Virtual forging course

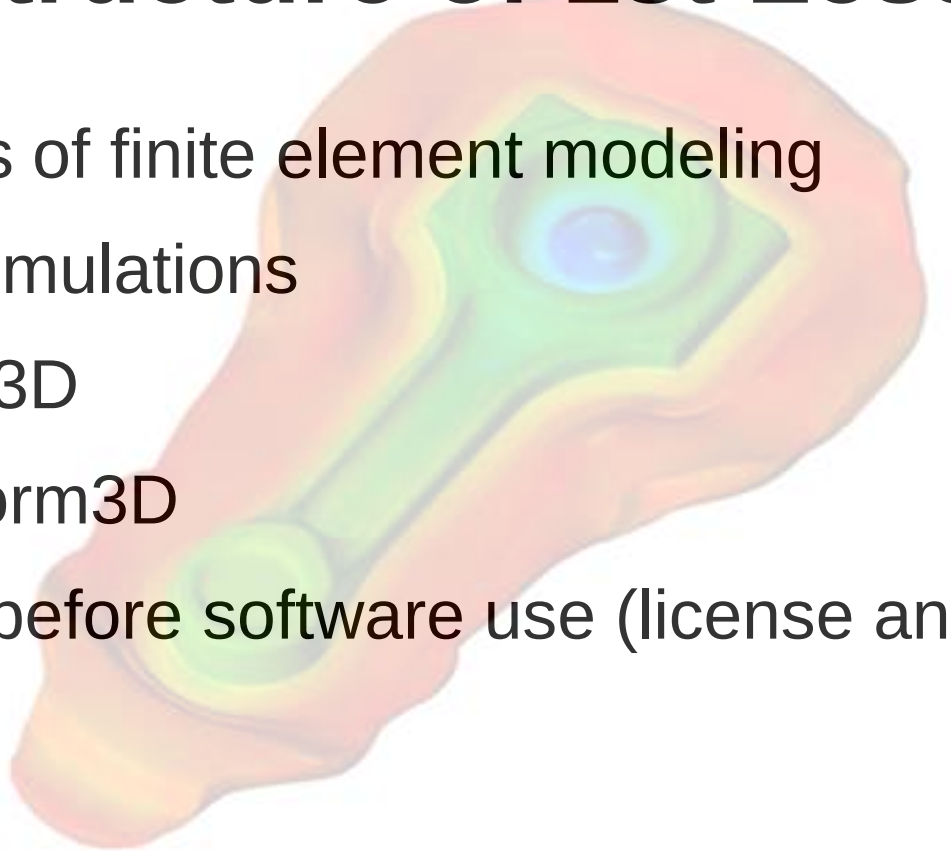
1st Lesson

First steps of a long journey

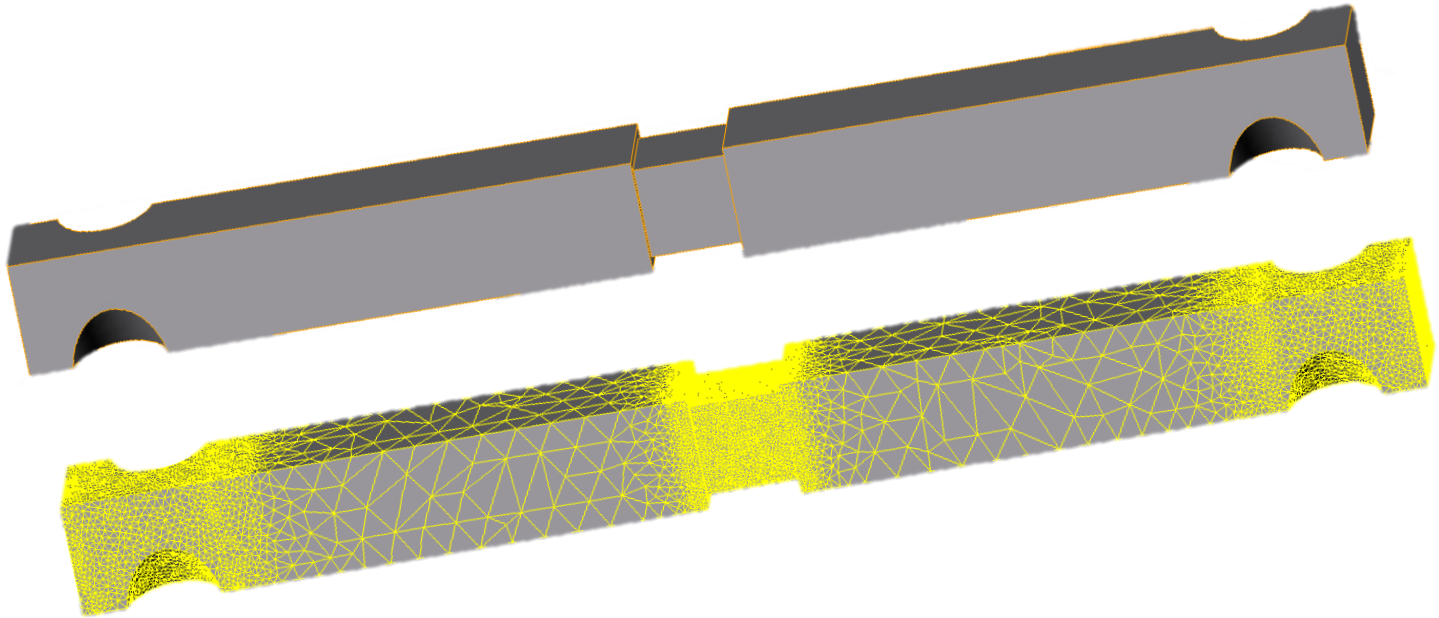
Renkó József
renko.jozsef@edu.bme.hu

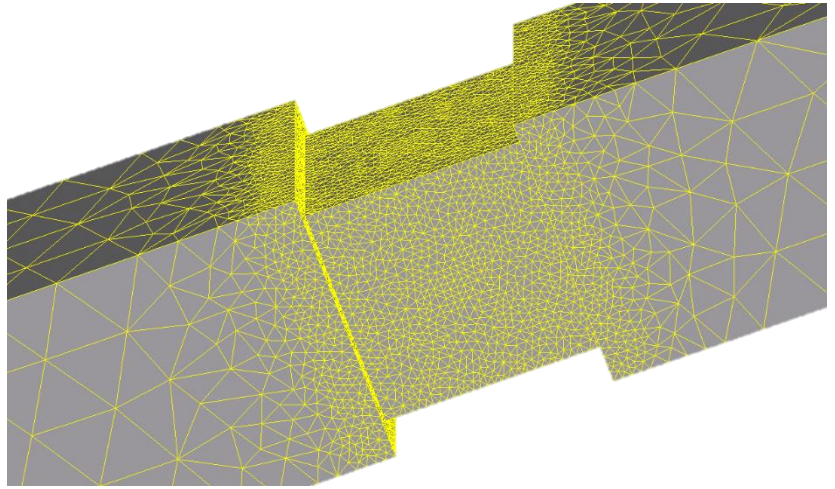
Structure of 1st Lesson

- Fundamentals of finite element modeling
- Structure of simulations
- About QForm3D
- Basics of QForm3D
- Preparations before software use (license and install check)
- Solving tasks



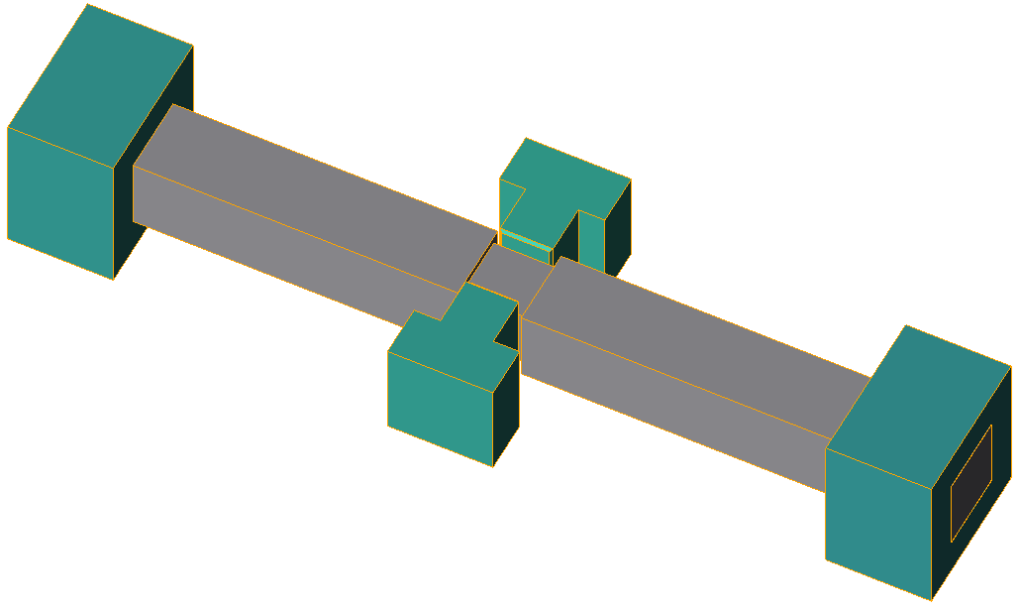
Basics of finite element modeling

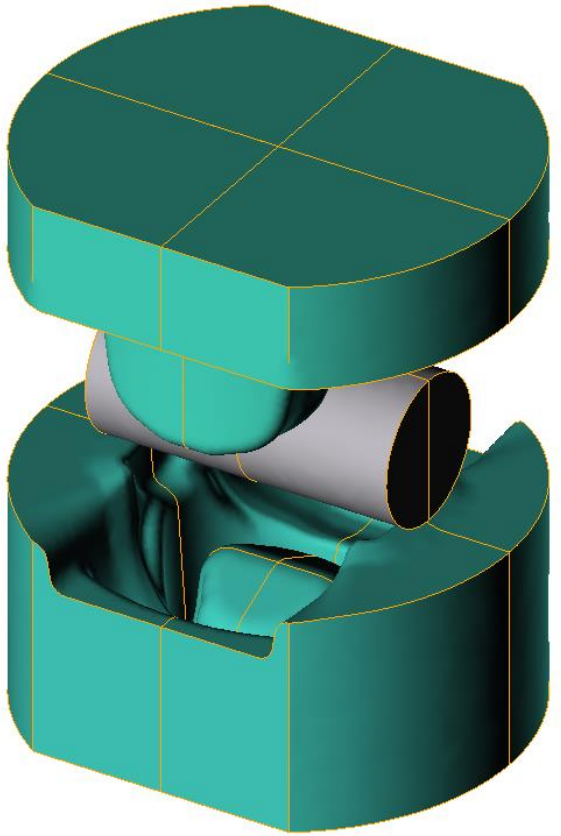




Simulation of a model made of simple elements (triangles, squares, tetrahedrons, cubes) significantly smaller than the size of the original body

