton

Rozložení -
dispozice linky
na ploché sklo

Washing Machine Skeleton Layout

Dimensions and Annotations:

- Water inlet connection: 1.5" fast coupling 1/2" NPT
- Water supply: 2 V2" External thread
- Water circuit: Water filter install and connect by buyer, connection point - hose Ø25 near
- Electrical table tray: Height: 250-260mm
- Buttons: Button Height setting, Second button Small speed, Emergency stop
- Water drain: 1.5" fast coupling 1/2" NPT
- Water suction: 2 V2" External thread
- Water circuit diagram showing pump, valves, and connections.

Specifications Table:

Component	Model	Flow Rate
Washing motor	-	1700
Drum motor	5	1000
Compressor	1	1700

Performance Table:

Parameter	Value
Capacity (kg)	5
Power consumption (kW)	0.68
Max. pressure (psi)	75
Operating voltage (V)	400
Frequency (Hz)	50

Technical Details:

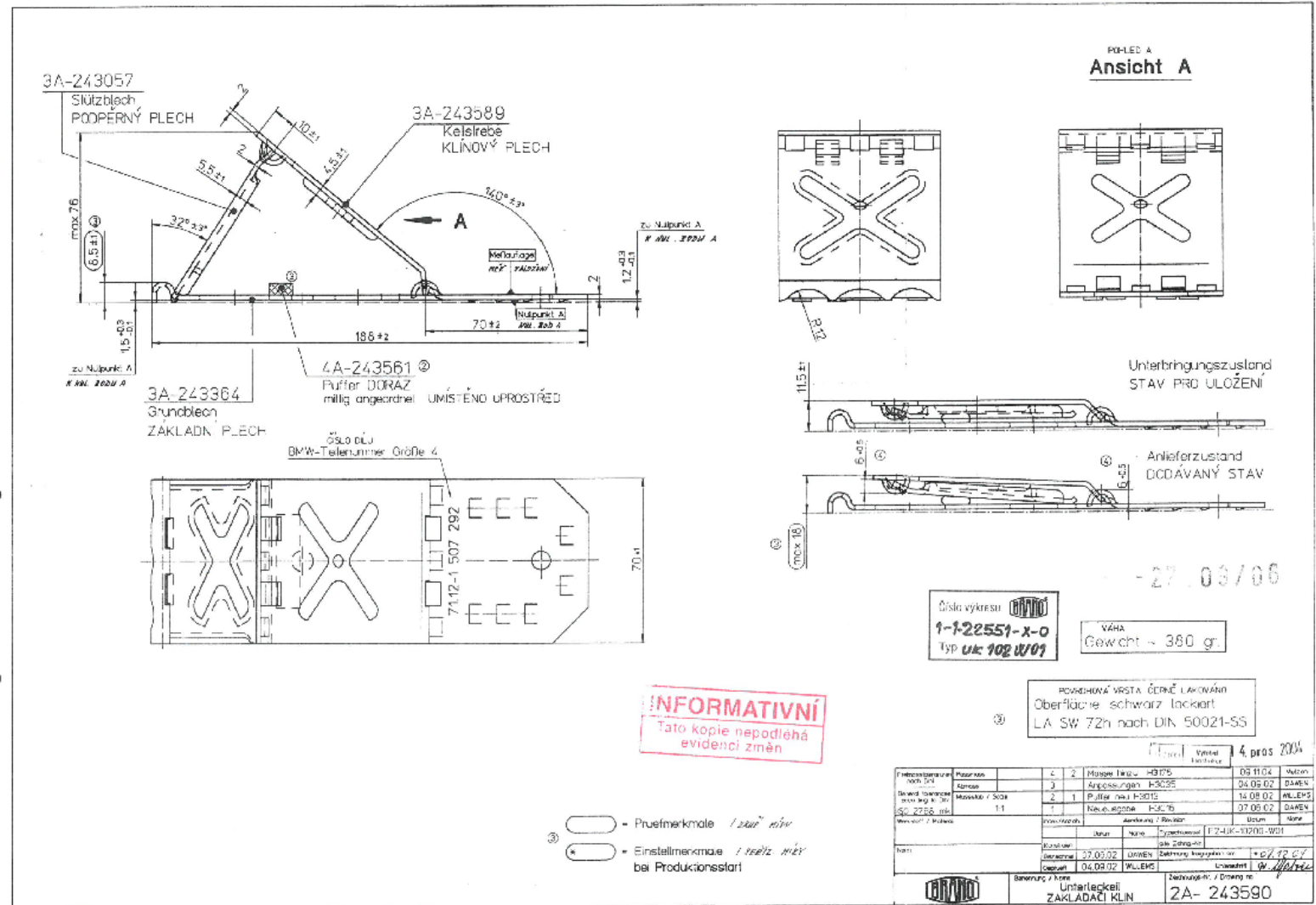
- Water filter install and connect by buyer, connection point - hose Ø25 near
- Water circuit diagram showing pump, valves, and connections.
- Water connected by buyer
- Water drain: 1.5" fast coupling 1/2" NPT
- Water suction: 2 V2" External thread

Product Information:

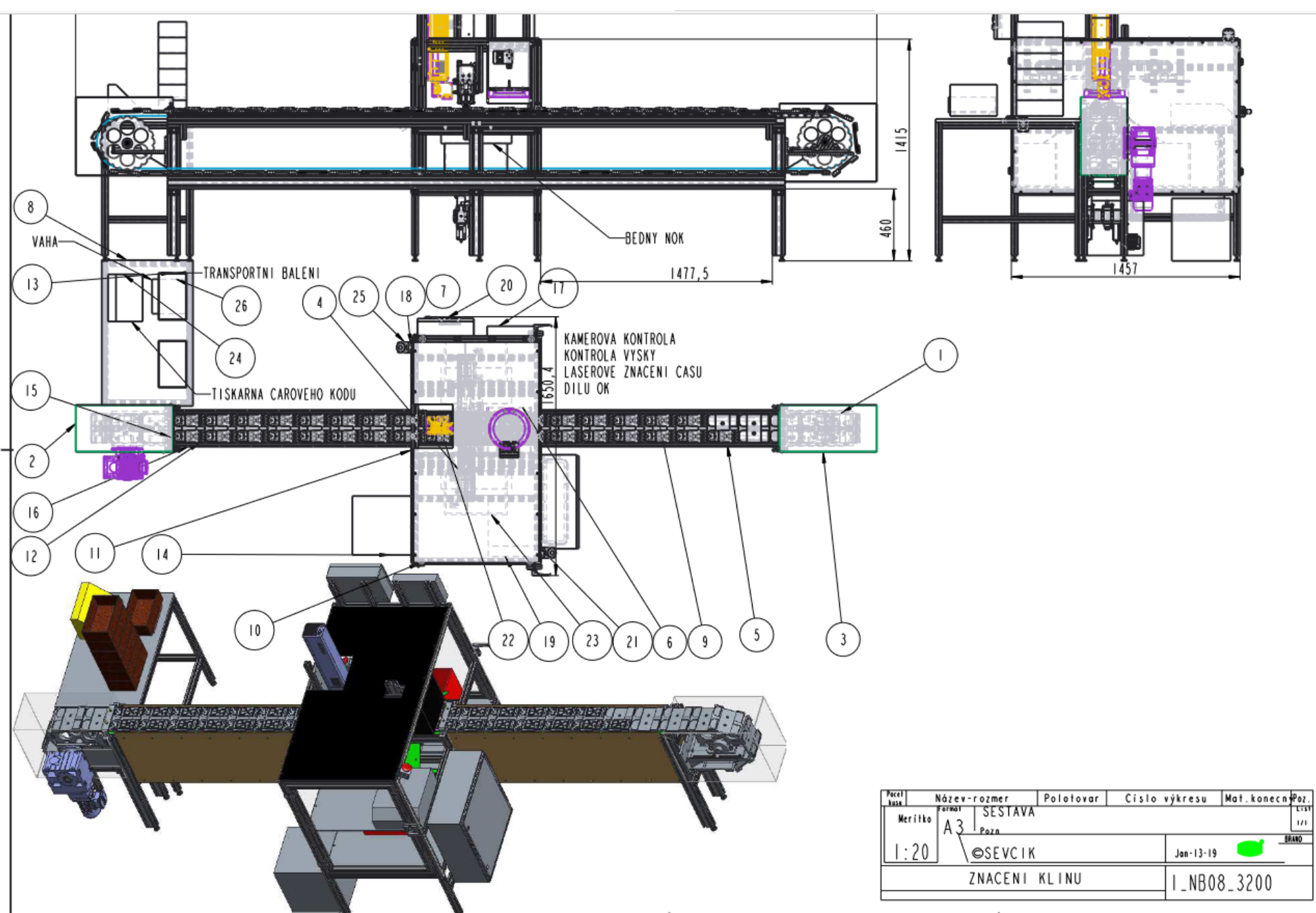
Washing Machine Model: WA 2500-08/1A
 Page: 147

Testovací zařízení popisu klínů- nespolehlivost obsluhy

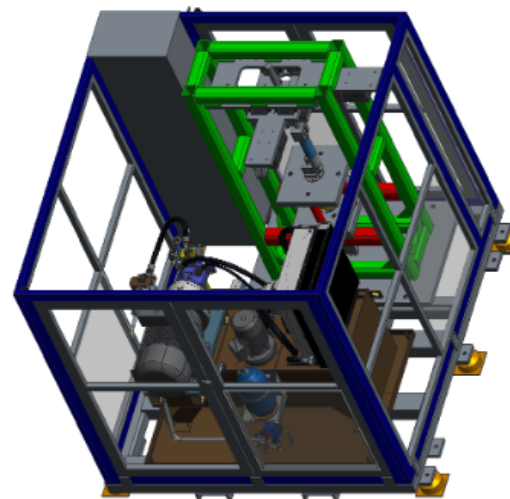
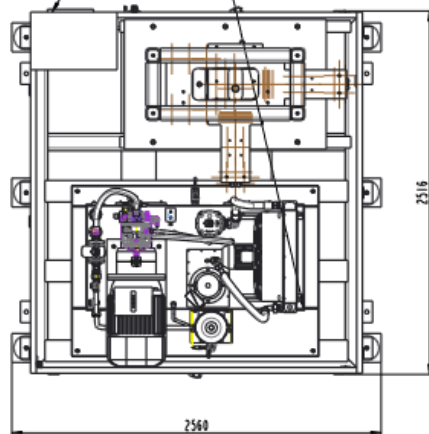
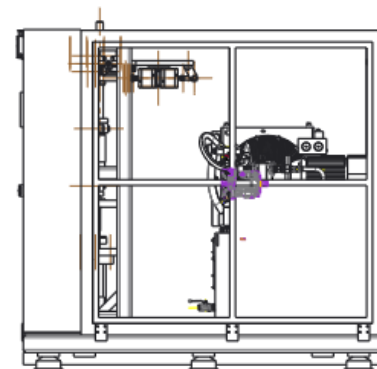
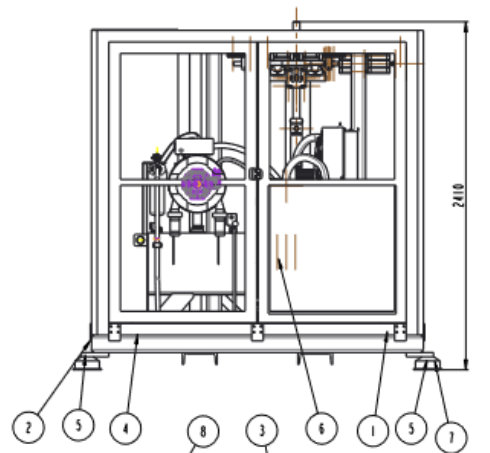
- Kontrola nápisu na klínech před balením a balení – odstranění lidské nepozornosti



Kontrola klínů

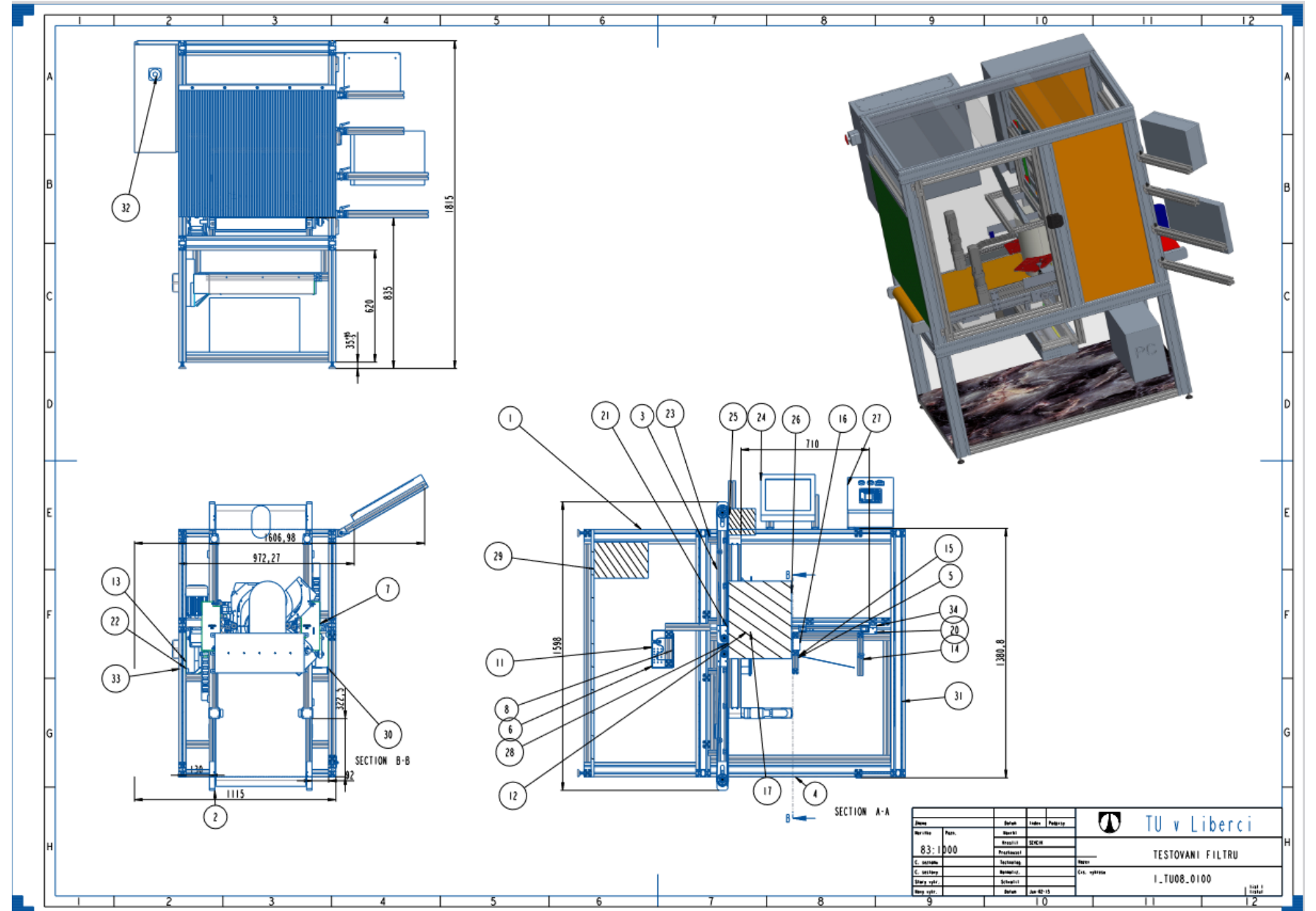
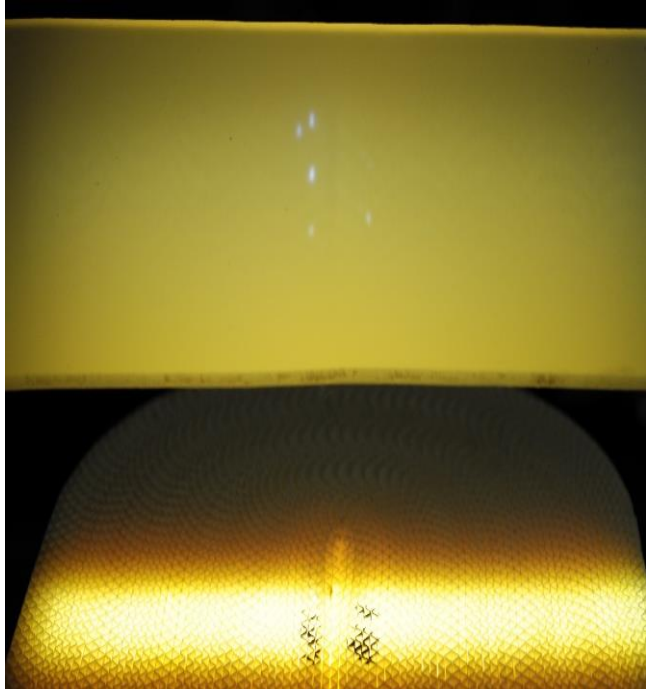


Testovací
zařízení
bezpečnost
ní prvky -
oploceni

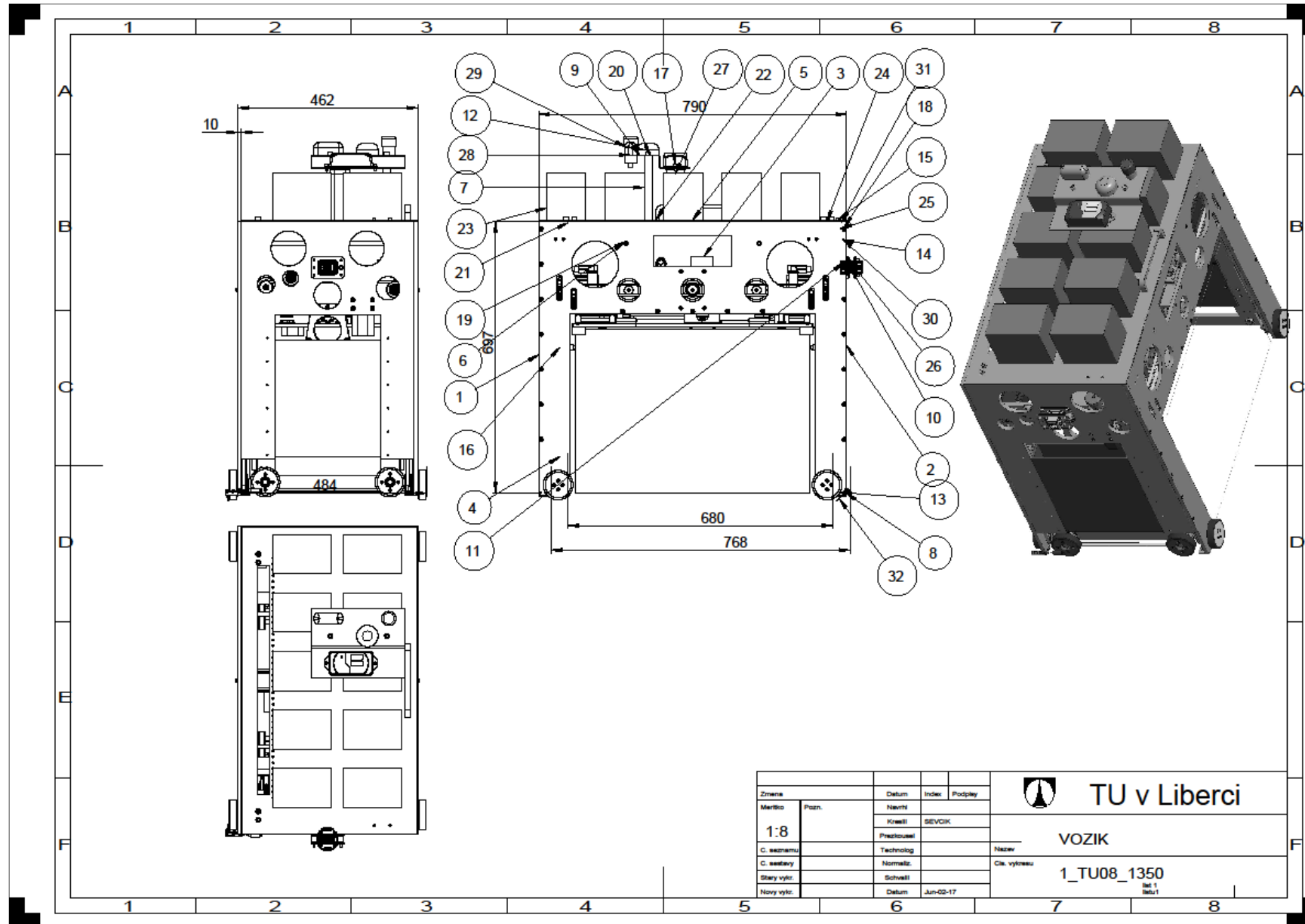


Návrh	Název-číslo	Podpis	Číslo výkresu	Mat.koncový	Per.
Verze	A2	SESTAVA			
1:20	SEVCIK		01-09-14		
DYNAMICKÝ ZKUSEBNÍ STAV			I_NB08_1500		

