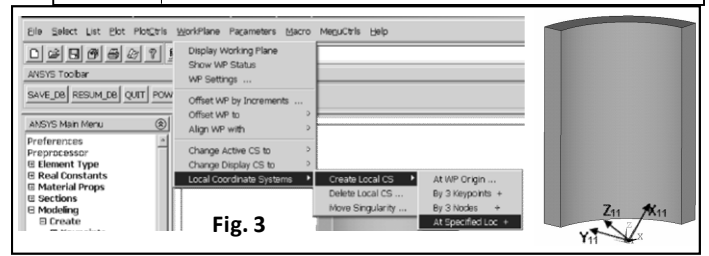
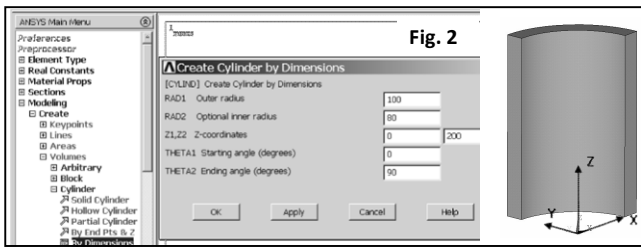
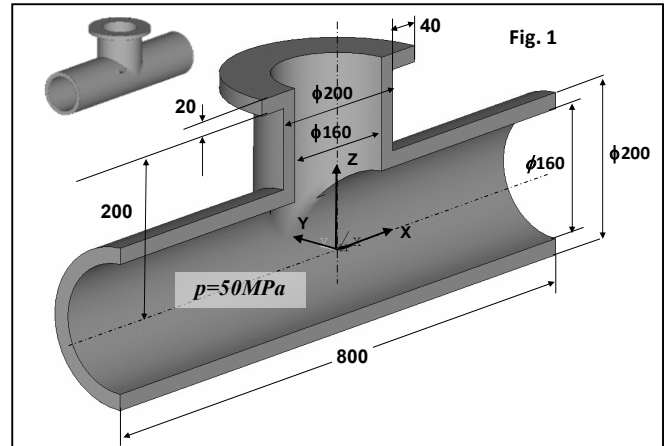


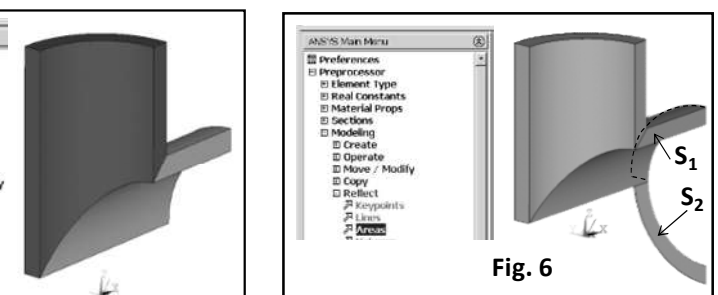
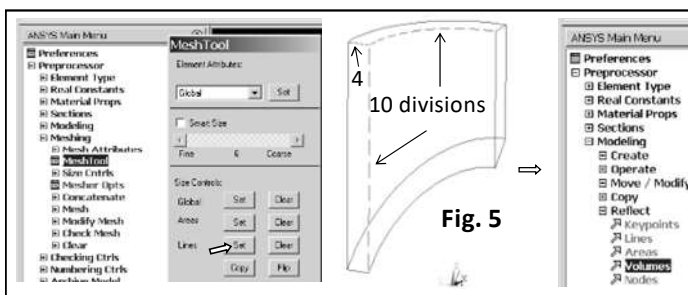
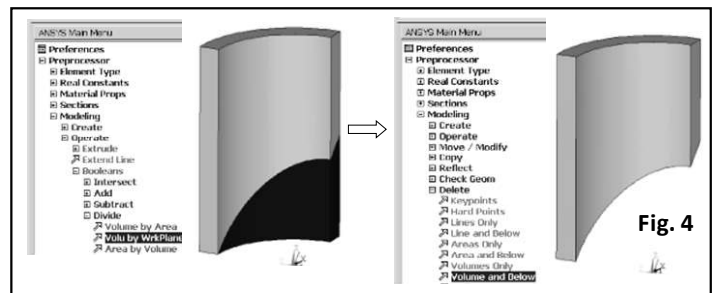
LAB 2. A 3D quarter model of a T-pipe connection. Stress state in a thick-walled pipe. Effect of discretization type.