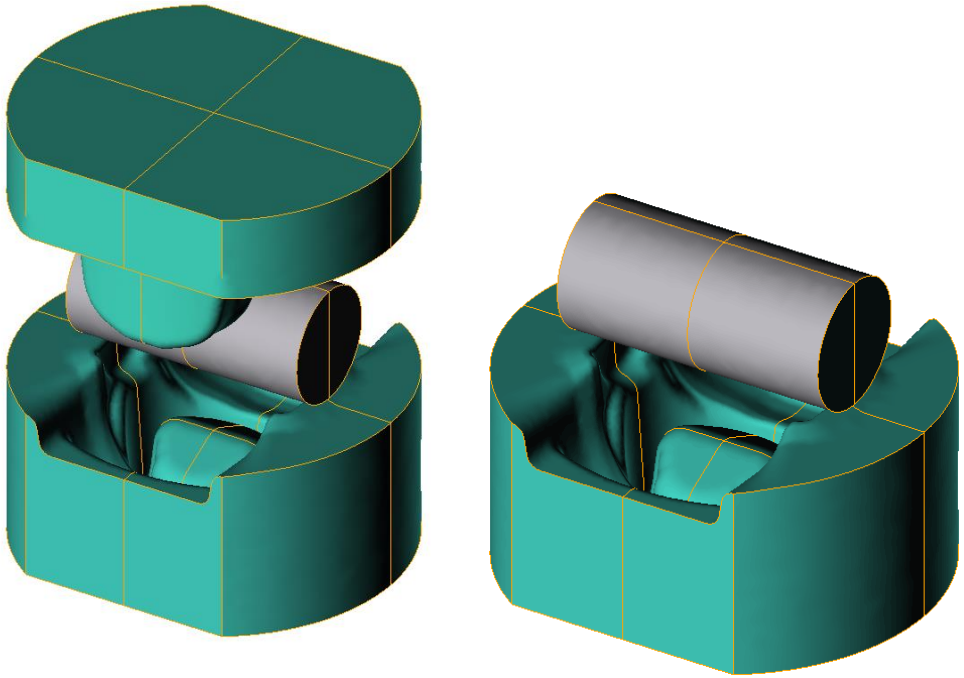
Basics of finite element modeling





The finite element method can be applied
from the simplest to the most complex tasks

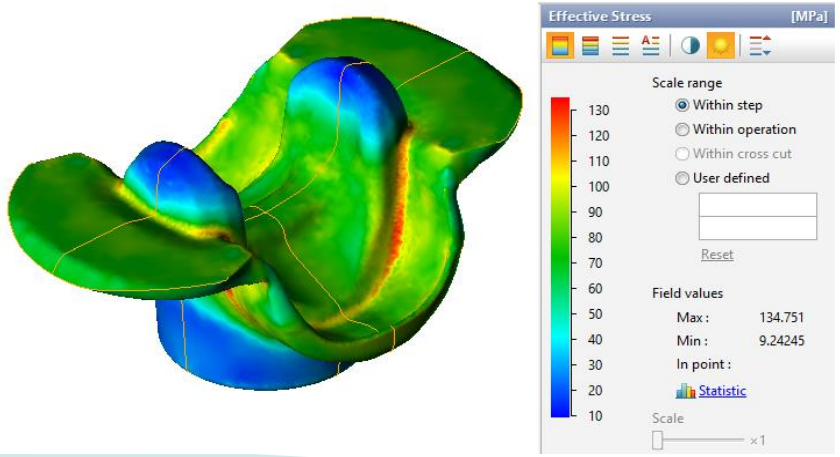
Advantages of finite element simulations

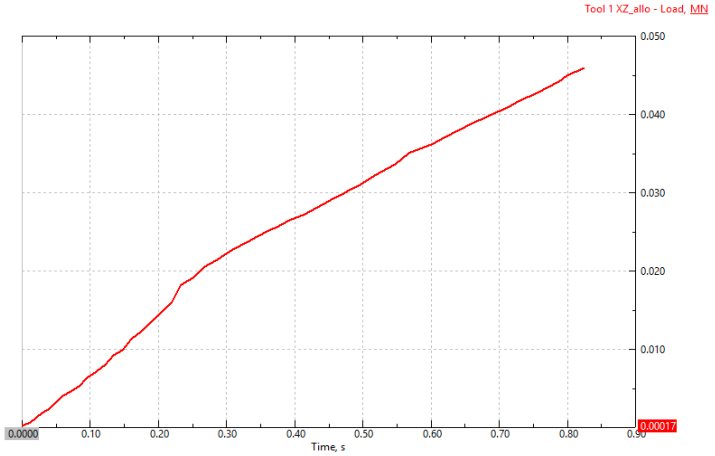


- Any geometry can be examined
- We can inspect the workpiece and tools at any time during the process
- Not only the final state can be examined, but also the flow of the process
- A more comprehensive picture of the forming process can be examined
- Cheap
- Can minimize tool design failures

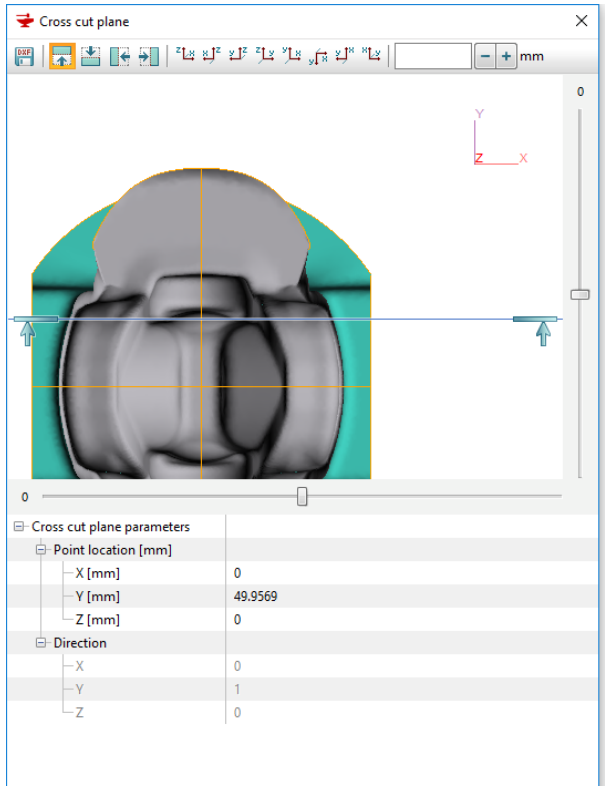
Advantages of finite element simulations

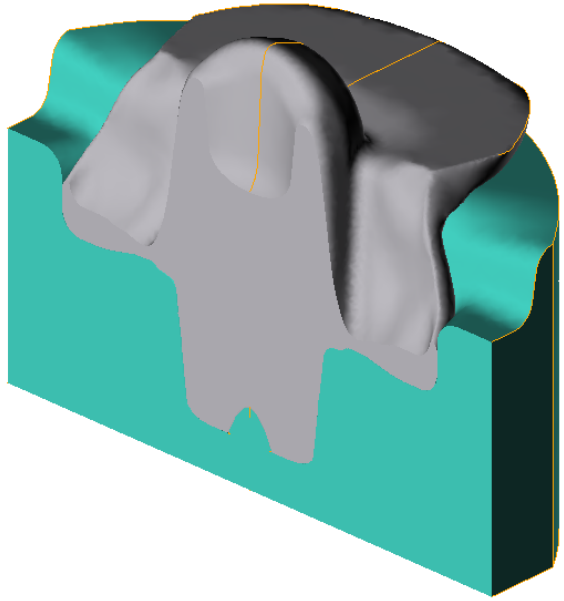
- You can find errors that could not be detected using basic calculations
- Force-displacement curves can also be determined
- Residual stresses can be determined
- Temperature and deformation properties are simultaneously testers





Advantages of finite element simulations





- We can “look” inside the material at any time
- Make spectacular presentations

Disadvantages of finite element simulations

- The required software must be obtained (costs money)
- In most cases, prior knowledge of a lot of variables is required
  → There are some variables we can only know from preliminary measurements
  → We approximate values that are not or difficult to measure
- Most simulation softwares cannot handle special characters, accents and spaces, so the use of them should be avoided !!!

