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Abstrakti, sisällysluettelo, tms. - Abstract, list of contents etc.

Abstract

The structural behaviour of the visor hinge of the ro-ro passenger ship MV Estonia was analysed using finite element method (FEM). Non-linear static analyses with linear material behaviour using solid elements and contact elements were performed. Contact elements allow sliding of the corresponding surfaces and these surfaces can not penetrate into each other. No friction was modelled between the contact surfaces. A 90° sector of the fillet weld joining the hinge plate and the sleeve was left open.

Two load cases were analysed representing possible cases which may have damaged the structure. In the first load case a total force of 2MN was applied to the hinge. In the second load case a total force of 4MN was applied to the hinge. Only one hinge plate was modelled with symmetric boundary conditions.

Contact elements were modelled between the hinge plate and the sleeve and also between the sleeve and the shaft, no friction was modelled. A 1mm gap was modelled between the hinge plate and the sleeve.

Stress results are presented as contour plots and also in tabulated form at selected nodes on hinge plates surface. Maximum stresses by von Mises criteria in load cases 1 and 2 are 736MPa and 872MPa respectively. Maximum displacements in load cases 1 and 2 are 0.36mm and 0.62mm.

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1 INTRODUCTION

The objective of this study is to calculate the structural behaviour of the visor hinge of MV Estonia. Two load cases are analysed using finite element method (FEM). Non-linear static analyses with linear material behaviour were performed. The loading was assumed to be caused by wave pressure distribution acting on the visor side plating. A 90° degree sector of the fillet weld connecting the sleeve and the hinge plate was left open. The material used in calculations was linear isotropic steel.

2 STRUCTURE AND LOADING

The visor is supported by two hinges. The structure of one hinge is presented in Figure 1. The hinge consists of two hinge plates. Thickness of one hinge plate is 60mm. The diameter of the sleeve hole is 250mm. Both plates have a sleeve which is welded to the hinge plate by a filled weld. The effective throat thickness of the fillet weld is 7mm. The inner and outer diameters of the sleeve are 180mm and 248mm respectively, length of the sleeve is 150mm. Inside the sleeve there is a shaft which is supported to the ship structure. The outer diameter of the shaft is 180mm, length is 150mm. The hinge plate is supported to the visor structure. There is no gap between the shaft and the sleeve but there is a 1mm gap between the sleeve and the hinge plate surfaces.

Two separate load cases were analysed. In the first load case a vertical force of F_y=-2MN was applied to the hinge. In the second load case a total force of 4MN (components F_y=3.98MN and F_x=-0.398MN) was applied to the hinge. Positive co-ordinate directions are presented in Figure 2 where the geometry of one hinge plate with a welded sleeve is presented. In this picture the geometry of the weld is continuos, no 90° open sector is present. In both loads cases forces were applied into the same point. This point is at the shaft axis in that end cross-section which is not at the symmetry plane.

3 NUMERICAL MODELS

Only one hinge plate and one sleeve was modelled. Because of symmetry only half of the hinge plate and the sleeve were actually meshed. Also only this part of the shaft which is in the sleeve was modelled. Symmetric boundary conditions were applied to nodes which were on the symmetry plane. All nodes lying on edge of the hinge plate which is connected to the visor structure had all displacements fixed.

Parabolic solid elements were used. Because the shaft is not fixed to the sleeve special contact elements were used to model the interaction between those members. This allows sliding between the surfaces, no friction between the surfaces was modelled. Similar contact elements were also modelled between the sleeve and the hinge plate.

The fillet weld was modelled as a complete continuos weld then the corresponding elements lying on the 90° sector were deleted. This gives a representation of an open weld which can be seen in Figure 2.

Linear isotropic steel with Young's modulus of 206.8GPa and Poisson's ratio of 0.29 were used.

4 ANALYSIS METHODS AND PROGRAMS

Pre processing, analyses and post processing were done with I-DEAS /2/. Static analyses with contact elements were performed. Iteration is needed to obtain the equilibrium because contact elements are present. Contact elements are generated automatically during the solution process.

5 STRESS AND DISPLACEMENT RESULTS

Deformed geometry of the mesh in load case 1 is presented in Figure 6 as a hidden line plot. Maximum displacement is 0.36mm.

Von Mises criteria stresses on deformed geometry in load case 1 are presented in Figures 7 and 8. Only hinge plate elements are shown. Maximum stress is 734MPa at the location where the opening of the fillet welt starts.

Nodal stress components of selected nodes in tabulated form in load case 1 are presented in Appendix 1. These are nodal average stresses, nodal stresses of neighbouring elements are averaged. The locations of the corresponding nodes are presented in Figures 4 and 5.

Deformed geometry of the mesh in load case 2 is presented in Figure 9 as a hidden line plot. Maximum displacement is 0.62mm.

Von Mises criteria stresses on deformed geometry in load case 2 are presented in Figures 10, 11 and 12. Only hinge plate elements are shown. Maximum stresses are 872MPa.

Nodal stress components of selected nodes in tabulated form in load case 1 are presented in Appendix 2. These are nodal average stresses, nodal stresses of neighbouring elements are averaged. The locations of the corresponding nodes are presented in Figures 4 and 5.

6 REFERENCES

1. Part-report covering technical issues on the capsizing on 28 September in the Baltic Sea of the ro-ro passenger vessel MV Estonia. The Joint Accident Investigation Commission of Estonia, Finland and Sweden.