Kontrola vzduchových filtrů



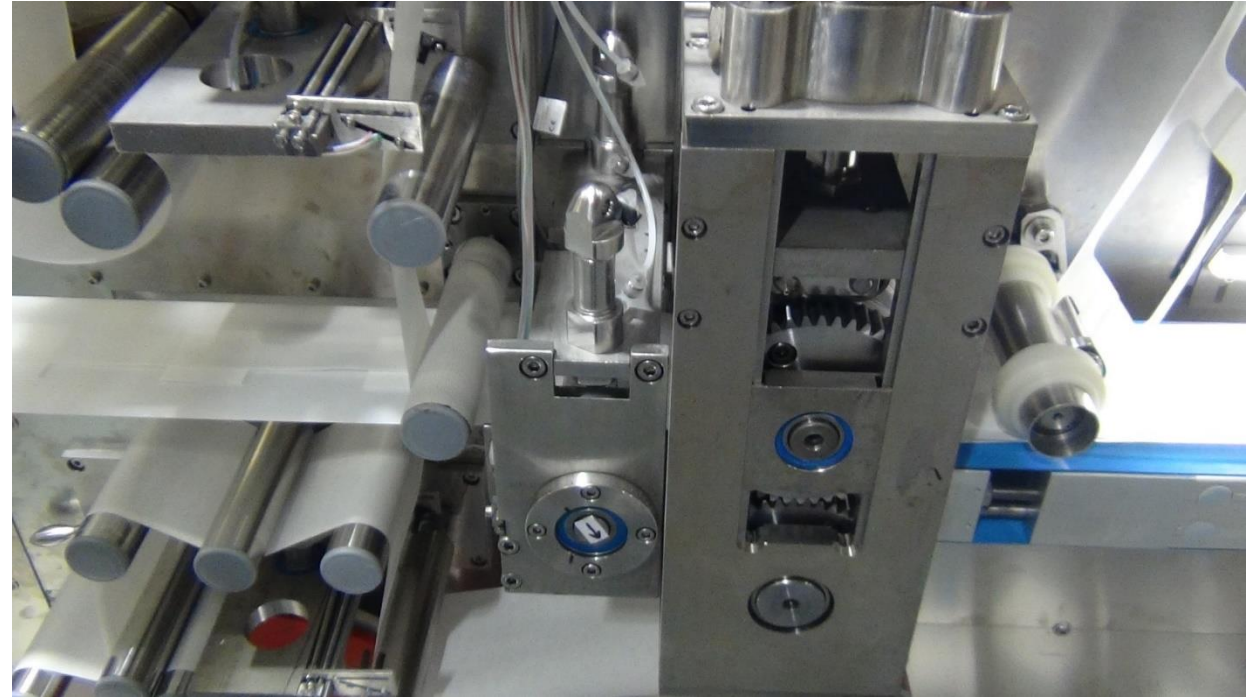
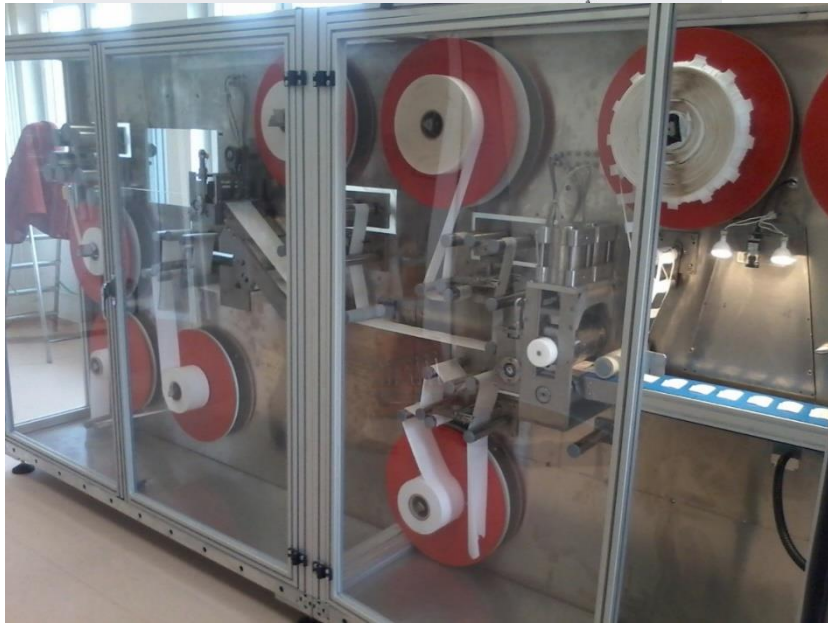
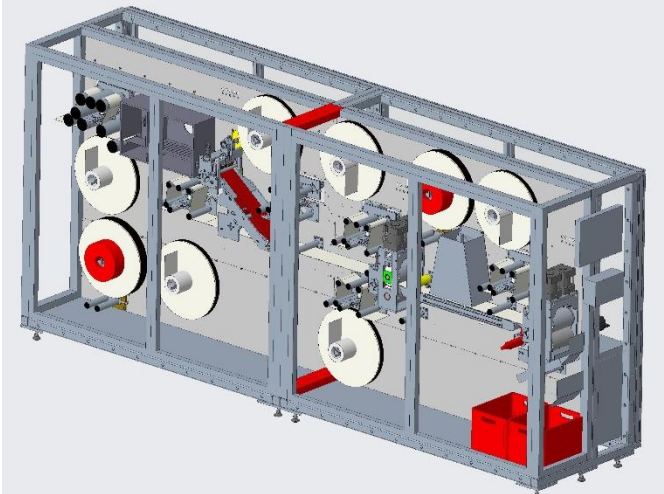
Robot zakladač cenin Kácov



Změna	Prizn.	Datum	Index	Podpis
1:8				
C. sestaveno				
C. sestavy				
Stary vykr.				
Novy vykr.				

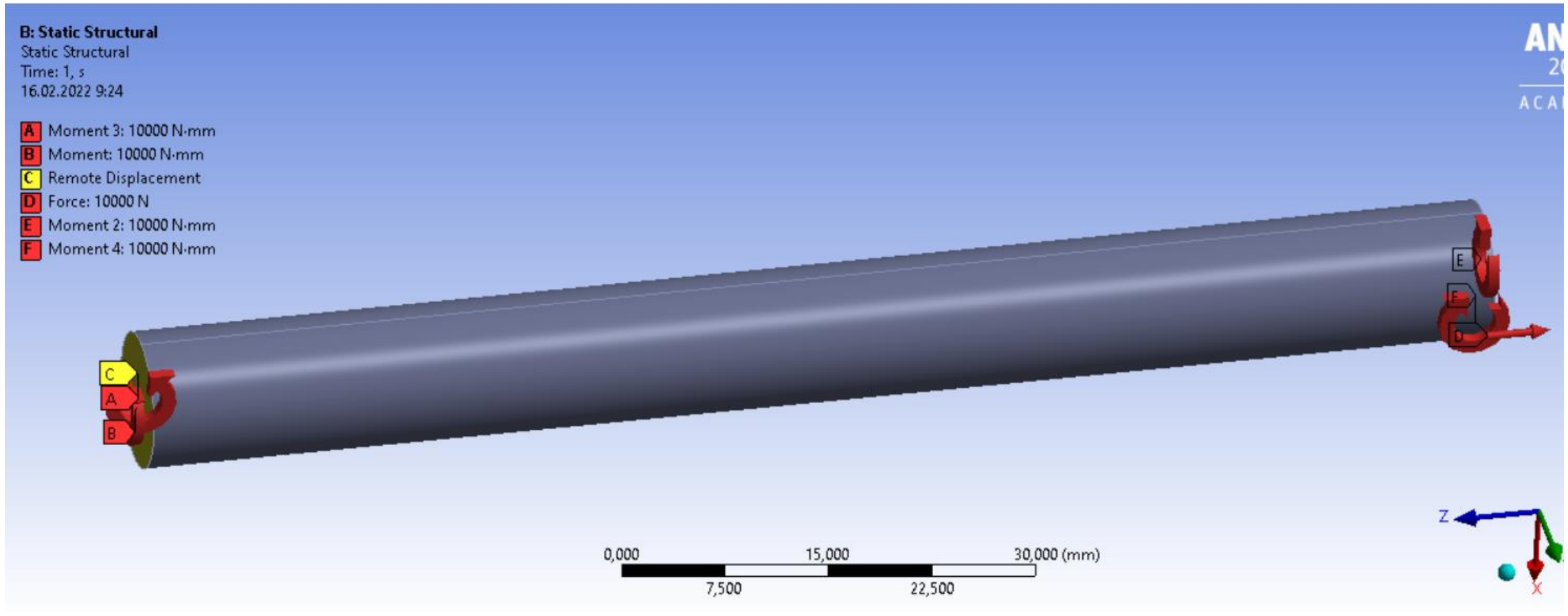
		Datum Index Podpis	
		Naverh Kreslil SEVOK	
Přehledoval		Technolog	
Normaliz.		Schválil	
Datum Jun-02-17		Názov VOZIK	
Ck. vytvořeno		1_TU08_1350	
list 1		ze 1	

Jednouchelový stroj na náplasti montáž, oživení, ověřovací provoz

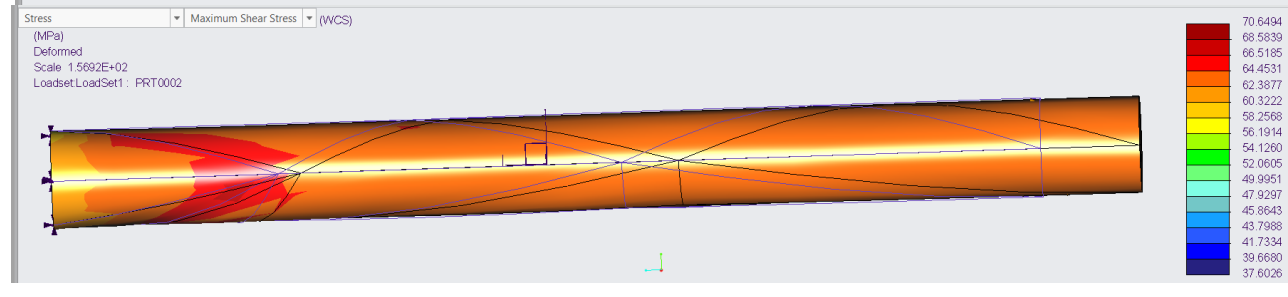
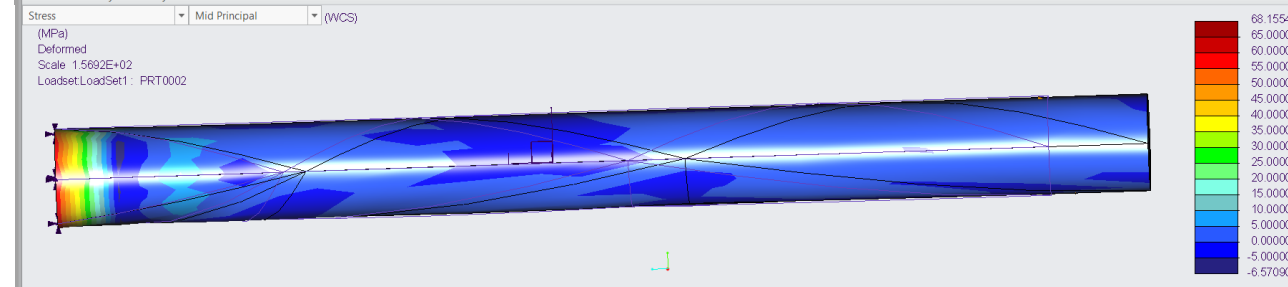
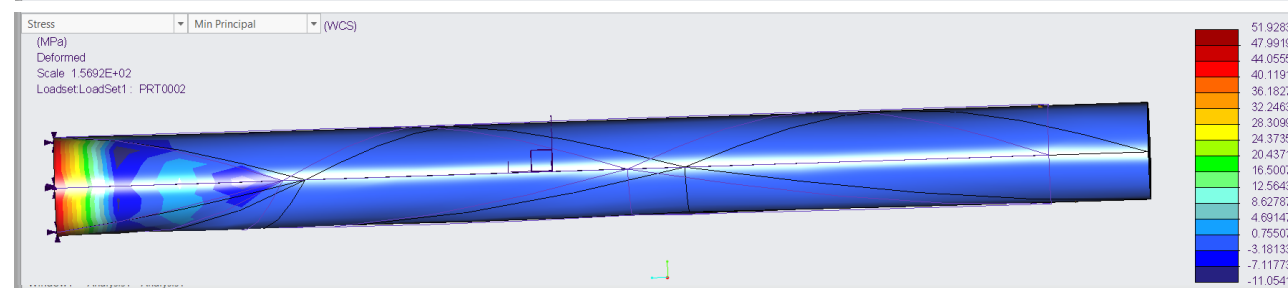
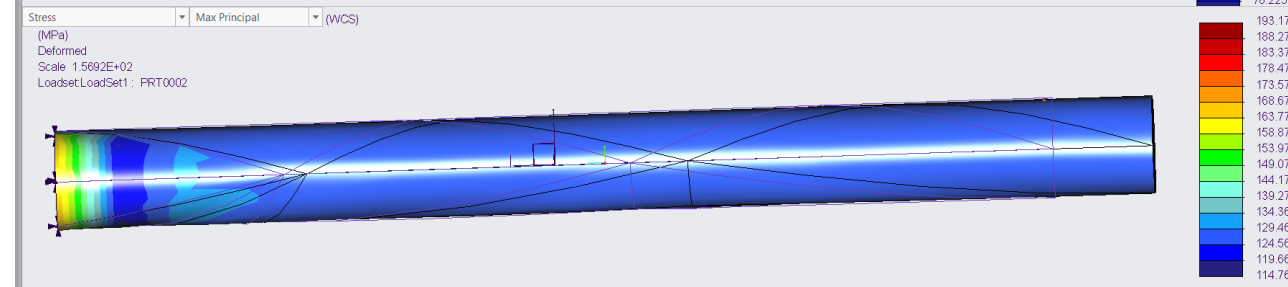
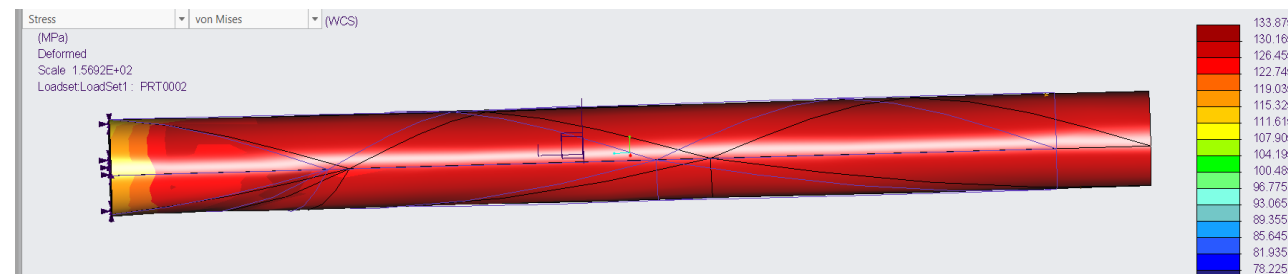
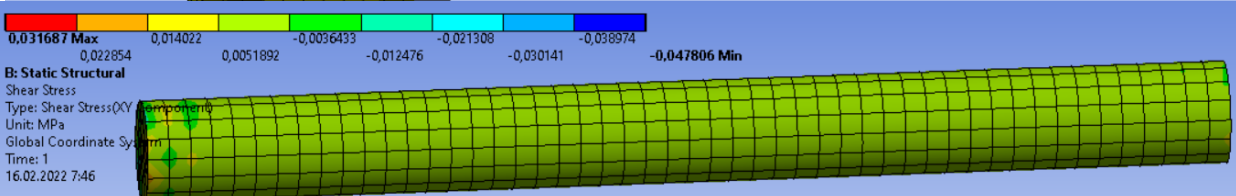
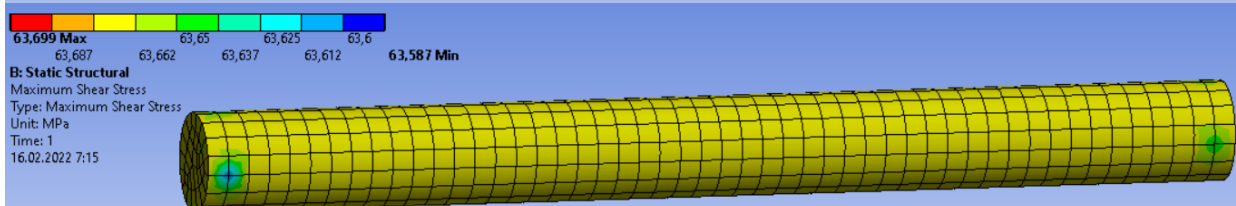
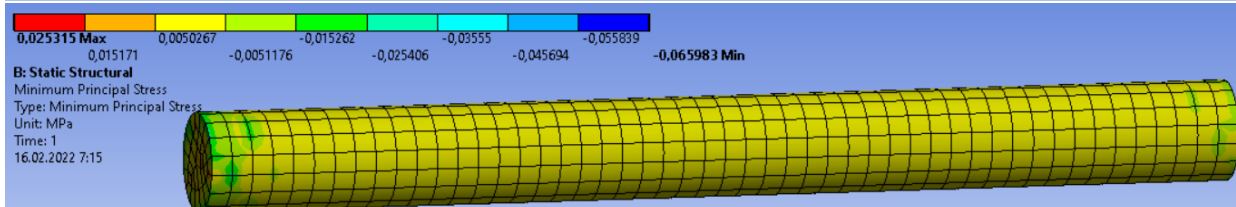
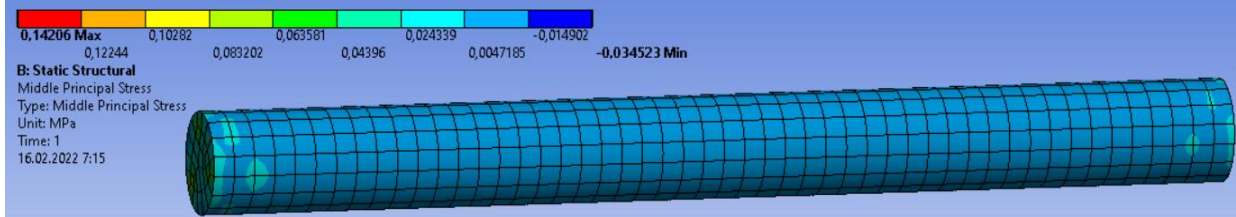
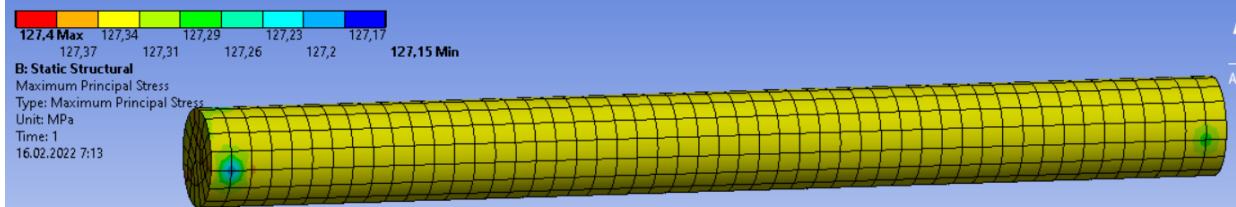
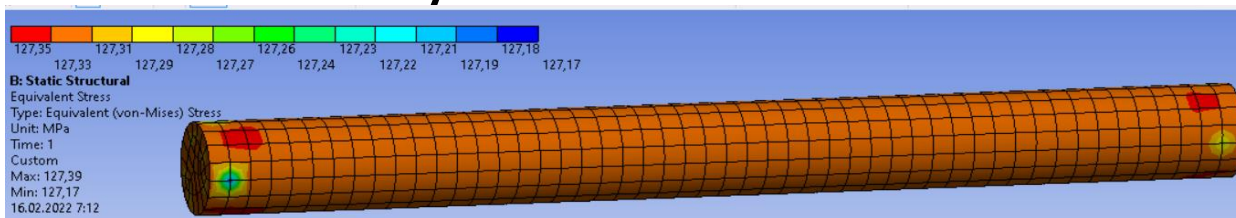