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- Depending on the software, the fractions may vary

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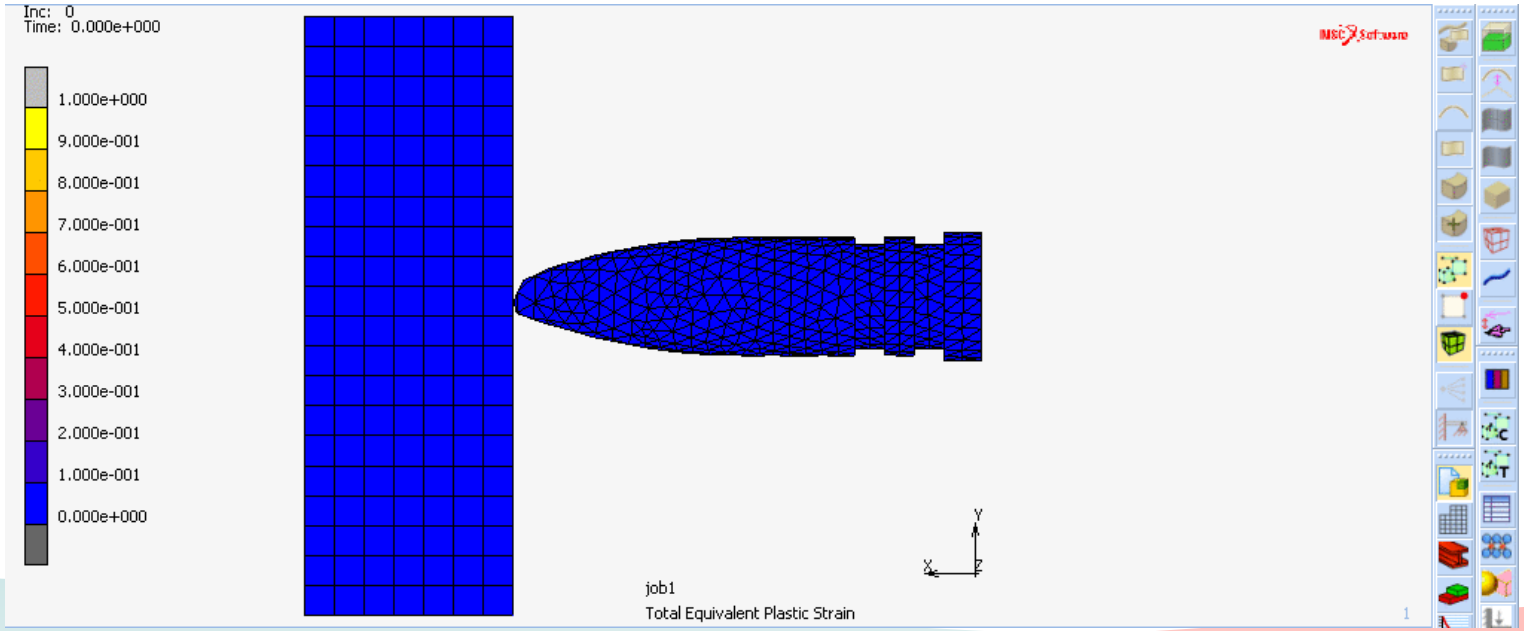
Disadvantages of finite element simulations

- In many cases, the calculation models are not known to the user
- Specifying units of measure is not always clear
- Results are usually the approximation of reality
- The results obtained should always be treated critically!!!

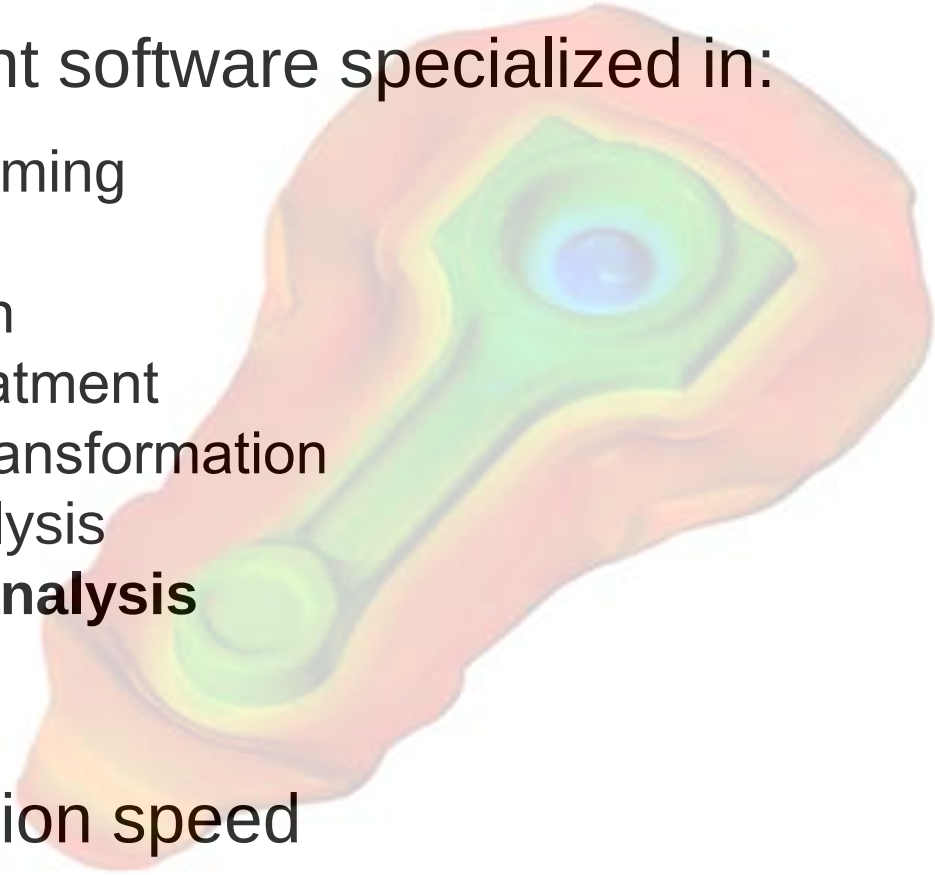


Structure of simulations

1. Create geometry and save to STL
2. Read geometry and then placing it in virtual space
3. Meshing
4. Adding material properties of bodies
5. Specifying the machine type
6. Add friction
7. Specify tool and workpiece temperatures
8. Set contacts, initial conditions, other important factors
9. Set tool movements and select calculation step types
10. Check
11. Running
12. Evaluation

About QForm

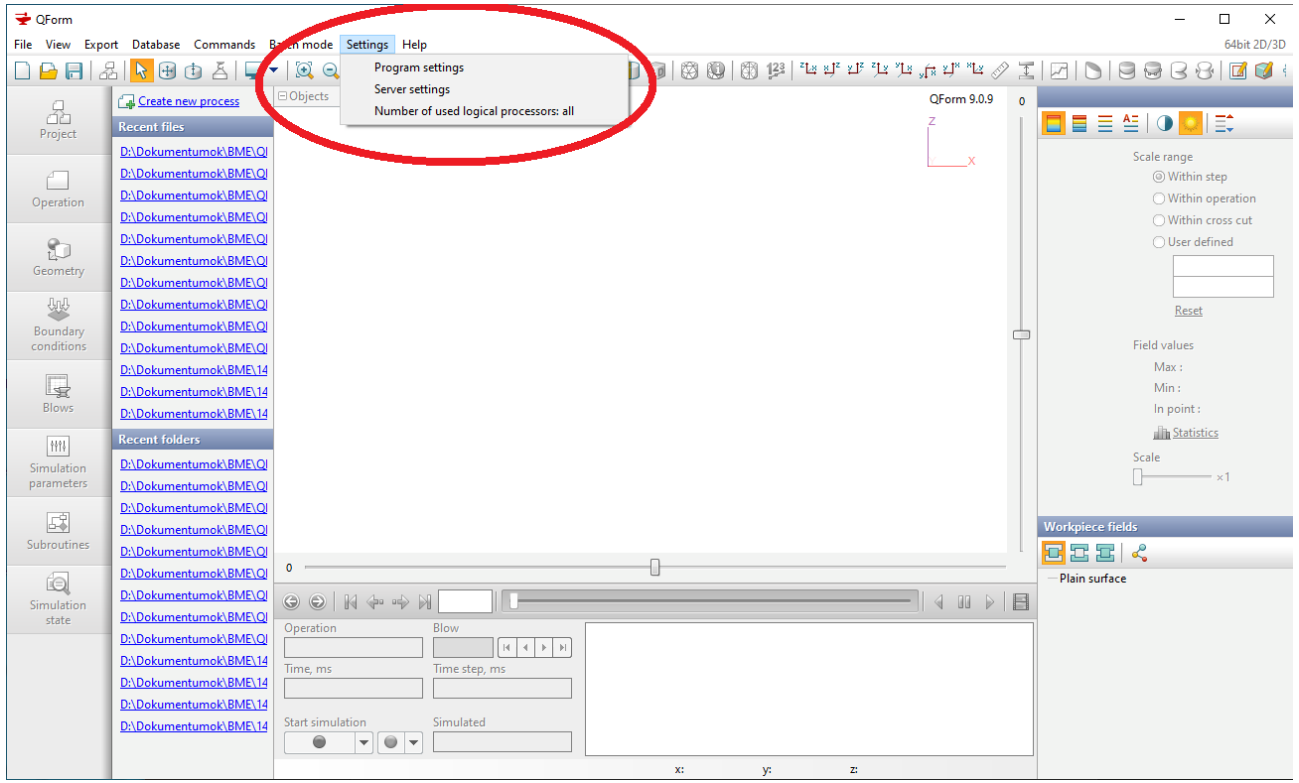
- Finite element software specialized in:
  - → Metal forming
  - → Rolling
  - → Extrusion
  - → Heat treatment
  - → Phase transformation
  - → Tool analysis
  - → **Defect analysis**
- Easy to use
- High calculation speed
- User friendly solutions