2 I-DEAS Master Series Release 4. Structural Dynamics Research Corporation.

FIGURES

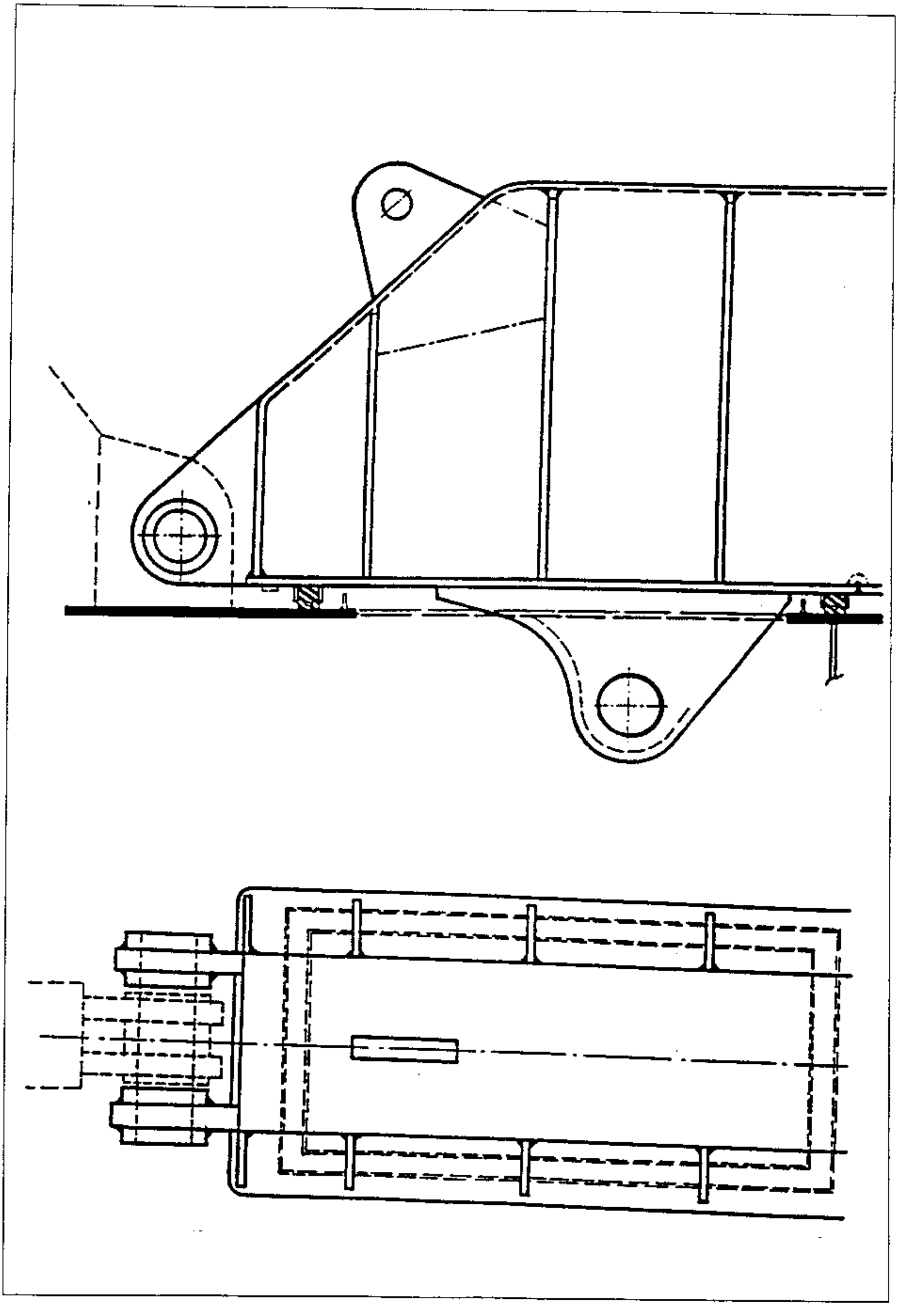

Figure 1. Hinge construction./1/

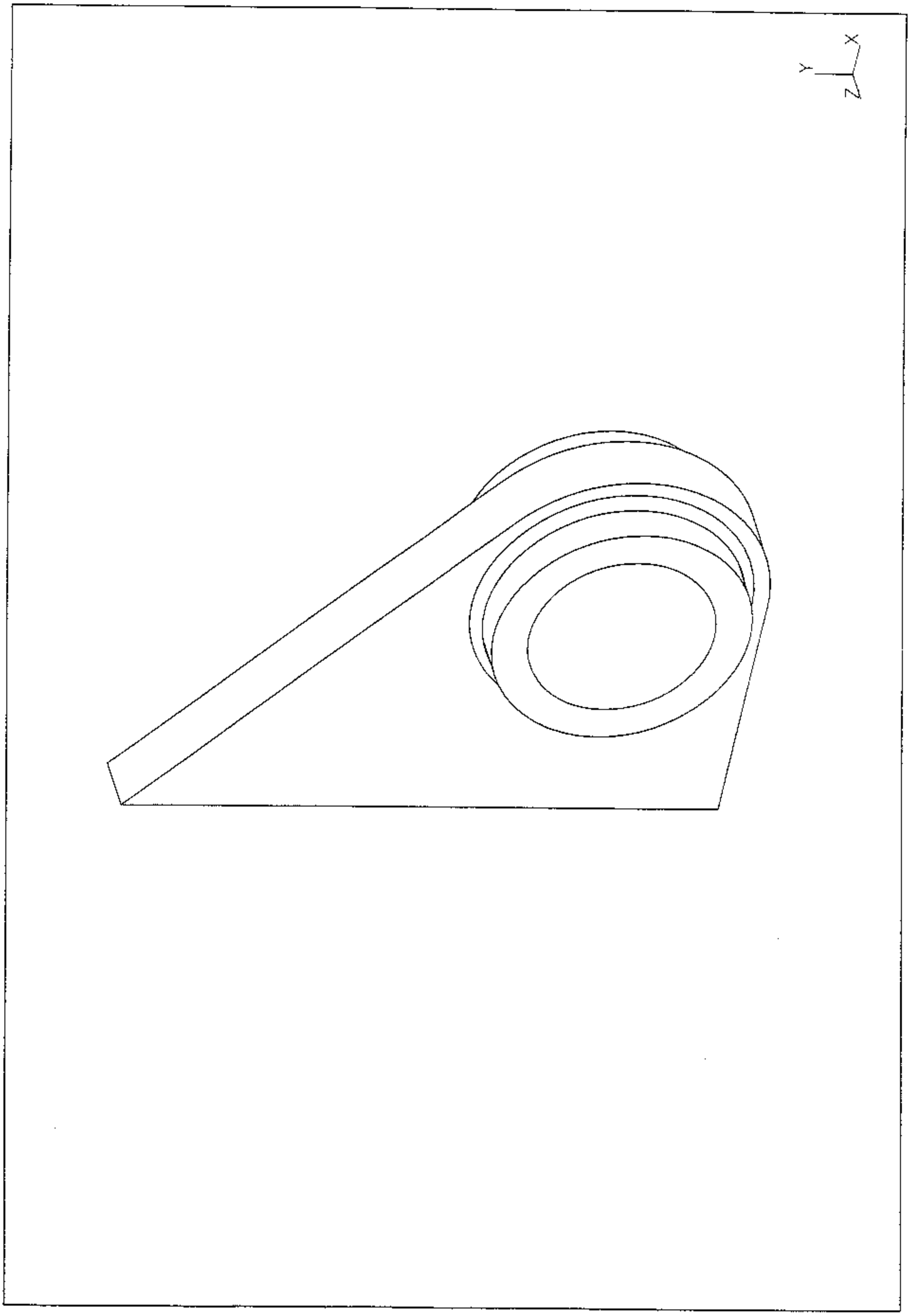

Figure 2. Geometry of the whole structure: hinge plate, sleeve with welds and shaft.

