Report on Modelling of Strain Ring for 70HV

JMWB 08 November 1994

1.0 Summary

Geometry from the DXF file "90505sim.dxf" was used to create a 2D BEASY model. A set of loadings was selected to simulate application of torque. The initial model was automatically meshed and solved. Plots of stress error norm were used to successively refine the mesh, in two stages. The third model was accepted as "accurate enough". Note the refinement procedure and definition of acceptability would in production be made more sophisticated. Two strings of internal points were placed along the centre lines of the strain gauge arrays, to provide graph plots in those areas.

2.0 Reading the DXF files and manipulation of geometry.

The (new) BEASY utility program "dxf2out2d" takes straight lines, arcs and circles from a DXF file and creates a file of commands which will create the same geometry in the BEASY system.

The "90505sim.dxf" file, which contained section XX as well as the "circular" view of the strain ring, was processed and read into BEASY (See figure 1). The lines and points associated with the section XX were deleted.

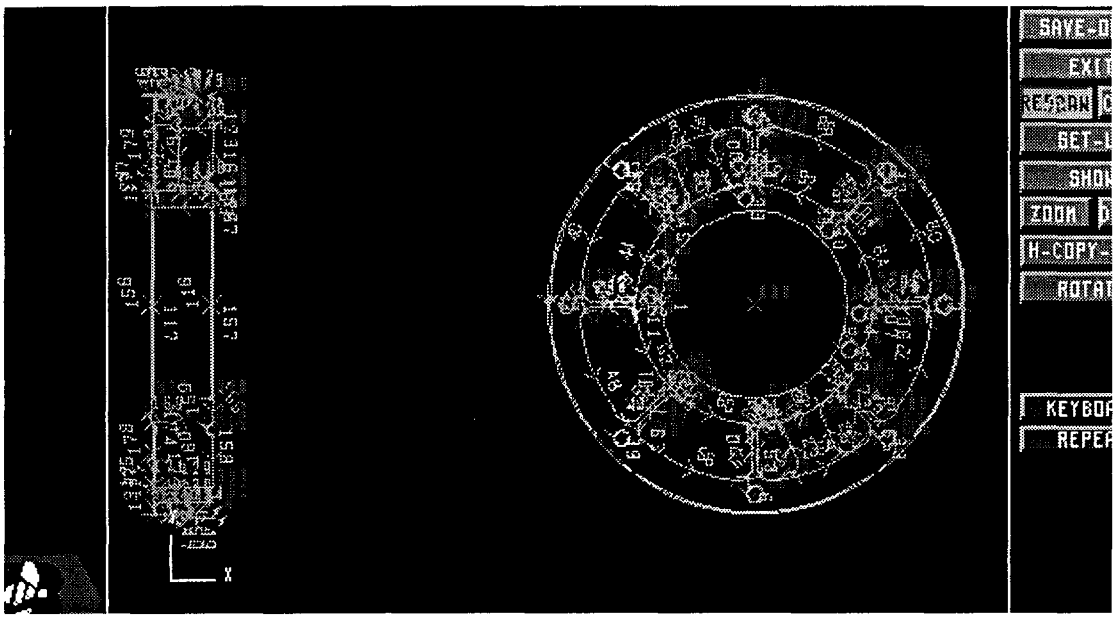


Figure 1: Geometry read from DXF file "90505sim.dxf"

A simple model of the complete ring (with constant thickness) was selected as appropriate for this study.

The arcs showing the reduced thickness near the strain gauges were removed, and new arcs created to complete the boundaries as necessary. Manipulation of the geometry was trivial, and mainly involved "joining the dots".

The BEASY "point merge" command was used, and then "line reverse" combined with "check direction" to make the line, arc and circle directions consistent from a BEASY point of view.

Two radial straight lines were added along the centre lines of the strain gauge arrays to simplify creation of internal points there. Figure 2 shows geometry at this stage.

