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Fermilab

TS-SSC 91-191
10-2-91
E. Haggard

Finite Element Analysis of Yoke, Skin, and Tooling Using Ansys

Finite element modeling and analysis of the yoke - skin - tooling interface using the SSC short model yoke and skinning press as a test bed is presented. Four models are included in this analysis. They are listed below.

Model #1: Complete press using 2-d elements with depth option. No friction allowed in gap elements. Press load: 5800 lb/in. No deflections applied due to thermal contraction of weld.

Model #2: Complete press using 2-d elements with depth option. Friction allowed in gap elements, Friction Coeff = .74 for steel on steel wo/lubrication. Press load: 5800 lb/in. No deflections applied due to thermal contraction of weld. Should simulate loading of the press before welding.

Model #3: Complete press using 2-d elements with depth option. Friction allowed in gap elements, Friction Coeff = .74 for steel on steel wo/lubrication. Press load: 5800 lb/in. Deflections applied due to thermal contraction of weld of 0.00214". Attempts to simulate a first pass weld.

Model #4: Complete press using 2-d elements with depth option. Friction allowed in gap elements, Friction Coeff = .74 for steel on steel wo/lubrication. Press load: 5800 lb/in. Deflections applied due to thermal contraction of weld of 0.004109". Attempts to simulate a third pass weld.

Analysis

The plots which follow are in a cylindrical coordinate system with the origin at the center of the cold mass. The values on the azimuthal stress plot are usually positive due to the direction in which the plot path command (which produced these graphs) was described. Therefore, distance is always from the vertical axis. The data is taken at the center of the skin to try to eliminate local bending effects.

Model #1, plot 1 (upper skin) & 2 (lower skin), show azimuthal skin stress in the frictionless tooling case. The model shows oscillation between positive and negative skin stresses between 27 and 75 degrees from horizontal. The largest spikes occur at 46 degrees from horizontal. This is due primarily to the large vertical force acting in this area. The bulk of the vertical support for the cold mass occurs in this area by design.

Model #2, plot 3 (upper skin) & 4 (lower skin), show the azimuthal skin stress tooling with friction model. The model shows well defined skin tension with a negative peak at 38 degrees of -4833 psi for the lower skin. The skin is being stretched azimuthally from 54 to 90 degrees and again from 23 degrees to the end. The skin is being compressed azimuthally from 23 to 54 degrees from horizontal.

Model #3, plot 5 (upper skin) & 6 (lower skin), show the case of tooling with friction, also with deflections applied to the ends of the skin of 0.00214". The model again shows well defined skin tension with a peak at 5 degrees. The maximum azimuthal stress is 23.7 ksi in the lower skin and 6.6 ksi in the upper skin. The lower skin is being stretched azimuthally over the entire length. The upper skin is still being compressed azimuthally in the region near 40 to 60 degrees from horizontal. The model shows that the skin between 90 and 45 degrees from horizontal is relatively isolated due to friction. This model attempts to simulate a first pass weld.

Model #4, plot 7 (upper skin) & 8 (lower skin) show the frictional tooling case with deflections applied to the ends of the skin of 0.00419". The skin stress peak is again at 5 degrees from horizontal. The maximum azimuthal stress is 39 ksi in the lower skin and 21 ksi in the upper skin. The highest equivalent stress occurs in the upper skin with a maximum stress condition of 41 ksi. The model again shows the isolation due to friction. The increase in skin tension from model #2 to model #4 from 60 to 90 degrees is approximately 500 psi to 1600 psi or triple in the lower skin. The upper skin shows an increase from 560 psi to 600. This model attempts to simulate a third pass weld.

The model uses 2-d stif 42 isoparametric solid with depth option (Plot #9 and #10). The depths are 6 inches for all sections of the model except the upper and lower beam flanges (.75" deep) and the upper and lower cross beams (3.75" deep). The gap elements are stif 52 with interference input as a real constant for all gaps. The model simulates the maximum material condition which has an interference in the spring arm section of the viking hats of slightly less than 0.007". The frictional coefficient for all applicable models is .74 . The modulus of stainless is 2.99 E +07 and Poissons ratio is .300 . The thermal contraction is applied via the displacement command and was calculated using the coefficient of thermal expansion of 9.9 x 10^-6 and a temperature rise of -2500 degrees F. Model #3 uses a characteristic length of .086" while model #4 uses a length of .166". I do not claim to have the magnitude of the thermal stresses exactly correct. Some adjustment should be made for the thermal expansion of the skin. [1] This would increase the skin stress and should be looked at further. Also, the removal of some viking hats in the long model press would exaggerate the effects of friction in that particular tooling. Removal would increase the normal force, increasing friction, further isolating the skin from 45 to 90 degrees from the horizontal. Analysis on the collaring press[2] showed a ± 6% (from nominal) pressure distribution due to linear spacing of the hydraulic cylinders. This effect is probably exaggerated in the long press with cylinder spacing of 18". This could increase the local stresses in sections directly under a cylinder.

Distribution:

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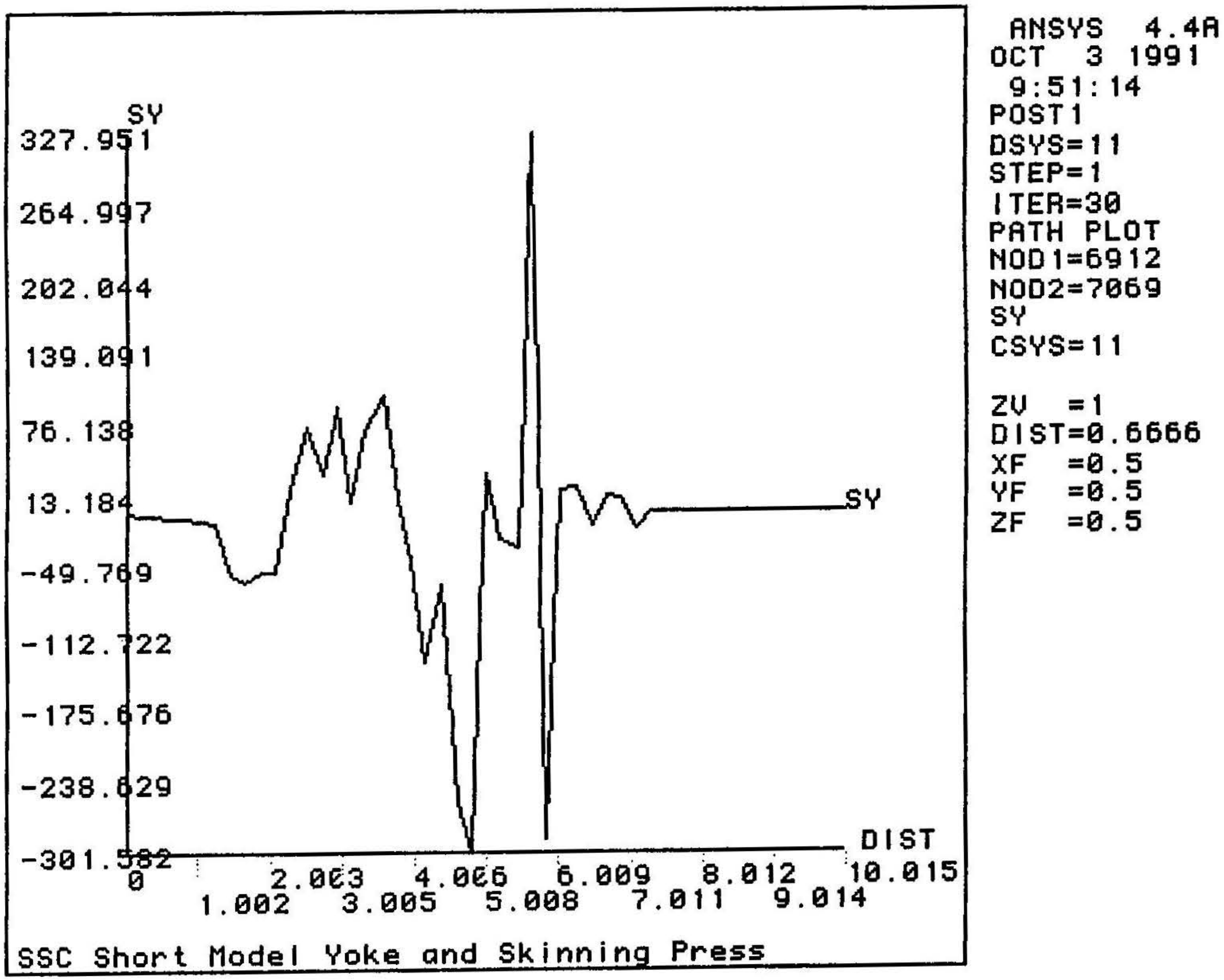
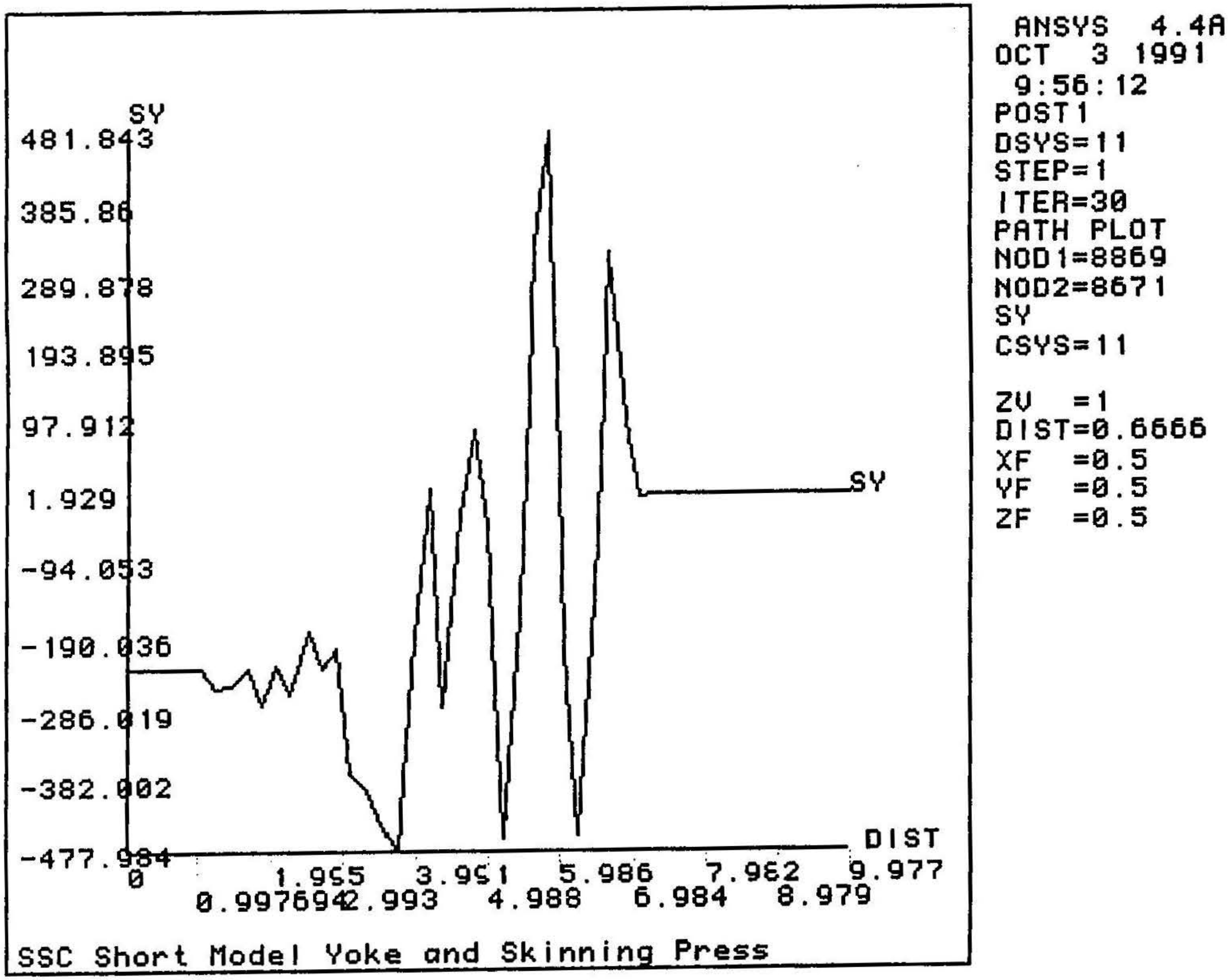
1 Conversations with Jim Strait and TS-SSC 91-184,"DCA313 Shell Gauge Data During Welding",Jim Strait