Metoda výpočtů

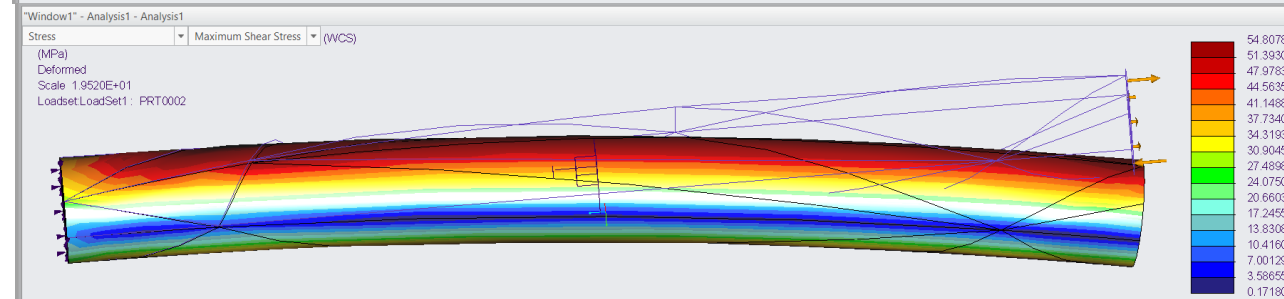
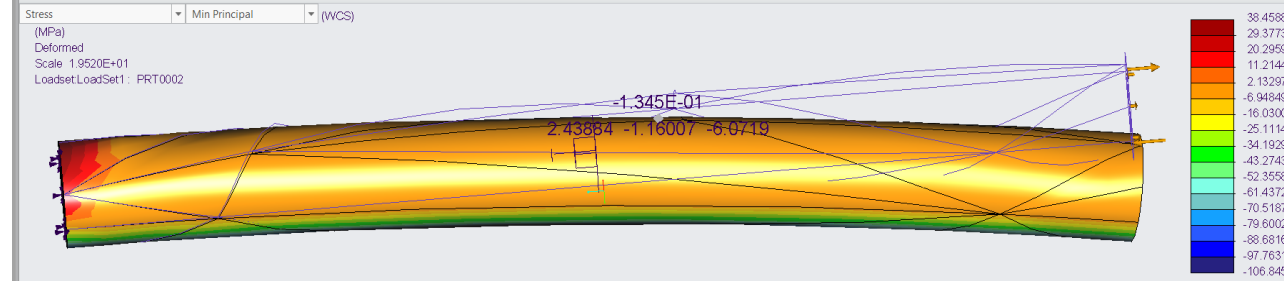
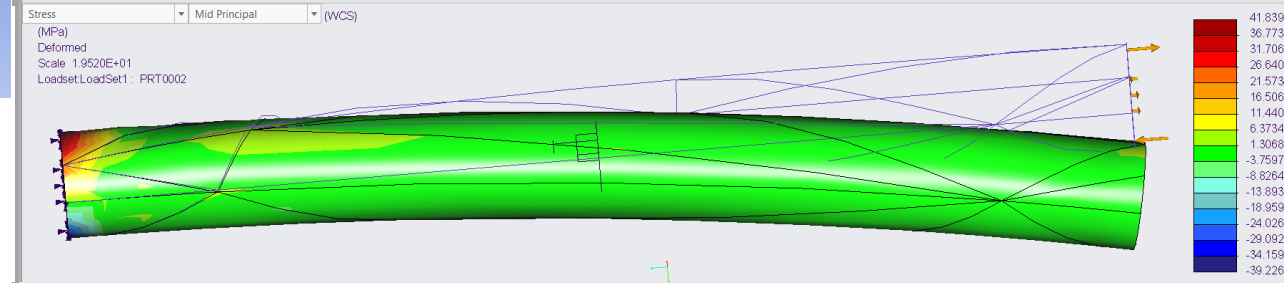
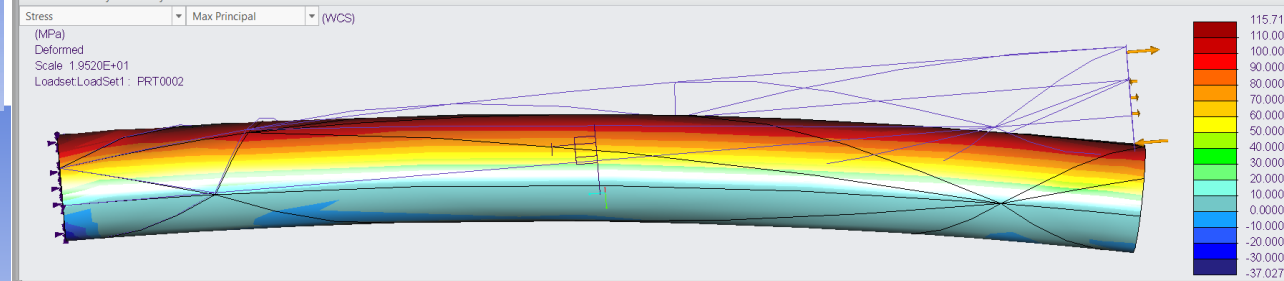
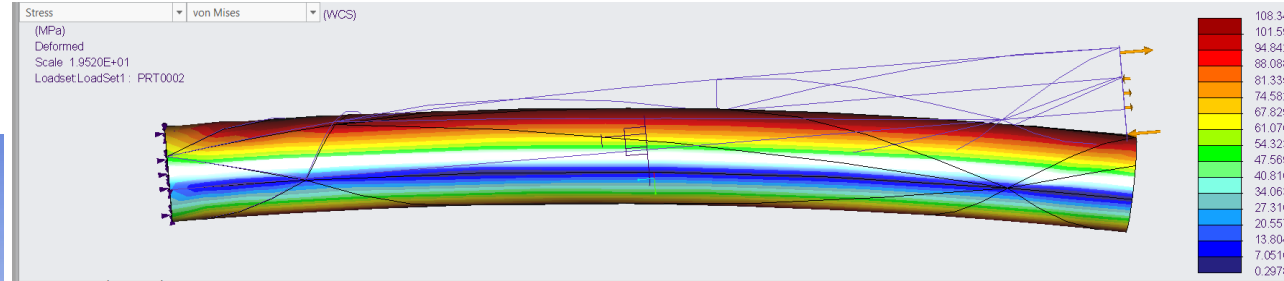
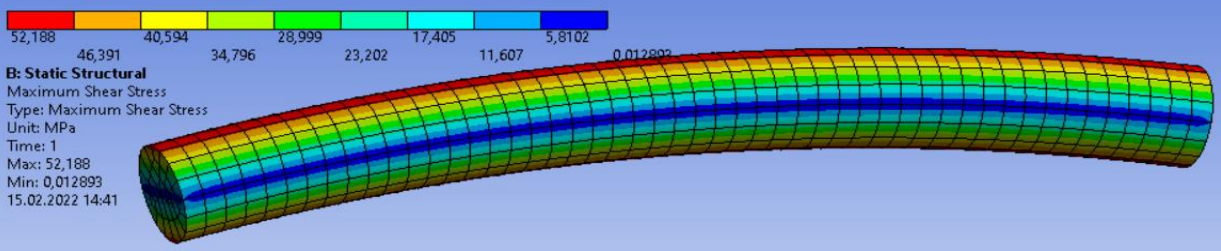
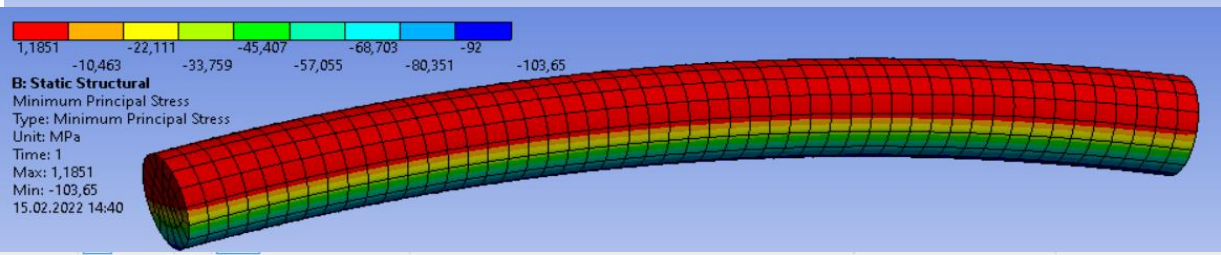
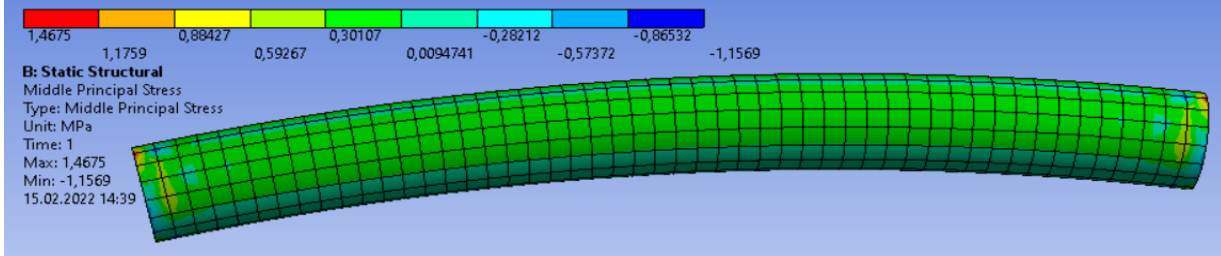
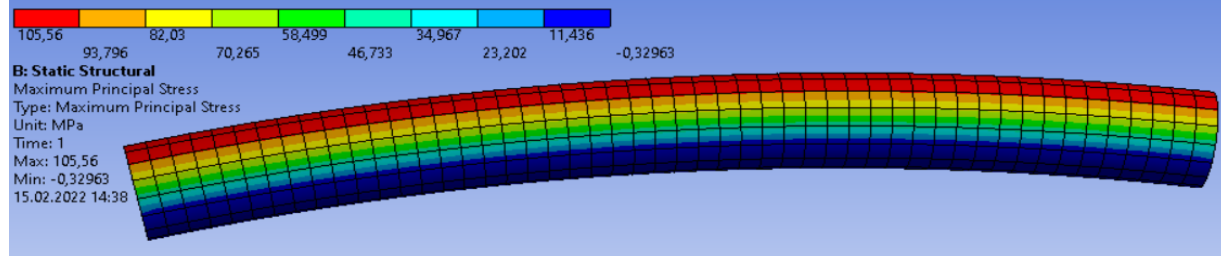
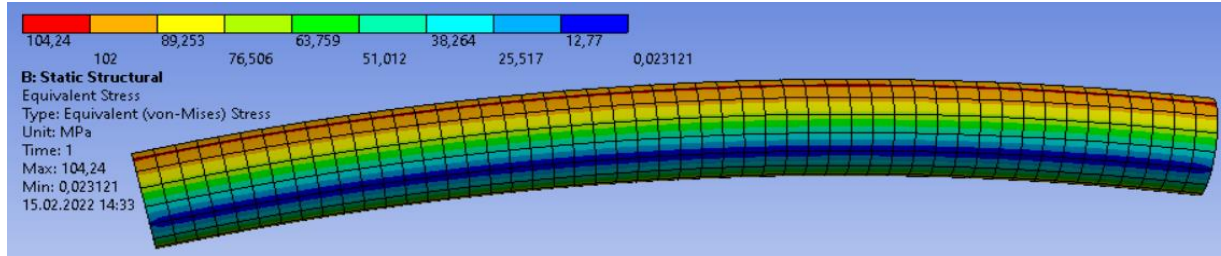
Okrajové podmínky, materiály



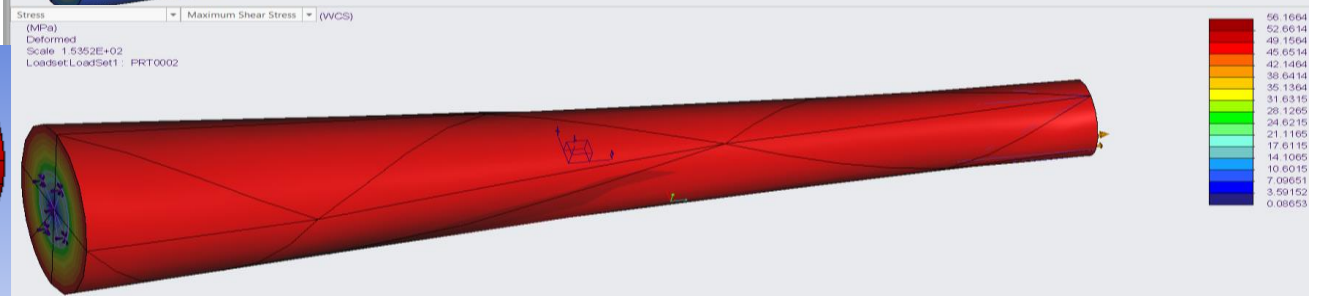
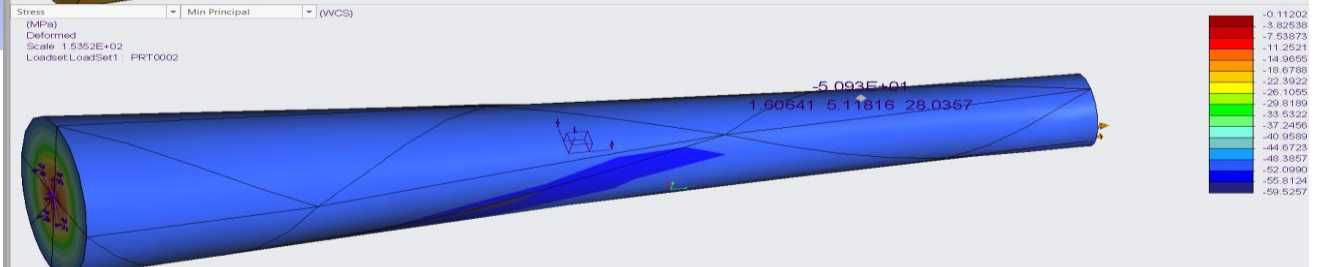
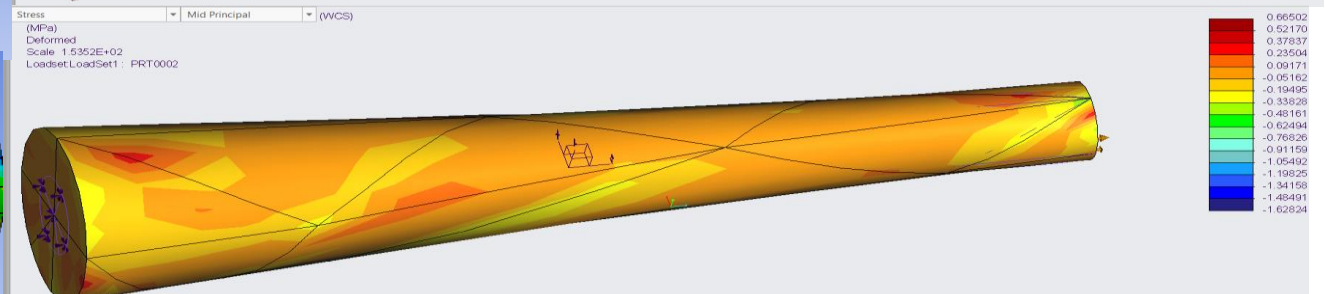
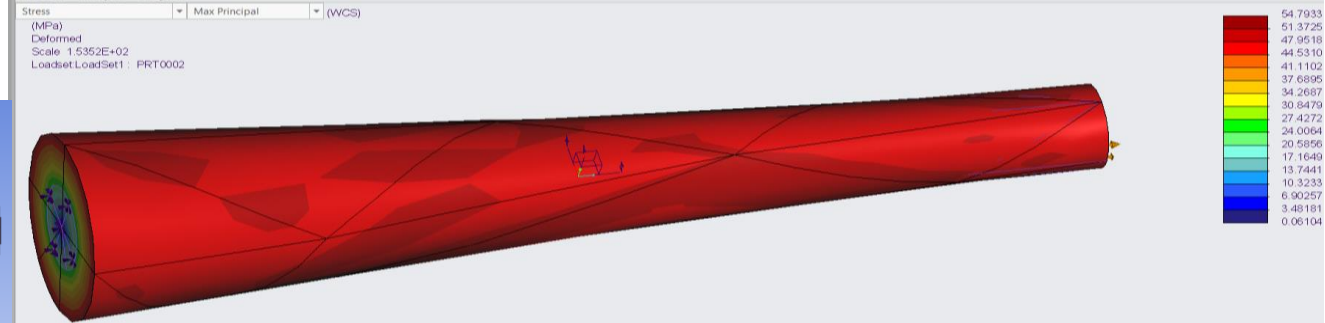
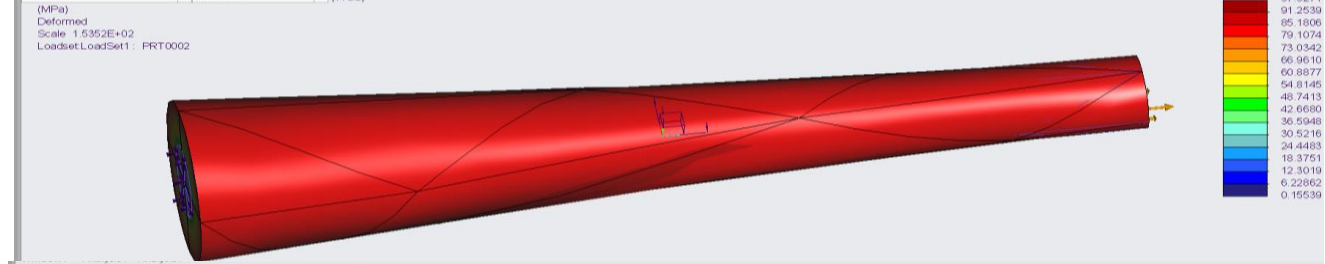
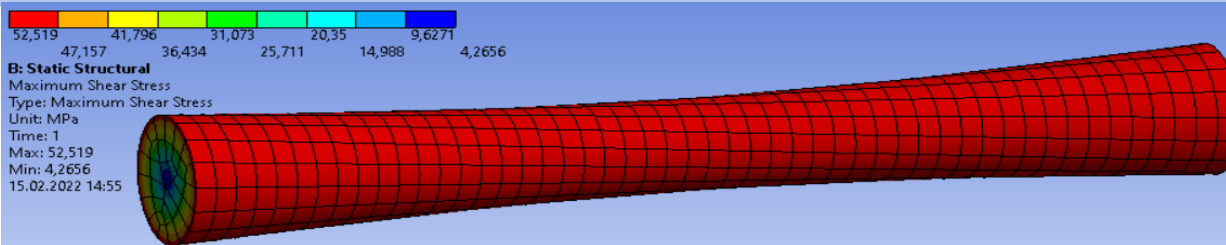
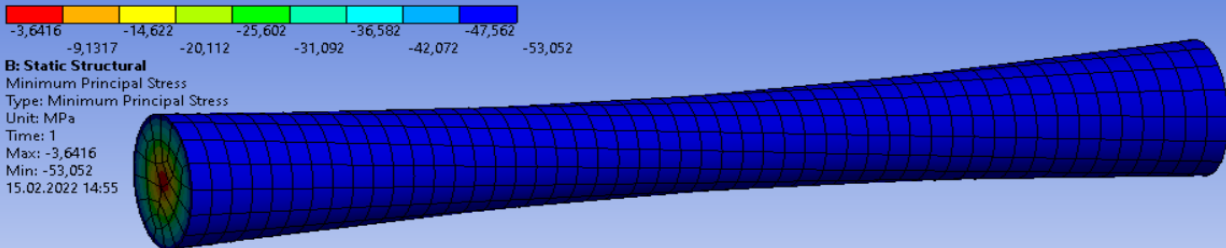
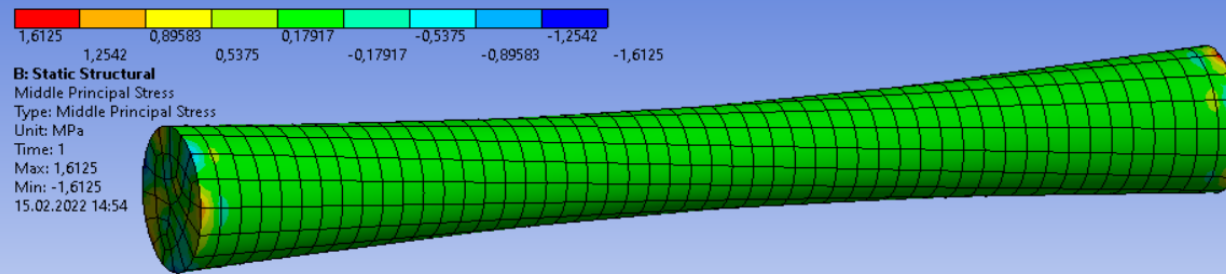
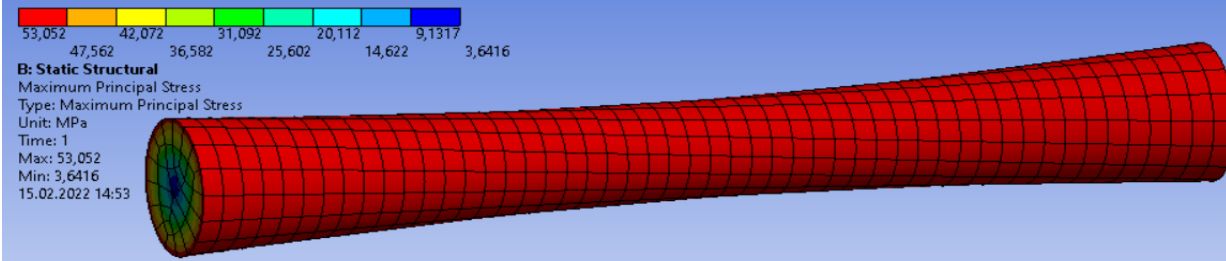
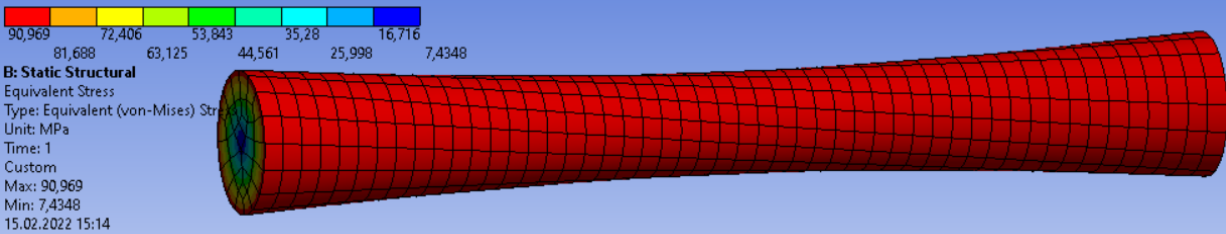
Prostý tah tlak 127MPa