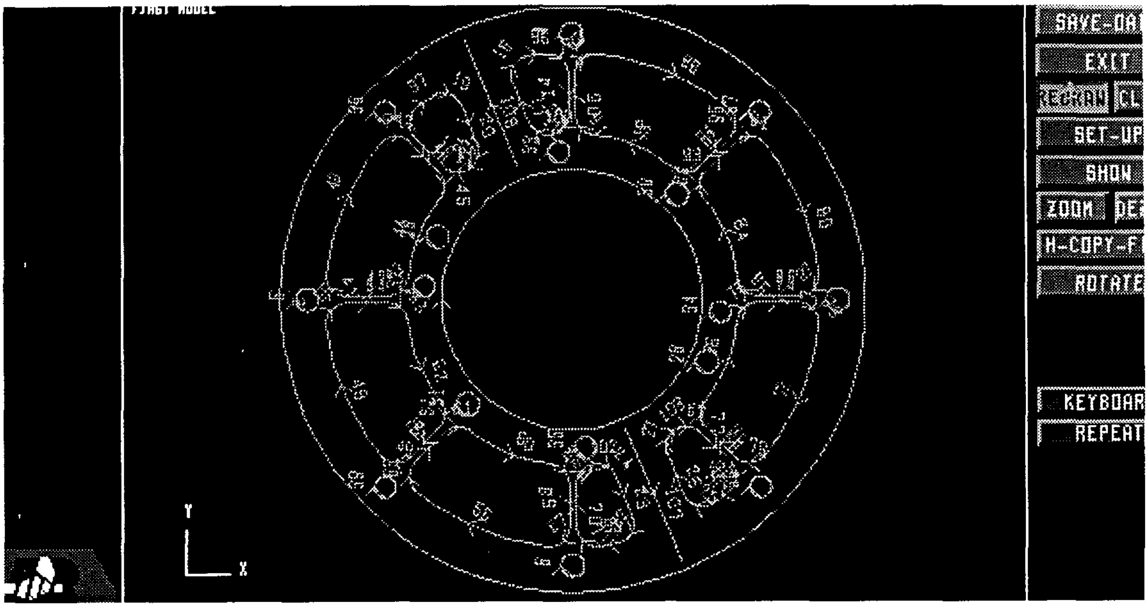


Figure 2: Geometry completed for BEASY modelling

3.0 Loading, Restraint and Properties

Loading was applied as a circumferential traction at the outside of the strain ring. The traction applied was 100 (per unit area).

Restraint was provided by "normal springs" at the surfaces of the inner 4 spring pin holes, and a circumferential spring stiffness around the inside of the strain ring. The "stiffnesses" were 21000 (per unit area).

Properties adopted were:

E = 210000

Poissons ratio = 0.3

The thickness of the plate was taken = 1.

4.0 Mesh Design

The BEASY "automesh" facility was used to create the mesh for model 1 in a single command. Figure 3 shows the completed mesh, with symbols indicating the location of the boundary conditions.

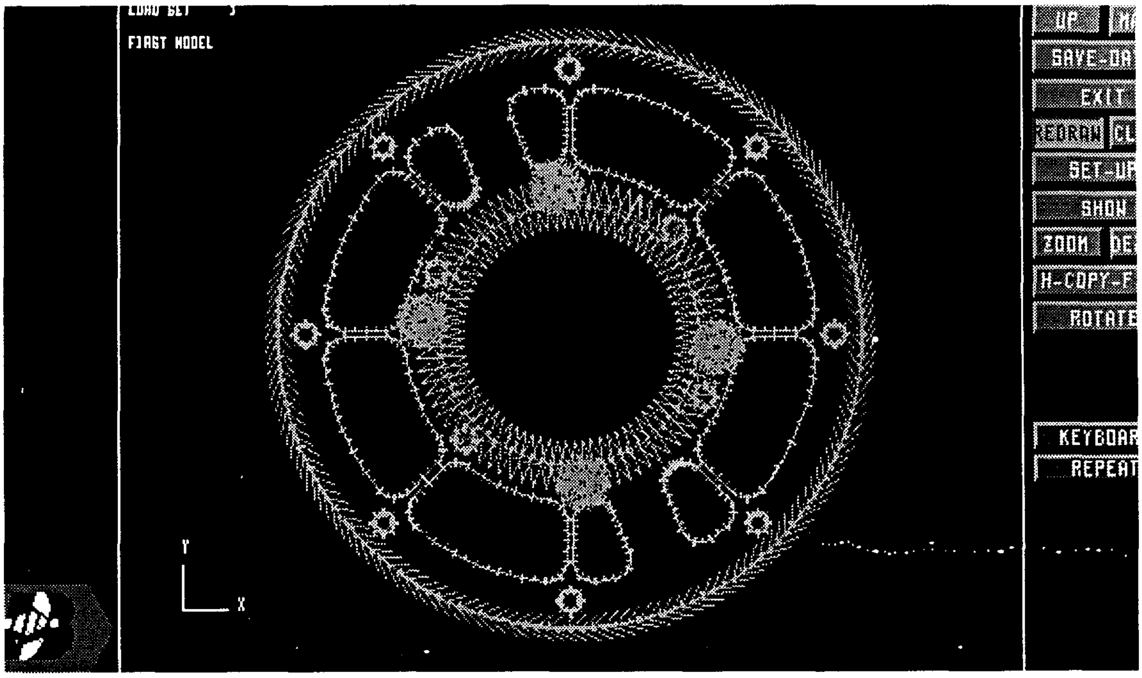


Figure 3: Mesh and boundary conditions

The first model was solved in 9 minutes on a (busy) RS6000, and results were available at 17:45pm on Monday 7th November, after I (JMWB) received the dxf files from Richard at 16:30pm on Monday 7th November.