1. Create geometry of a quarter model of a T-pipe connection (Fig. 1). The model is built "from the Top Down" by use of primitives:

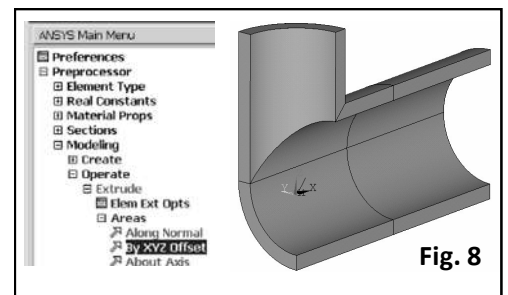
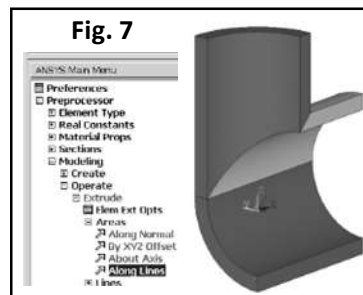
- a) create a cylinder sector: outer radius 100 mm, inner radius 80 mm, height 200 mm, sector angle 90° (Fig. 2.)
- b) create a new local cartesian coordinate system (CS): a number of 11, coordinates of the origin: (0, 0, 0) and rotation of -45° about Y axis (Fig. 3 - pick any location on Graphics Window (-> ok) and correct data),
- c) align the working plane (WP) with the previously created CS (*Working Plane> Align WP with> Specified Coordinate System*),



- d) divide the cylinder sector by use of the Working Plane and delete a lower volume (Fig. 4.),
- e) define the size of discretization on lines and reflect the volume with respect to the xy plane of an active coordinate system CS 11 (Fig. 5),
- f) activate the global coordinate system: *Utility Menu>Work Plane>Change Active CS to>Global Cartesian*, and reflect the area S_1 with respect to the xy plane: *Preprocessor>Modeling>Reflect>Area* (Fig. 6),
- g) merge keypoints and lines with coincident coordinates: *Preprocessor>Numbering Ctrl>Merge Items>All*,



h) extrude the area S_2 along the line: *Preprocessor> Modeling> Operate> Extrude> Areas>Along Lines* (Fig. 7), and repeat merging.

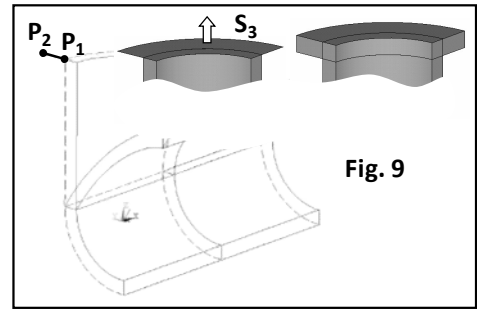


i) extrude areas S_1 and S_2 along the global x axis with the distance of 200 mm (Fig. 8): *Preprocessor> Modeling> Operate> Extrude> Areas> By XYZ Offset*