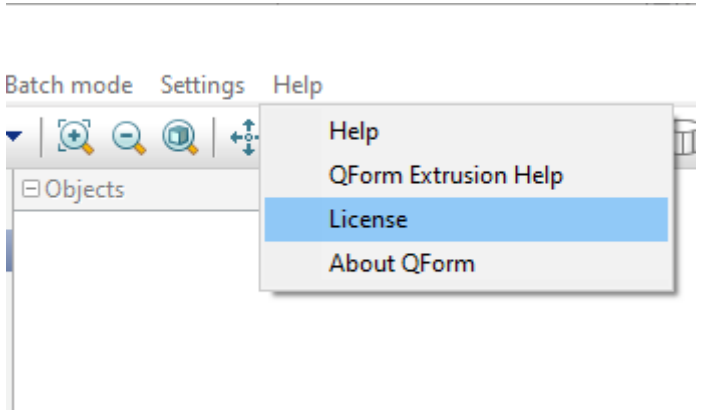


Structure of simulations in QForm

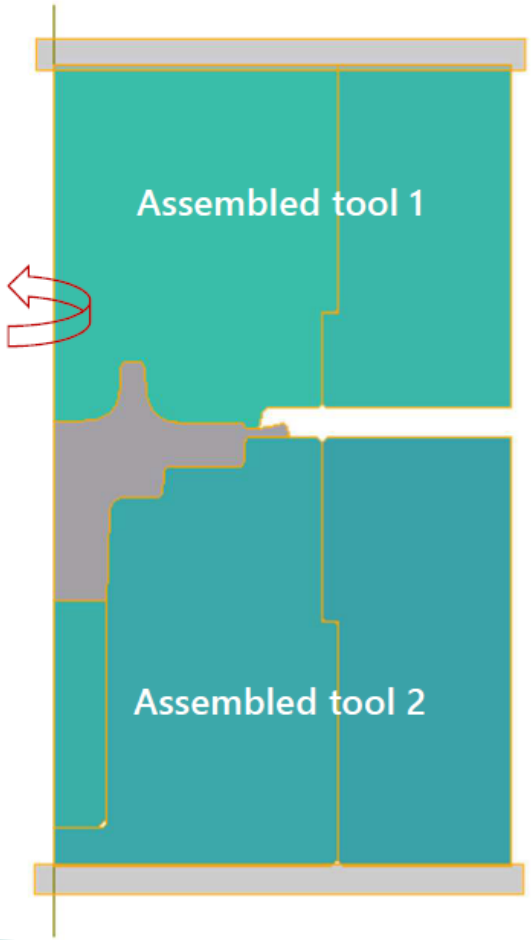
1. *Create a project and choose the simulation technique
2. Create geometry and save it ~~to STL~~
   (**qshape**, qmesh3d, **stp, step**, **dxf**, ntl, pda, unv, **stl**, nas, **nastran,** qmesh2d)
3. Read geometry and then placing it in virtual space
4. ~~Meshing~~
5. Adding material properties of bodies
6. Specifying the machine type
7. Add friction
8. Specify tool and workpiece temperatures
9. Set contacts, initial conditions, other important factors → **optional**!!!
10. Set tool movements and select calculation step types
11. Check
12. Running
13. Evaluation

Install and licence



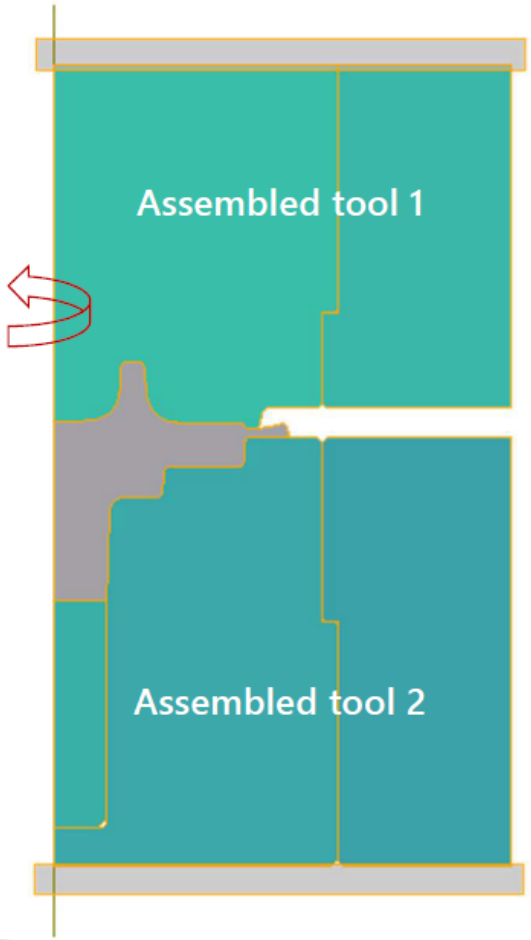


Task #1



Geometry	
File	Task#1.dxf
Workpiece	
Material	C22 (DIN)
Initial temperature	1200 °C
Cooling while in tools	2 sec
Cooling in air	5 sec
Tools	
Material	H13 (AISI)
Initial temperature	200 °C
Lubricant	Graphite + water
Machine	
Mechanic press	6,3 MN
Stop condition	
Distance of tools	3 mm

Task #1

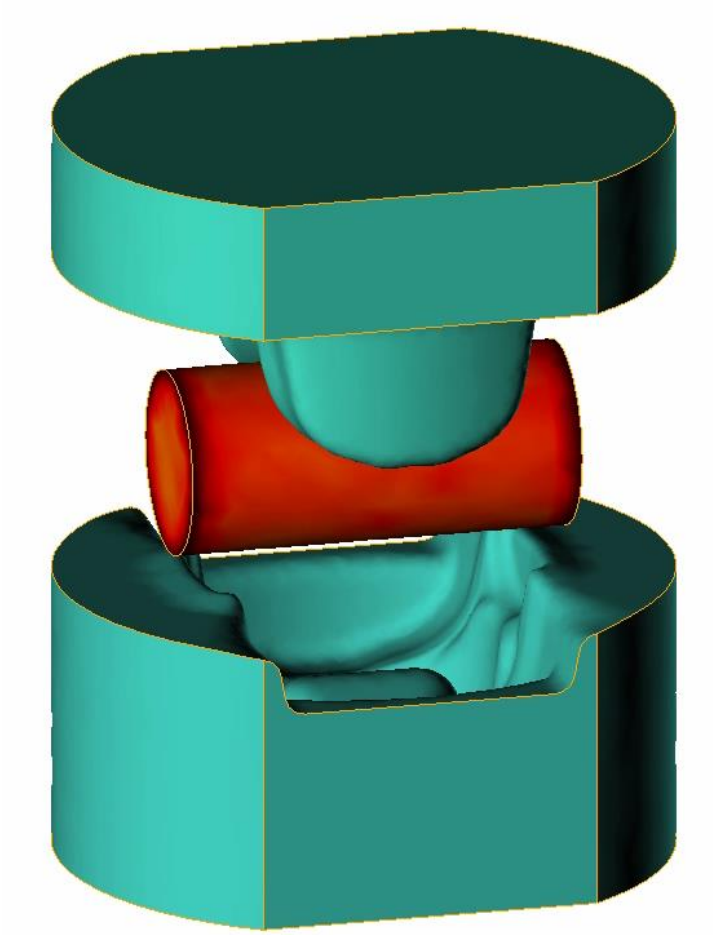


- Create simulation step by step
- Save file
- Run simulation

After a successful run:

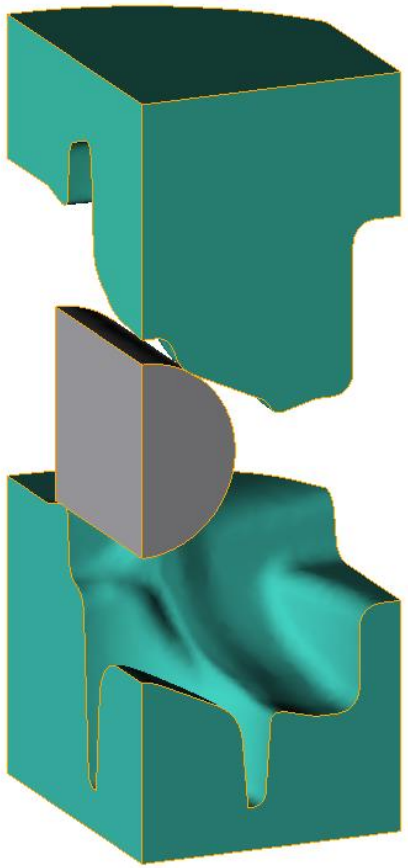
- Zoom in and out
- Create 3D from 2D
- Check whether stop condition fulfilled
- Plot tool loads according to time
- Make a video using simulation results

Task #2



Geometry	
File	task#2_full.qshape
Workpiece	
Material	C22 (DIN)
Initial temperature	1200 °C
Cooling while in tools	2 sec
Cooling in air	5 sec
Tools	
Material	H13 (AISI)
Initial temperature	200 °C
Lubricant	Graphite + water
Machine	
Mechanic press	16 MN
Stop condition	
Distance of tools	4 mm

Task #2

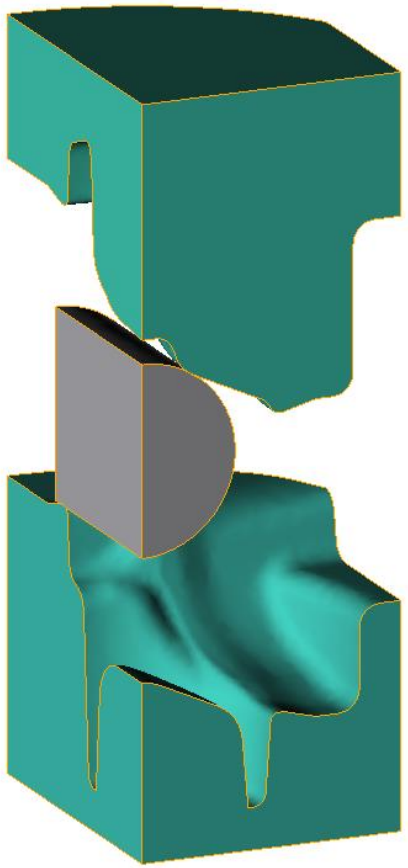


- Create simulation step by step
- Save file
- Run simulation
- Stop simulation
- Project structure

After a successful run:

- Check stop conditions
- Check meshing information and applied mesh
- Create a simplified simulation to reduce calculation time
- Symmetry options
- Compare simulations

Task #2



- Find initial and final elements of workpiece
- Evaluate tool movements
- Show temperature field
- Show plastic strain field
- Show strain rate field
- Compare simulations
- Create the animation of the simulation
- Save the temperature distribution in workpiece at a given moment (statistics)