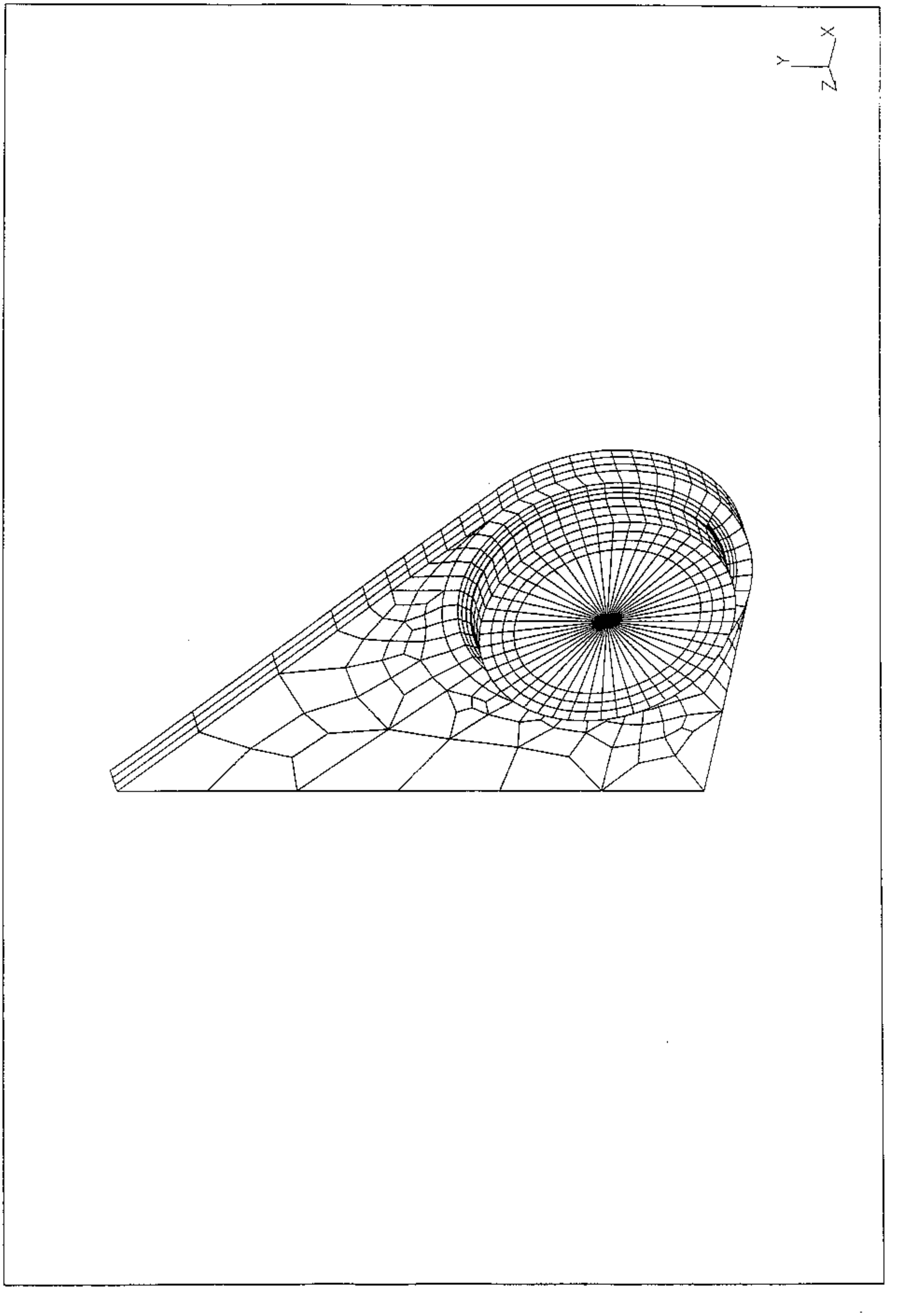

Figure 3. Finite element mesh of the model.