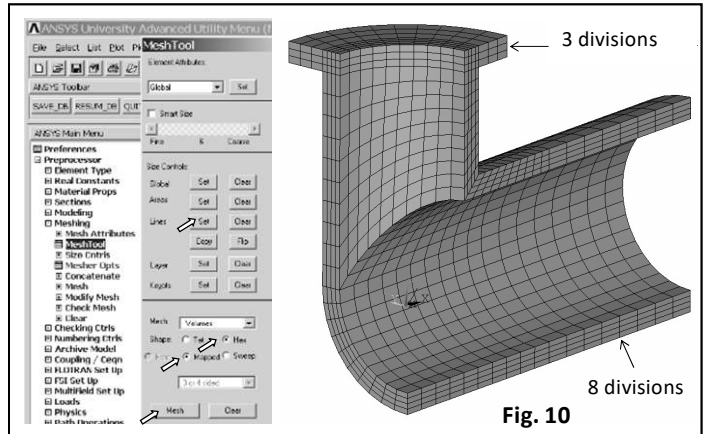
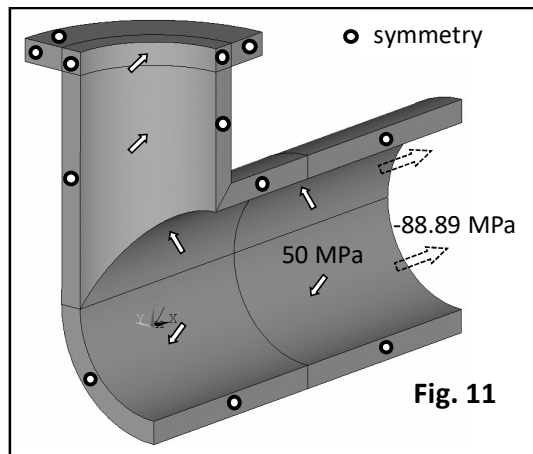
j) create a flange (Fig. 9):

- copy a keypoint P_1 along the global y axis with the distance of 40 mm *Preprocessor> Modeling> Copy> Keypoints*,
- create a line between points P_1 and P_2 : *Preprocessor> Modeling> Create> Lines> Straight Line*,
- extrude the line along an arc: *Preprocessor> Operate> Extrude> Lines > Along Lines*,
- extrude the area along the global z axis with the distance of 20 mm, and repeat merging,

- k) save the database (Utility Menu>File>Save As..., for example: Tpipe.db)
2. Choose an element SOLID185 (Brick 8 node, simplified enhanced strain)
3. Define a linear elastic, isotropic material properties: $E = 2 \cdot 10^5$ MPa (Young's modulus) and $\nu = 0.3$ (Poisson's ratio),
4. Specify the density of discretization on lines and create a mapped hexahedral mesh (Fig. 10)
5. Save the mesh as an image (Plot> Elements, PlotCtrls> Redirect Plots-> To JPEG File ...)

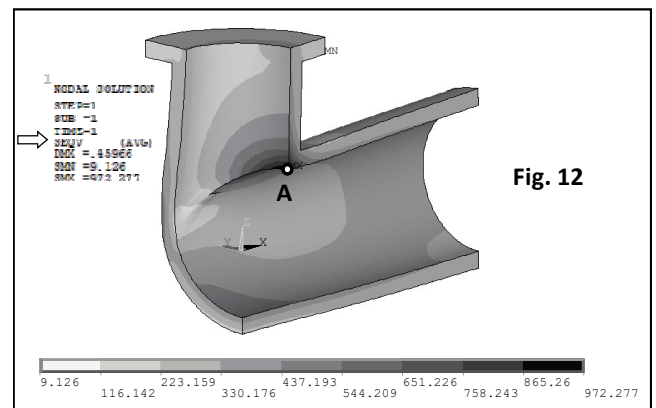


6. Fill numbers of nodes and elements in Tab. 1 for Case I (Utility Menu>List> Status> Global Status)
7. Apply boundary conditions: symmetry condition on areas and pressure (Fig. 11), Solution> Apply> Structural> Displacement> Symmetry B.C.> On Areas and Apply> Structural> Pressure> On Areas,
8. Solve (Solution-> Solve-> Current LS)