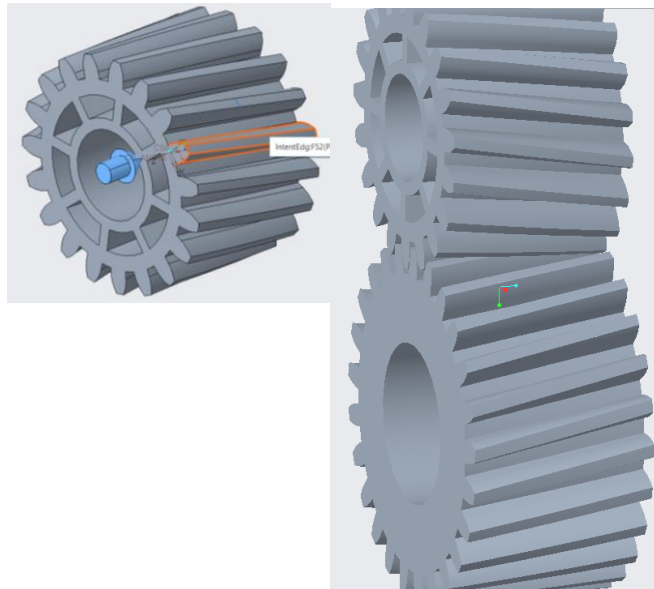
Prostý ohyb 101.9 MPa



Prostý krut 51 MPa



Výpočet napětí kompozitního vstřikovaného ozubeného kola – FEM metoda



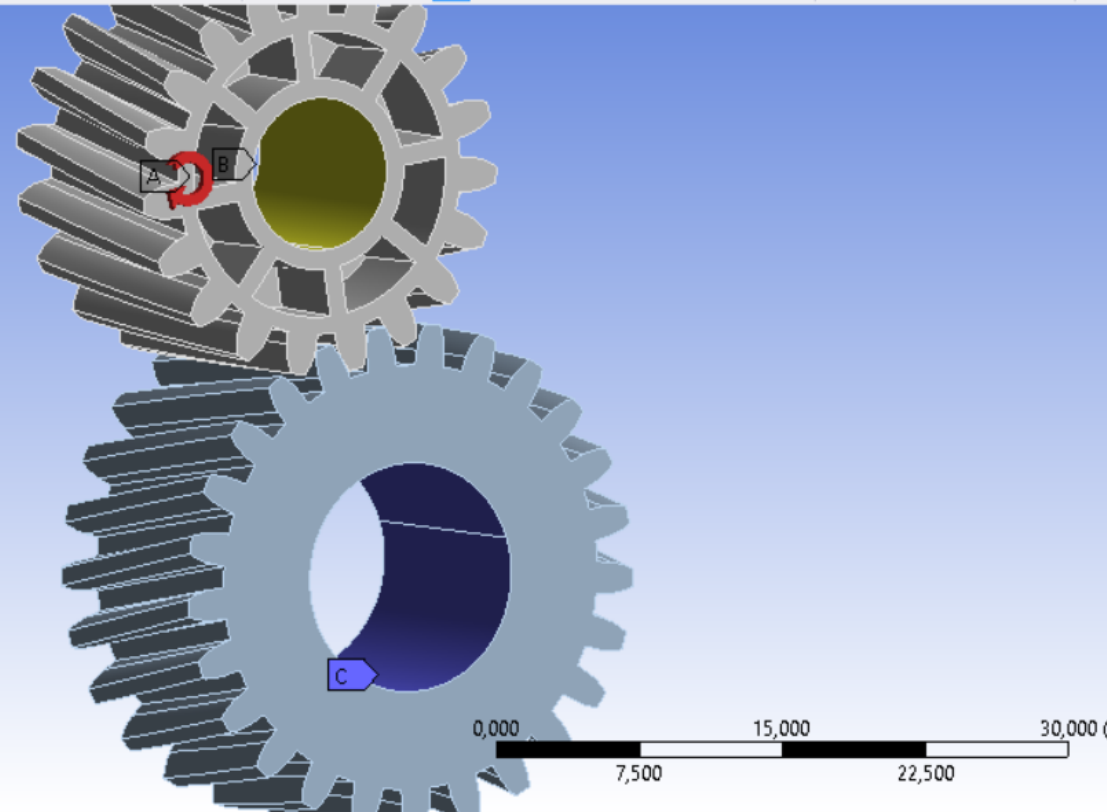
Outline

Name Search Outline

- Project*
- Model (B4)
 - Geometry
 - KST_EVOL_OZUBENI_SIKME_PST
 - KST_EVOL_OZUBENI_SIKME_KOL
 - Materials
 - Coordinate Systems
 - Connections
 - Mesh
 - Static Structural (B5)
 - Analysis Settings
 - Moment
 - Fixed Support
 - Remote Displacement
 - Solution (B6)
 - Solution Information
 - Total Deformation
 - Equivalent Stress
 - Maximum Principal Stress
 - Maximum Shear Elastic Strain
 - Vector Principal Stress
 - Shear Stress
 - Equivalent Plastic Strain
 - Contact Tool

B: Static Structural
Static Structural
Time: 1, s
21.02.2022 11:28

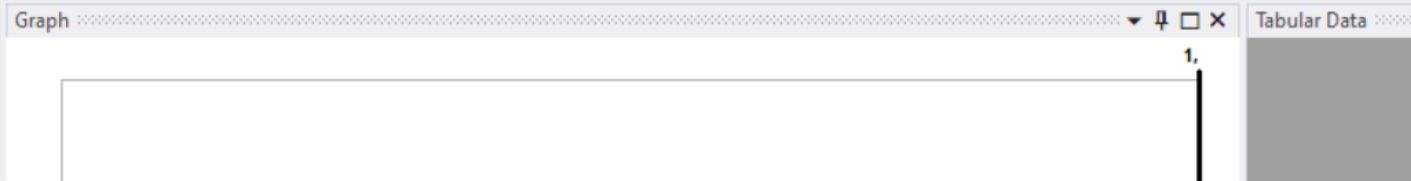
- A Moment: 1000, N-mm
- B Remote Displacement
- C Fixed Support



Benteler glass technics,
krátká skleněná vlákna,
PA matice
vstřikovací technologie

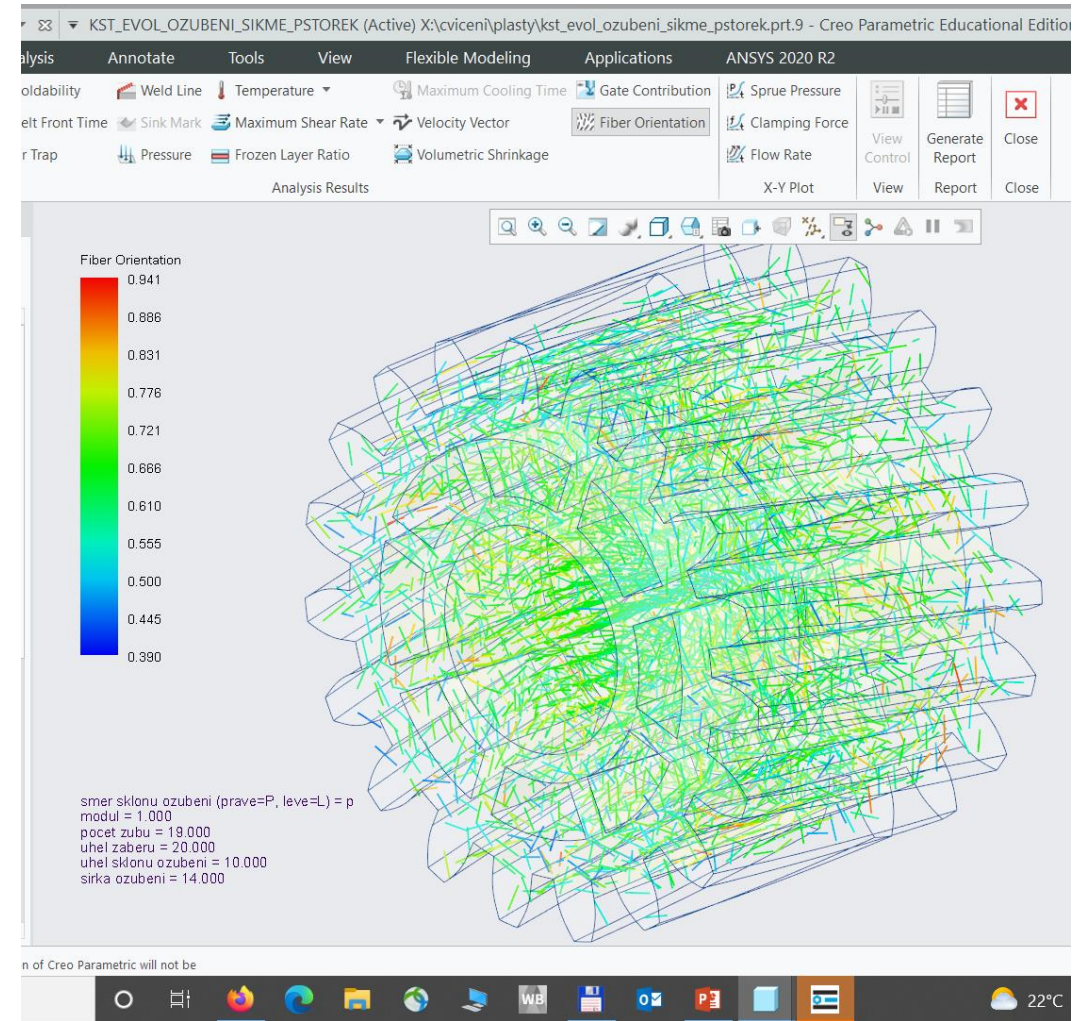
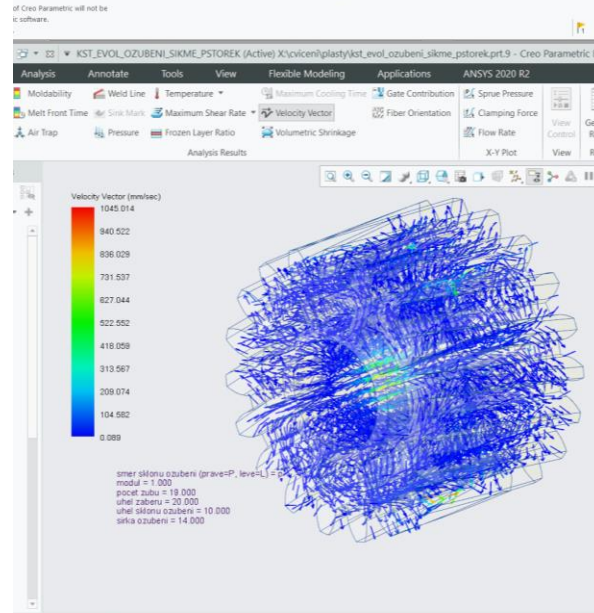
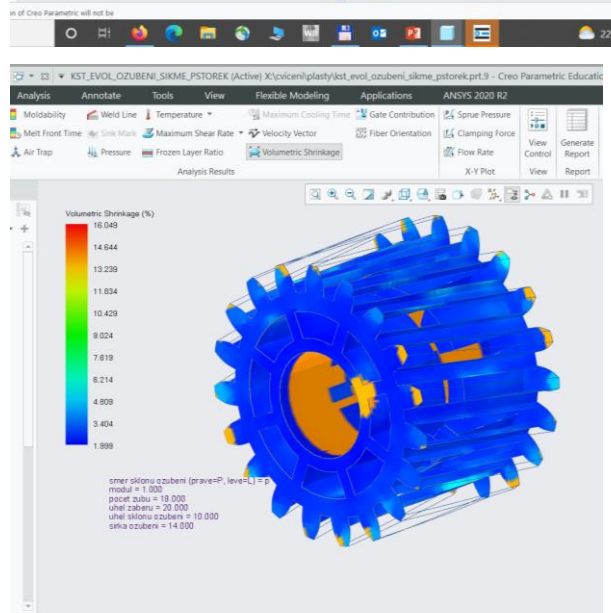
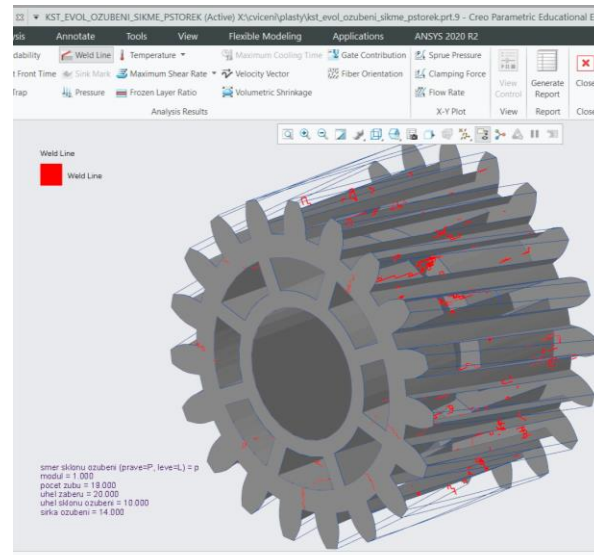
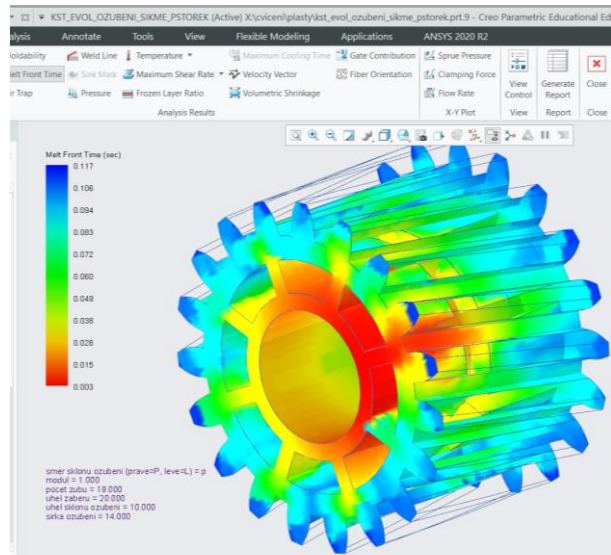
Details of "Static Structural (B5)"

Definition	
Physics Type	Structural
Analysis Type	Static Structural
Solver Target	Mechanical APDL
Options	
<input type="checkbox"/> Environment Temperature	22, °C
<input type="checkbox"/> Generate Input Only	No

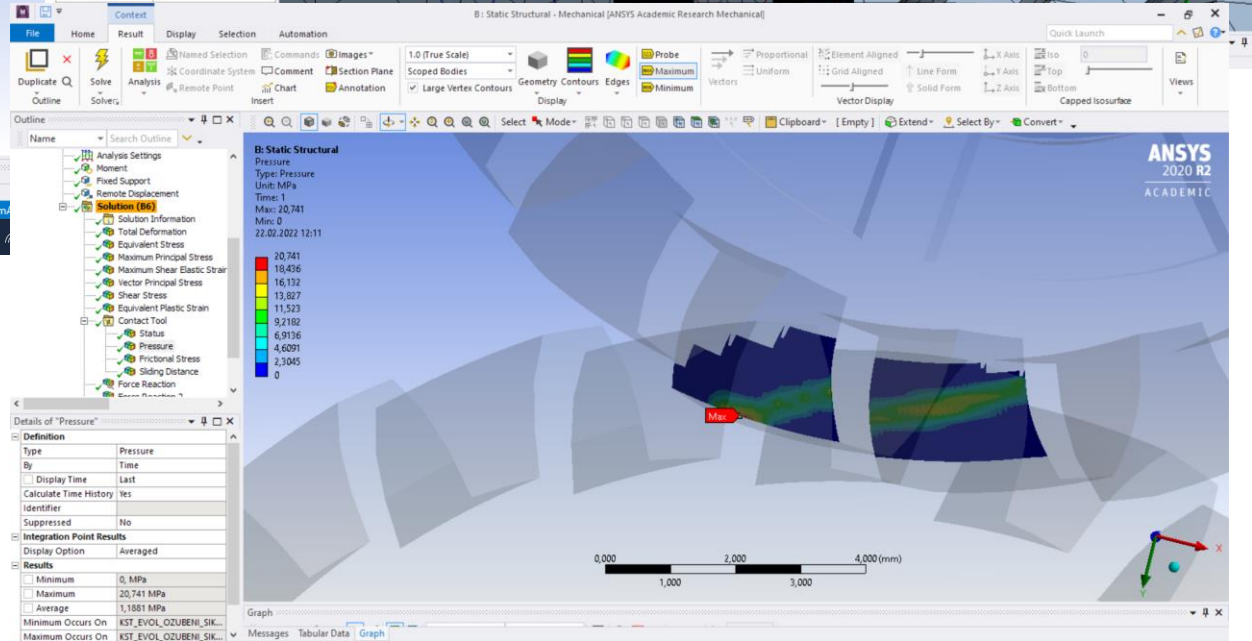
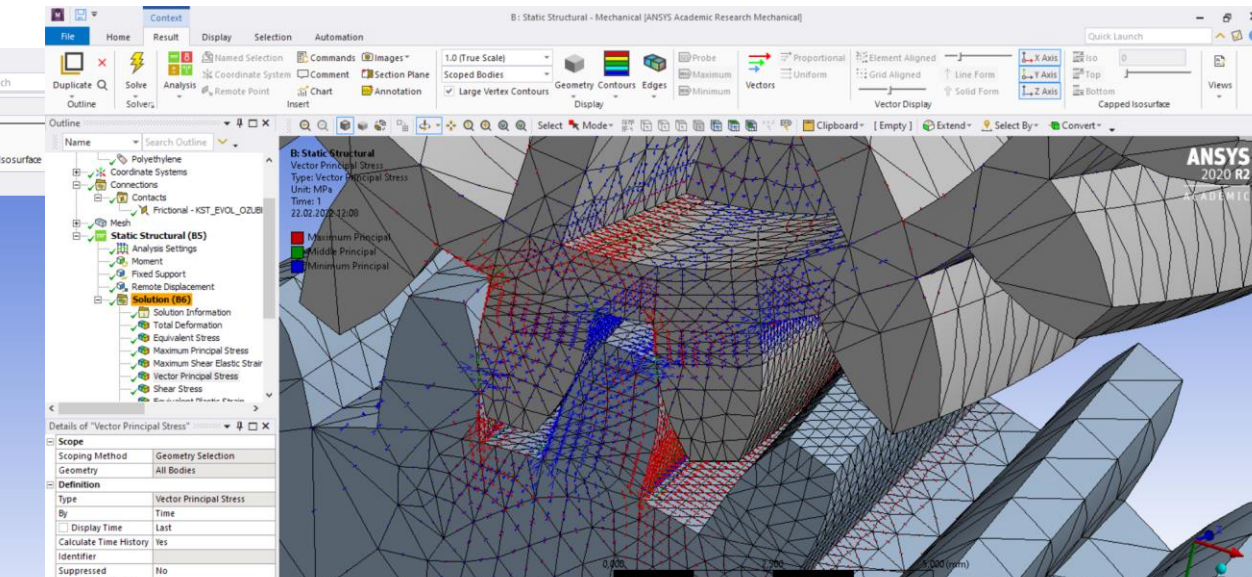
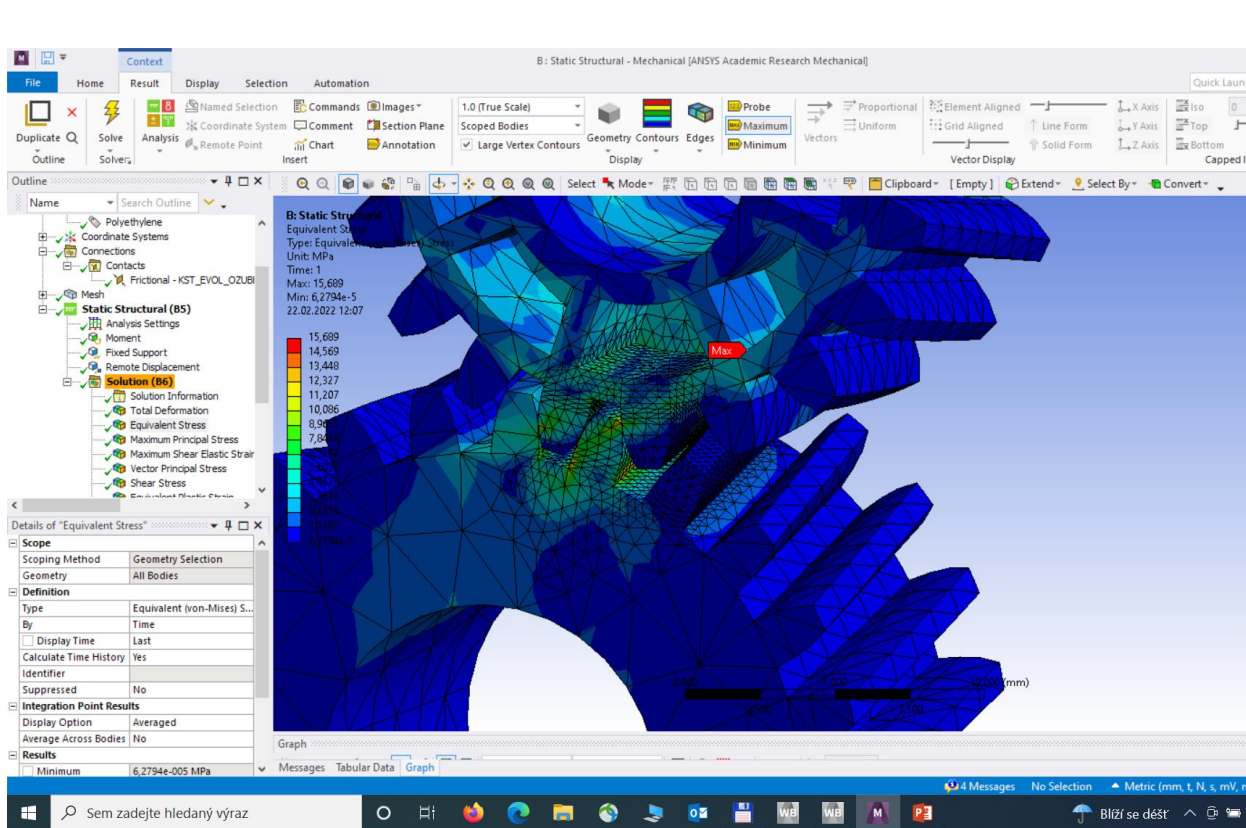