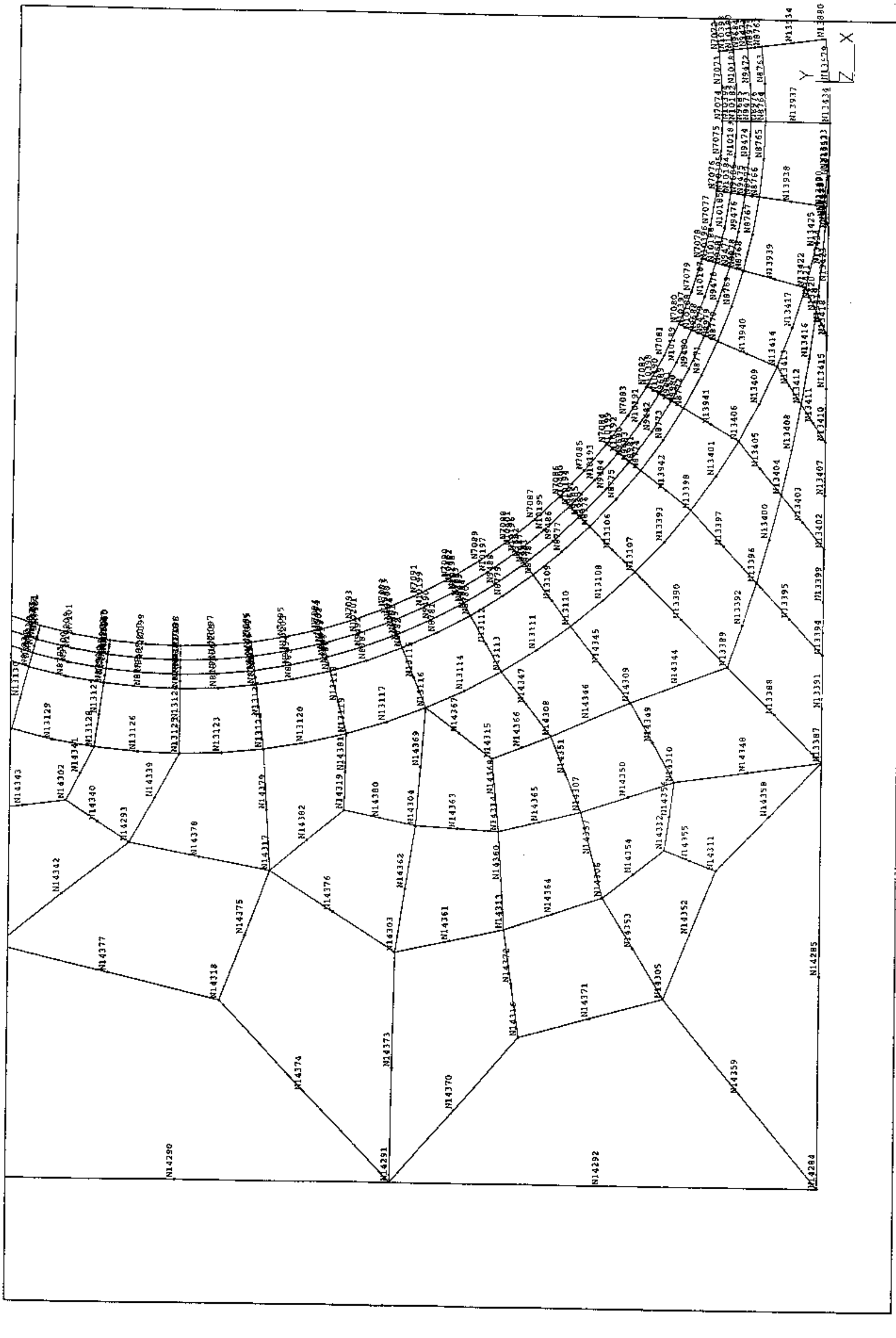

Figure 4. Nodes on the hinge plate.

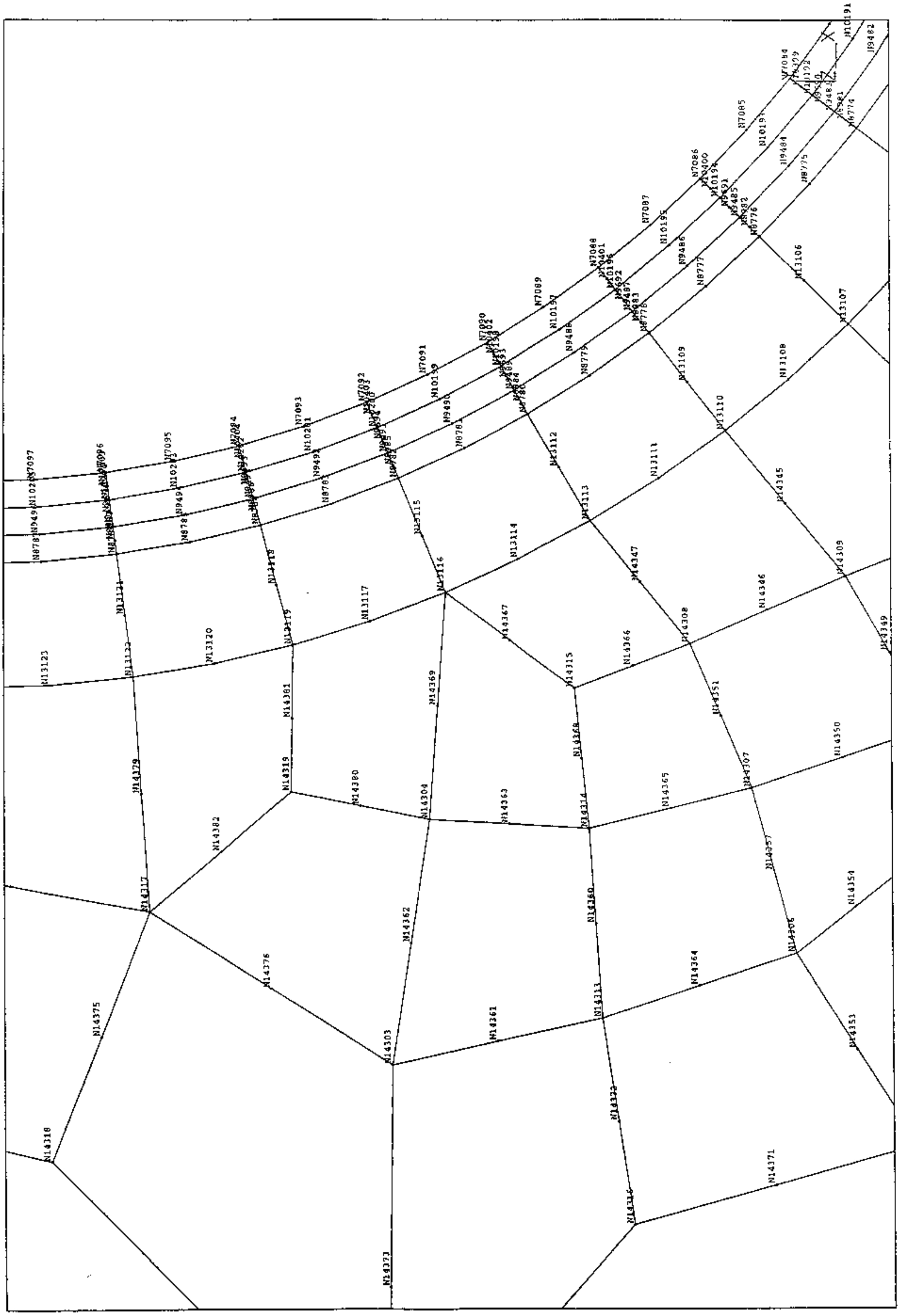

Figure 5. Nodes on the hinge plate, zoomed view.