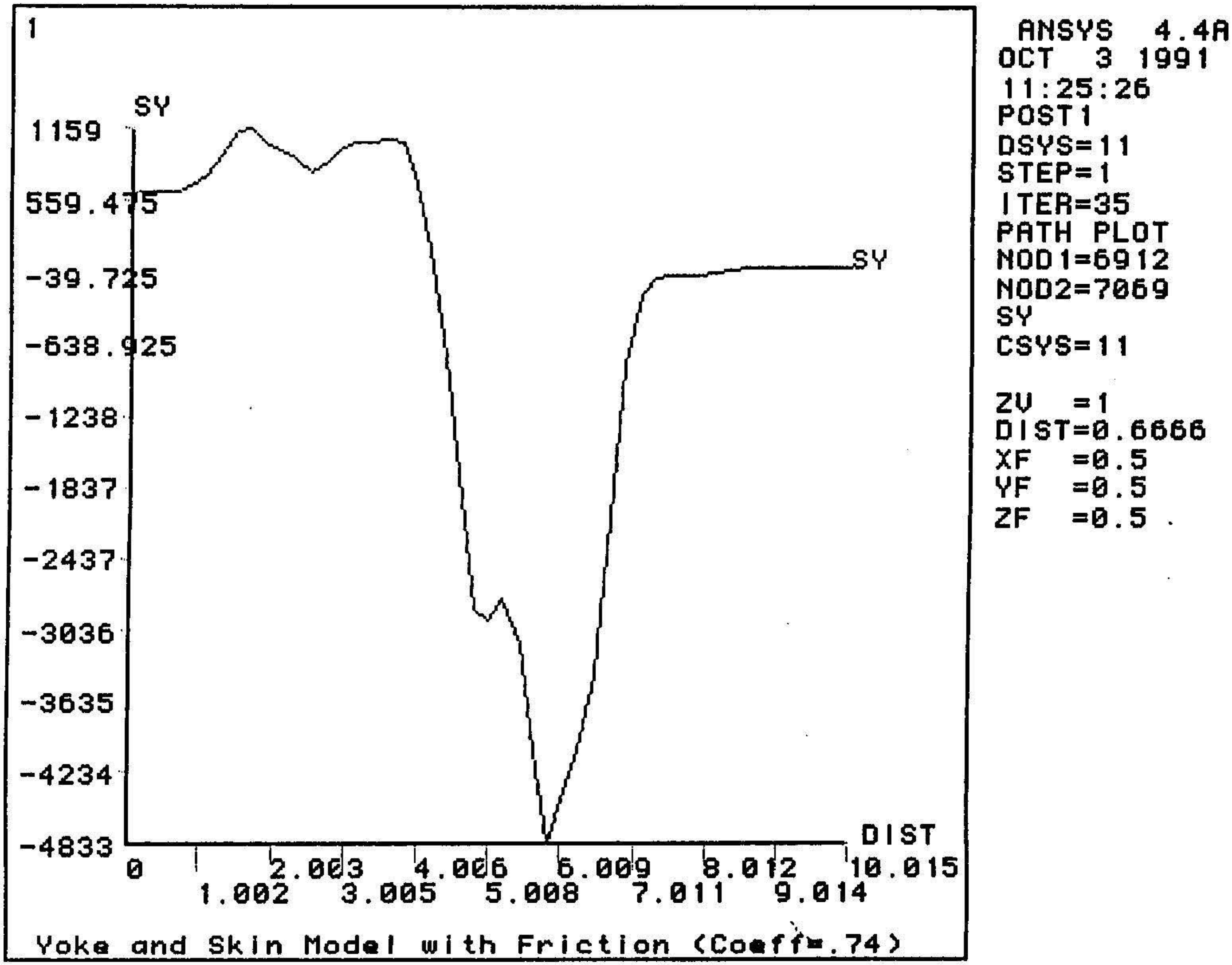
2 Notes from Collaring Press Design Review (see chairperson, Tom Nicol),1991