The normal procedure was now followed to verify and refine the results. This involved a contour plot of "stress error norm" (see figure 4) to highlight areas most in need of refinement.

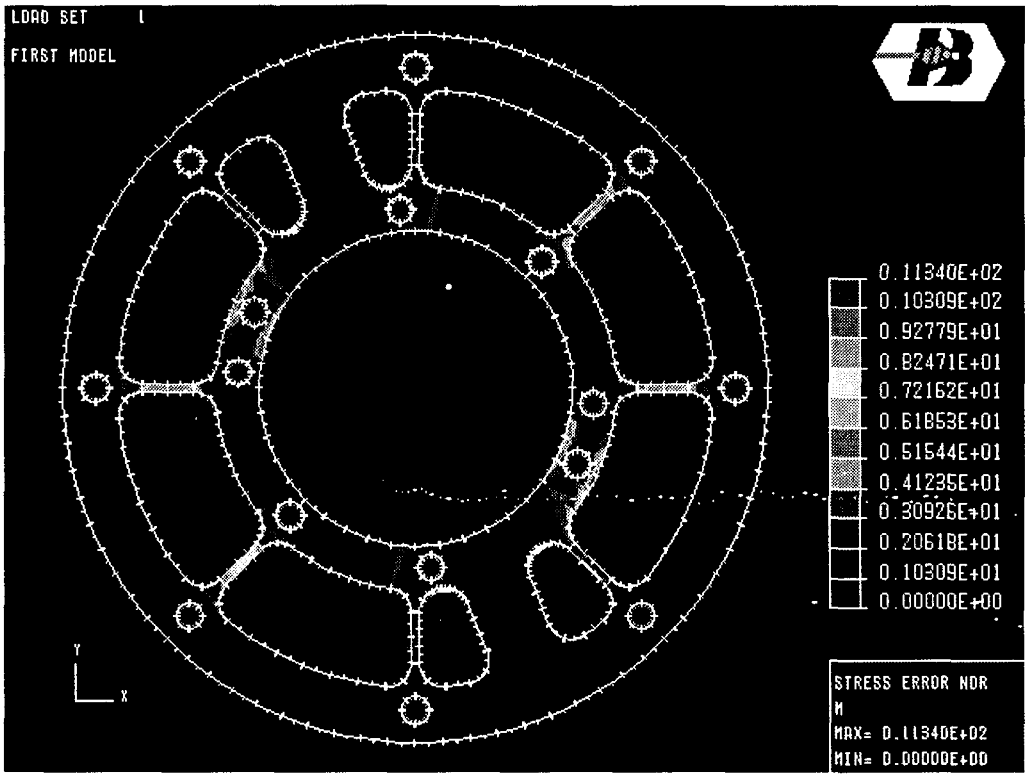


Figure 4: Stress error norm for model 1

Consequently the number of elements around the outer circumference was doubled. and the number of elements on the radial "ribs" was increased so that the elements were of similar size to the rib thickness. The second model was completed at 9:23 on 8th November, and results from it were available at 9:49am on 8th November.

The verification procedure was again followed (see figure 5). It is apparent that more care in preparing the second model could easily have removed the need for the third model! To create the third model, the number of elements around the (roughly 90 degree) fillets at each end of the ribs was increased to 4, and the number of elements around the inner circumference of the strain ring was increased. The third model was completed at 10:17am and results were available at 10:54am.