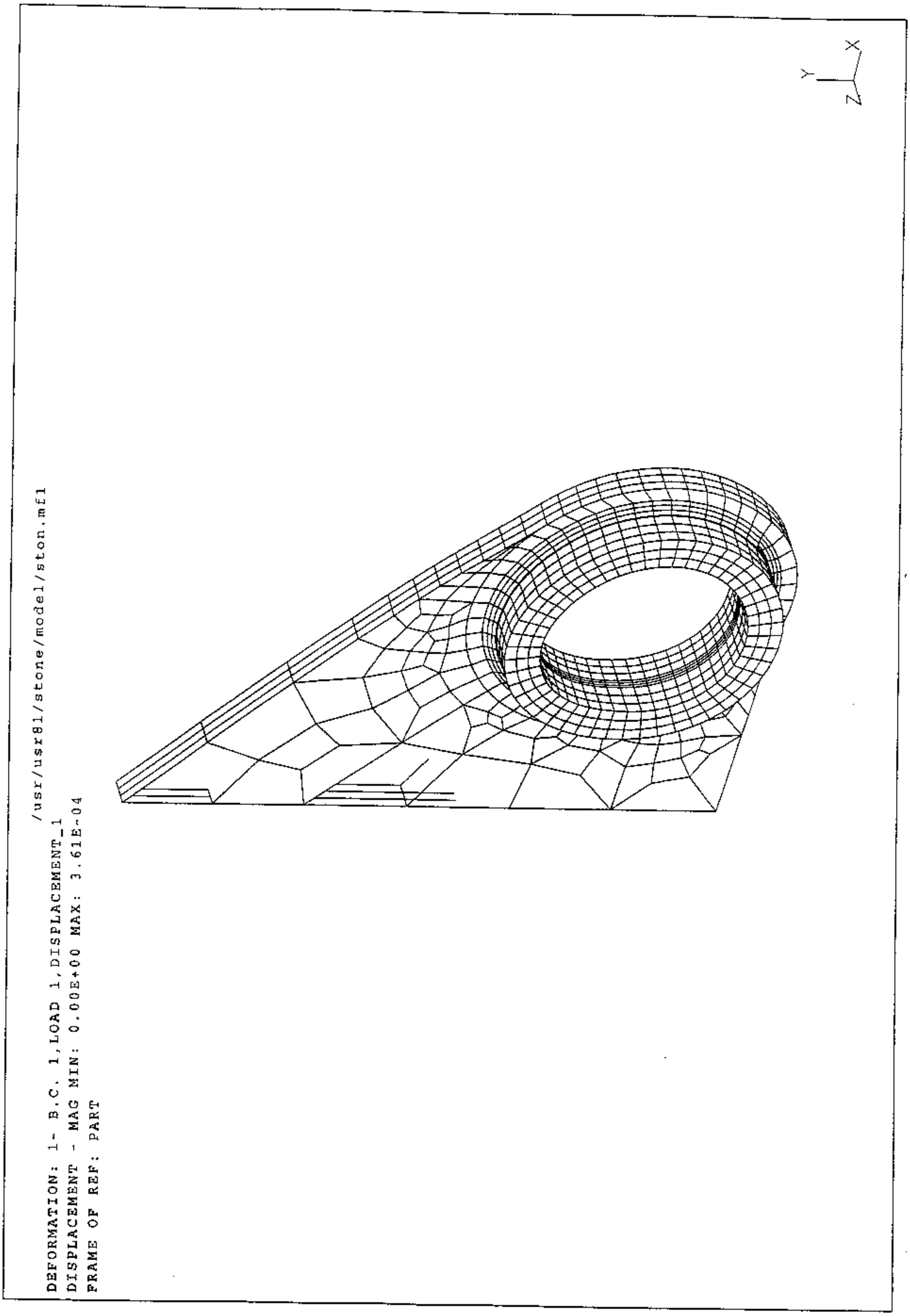

Figure 6. Load case 1, deformations.

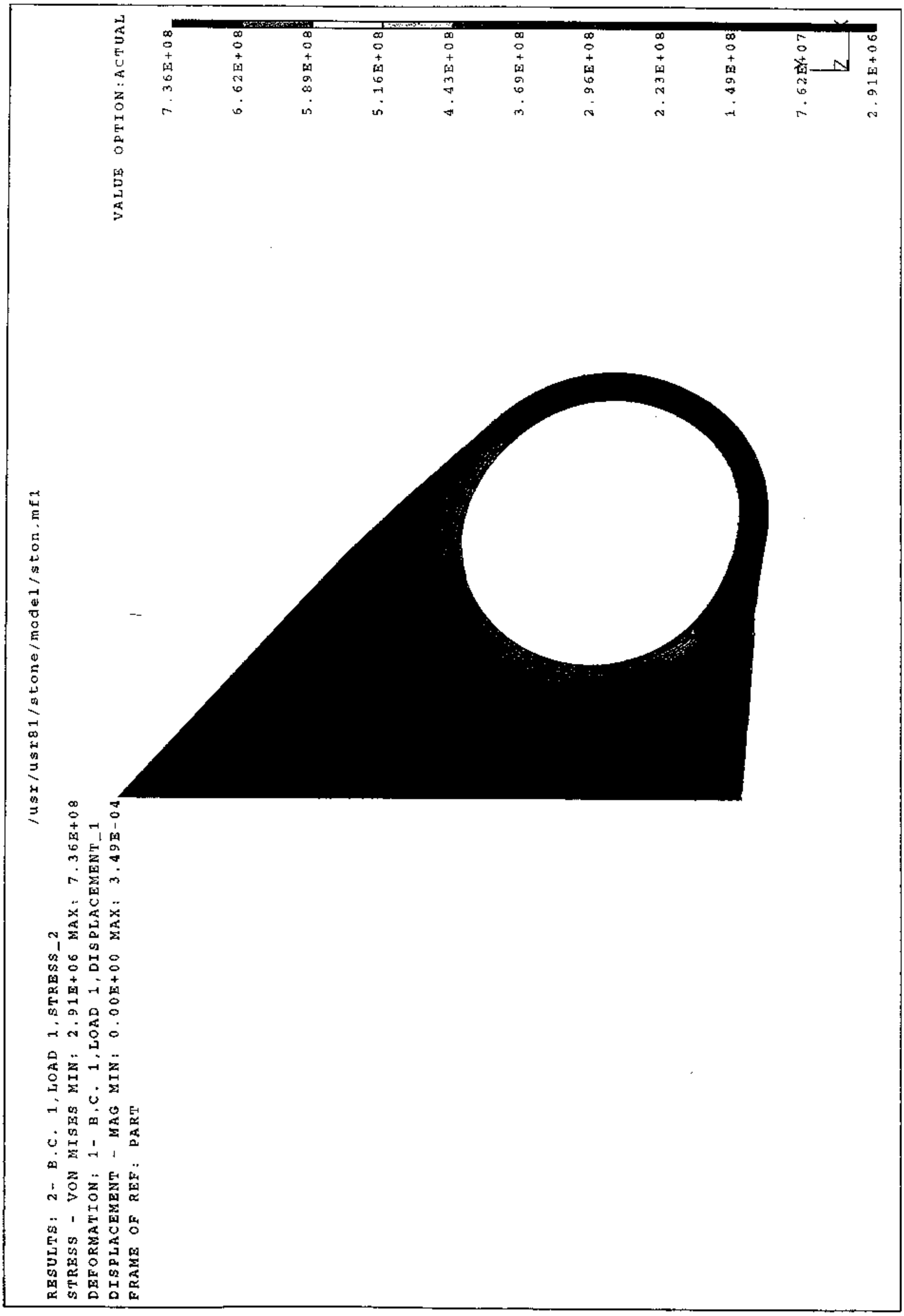

Figure 7. Load case 1, von Mises criteria stresses on deformed shape.