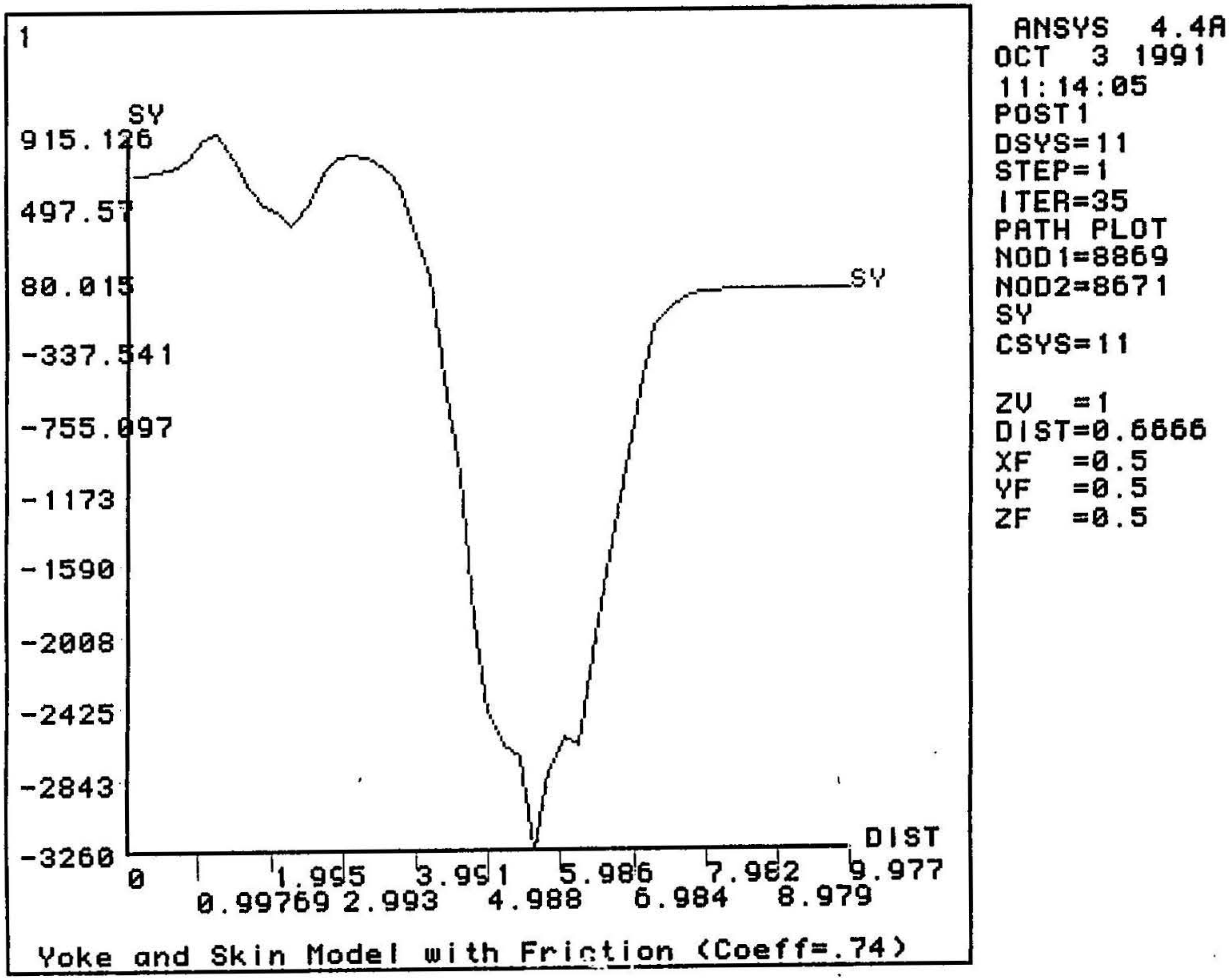
Plot #1 Azimuthal Skin Stress In the Frictionless Case Upper Skin



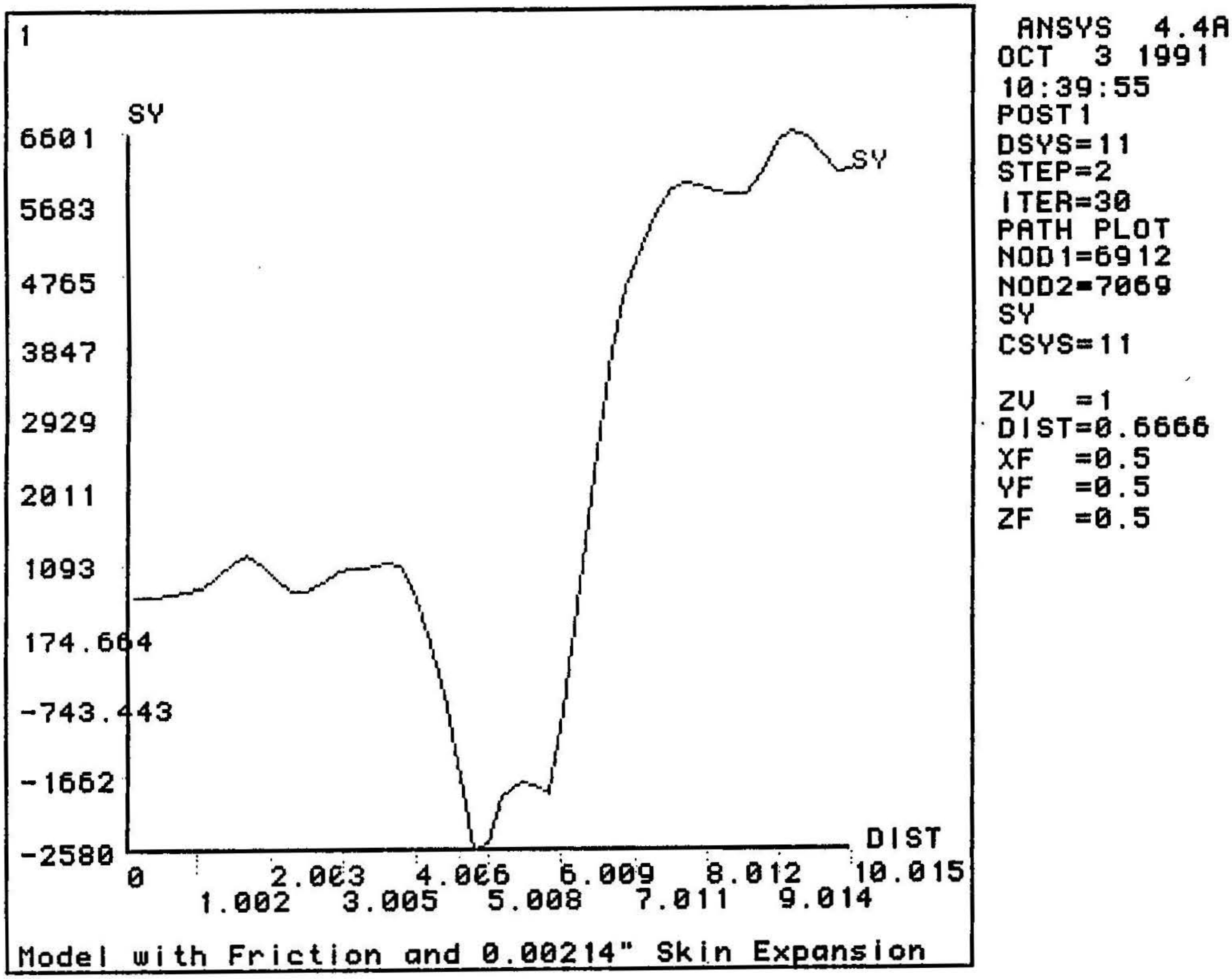
Plot #2 Azimuthal Skin Stress In the Frictionless Case
Lower Skin