Analýza vstřikování – orientace skleněných vláken

- Pozice vstřiku
- Čas vstřiku
- Objemové stažení
- Studené spoje
- Rychlostní vektory
- Orientace vláken



Pevnostní výpočet s respektováním orientace vláken



Equivalentní napětí, vektory hlavních napětí- Mohr's napětí, kontaktní napětí.

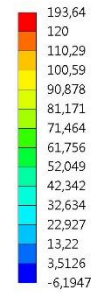
FEM výpočet lineární pružnosti



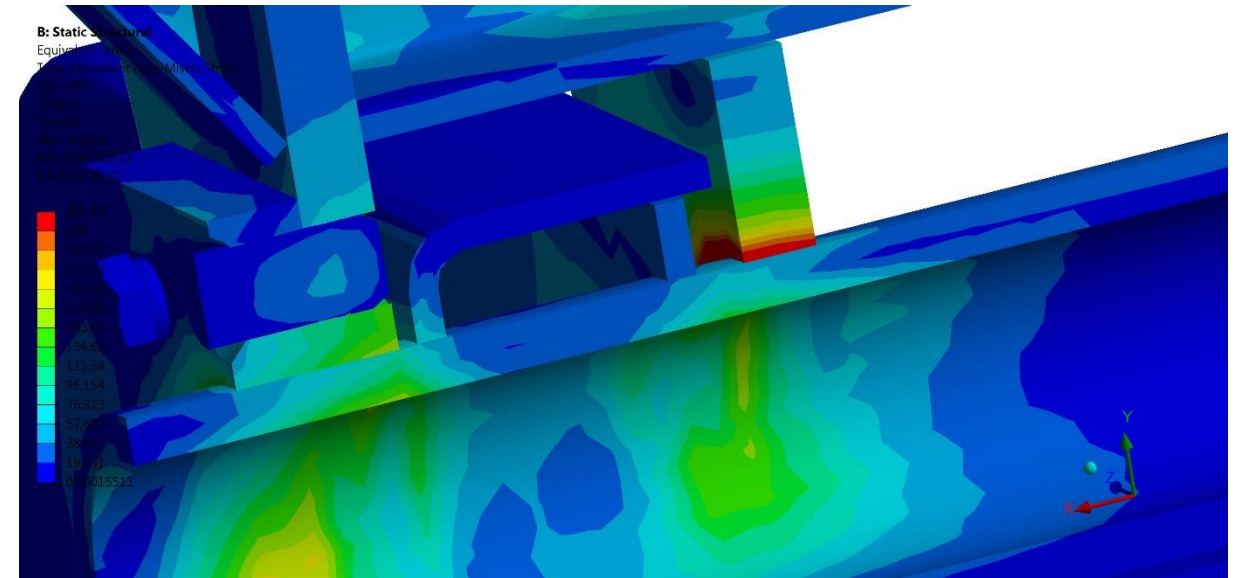
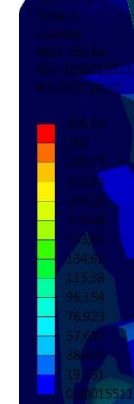
- E, μ
- Uložení sestavy
- Zatížení
- Vazby mezi díly

síť, uzly
rovnováha sil a momentů
deformace, posunutí
odvození napětí

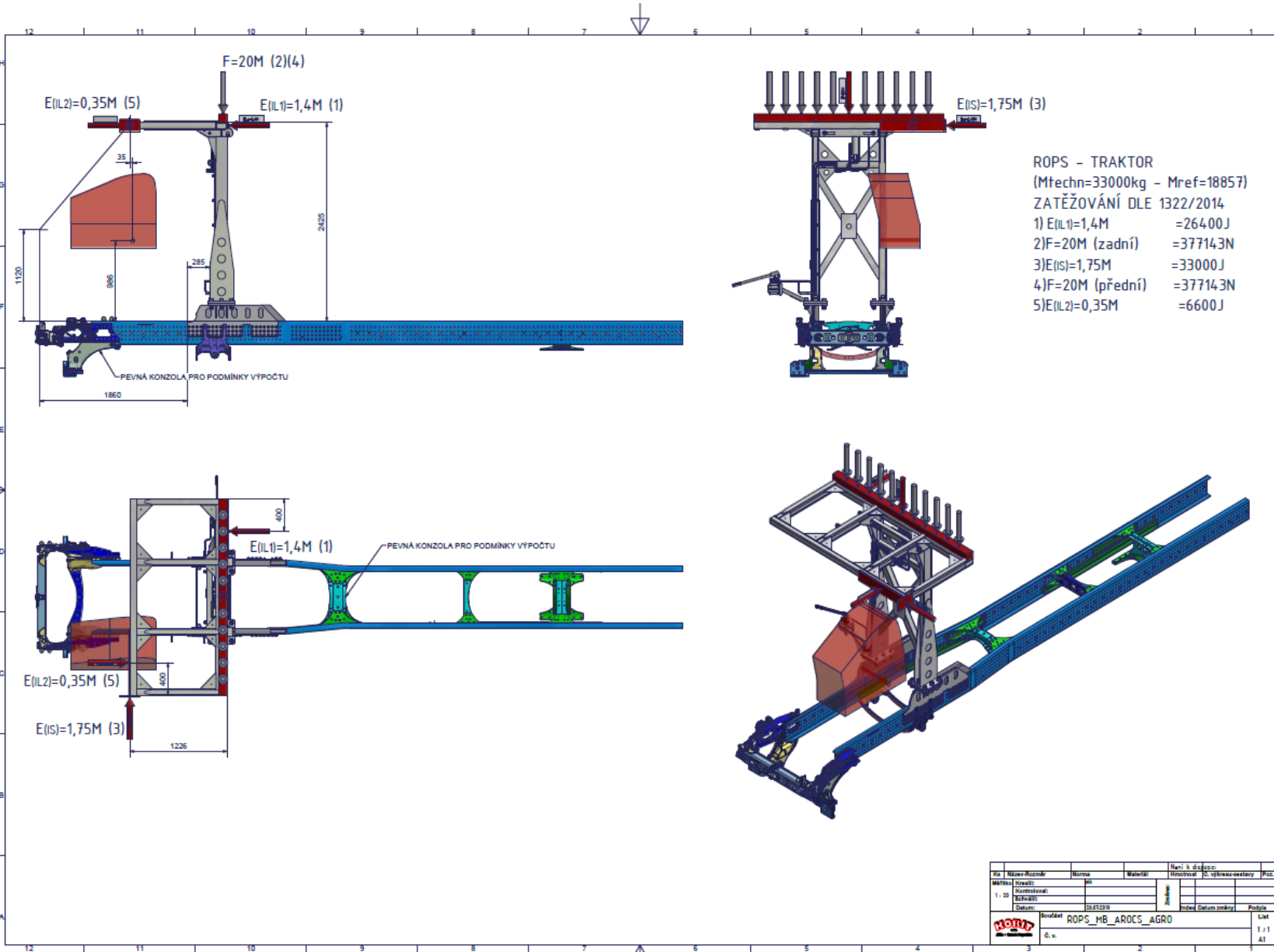
B: Static Structural
Pressure
Type: Pressure
Unit: MPa
Time: 1
Custom
Max: 193,64
Min: -9,1471
4.8.2019 20:34



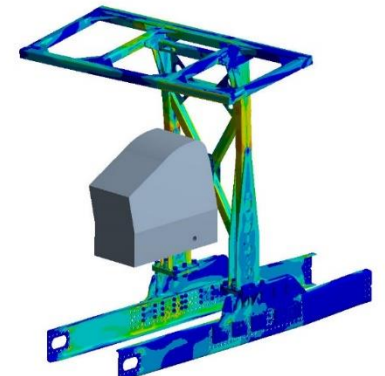
B: Static Structural
Equipment



MKP nelineární transcendentní úlohy. Únava, elastické a plastické deformace

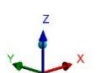


B: Transient Structural
 Equivalent Stress
 Type: Equivalent (von-Mises) Stress
 Unit: MPa
 Time: 1
 Custom
 Max: 761.17
 Min: 6.6554e-9
 1.10.2019 11:40



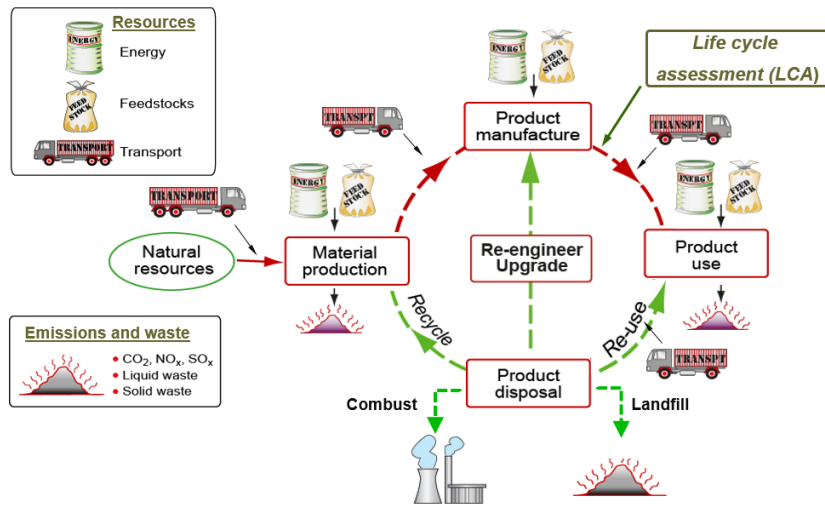
№	Název komponentu	Norma	Materiál	Neříká se	Neříká se	Neříká se
1	ROPS	EN 10025-2	S235JR			

ROPS_MB_AROCS_AGR0



Ansys Granta Design- Ekologie návrhu

The product life-cycle



© Granta Design and Mike Ashby, 2019

ANSYS GRANTA

Design for X

- assembly, disassembly, manufacturing,
- ekology, solar, wind, e-kerosene

Click
Compare with....
Copy of current
content

Set Recycle content
to 100%



Virgin PET

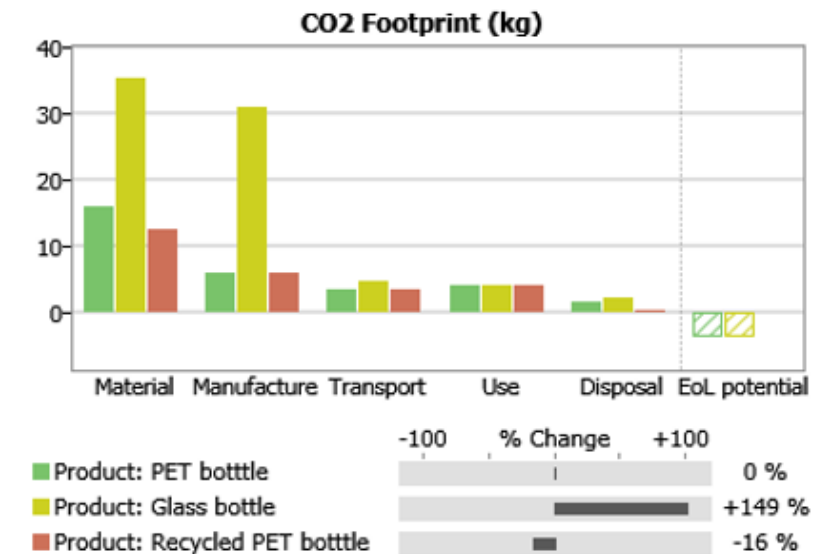
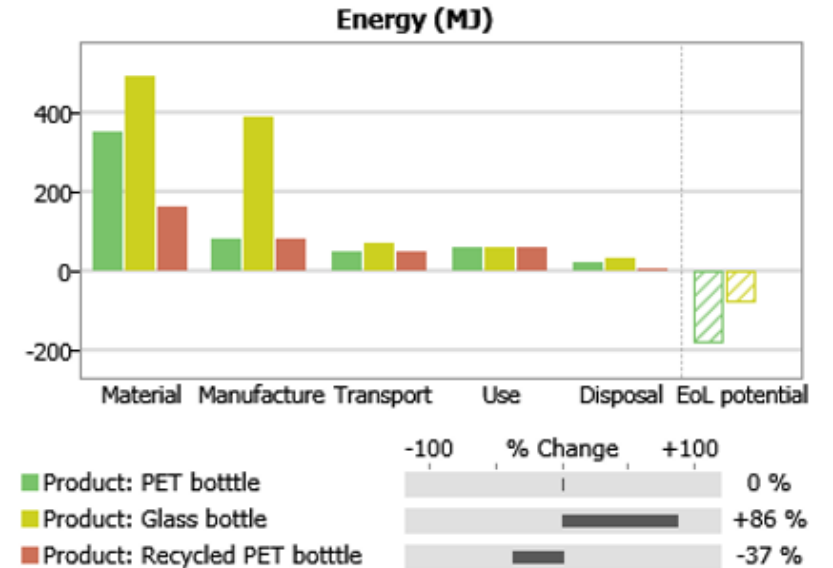


Glass

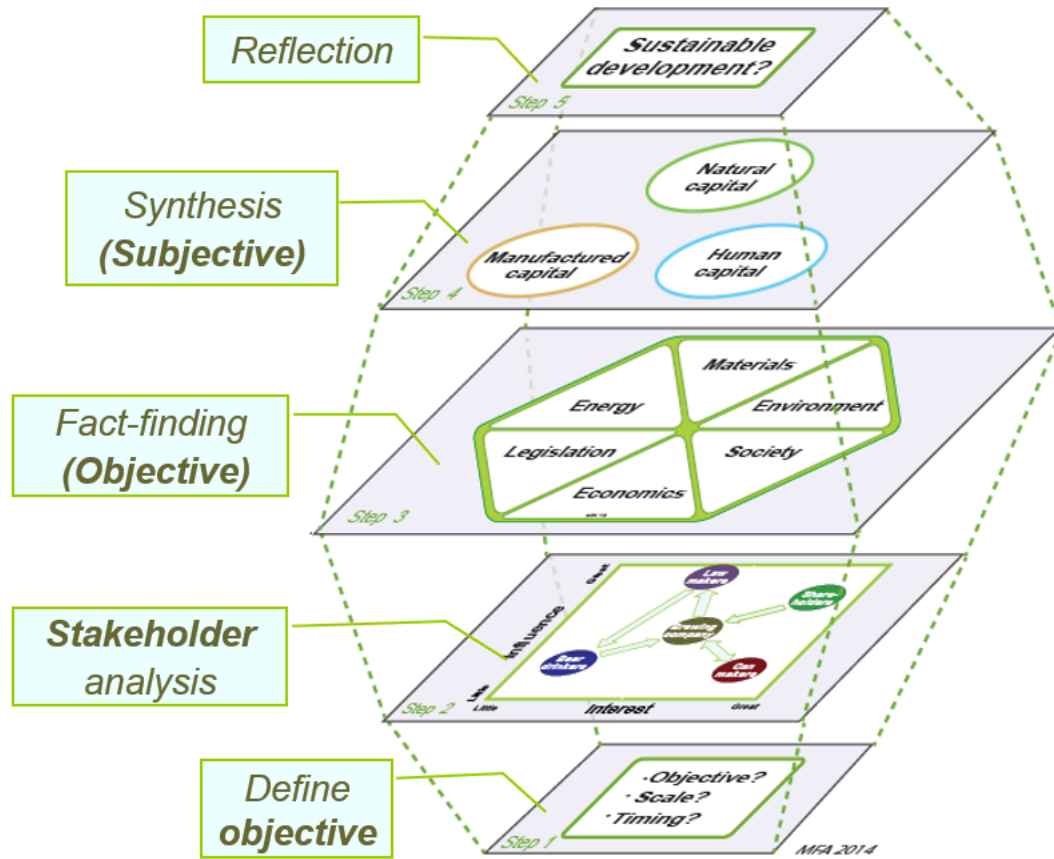


Recycled PET

ANSYS GRANTA

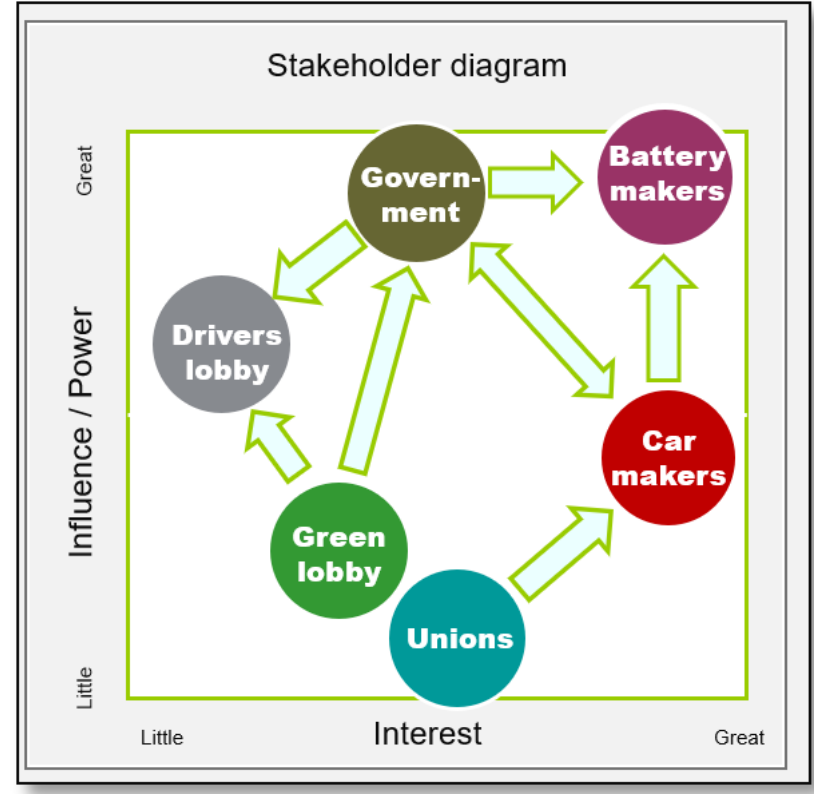
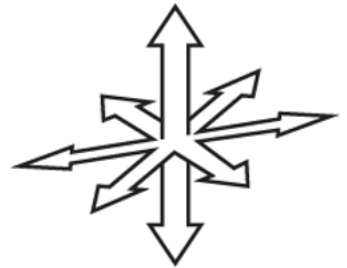


Ansys Granta Design – Udržitelný rozvoj



- 1 Objective
- 2 Stakeholders
- 3 Fact-finding
- 4 Synthesis
- 5 Reflection

Interaction between layers

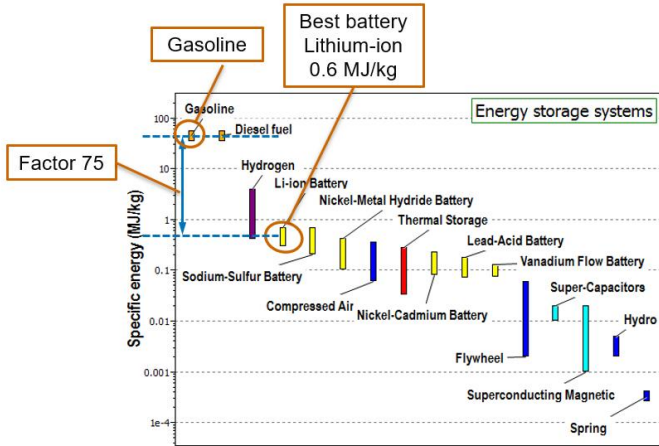


government regulations - laws
 political decisions
 lobby

Ansys Granta Design – udržitelný rozvoj - příklad

Alternative batteries?