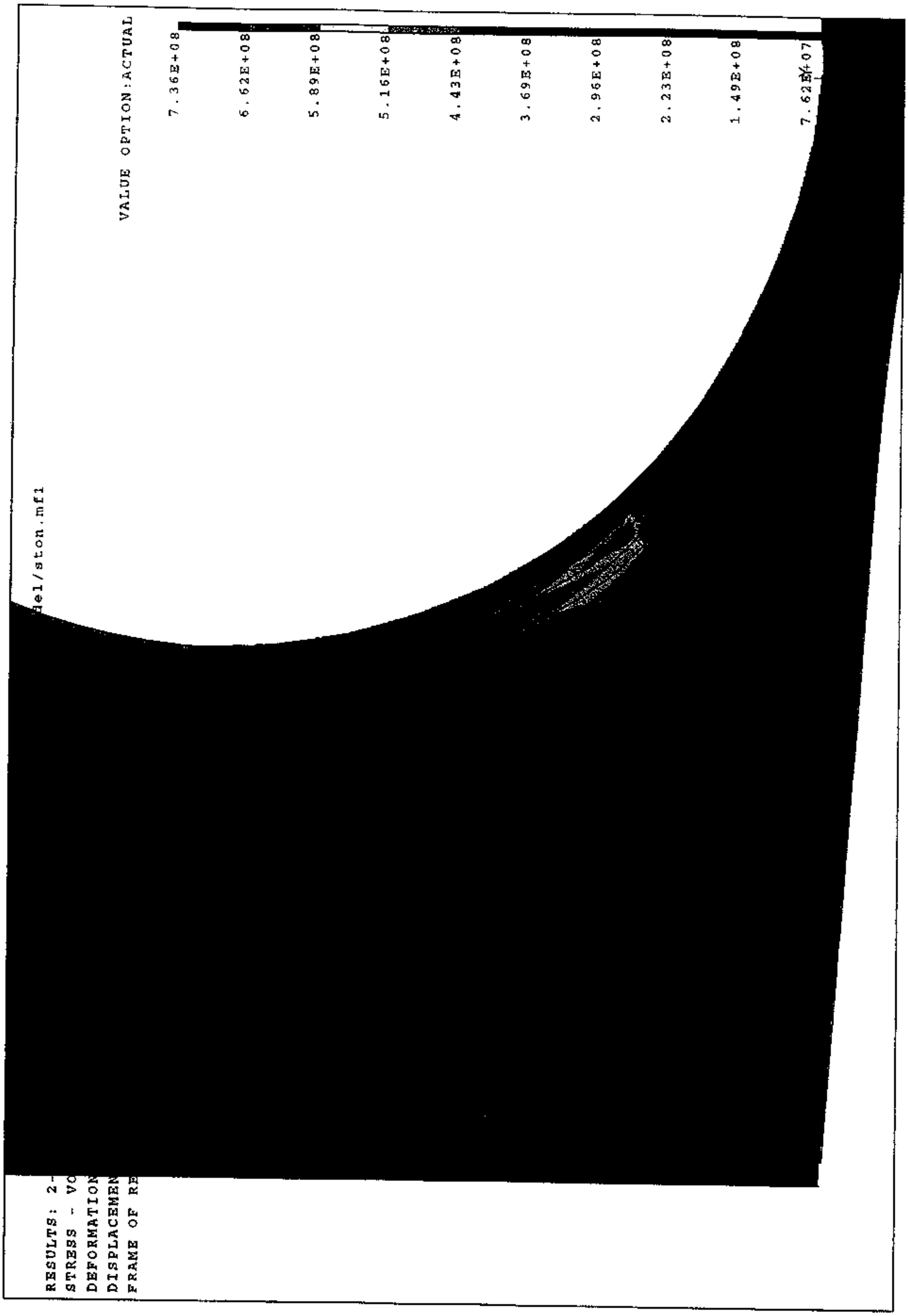

Figure 8. Load case 1, von Mises criteria stresses on deformed shape, zoomed view.