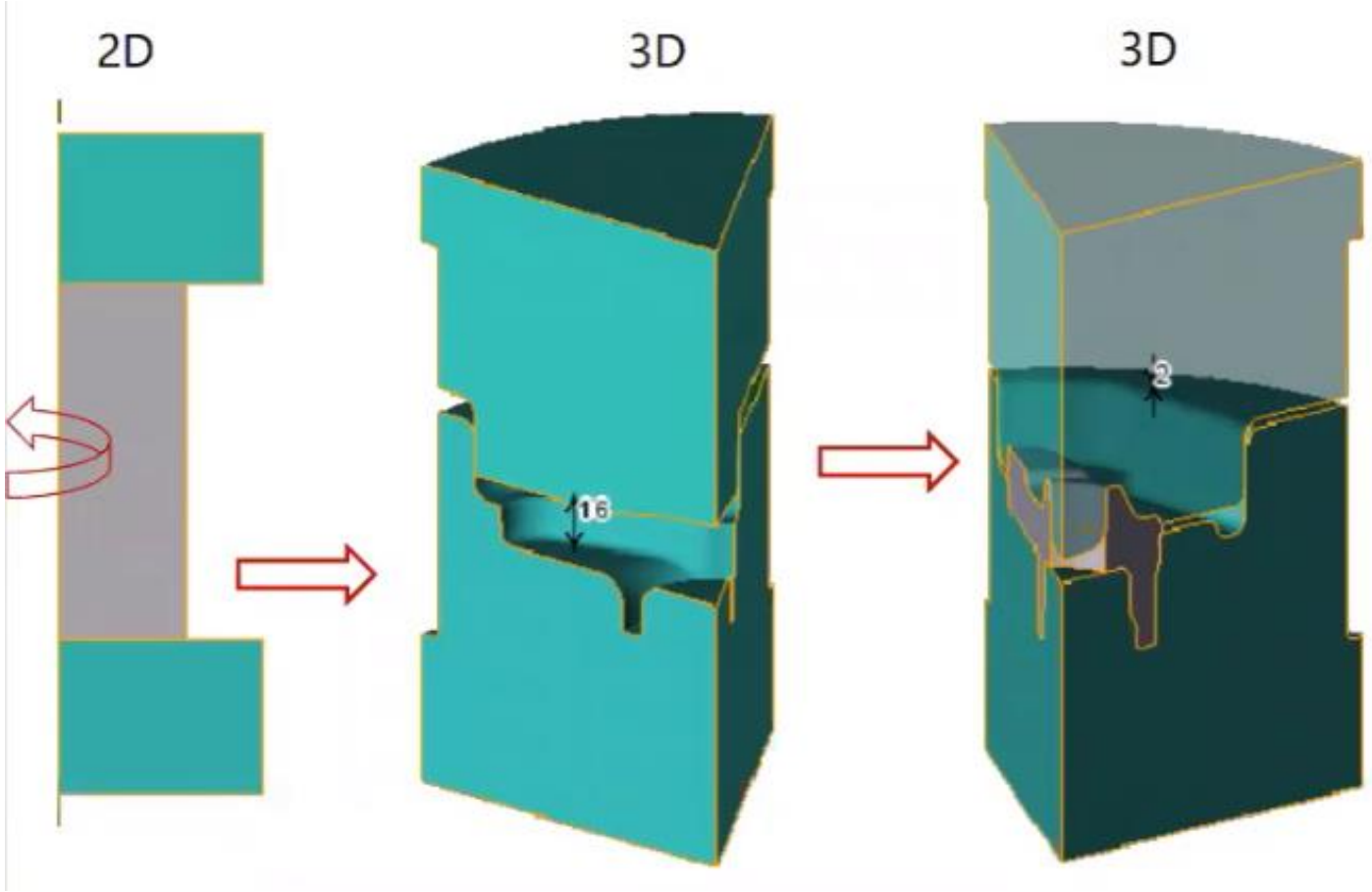
Virtual forging course

2nd Lesson

Operations, tracked lines, 2D into 3D

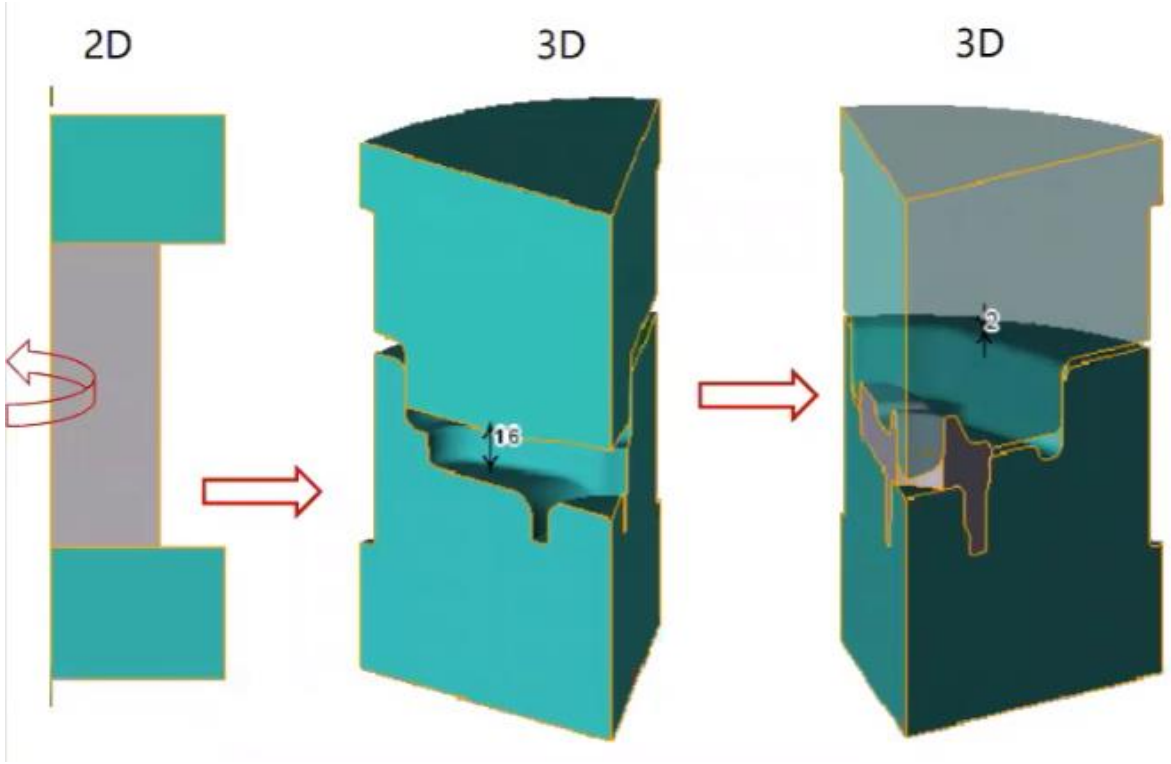
Renkó József
renko.jozsef@edu.bme.hu

Task #3



Workpiece	
Material	C45 (DIN)
Initial temperature	1200 °C
Cooling while in tools	2 sec
Cooling in air	5 sec
Tools	
Material	L6 (AISI)
Initial temperature	200 °C
Lubricant	Graphite + water
Machine	
Mechanic press	10 MN
Stop condition	
Distance of tools (O1)	48 mm
Distance in point (O2)	16 mm
Distance of tools (O3)	2 mm

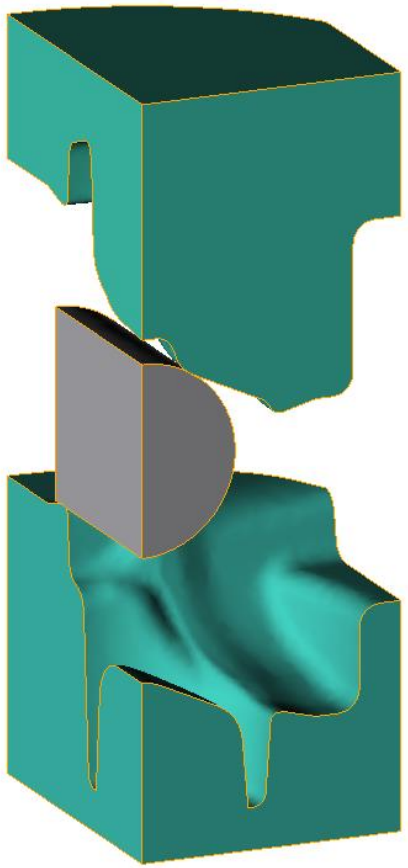
Task #3



Tools	
Material	L6 (AISI)
Initial temperature	200 °C
Lubricant	Graphite + water
Machine	
Mechanic press	6,3 MN