Seek high energy density (MJ/kg)



Lithium ion



Nickel metal hydride



Nickel cadmium



Lead-acid

Lithium-ion
batteries



8 million cars per year, 7.3 kg Lithium per car
= 58,400 tonnes per year

Lithium production (2011)

Nation	Tonnes/year
Chile	13 500
Australia	12 000
China	4 000
Argentina	3 000
USA	1 500
World	32 400

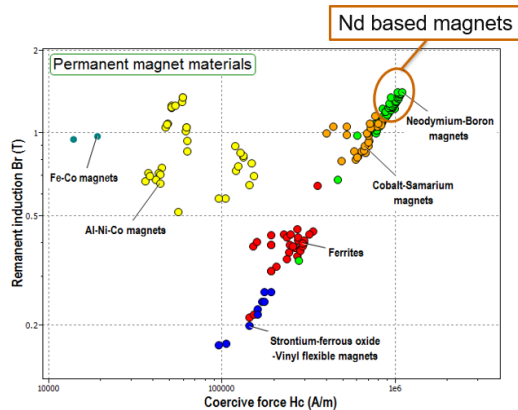
Li demand = 180% present world production

Lithium mine production (tonnes)

Rank	Country	2018	2019	2020 ^[2]	2021 ^[3]
1	Australia	58,800	42,000	40,000	55,000
2	Chile	17,000	18,000	18,000	26,000
3	China	7,100	7,500	14,000	14,000
4	Argentina	6,400	6,400	6,200	6,200
5	Brazil	300	300	1,900	1,500
6	Zimbabwe	1,600	1,600	1,200	1,200
7	Portugal	800	1,200	900	900
8	Namibia	500			
8	Bolivia				540 ^[4]

Alternative magnets?

Need high remanence and high coercive force



One common part:
Neodymium-boron
magnet rotors



8 million cars per year, 1.5 kg neodymium per car
= 12,000 tonnes per year

Rare earth production

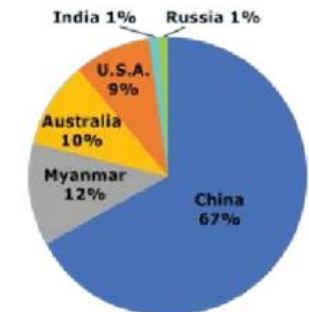
Nation	Tonnes/yr
China	100 000
USA	4 000
India	2 900
Russia	2 400
World	112 000

Critical material!

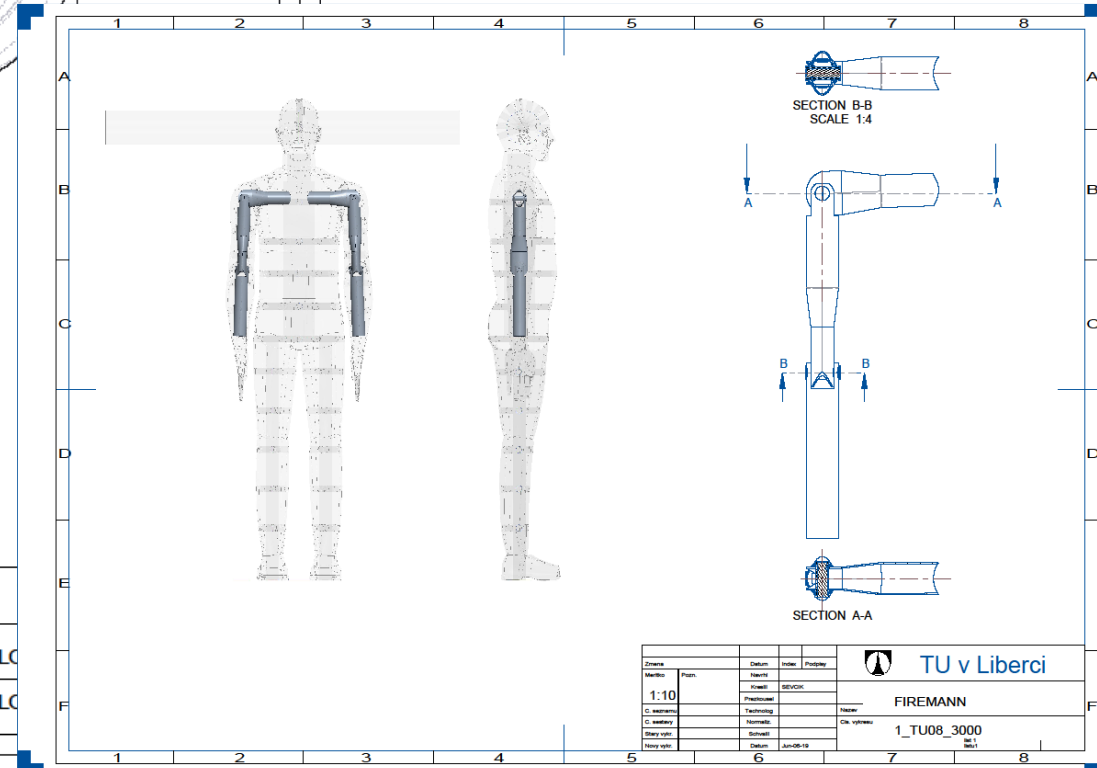
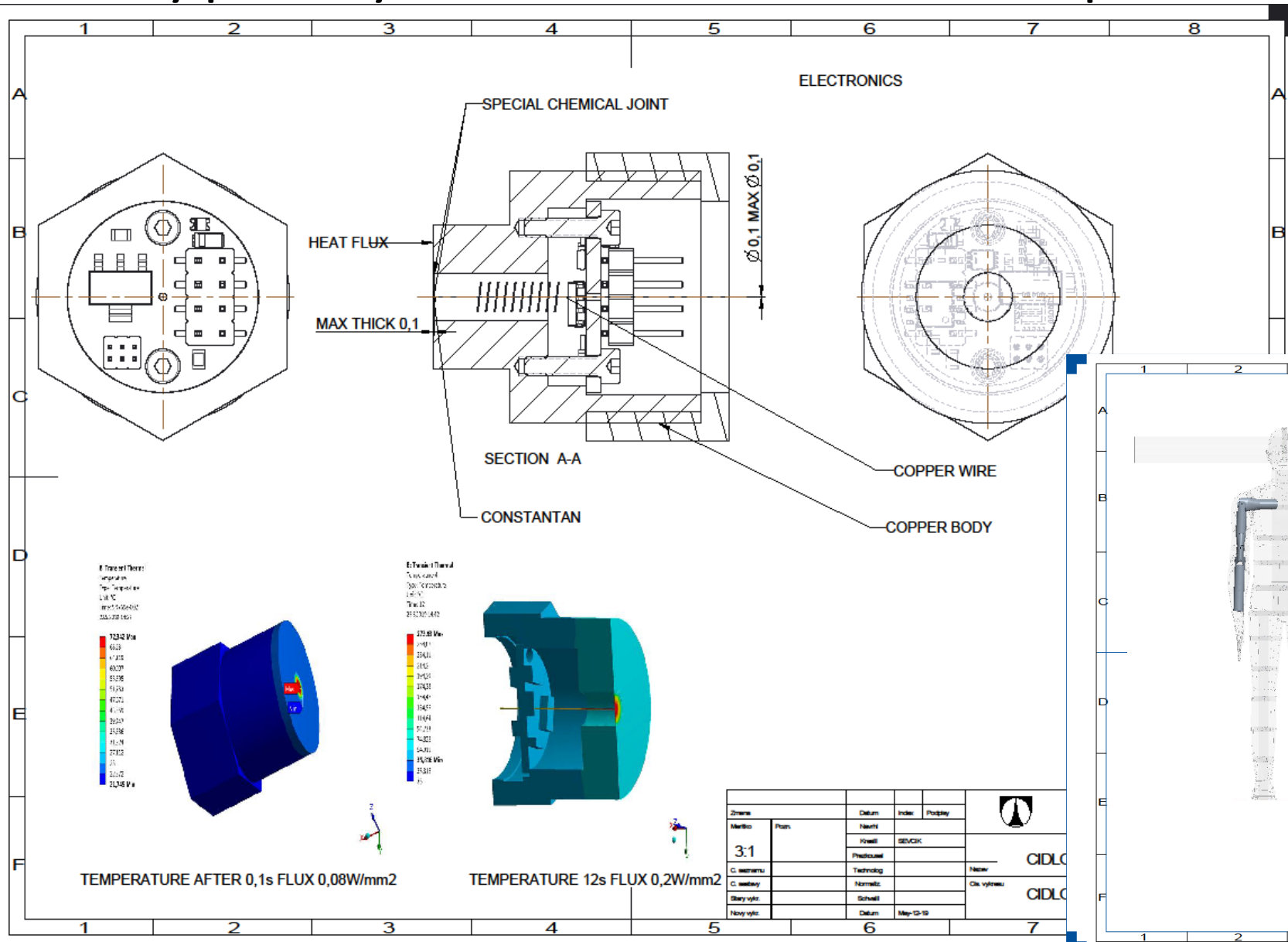
Of which 17 000 tonne is Nd

Nd demand = 70% of present world production

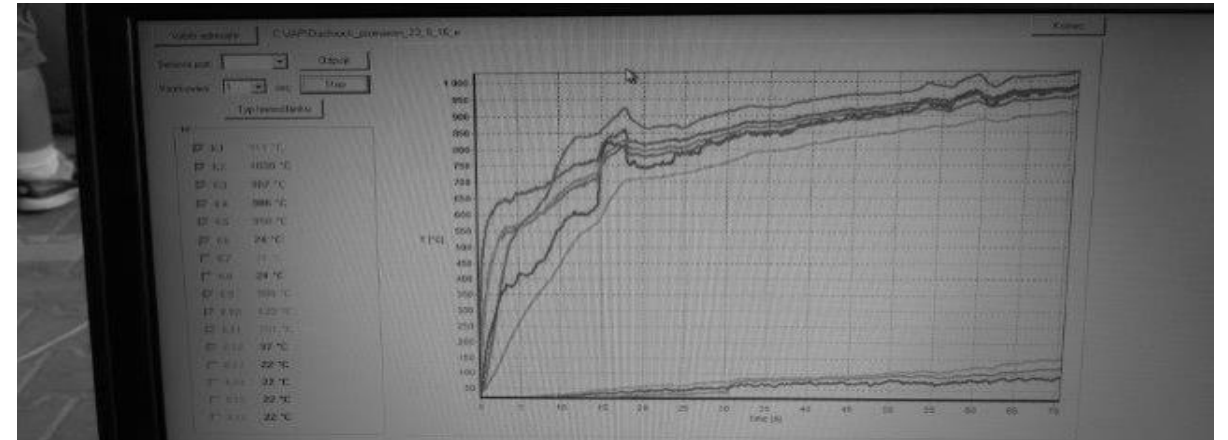
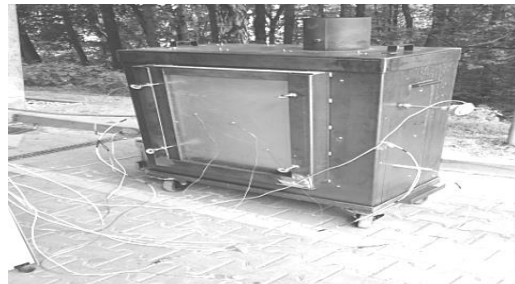
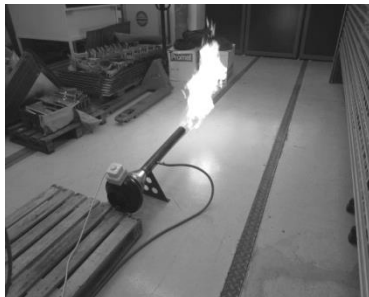
C- Production shares of neodymium, praseodymium, dysprosium and terbium oxides per country



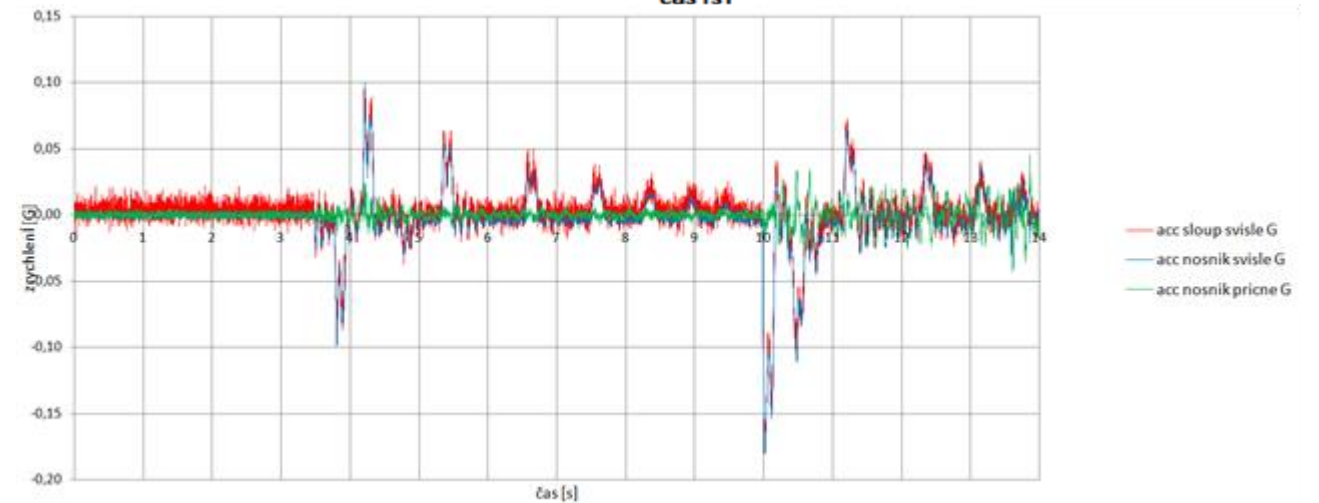
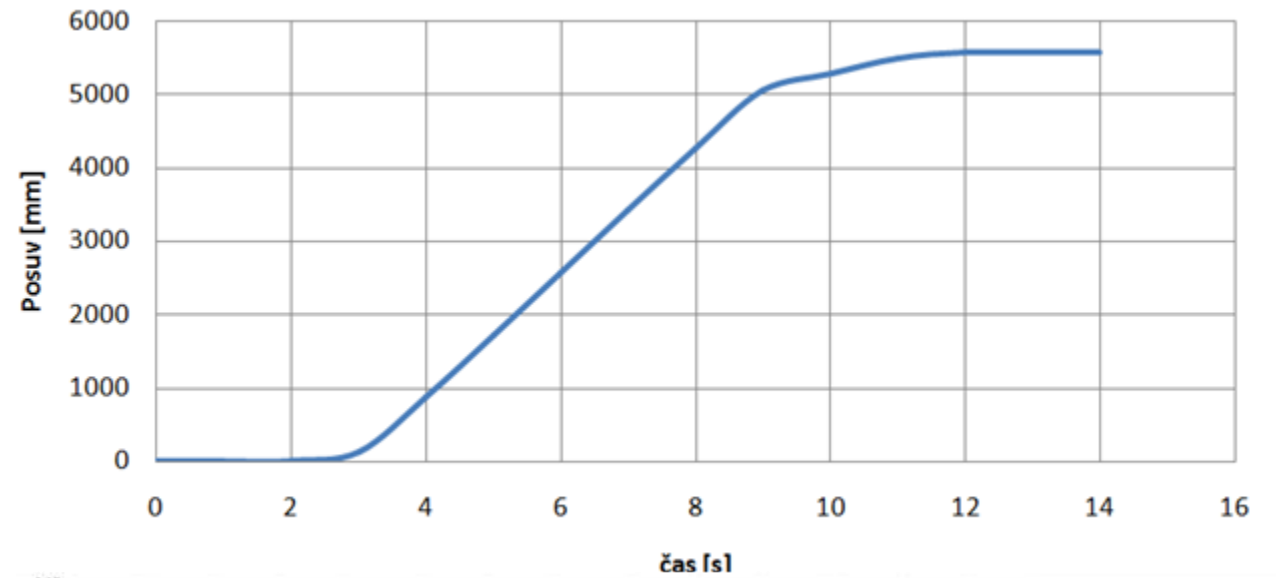
Výpočty a měření - čidla teplotního toku