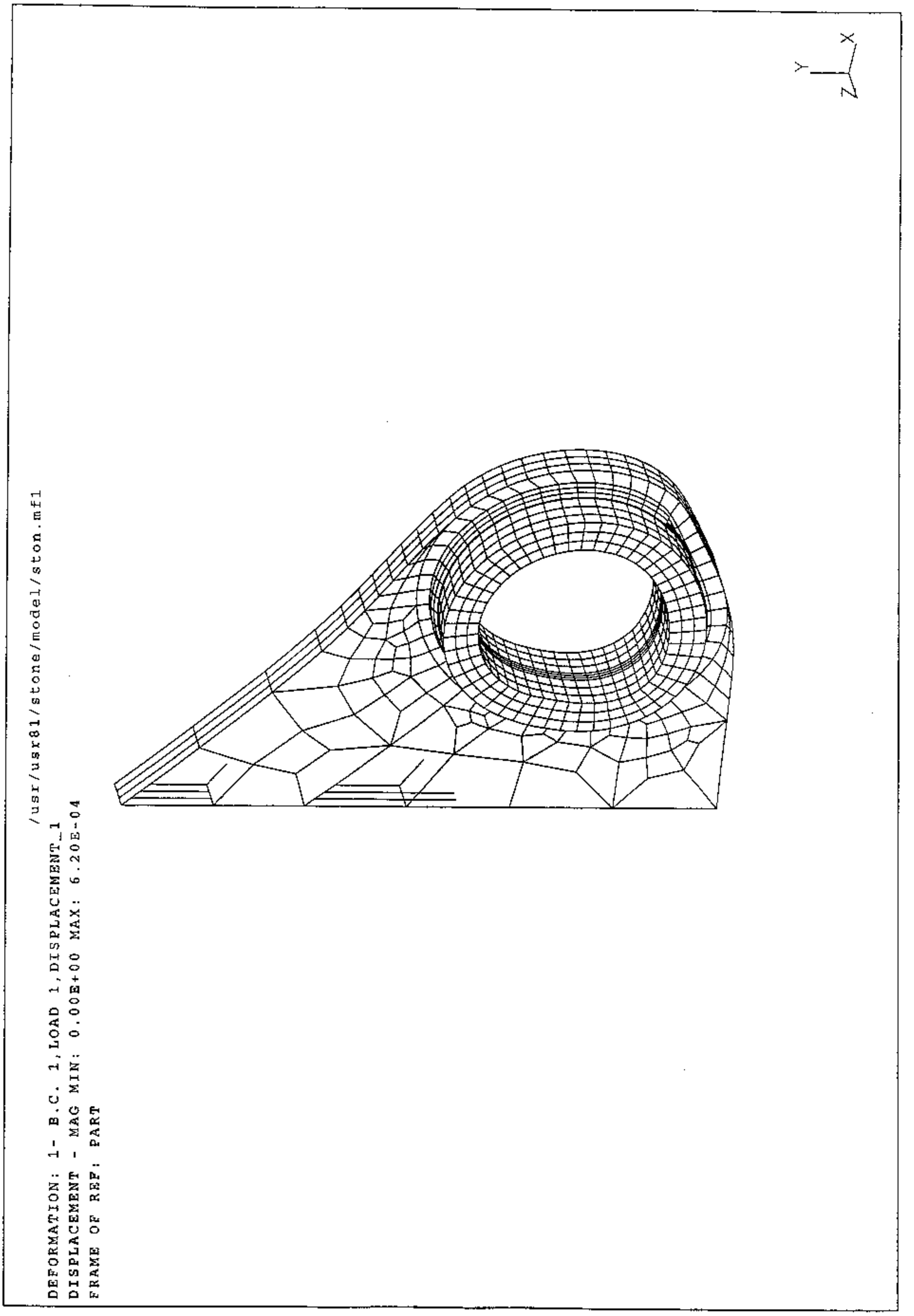

Figure 9. Load case 2, deformations.

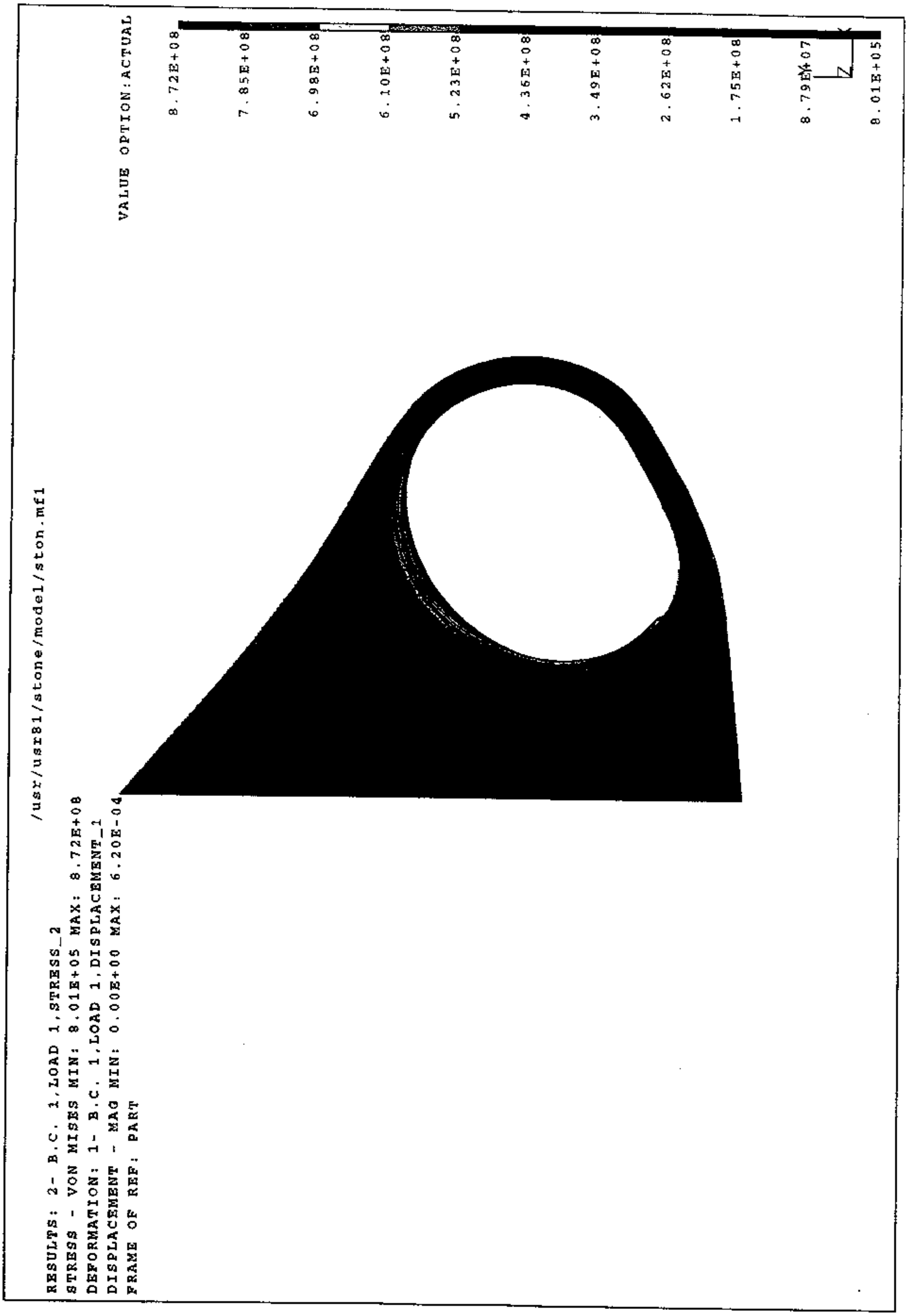

Figure 10. Load case 2, von Mises criteria stresses on deformed shape.