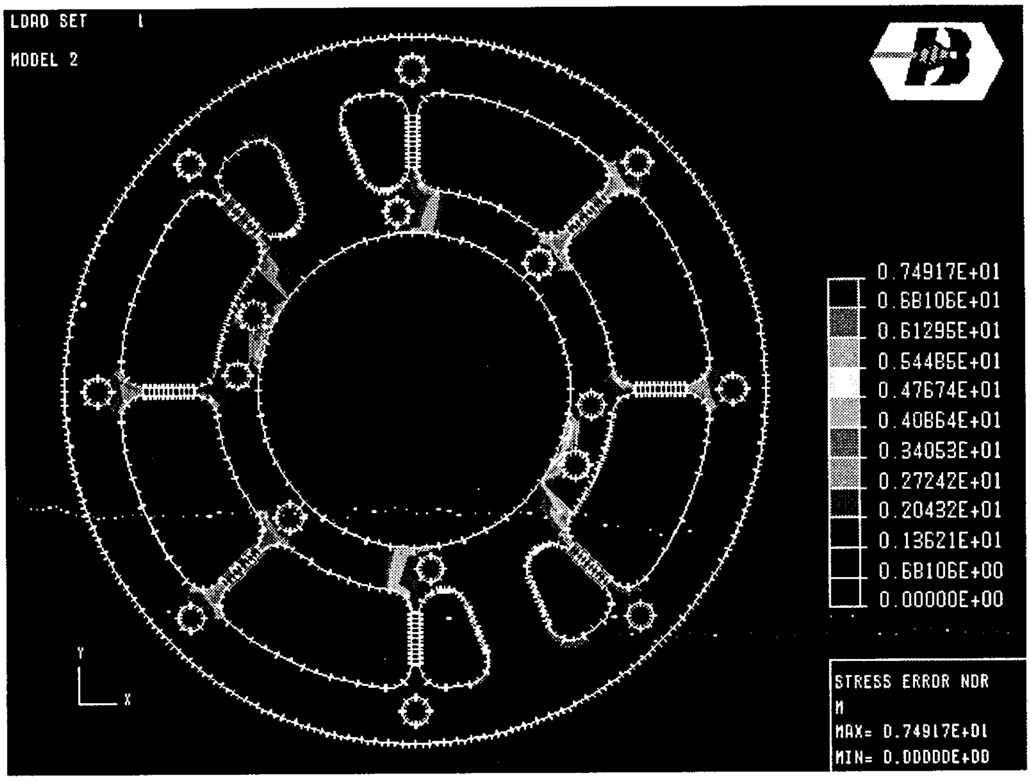


Figure 5: Stress error norm for model 2

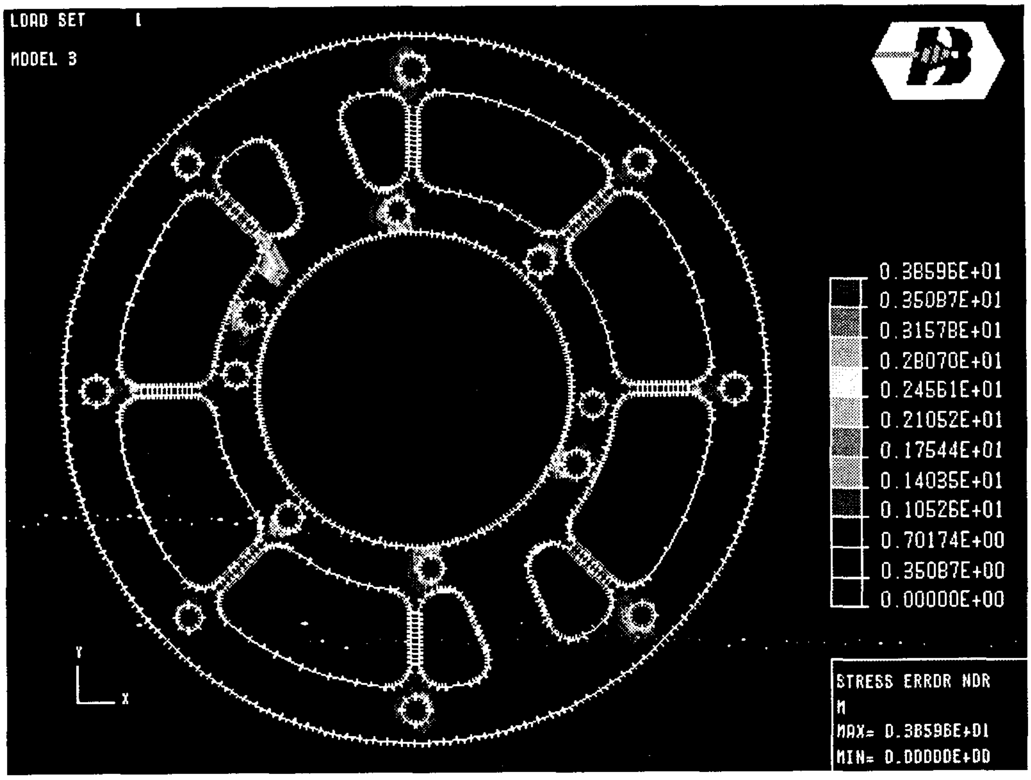


Figure 6: Stress error norm for model 3

In the third model the maximum stress error norm is 3.8 (see figure 6), and occurs at one of the fillets where a rib joins the "inner ring": where in fact the increase in the number of elements described in the previous paragraph had been carelessly not carried out!