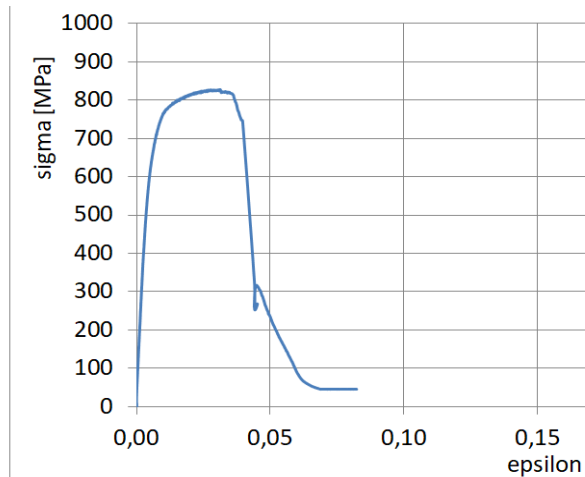
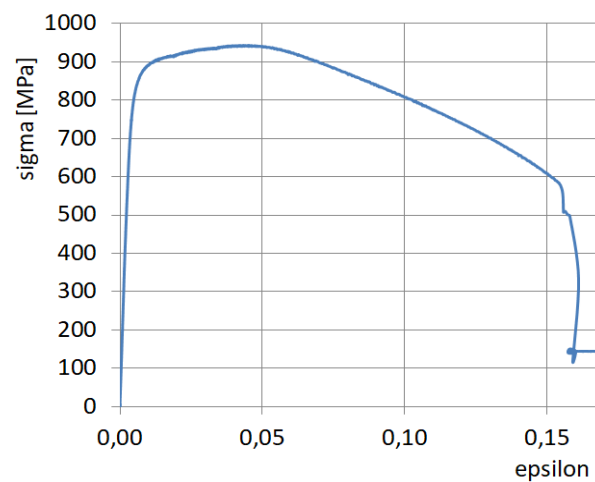
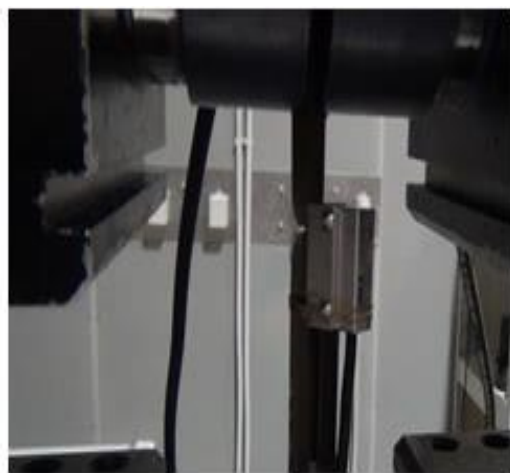
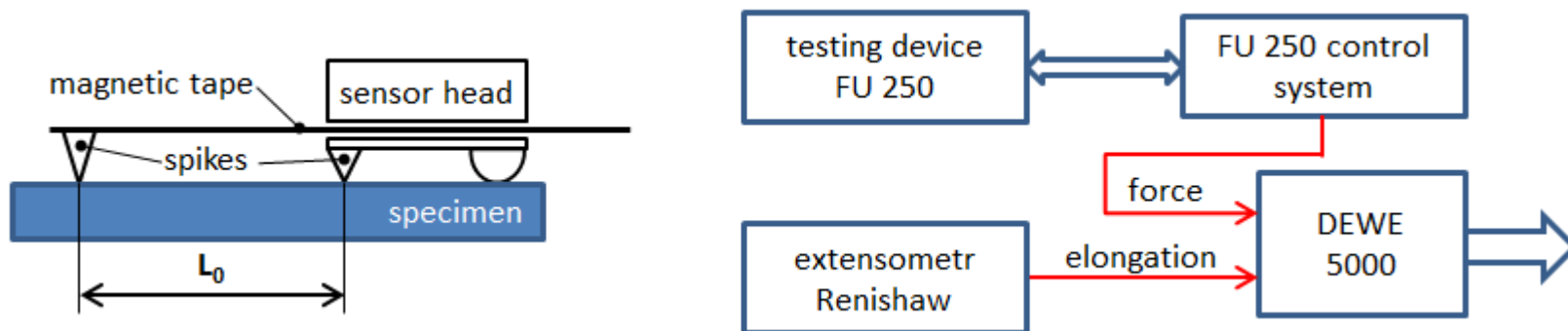
Měření teploty, termočlánek



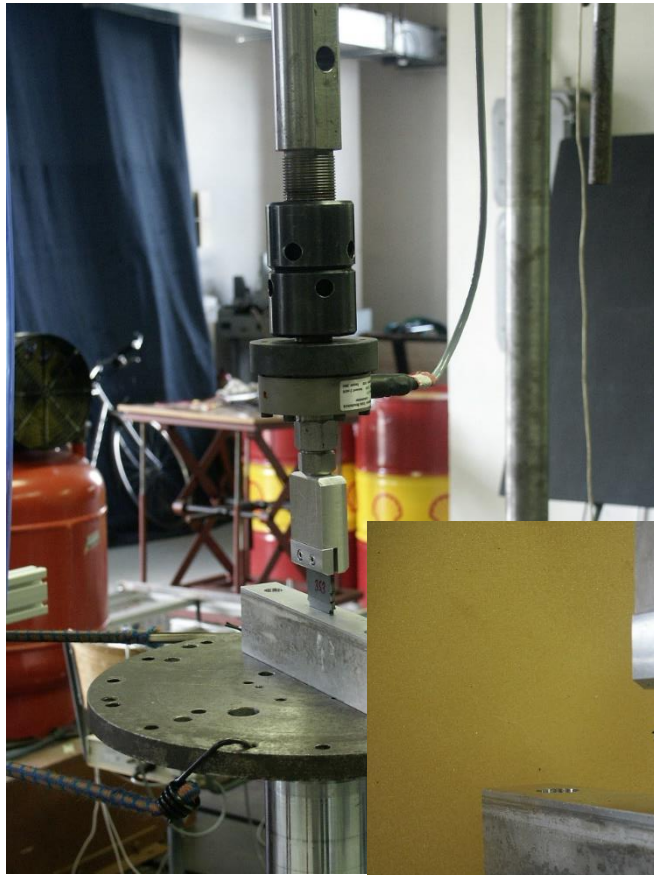
Měření kinematických veličin dráha, zrychlení



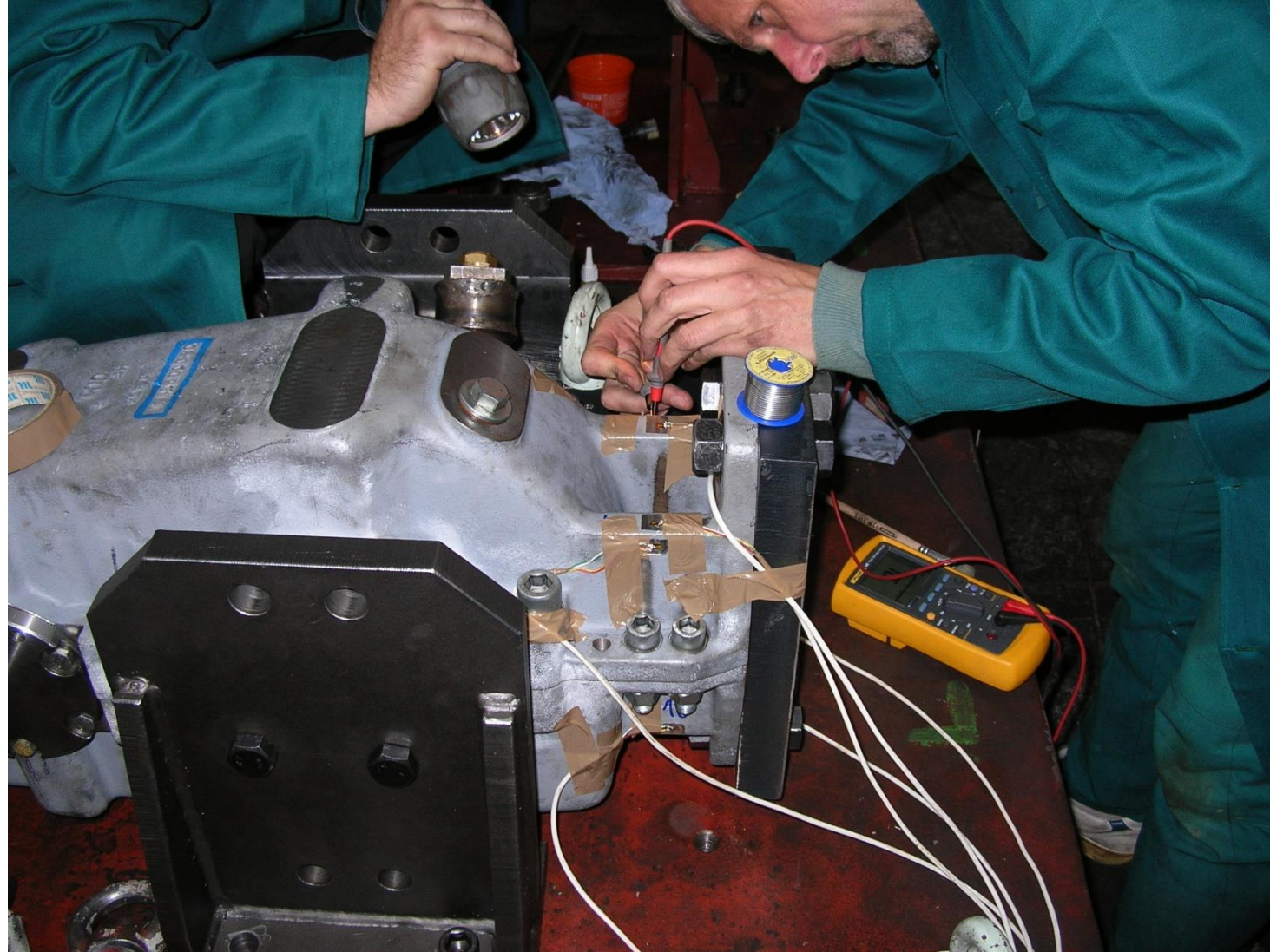
Měření sil a momentů



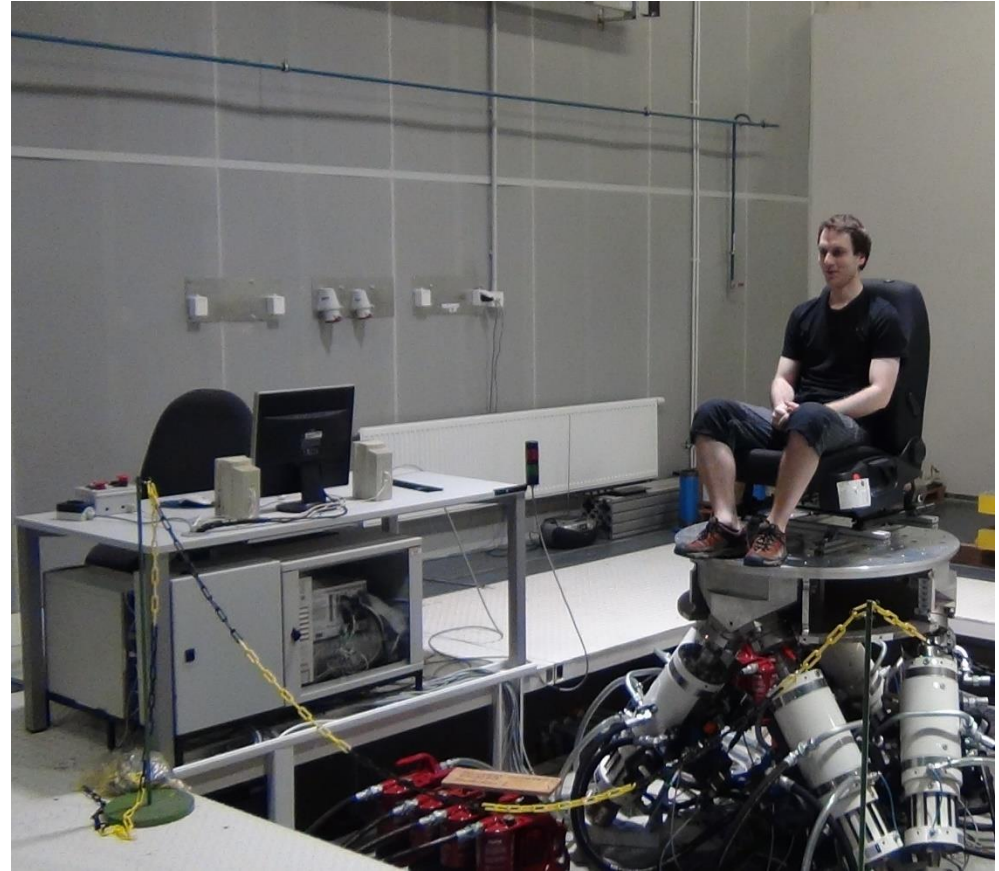
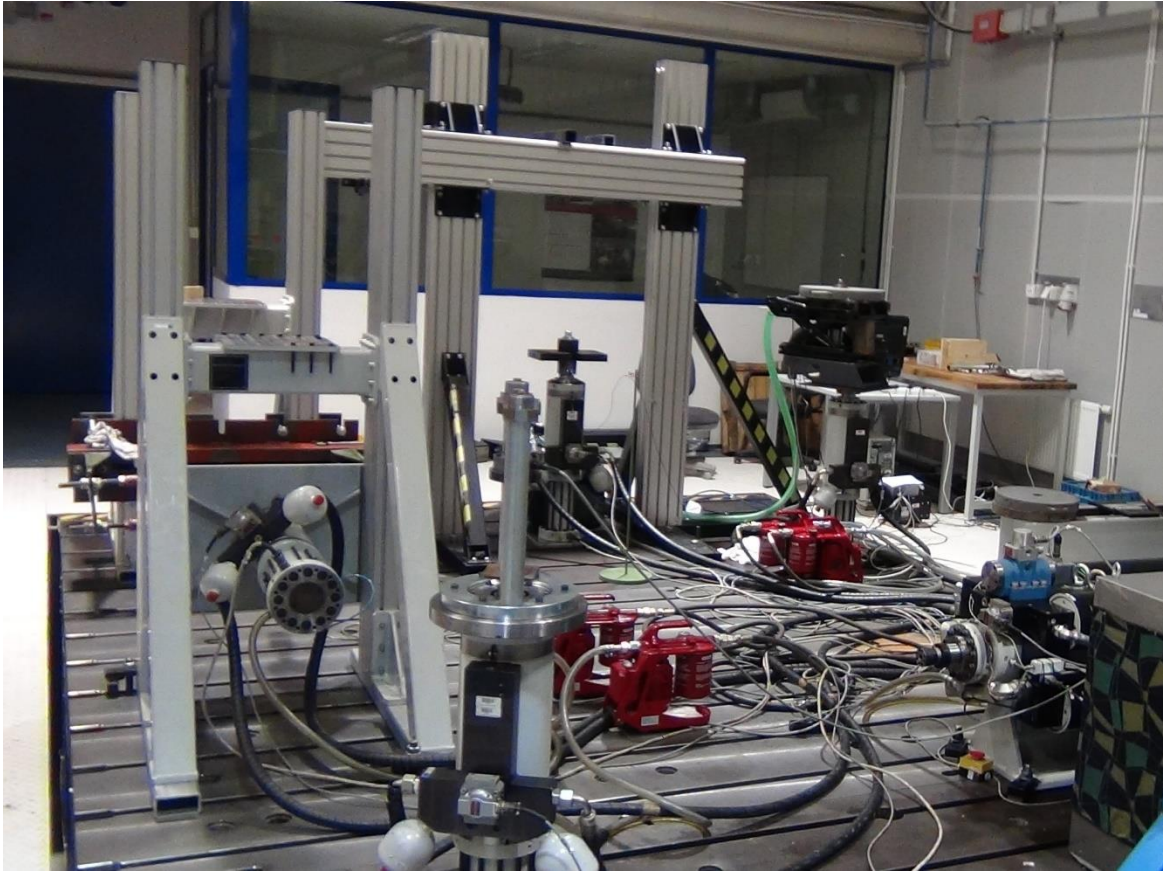
Měření pohlcení energie a únavy



Tenzometrie-měření deformací

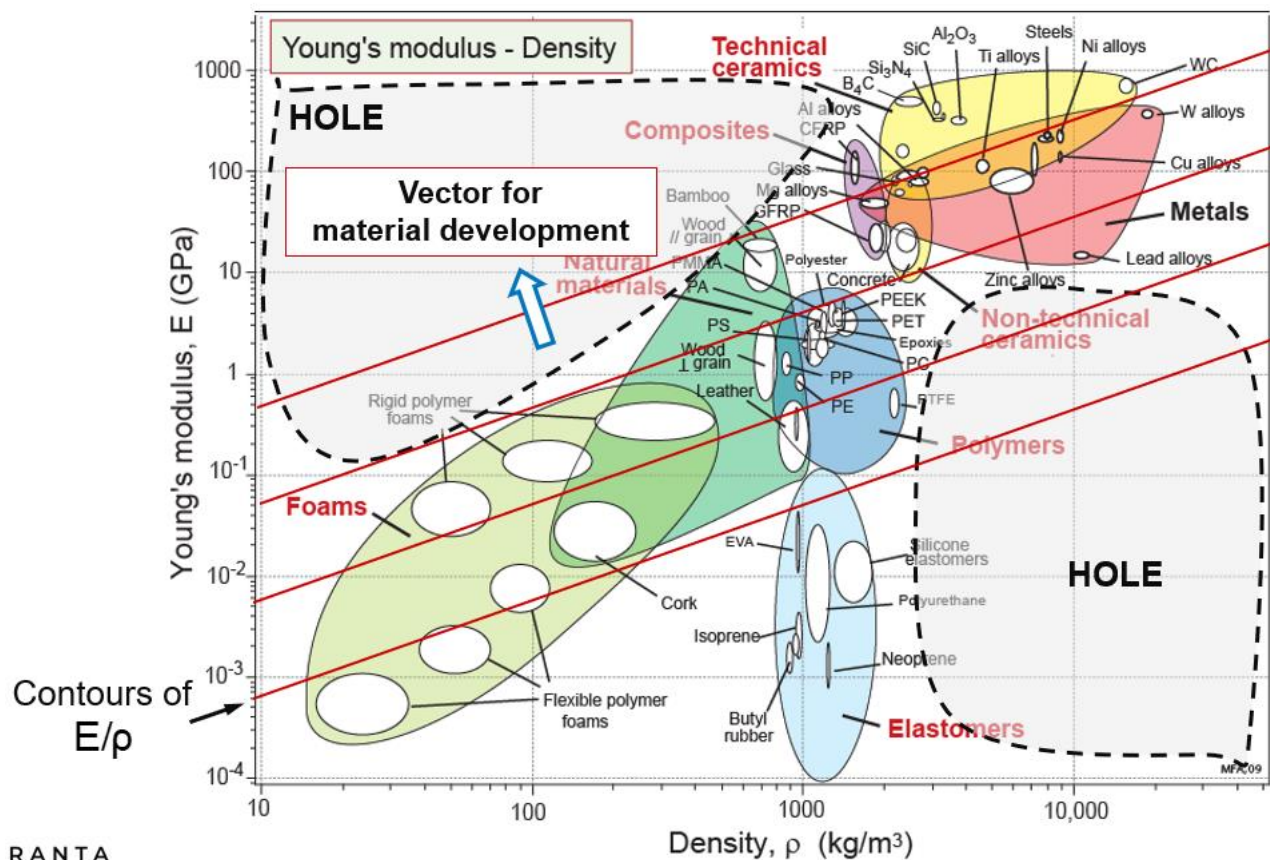


Laboratoř KST hlavní část

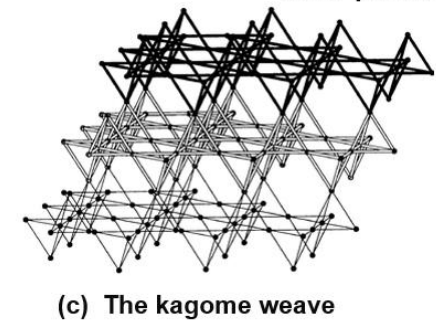
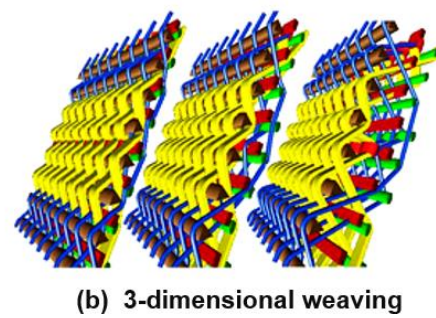
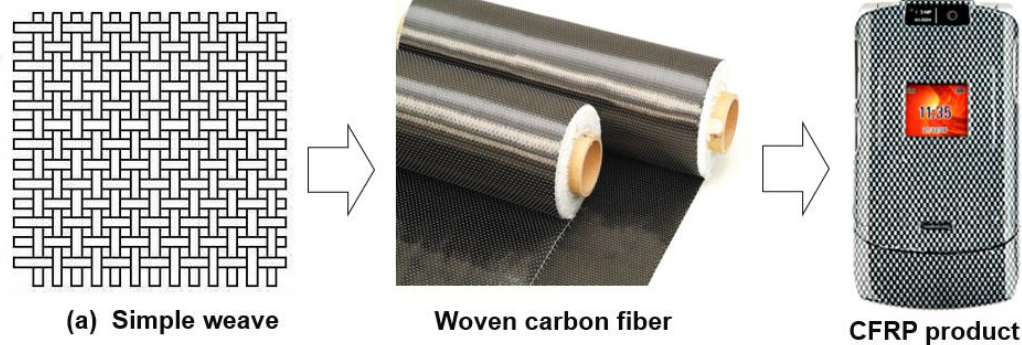


Anslys Granta Design – Materialové vlastnosti- struktury

Modulus and Density

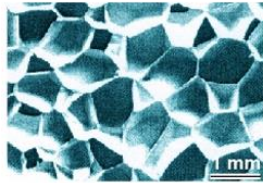
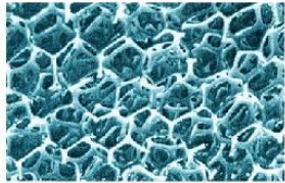