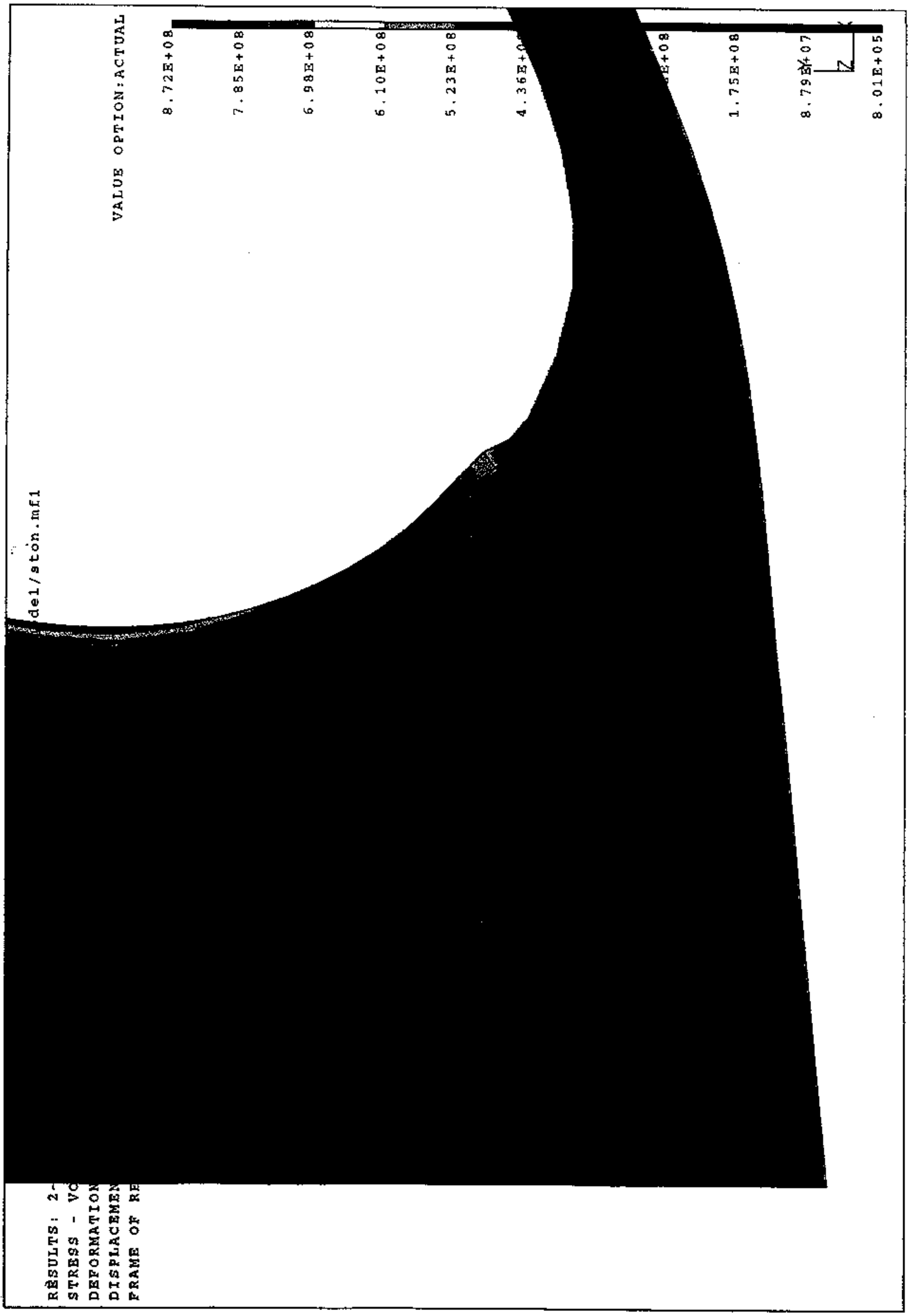

Figure 11. Load case 2, von Mises criteria stresses on deformed shape, zoomed view.

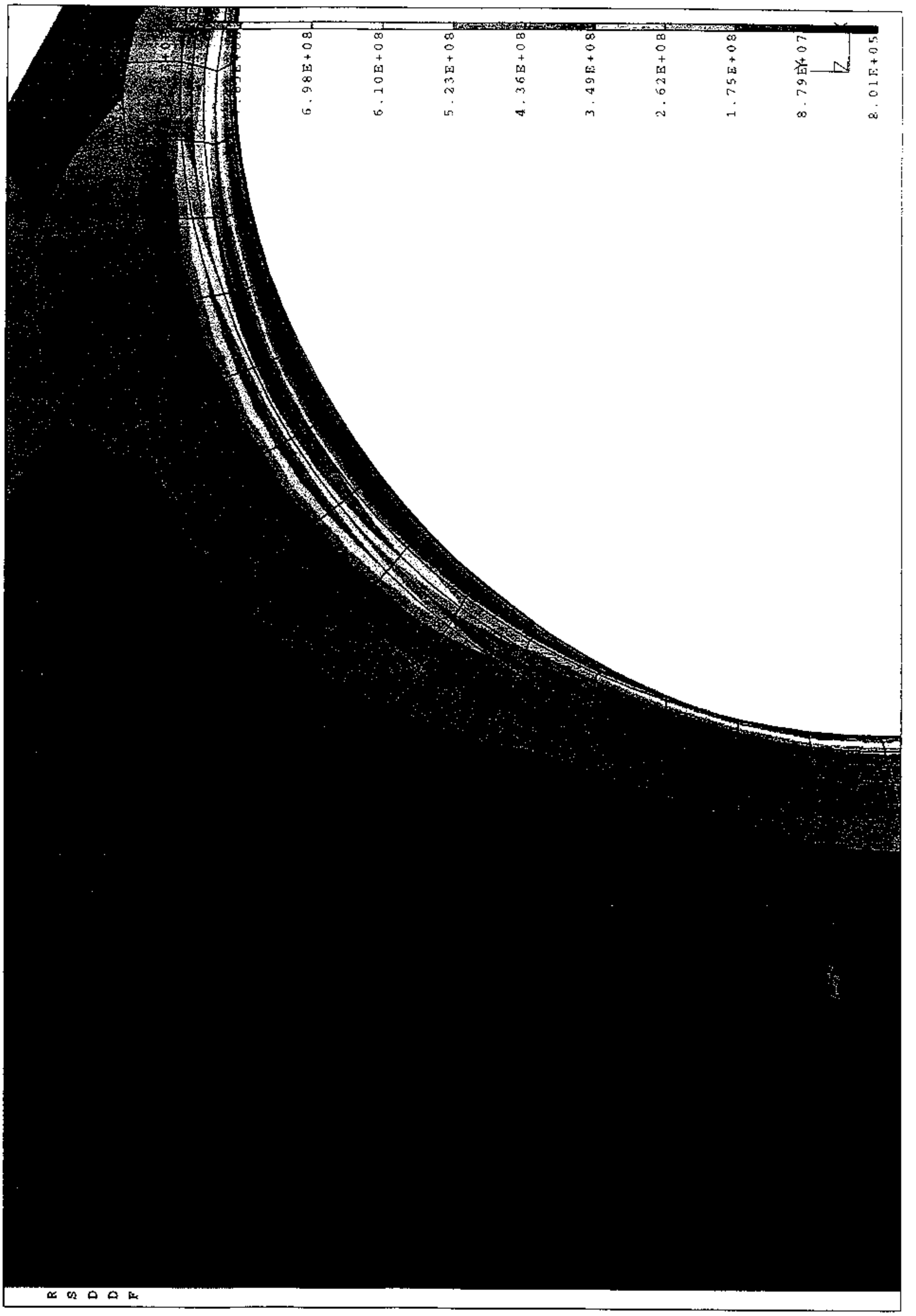

Figure 12. Load case 2, von Mises criteria stresses on deformed shape, zoomed view.