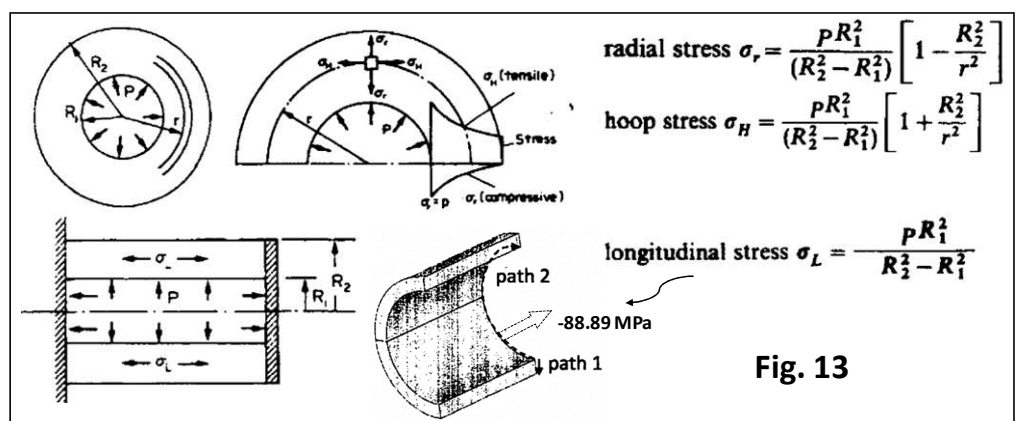


Negative pressure of -88.89 MPa applied on free areas, shown on the right side in Fig. 11, was equal to the longitudinal stress caused by an internal pressure of 50 MPa. It was assumed that only outer surface of the flange was supported because a flexible gasket was placed on the inner surface.

9. Plot a contour map of the resultant displacement (Main Menu> General Postproc> Read Results> First Set and Main Menu>General Postproc>Plot Results>Contour Plot>Nodal Solu>DOF Solution>Displacement Vector sum 'USUM') and save it as image and note the maximum value of USUM in Tab. 1.
10. Plot and save as images contour maps of stress components SX, SY, SZ, SXY, SYZ, SXZ, and Von Mises stress SEQV (Main Menu>General Postproc>Plot Results>Contour Plot>Nodal Solu>Stress...)
11. Find stress components at the node located at point A (Fig. 12) (Main Menu>General Postproc> Query Result> Subgrid Solu) and save the data in Tab. 1:
12. Create a new coordinate system 12 (as in point 1.b): coordinates of the origin: (200, 0, 0) and rotation of -90° about Y axis, cylindrical type,
13. Choose a cylindrical system 12 for results presentation (Main Menu> General Postproc> Options for Output> [RSYS]-> Local system, Local system reference no.-> 12)
14. Select the two volumes shown in Fig. 13: Select> Entities, Volumes, By Num/Pick, From Full, Apply, ... and then Select> Everything Below> Selected Volumes



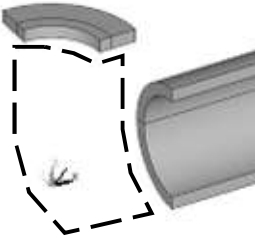
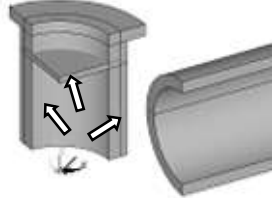