Combining textile technology, mechanics and material

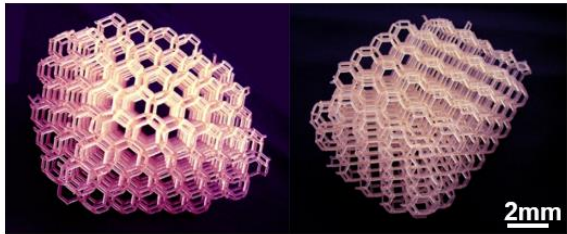


NEW AREAS OF COMPONENT DESIGN

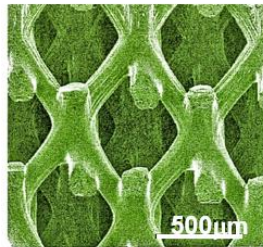
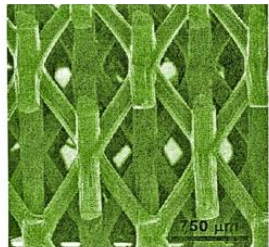
Ansys Granta Design – pěny a mikrostruktury



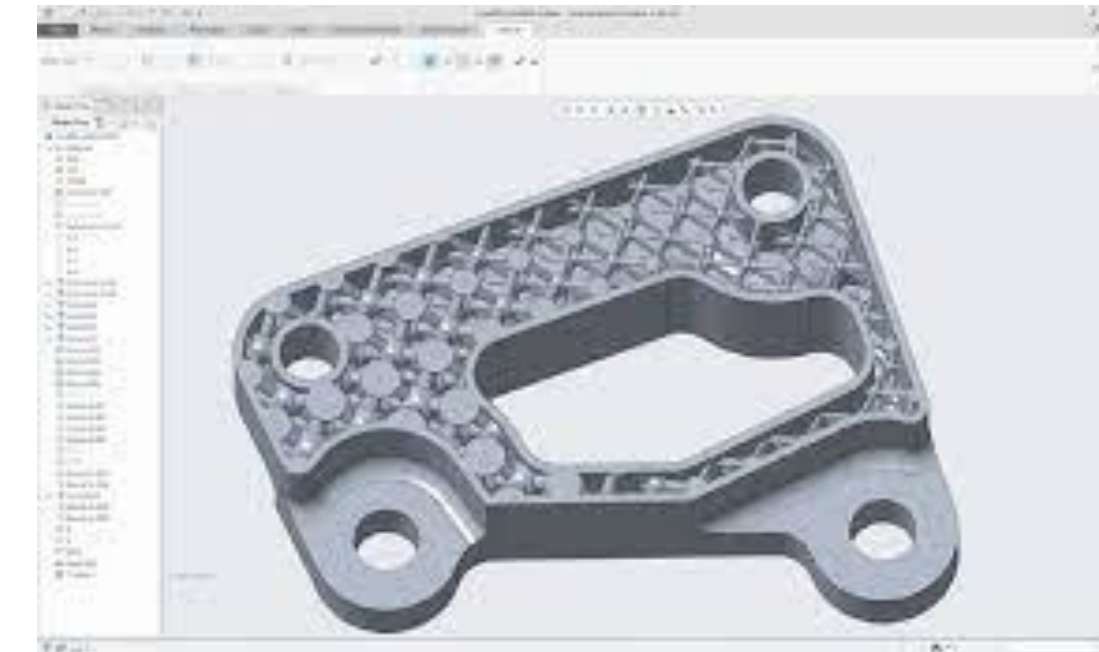
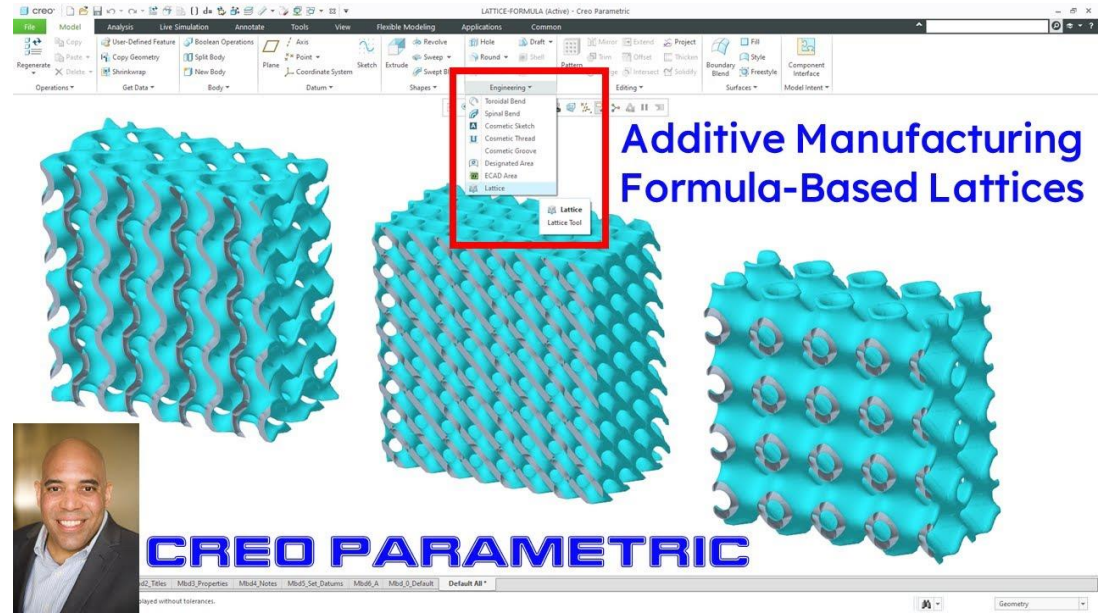
Polymer foams



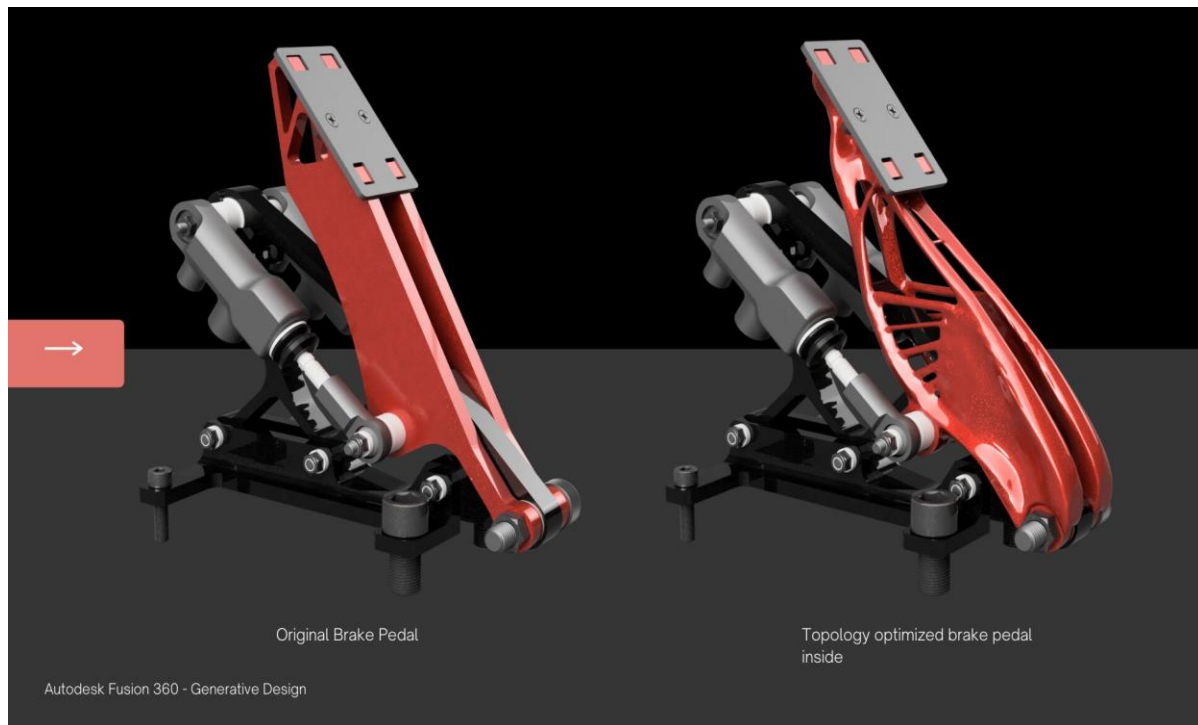
Bending-dominated
micro-lattices



Stretch-dominated
micro-lattices



Topologická optimalizace

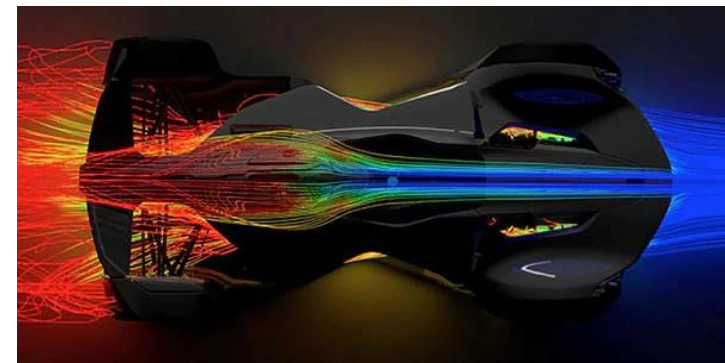
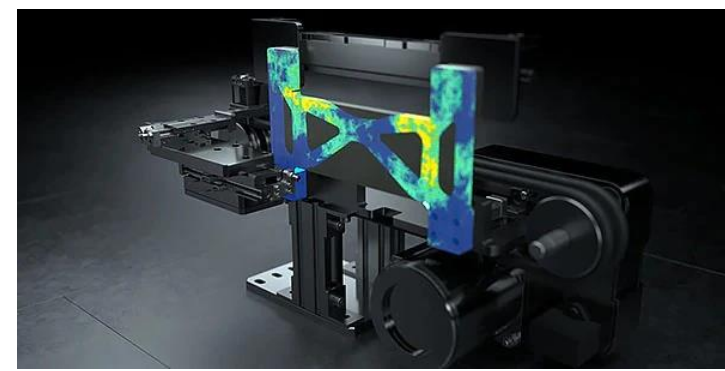
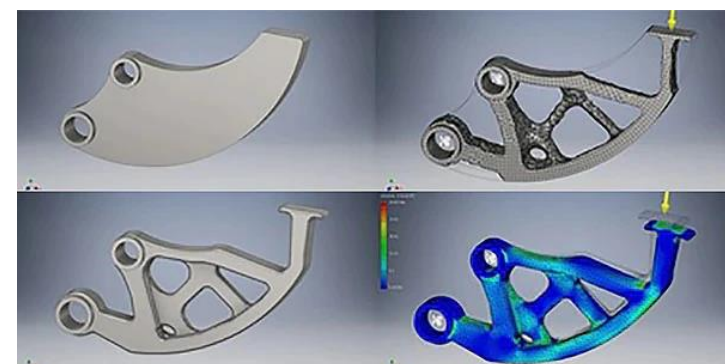
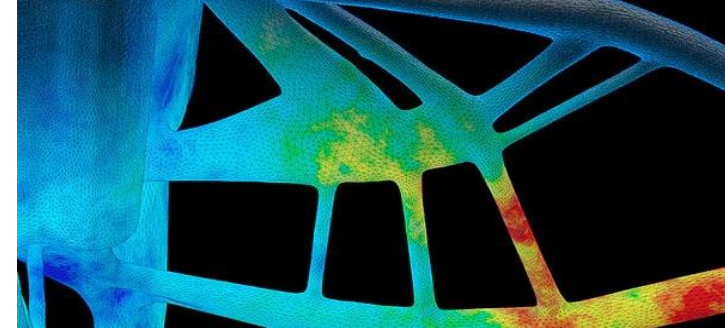


Snížení hmotnosti

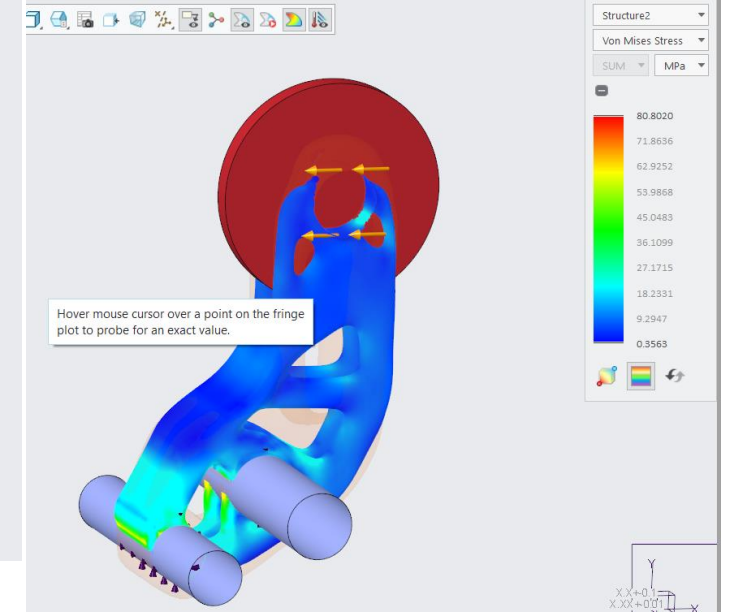
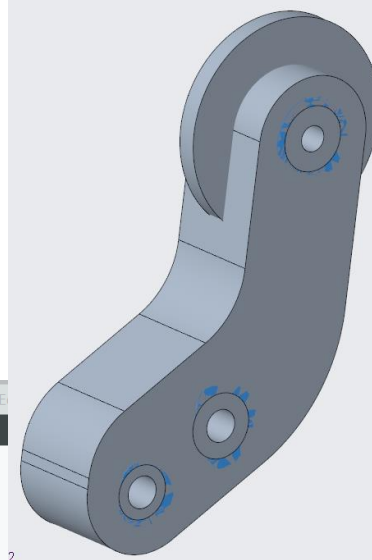
Tvarová optimalizace

Konstrukční optimalizace

Multi fyzikální optimalizace



Topologická optimalizace školní případ



creo GENERATIV DESIGN (Active) X:\civcen\pt-cad CATI CATI\topologická optimalizace\generativ_design.prt.15 - Creo Parametric Educational E

File Generative Design Model Analysis Annotate Tools View Flexible Modeling Applications ANSYS 2020 R2

Starting Geometry Preserved Geometry Excluded Geometry Add Load Case Constraints Loads Contact Design Spaces Physics Design Criteria Generate Validate Options Close

Model Tree Folder Browser Favorites

Generative Tree

- Structure_Study_1
 - Design Spaces
 - Starting Geometry
 - Preserved Geometry
 - Excluded Geometry
 - Structure2
 - Constraints
 - Loads
 - DesignCriteria2
 - DesignCriteria3
 - DesignCriteria4
 - DesignCriteria5

Model Tree

- GENERATIV DESIGN.PRT
 - Materials
 - Bodies (5)
 - Annotations
 - RIGHT
 - TOP
 - FRONT
 - PRT_CSYS_DEF
 - Extrude 1
 - Round 1
 - Round 2
 - Round 3
 - Extrude 2

Optimization finished

- DesignCriteria6
- STAINLESS_STEEL_AUSTENITIC
- 1.925 kg
- 3.890 mm (10649)

Design Criteria

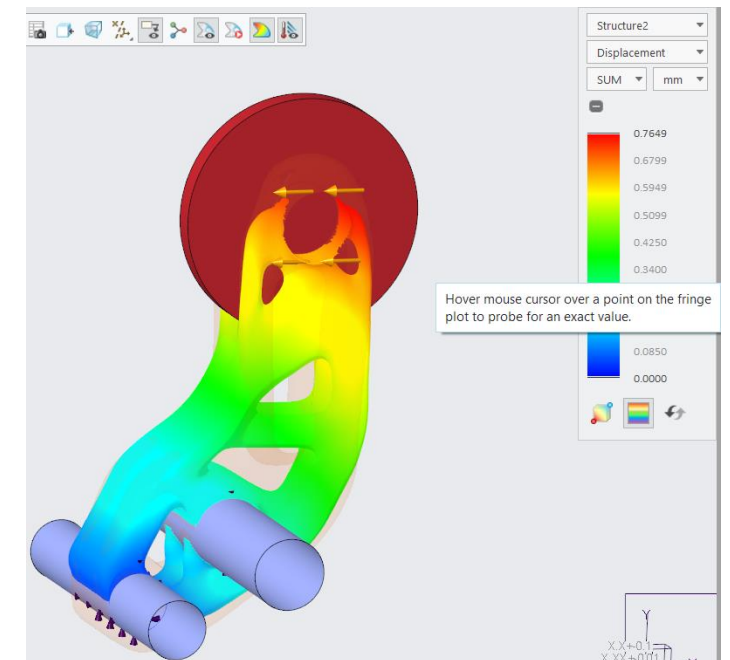
Design Goals

Limit Volume 50 %

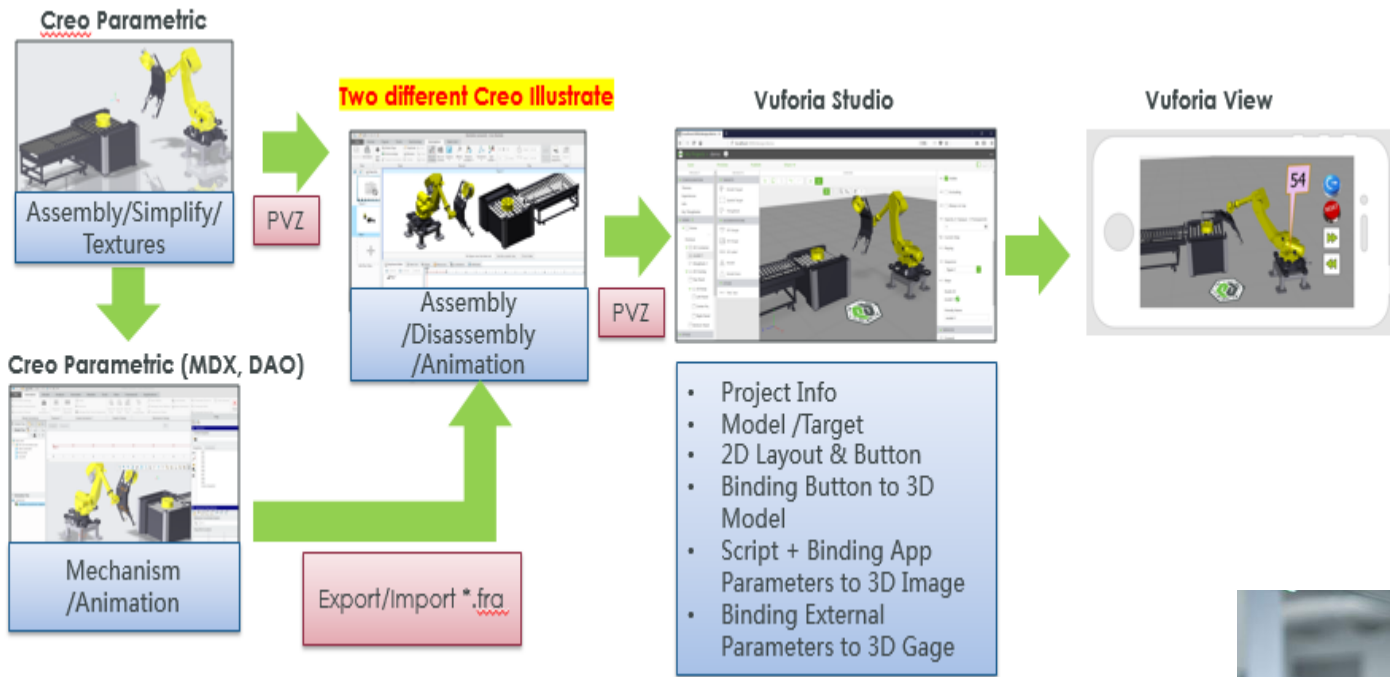
Design Constraints

- Manufacturing Constraints
 - Build Direction
 - Reduces the number of supports for additive manufacturing
 - Parting Line
 - Creates an angle between the pull direction and the resulting drafted surfaces
 - Linear Extrude
 - Creates a linear pull direction extrude
- Geometric Constraints
 - Planar Symmetry
 - Builds and mirrors individual halves of geometry
 - Material Spreading
 - Controls the spreading of the material

ASME Y14.5-2018
ASME Y14.41-2012
ALL DIMENSIONS SPECIFIED IN MILLIMETERS



Rozšířená realita a CAD



Okruhy otázek

- Jaké jsou rozdíly v konstrukci dílů sériové a kusové výroby?
- Co musí konstruktér definovat, aby proběhl výpočet metodou konečných prvků?
- Jaké jsou moderní směry v konstruování?