Nevertheless, for this study the third model was deemed "acceptable".

A series of extra internal points were scattered around for contour plotting purposes.

5.0 Production Considerations

In production it is likely that a number of factors would be considered when performing modelling of the strain ring:

- Multiple zones with different thicknesses to represent the reduced thickness near the strain gauges.
- Application of part of the torque at the outer spring pin holes.

6.0 Consideration of the results

A series of plot are included with this report.

- Figure 7 shows the deformed and original shape for model 3
- Figure8 shows the mesh and location of the two strings of internal points in model 3
- Figures 9 and 10 show direct xx and direct yy stress variation along the strings of internal points
- Figures 11 and 12 show Von Mises stress on the exaggerated deformed shape.

The distortion of the rings (to non circular shape) is very evident in figure 7.

The rotation of the "thick rib" at top left appears to reduce stressing in the thin rib to its left, and to increase stressing in the thin rib to its right..

7.0 Conclusion

The BEASY modelling of the strain ring, taking geometry from DXF, is quick and easy.

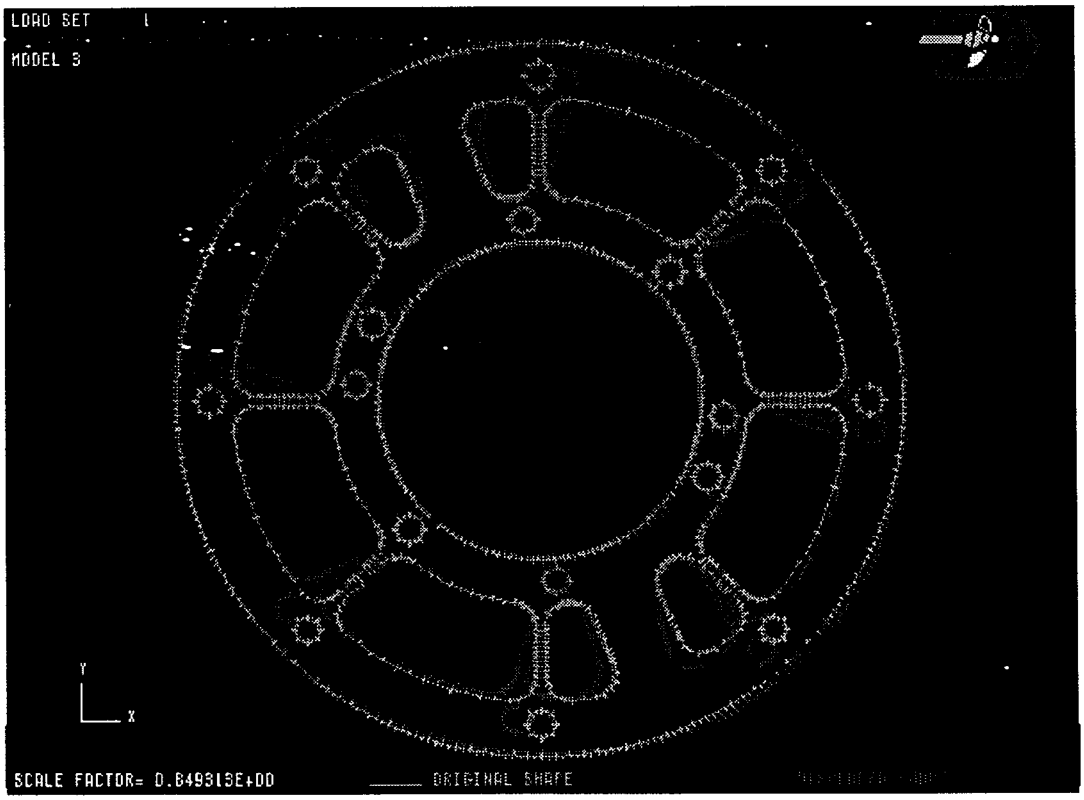


Figure 7: Exaggerated deformed, and original shape

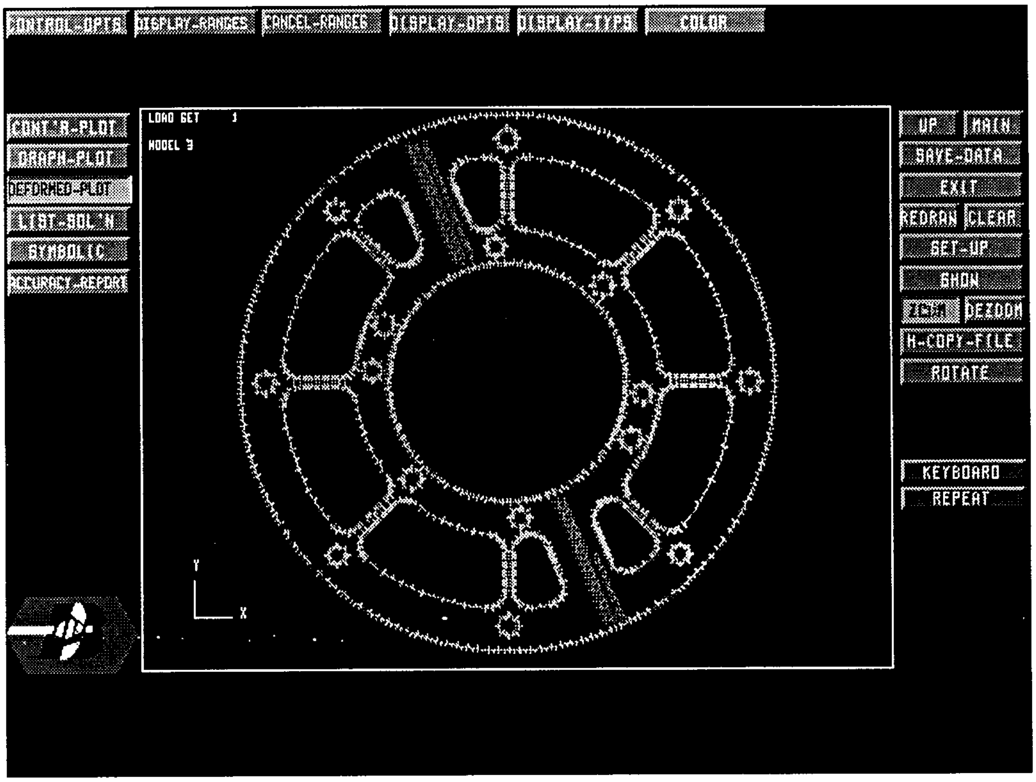
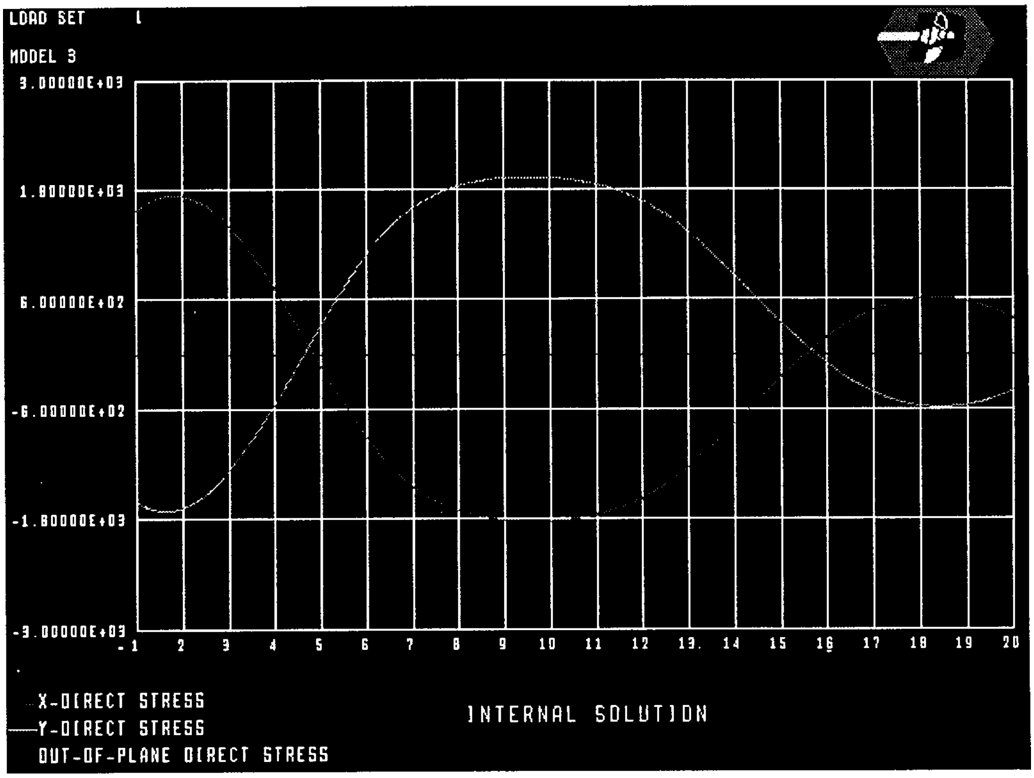