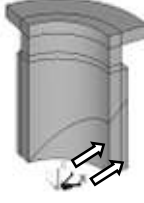
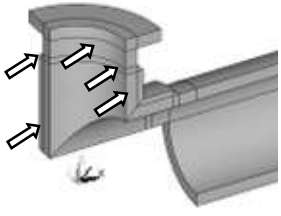
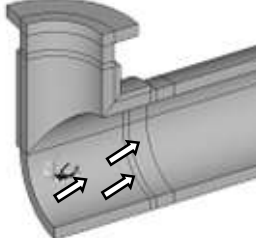
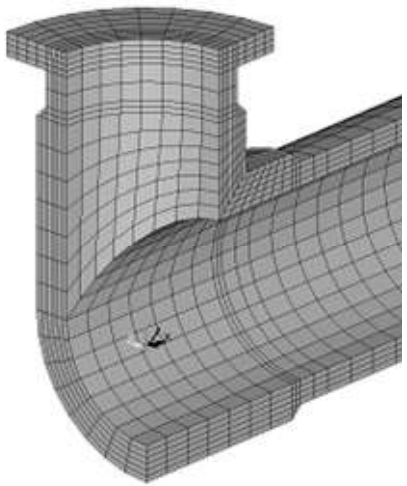
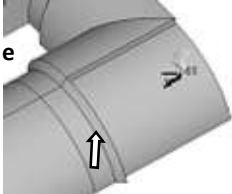
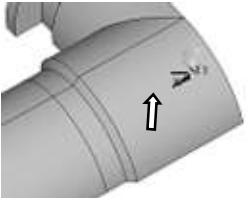
15. Save contour maps of stress components: SX (radial), SY (hoop) and SZ (longitudinal)
16. Save graphs of SX, SY, and SZ along path 1 and 2 (Fig. 13), and compare the results with Lamé theory for thick shells, for $r = R_1$ and R_2 .
17. Select> Everything



18. Perform analysis of Case II using a finite element SOLID186 (Brick 20 node, uniform reduced integration) and a mapped hexahedral mesh. Fill the Tab. 1 and save contour maps of the displacement magnitude (USUM) and Von Mises stress (SEQV).

19. Change a finite element to SOLID185 (Brick 8 node, simplified enhanced strain) and perform analysis of Case III using a free tetrahedral mesh. Fill the Tab. 1 and save contour maps of USUM and SEQV.

20. Improve the geometry (as shown below) and perform analysis of Case IV using a mapped hexahedral mesh and the 8 node finite element SOLID185. Fill the Tab. 1 and save contour maps of USUM and SEQV.

<p>A. clear and delete 3 volumes</p>  <p>Main Menu>Preprocessor>Meshing>Clear>Volumes Main Menu>Preprocessor>Modeling>Delete>Volume and Below</p>	<p>B. create and overlap 2 cylinders and 1 cone</p>  <p>Utility Menu>WorkPlane > Align Working Plane with> Global Cartesian Menu>Preprocessor>Modeling>Create>Volumes>Cylinder>By Dimensions RAD1=100, RAD2=80, Z1=0, Z2=200, THETA1=0, THETA2=90 RAD1=100+a, RAD2=100, Z1=0, Z2=200, THETA1=0, THETA2=90 Main Menu>Preprocessor>Modeling>Create>Volumes>Cone>By Dimensions RBOT=100+a, RTOP=100, Z1=b, Z2=b+a, THETA1=0, THETA2=90 Main Menu>Preprocessor>Modeling>Operate>Booleans>Overlap>Volumes</p>	
<p>C. delete 2 volumes</p>  <p>Main Menu>Preprocessor>Modeling>Delete>Volume and Below</p>	<p>D. divide by WP and delete 2 volumes</p> <p>Utility Menu>WorkPlane > Change Active CS to> Specified Coordinate System > 11 Utility Menu>WorkPlane > Align Working Plane with> Active Coordinate System Main Menu>Preprocessor>Modeling>Operate>Booleans>Divide>Volu by WrkPlane Main Menu>Preprocessor>Modeling>Delete>Volume and Below</p> 	
<p>E. reflect 5 volumes</p>  <p>Menu>Preprocessor>Modeling>Reflect>Volumes => X-Y plane</p>	<p>F. create 3 volumes</p>  <p>Menu>Preprocessor>Modeling>Operate>Extrude>Areas>Along Lines</p>	<p>FE model</p>  <p>Menu>Preprocessor>Numbering Ctrl> Merge Item > All Menu>Preprocessor>Meshing > Mesh Tool</p>
<p>G. reflect 1 volume</p>  <p>Utility Menu>WorkPlane > Change Active CS to> Global Cartesian Menu>Preprocessor>Modeling>Reflect>Volumes => X-Y plane</p>	<p>H. create 1 volume</p>  <p>Menu>Preprocessor>Modeling>Operate>Extrude>Areas>Along Lines</p>	

21. Discuss results and write conclusions.