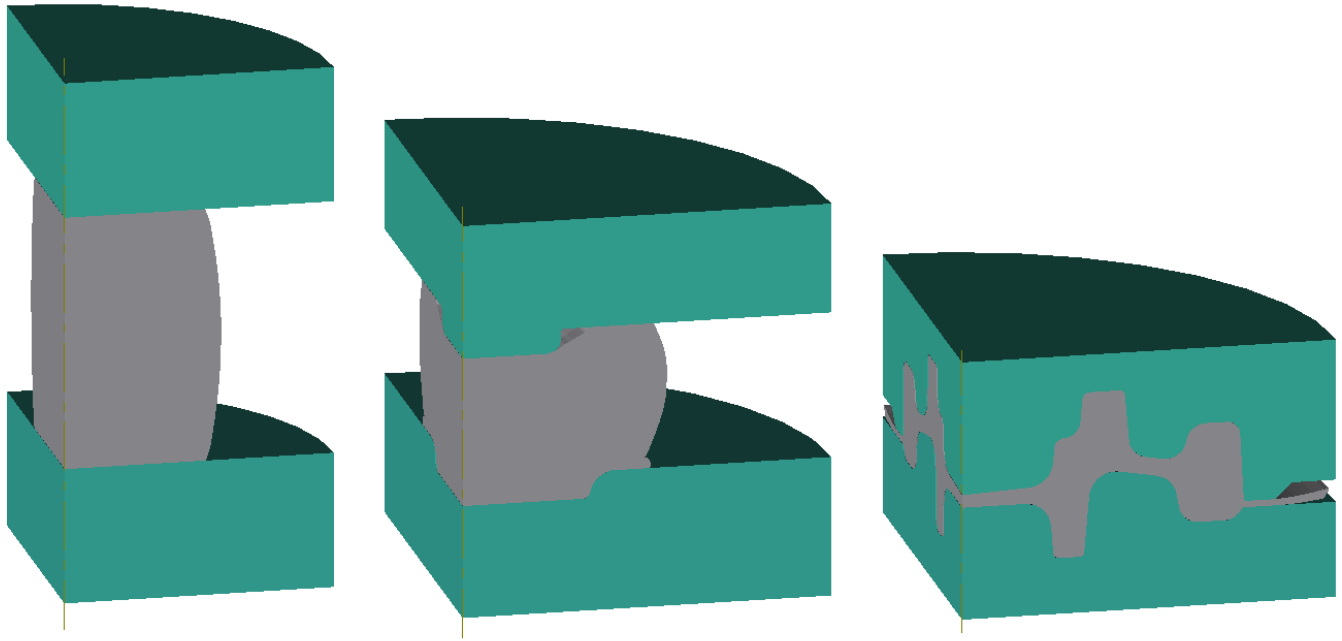
- Create 1st Operation
- Use results to create 2nd Operation
- Create 3rd Operation
- Create the copy of Project
- Remake 3rd Operation with trim

Task #3



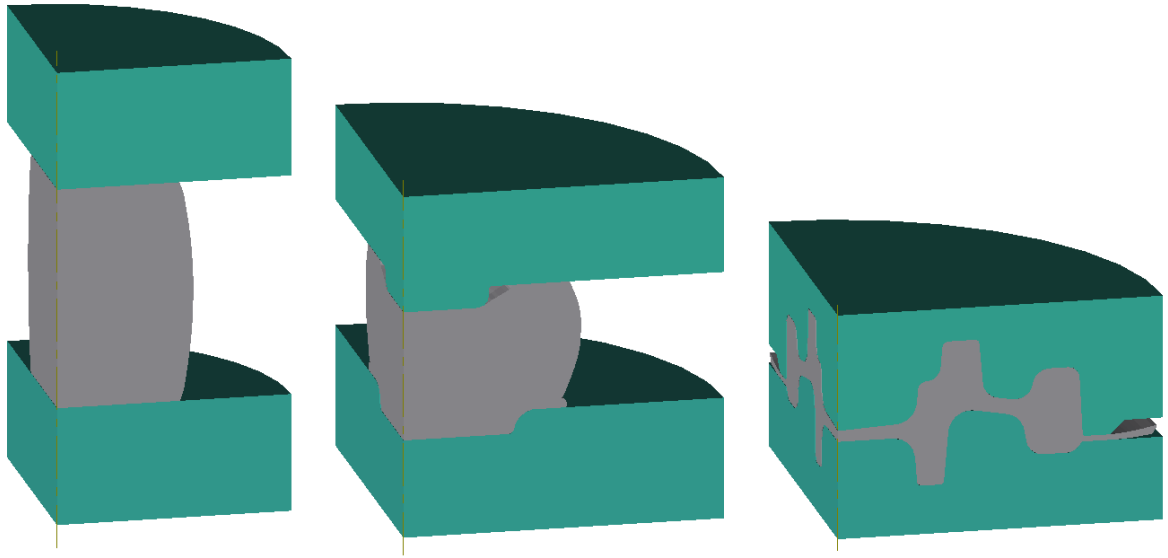
- Contact nodes on surface
- Meshing of workpiece
- Create the animation of the whole process
- Export final workpiece geometry
- Create tracked lines and undersurface flow lines
- Execute tracking
- Evaluate results

Task #4



Workpiece	
Material	AlMgSi1
Initial temperature (P1)	450 °C
Initial temperature (P2)	20 °C
Tools	
Material	5140
Initial temperature (P1)	200 °C
Initial temperature (P2)	20 °C
Lubricant	Mineral oil
Machine	
Mechanic press	10 MN
Stop conditions	
Distance of tools (O1)	80 mm
Distance in point (O2)	46 mm
Distance in point (O3)	2 mm

Task #4



- Create all Operations
- Create the copy of Project
- Modify to cold forming simulation
- Compare results to each other
- Apply modified model in 2nd operation
- Run new simulation
- Compare new results

- Apply parametric stop condition for hot forming Operation 1
- Compare simulation results

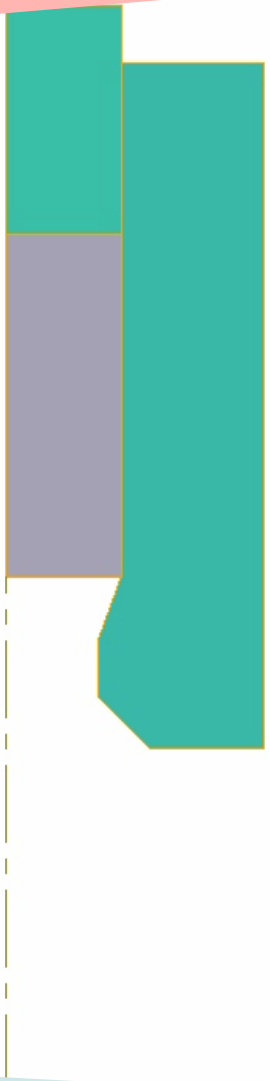
Task #5

Geometry			
File	1.a reduction 2D INC_GEOM.dxf	1.b reduction 2D friction analysis.dxf	1.c reduction 2D QDRAFT
Workpiece			
Material	AlMgSi1	AlMgSi1	AlMgSi1
Initial temperature	20 °C	20 °C	20 °C
Tools			
Material	5140	5140	5140
Initial temperature	20 °C	20 °C	20 °C
Lubricant	Unlubricated	No friction	Unlubricated
Machine			
Mechanic press	10 MN	10 MN	10 MN
Stop condition			
Distance of tools	10 mm	2 mm	2 mm

Task #5

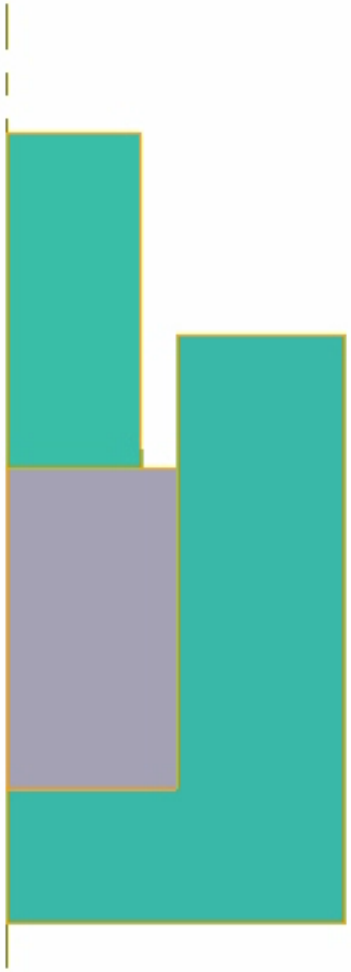
- Create and run 1.a simulation
- Define new friction model
- Evaluate contact nodes
- Change mesh parameters in contact zones
- Create 1.b and 1.c simulations
- Preset mesh parameters in contact zones
- Run 1.b and 1.c simulations
- Evaluate contact nodes
- Compare different friction cases
- Solve simulation 1.b and 1.c using variables

Task #6



Geometry				
File	2. forward extrusion 2D.dxf	3.a backward extrusion INC_TOOL.dxf	3.b backward extrusion.dxf	3.c wall reduction after backward extrusion.dxf
Workpiece				
Material	AlMgSi1	AlMgSi1	AlMgSi1	AlMgSi1
Initial temperature	20 °C	20 °C	20 °C	20 °C
Tools				
Material	5140	5140	5140	5140
Initial temperature	20 °C	20 °C	20 °C	20 °C
Lubricant	Unlubricated	No friction	Unlubricated	Unlubricated
Machine				
Mechanic press	10 MN	10 MN	10 MN	10 MN
Stop condition				
Distance of tools	25 mm	10 mm	10 mm	40 mm

Task #6



- Create and run simulation 2
- Compare force-distance curves with reduction from task #5
- Create 3.a and 3.b simulations
- Compare force-distance curves to each other
- Run 3.c simulation
- Find the proper settings to finish reduction process