Figure 8: Showing strings of internal points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1.80000E+03
6.00000E+02
-6.00000E+02
-1.80000E+03
-3.00000E+03
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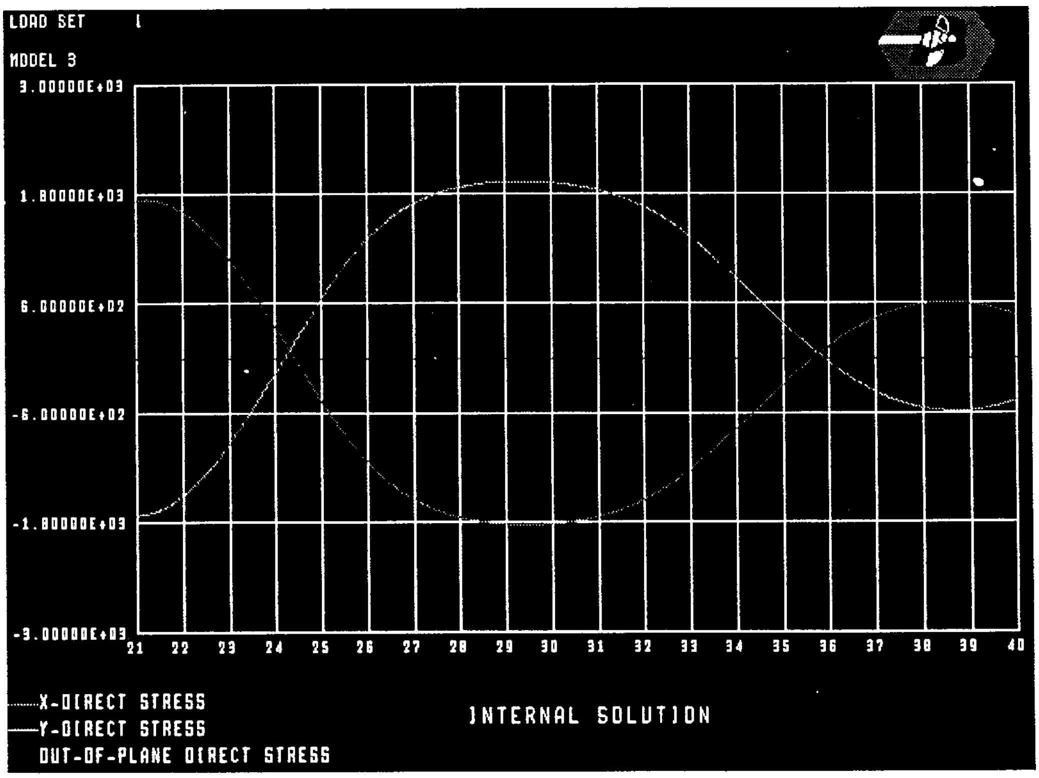
X-DIRECT STRESS
Y-DIRECT STRESS
OUT-OF-PLANE DIRECT STRESS
INTERNAL SOLUTION

Fig


LOAD SET 1
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X-DIRECT STRESS
Y-DIRECT STRESS
OUT-OF-PLANE DIRECT STRESS
INTERNAL SOLUTION