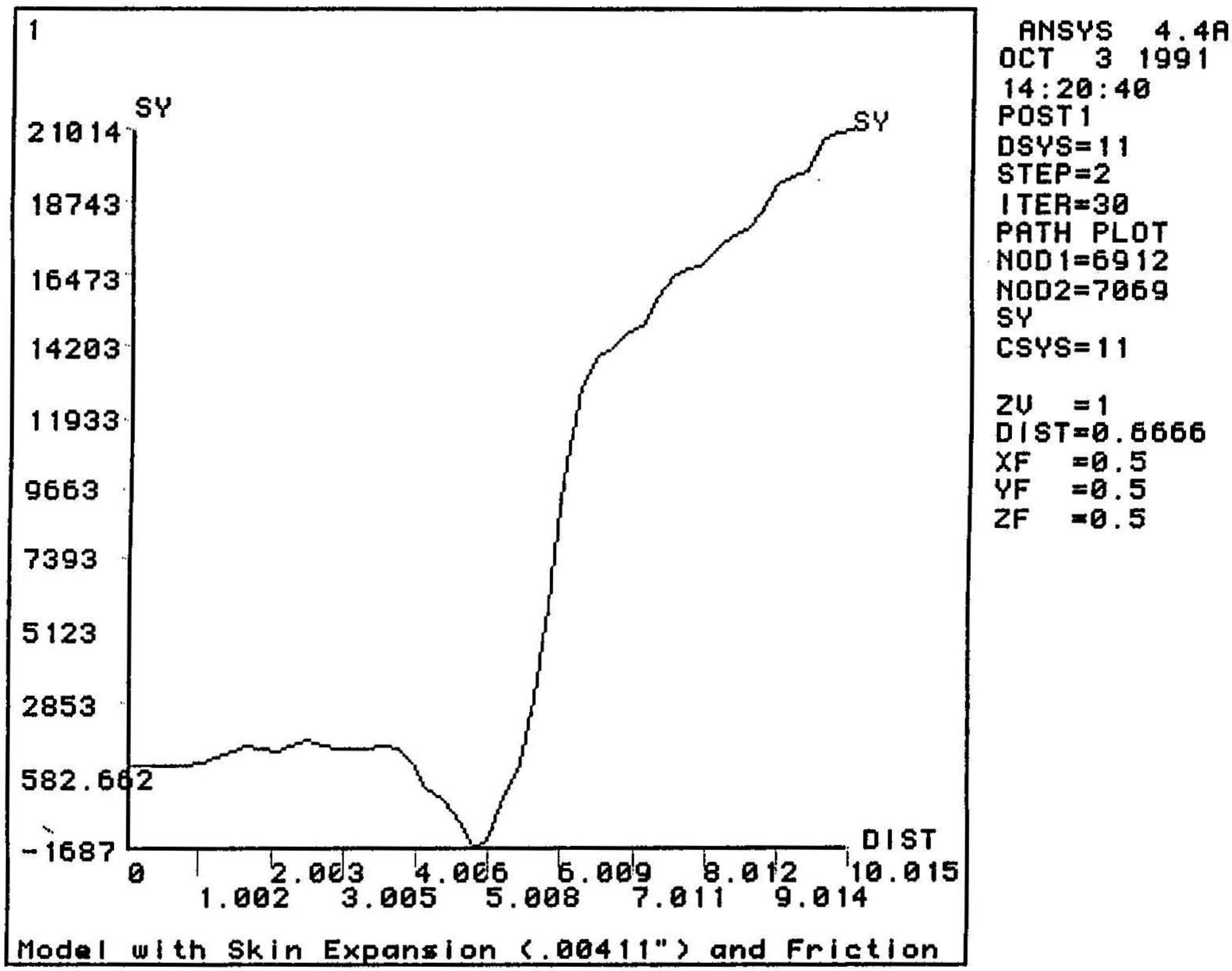
**Plot #3 Azimuthal Skin Stress In the Tooling w/Friction Model
Upper Skin**