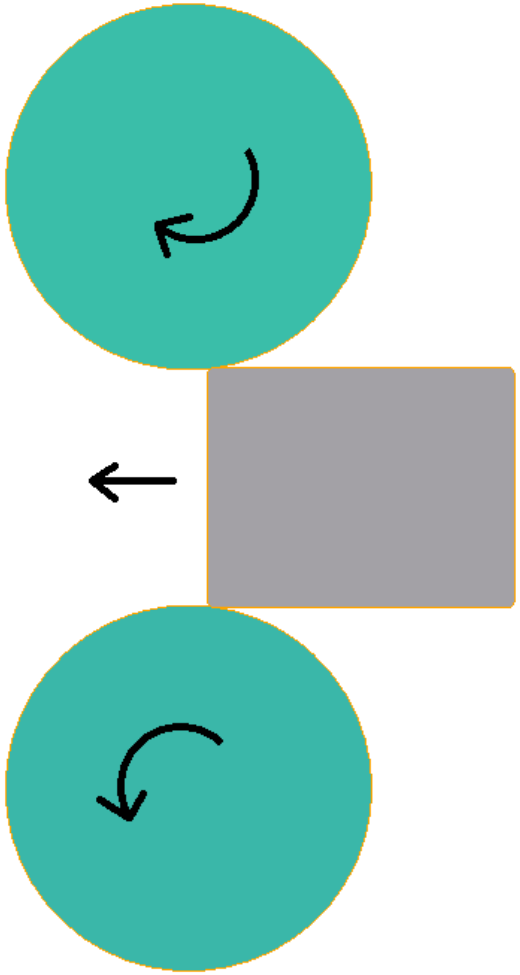
Virtual forging course

3rd Lesson

Meshing, rotating movements and boundary conditions

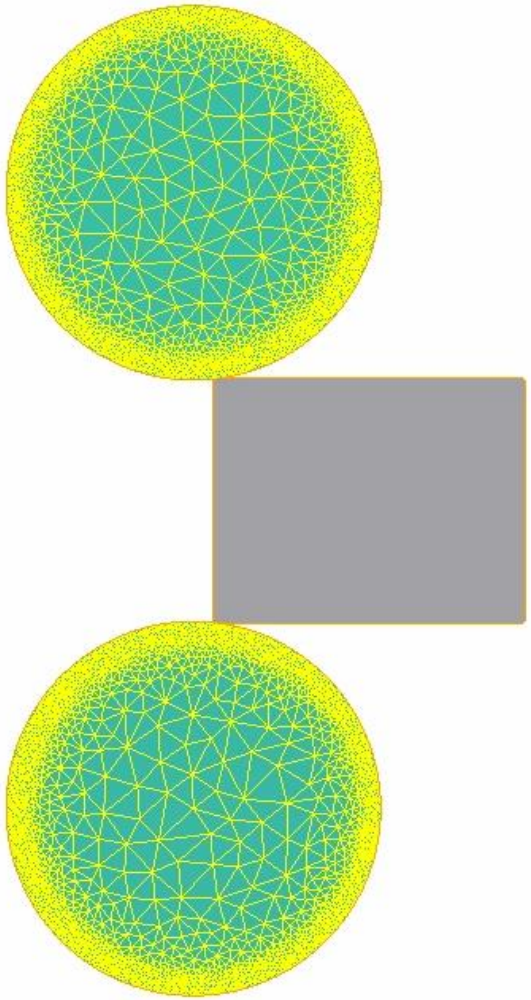
Renkó József
renko.jozsef@edu.bme.hu

Task #7

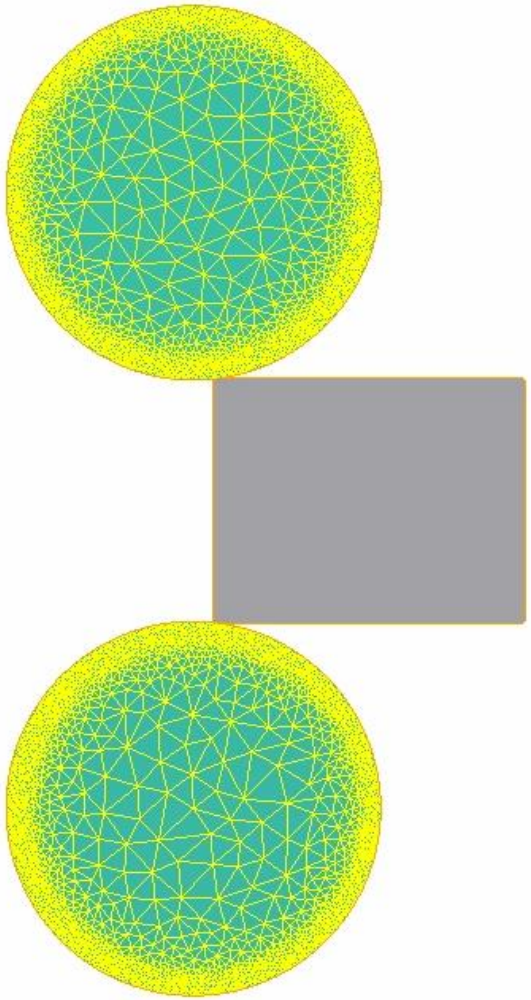


Geometry	
File	Task#7.dxf
Workpiece	
Material	AA 6082 (AISI)
Initial Temperature	500 °C
Length	1220 mm
Tools	
Material	1.2510
Lubricant	0.95 (Siebel/Kudo)
Initial Temperature	200 °C
Rotation axes	
Upper roll	Z = 740 mm
Lower roll	Z = -740 mm

Task #7



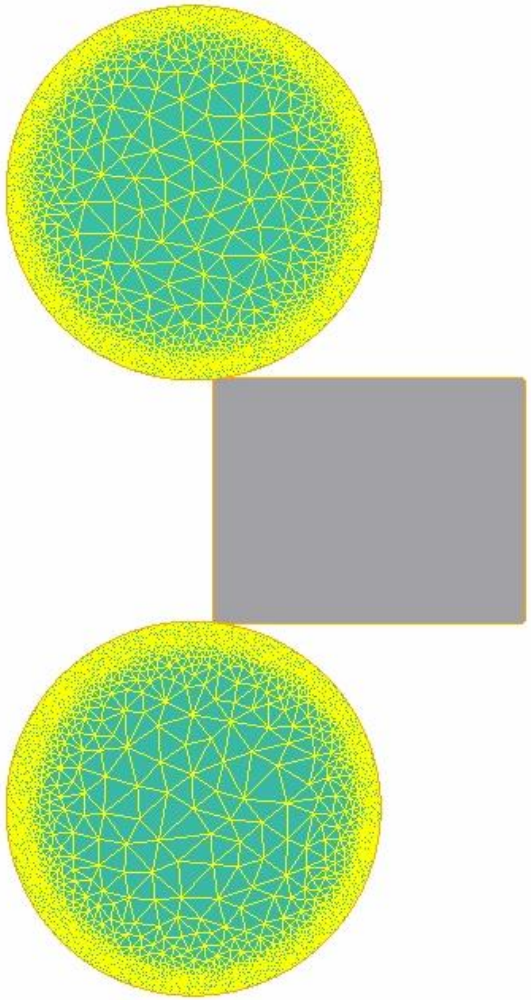
Rolling steps			
#	Velocity	Distance of rolls	Movement of rolls
1	93 rpm	580 mm	-
2	103 rpm	563 mm	-8,5 (x2)
3	108 rpm	543 mm	-18,5 (x2)
4	105 rpm	393 mm	-75 (x2)



Task #7

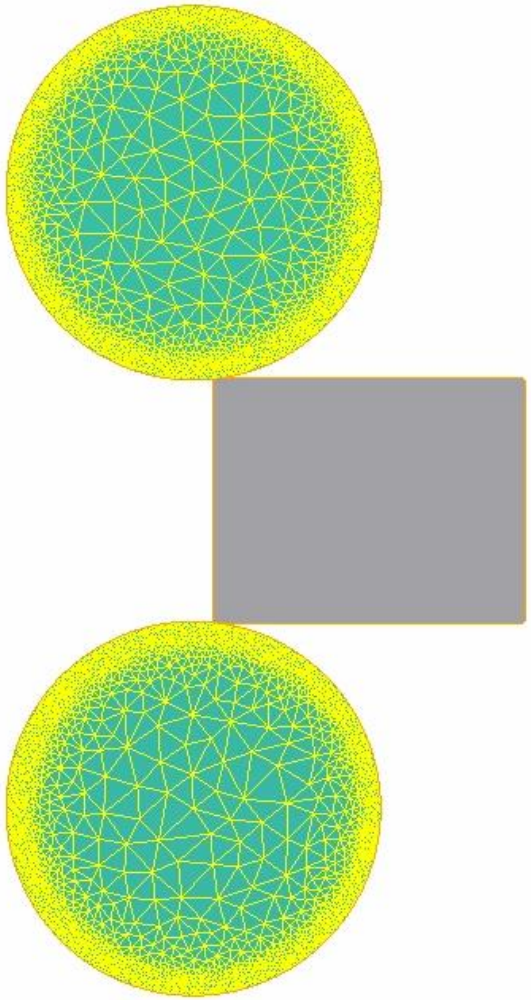
- Create 1st Operation
- Define stop conditions
- Run simulation
- Modify boundary conditions if necessary
- Create 2nd Operation
- Calculate tool movements
- Run simulation
- Create and run 3rd and 4th Operations
- Evaluate results and modify simulation if necessary
- Save workpiece final geometry

Task #7



Rolling steps			
#	Velocity	Distance of rolls	Movement of rolls
1	93 rpm	580 mm	-
2	103 rpm	563 mm	-8,5 (x2)
3	108 rpm	543 mm	-18,5 (x2)
4	108 rpm	543 mm	-45 (x2)
5	105 rpm	393 mm	-30 (x2)