Figure 10: Direct stress along internal points at top left

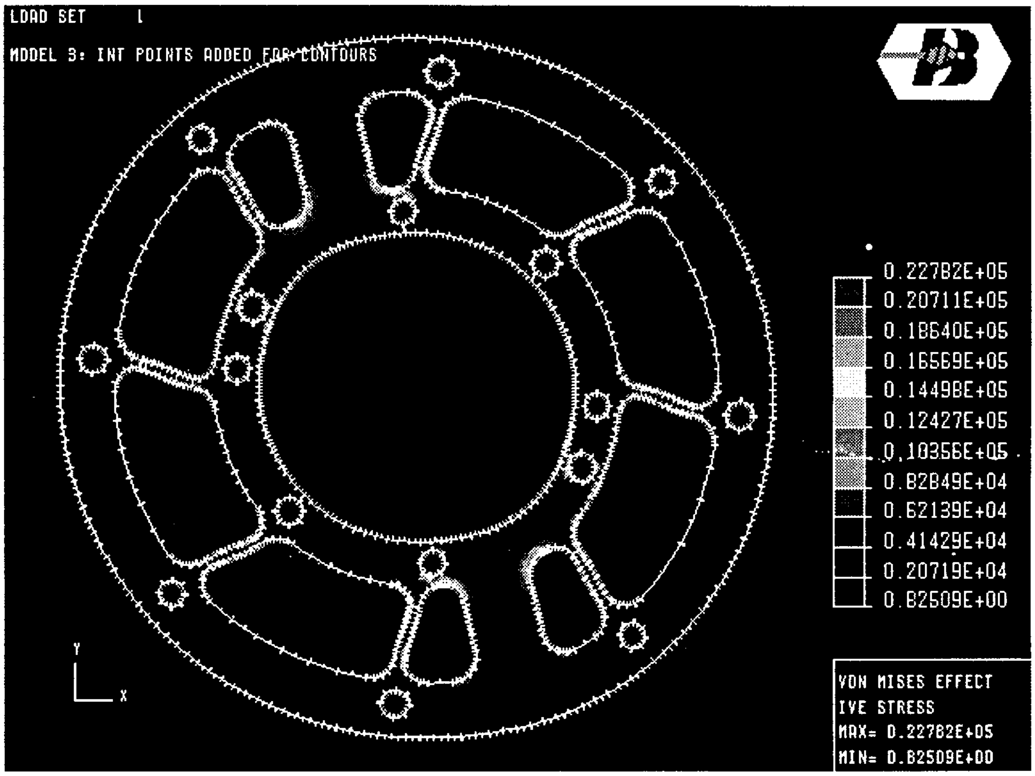

Figure 11: Von Mises stress on exaggerated deformed shape

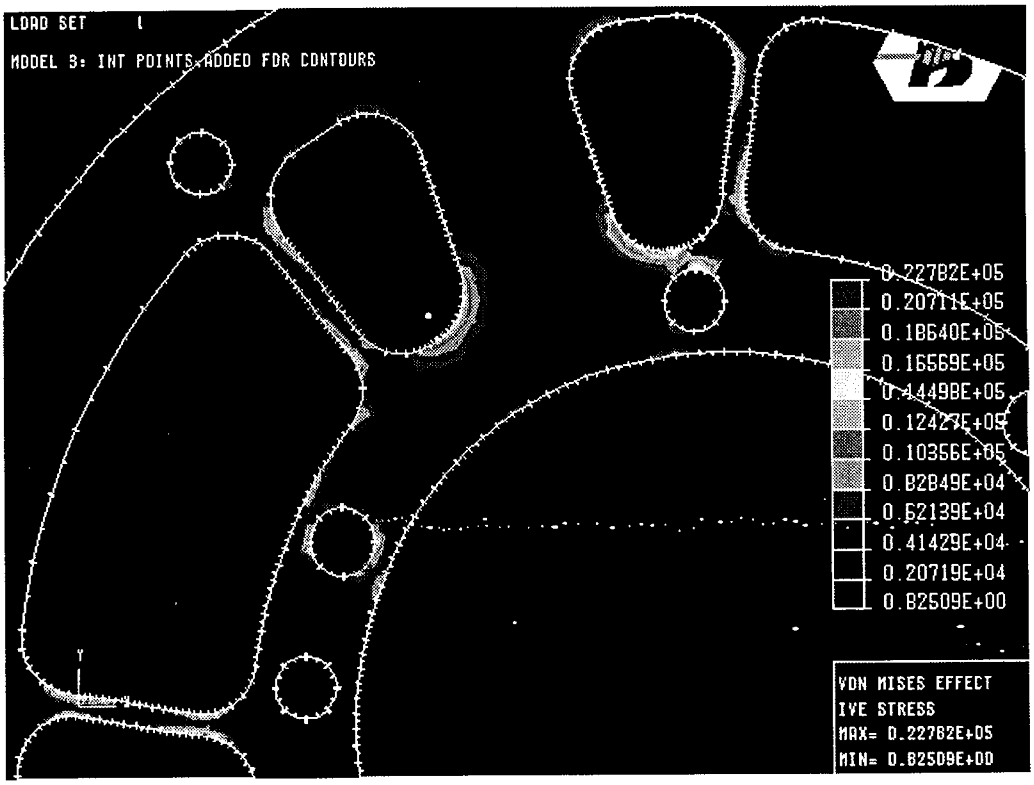

Figure 12: Von Mises stress (detail)