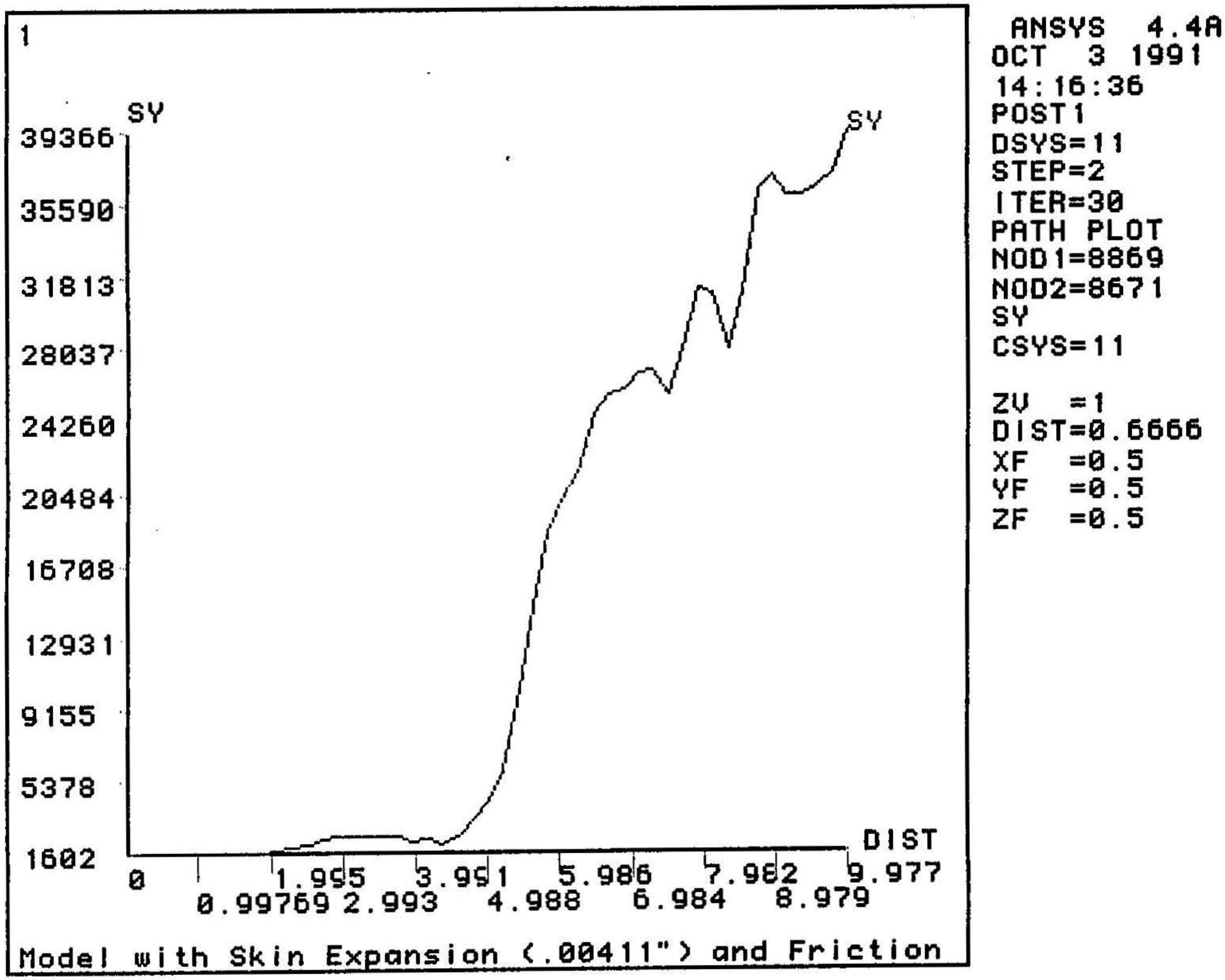
Plot #4 Azimuthal Skin Stress In the Tooling w/Friction Model
Lower Skin



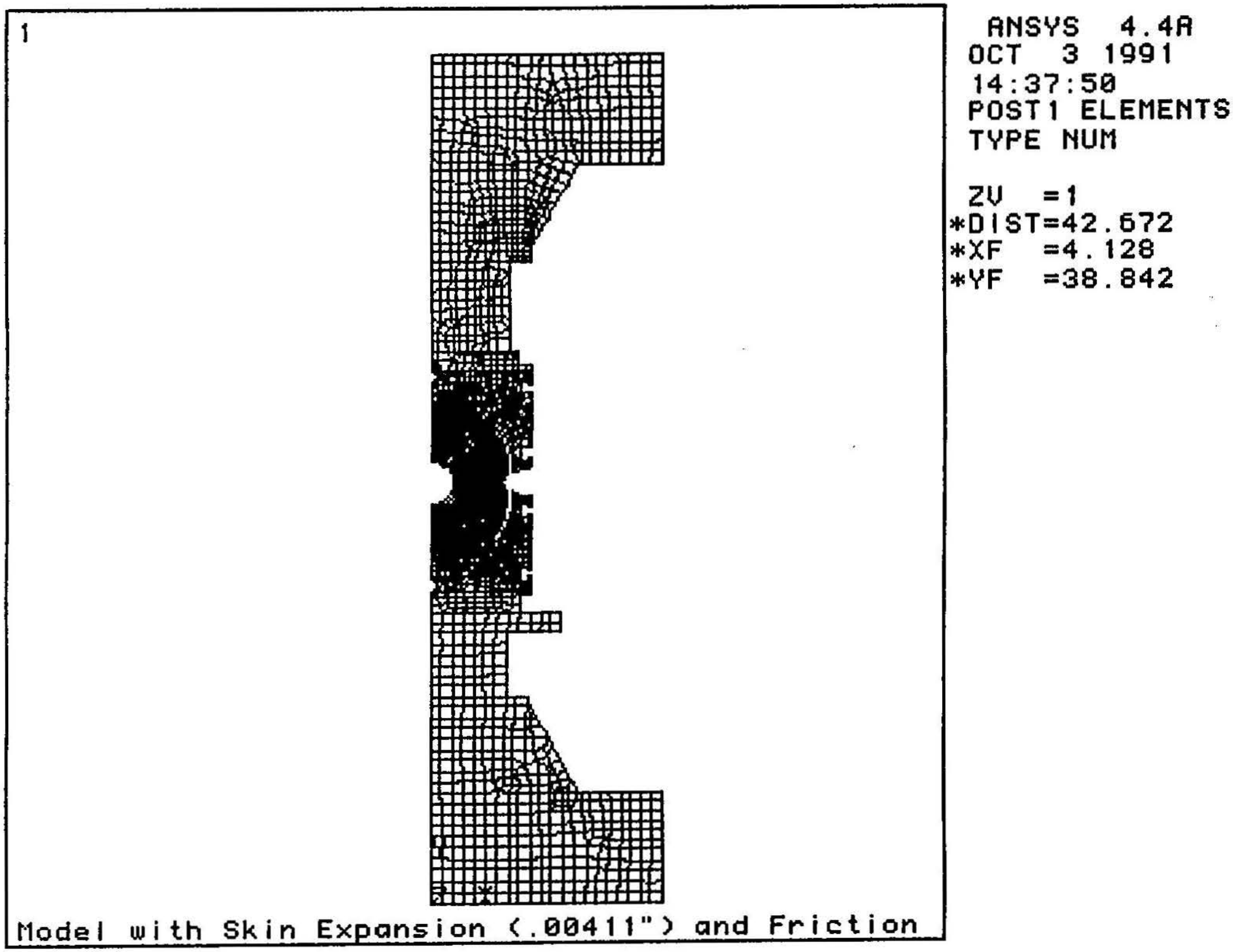
Plot #5 Azimuthal Skin Stress In the Tooling w/Friction and 0.00214" Deflection Model Upper Skin