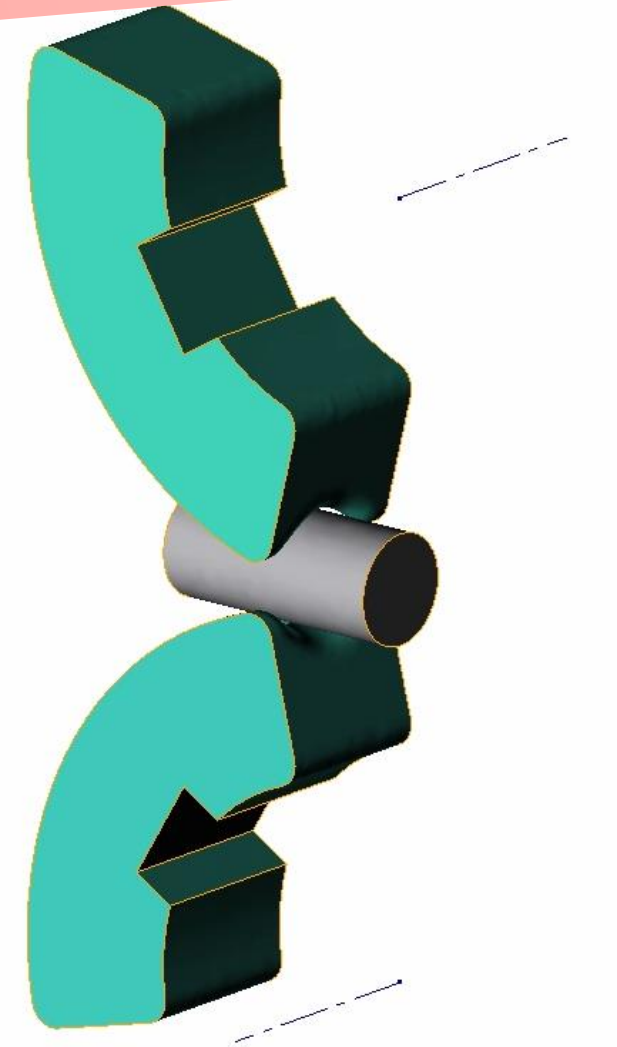
Task #7



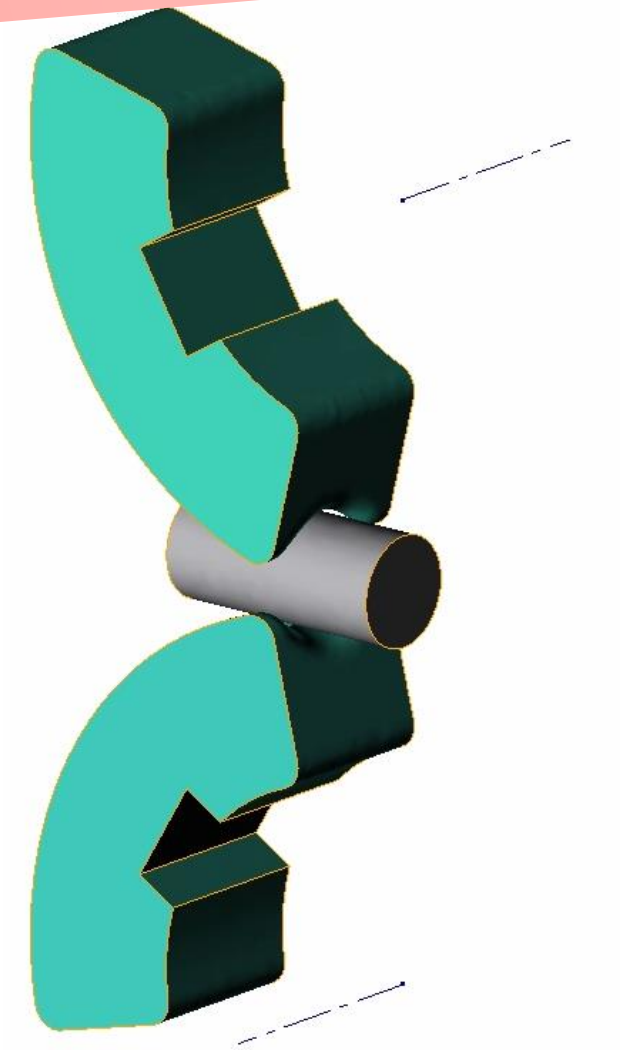
- Evaluate force and plastic strain in different operations

- Create 3D simulation of the 1st rolling step as new process
- Define new stop conditions
- Apply volumetric boundary conditions (not „only for surface”)
- Run simulation

Task #8



Workpiece	
Material	AA 6082 (AISI)
Initial Temperature	500 °C
Tools	
Material	55NiCroMoV7
Lubricant	Mineral Oil + Graphite
Temperature	200 °C
Rotation axes	
Upper roll	Z = 159 mm
Lower roll	Z = -159 mm
Full rotation (Op. 1)	30 °
Full rotation (Op. 2)	60 °



Task #8

- Create Operation 1 for simulation of Task#8
- Use only one tool drive for both tools
- Create Operation 2 using simulation results of previous operation
- Check workpiece positioning in Operation 2
- Use Task#8_mod.stp and create the same simulation making both steps at the same time
- Rotate workpiece at 90° after step 1
- Compare tool loads finishing one or two steps at once

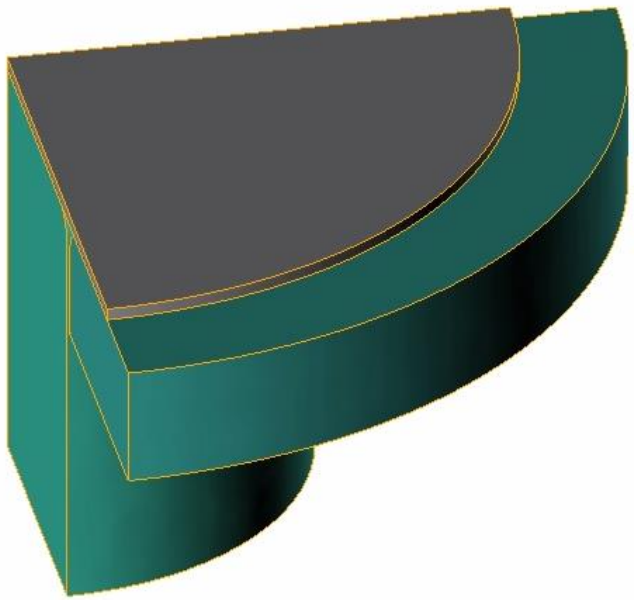
Virtual forging course

4th Lesson

Materials and complex tool movements

Renkó József
renko.jozsef@edu.bme.hu

Task #9



Workpiece	
Material	C10 (defined later)
Initial Temperature	20 °C
Tools	
Material	1.2343 (for extrusion)
Lubricant	Mineral oil (defined later)
Temperature	20 °C
Stop conditions	
Tool stroke (Op. 1)	65 mm
Tool stroke (Op. 2)	90 mm

Task #9

Lubricant	
Friction law	Coulomb
Friction coefficient	0,1
Heat transfer coefficient	50000 W/(m^2*K)

Material	
Material	C10 (from database)
Initial Temperature	20 °C
Density	7800 kg/m^3
Thermal conductivity	50 W/(m*K)
Specific heat	500 J/(kg*K)
Young modulus	200 GPa
Poisson ratio	0,13
Anisotropy	
R0	0,9
R45	0,8
R90	1,5

Task #9

- Create 2D simulation of deep drawing Op. 1
- Use own defined material model and lubricant
- Modify tool distances to reduce chance of rupture
- Create Operation 2 with auto positioning
- Create Operation 2 with manual positioning
- Evaluate positionings
- Apply anisotropy
- Run simulation
- Create 3D simulation of Operation 1 with anisotropy
- Use only 2 tools and apply boundary condition to evade crease
- Evaluate anisotropy results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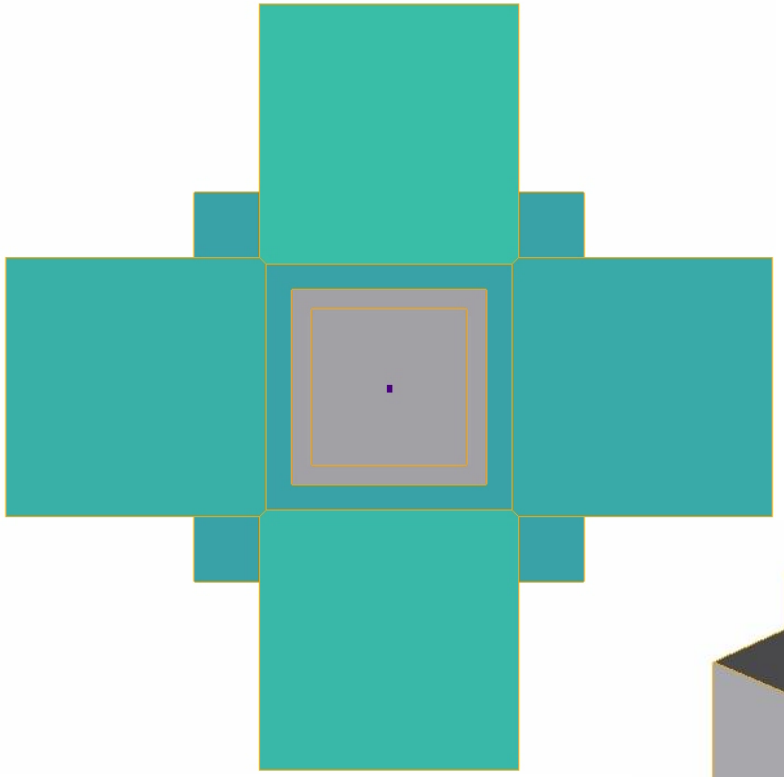
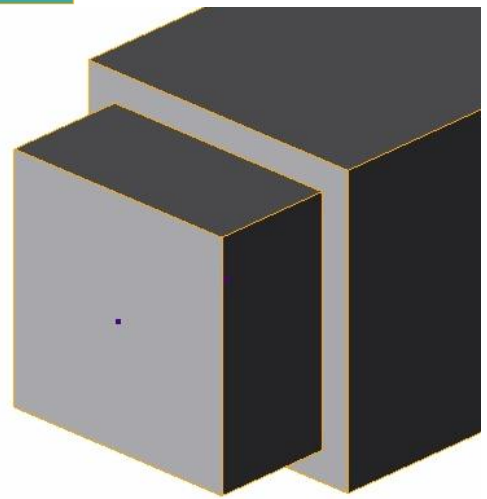
Task #10





Workpiece	
Material	CuE
Initial Temperature	28 °C
Tools	
Material	1.2343 (for extrusion)
Lubricant	Unlubricated
Temperature	20 °C
Tool movements	
Tool stroke	2,5 mm
Number of tool strokes	5 - 5

Task #10

- Create 2D simulation of multi-axial forging
- Put tool movements into an excell file and import it
- Run simulation
- Create undersurface flow lines

- Create 3D simulation of multi-axial forging
- Run simulation
- Create tracked points, lines and undersurface flow lines
- Export fields into excell

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Virtual forging course

5th Lesson

Applications

Renkó József
renko.jozsef@edu.bme.hu

att

Nemzeti Tehetség Program

Emberi Erőforrások Minisztériuma

Task #11

- Lánchajlítás

Task #12

- Csőhajlítás

Task #9

- Nakashima teszt
- szerszámdeformáció