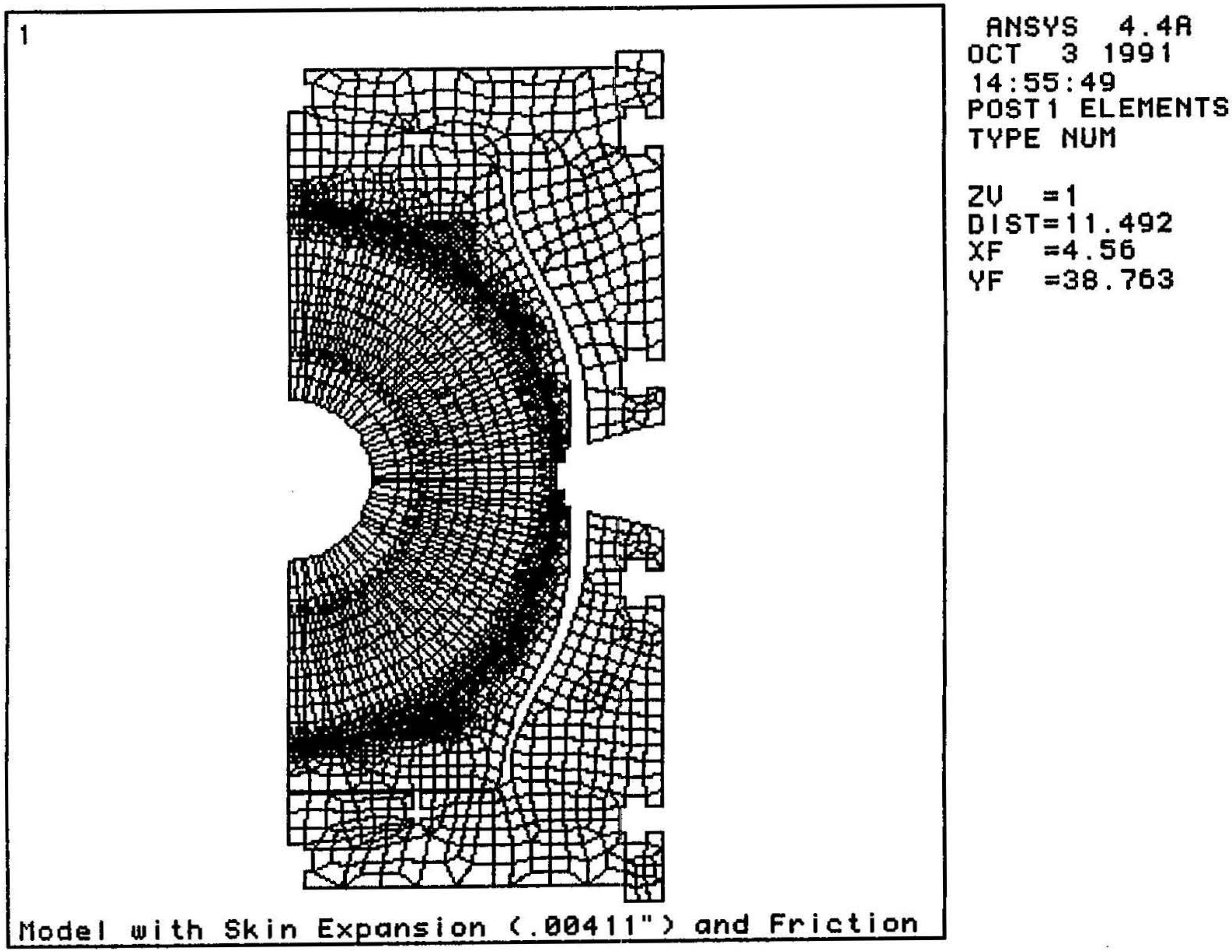
Plot #7 Azimuthal Skin Stress In the Tooling w/Friction and 0.00411" Deflection Model Upper Skin



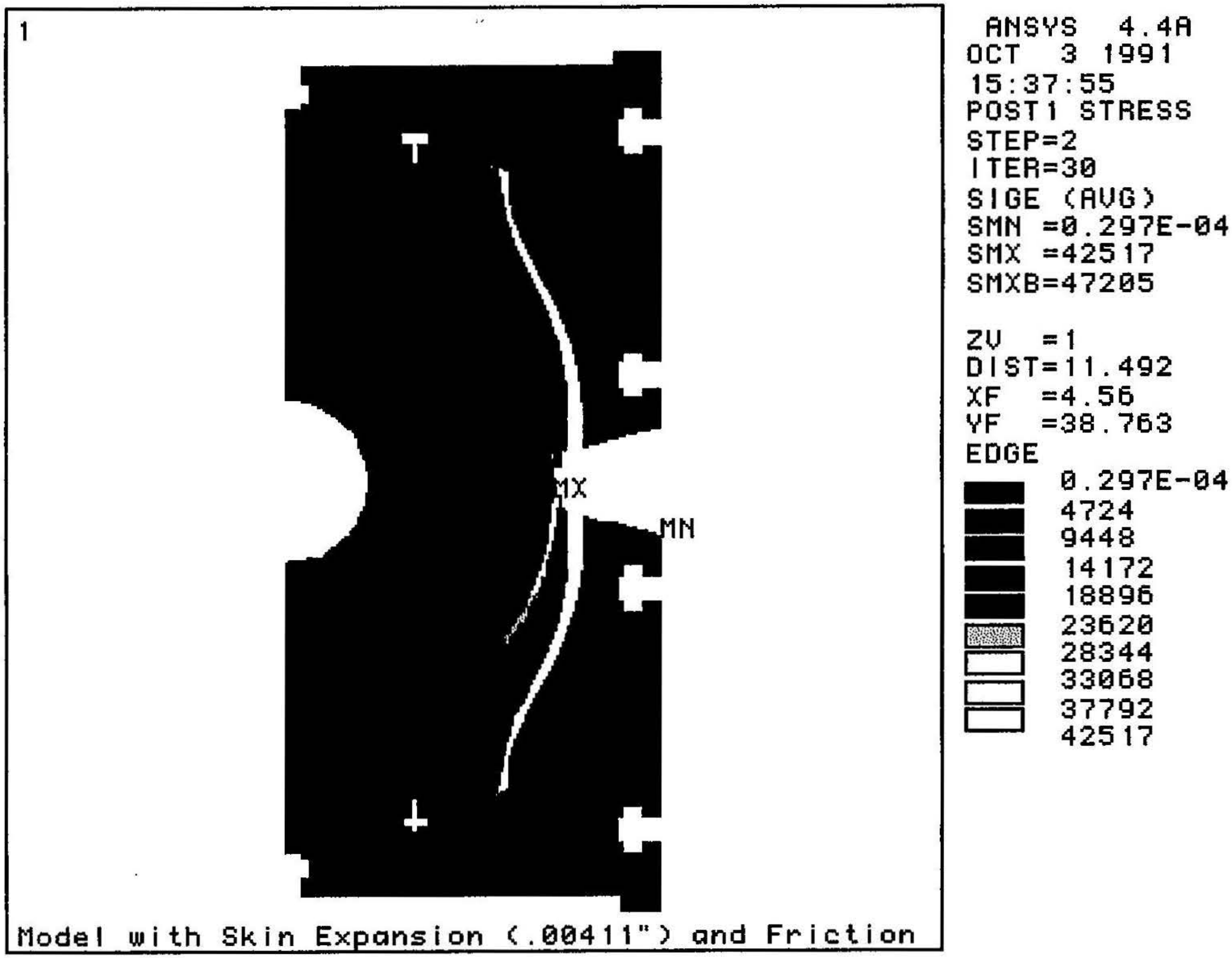
Plot #8 Azimuthal Skin Stress In the Tooling w/Friction and 0.00411" Deflection Model Lower Skin



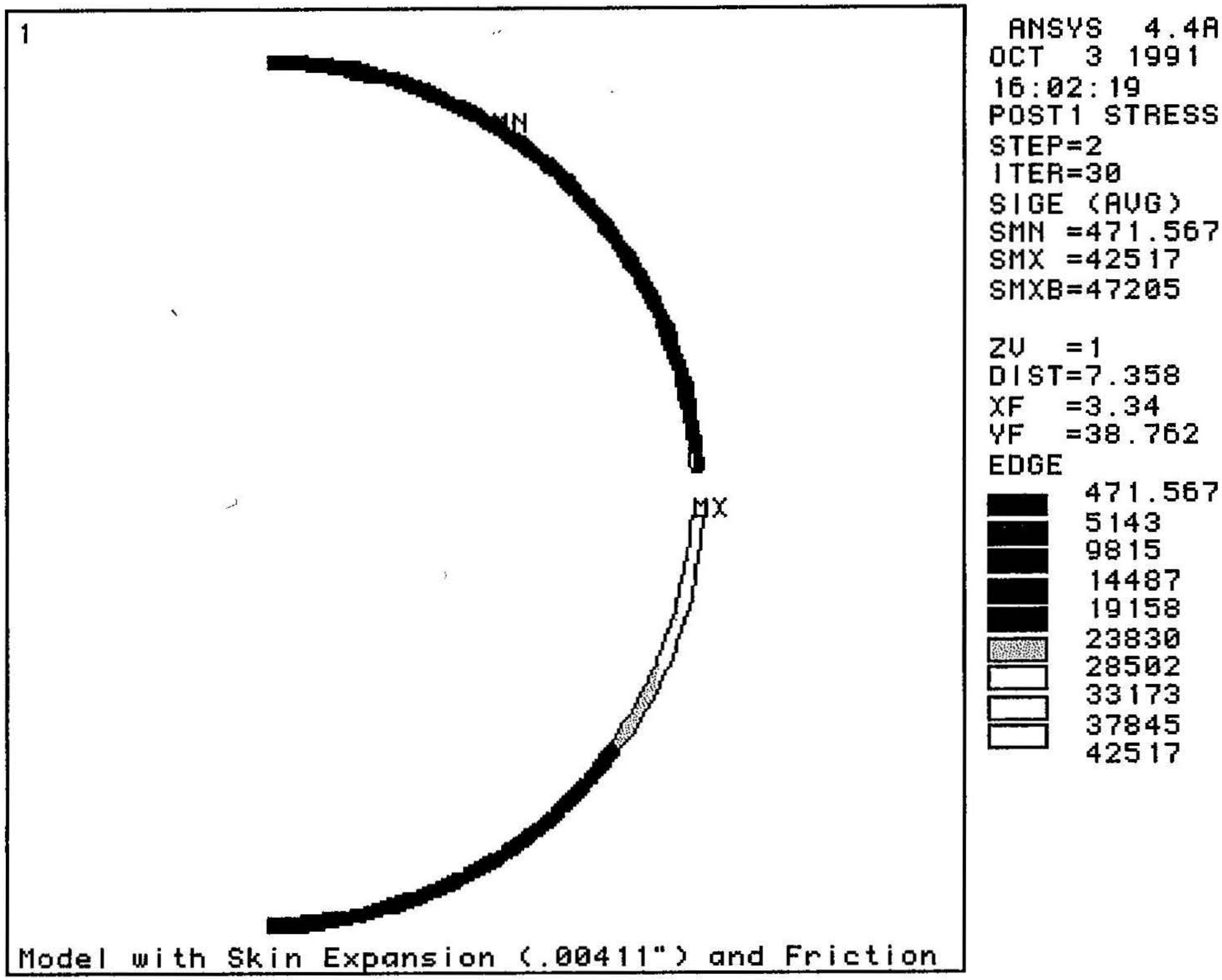
Plot #9: Model of SSC Short Model Yoke and Skinning Press



Plot #10: Tooling Mesh Detail



Model with Skin Expansion (.00411") and Friction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SMX =42517
SMXB=47205
ZV =1
DIST=7.358
XF =3.34
YF =38.762
EDGE
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14487
19158
23830
28502
33173
37845
42517
Model with Skin Expansion (.00411") and Friction