MEG 795 Special Topics: Energy Methods II

Simulation of Blast Loaded Composite Pressure Vessel Using LS-DYNA

(Open Cylinder and AT595 Container Model)
(Type-1 Lagrange Conwep)

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Objectives

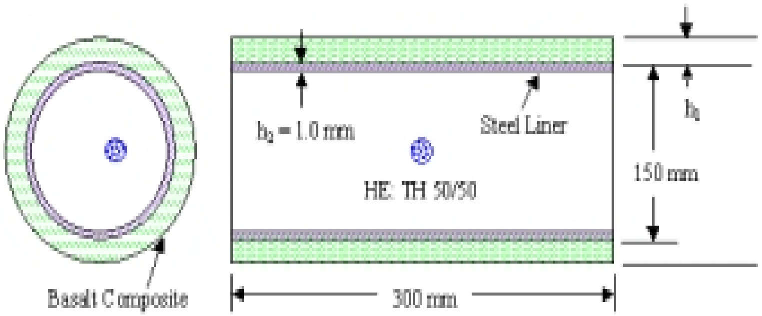
- The primary objective of this study is to minimize the effect of impact blast in pressure vessels and safe transportation of the high explosive materials.
- To study the response of blast loaded composite cylinder with a inner steel liner,and to compare the results from FEA with the experimental results.

The parameters of interest

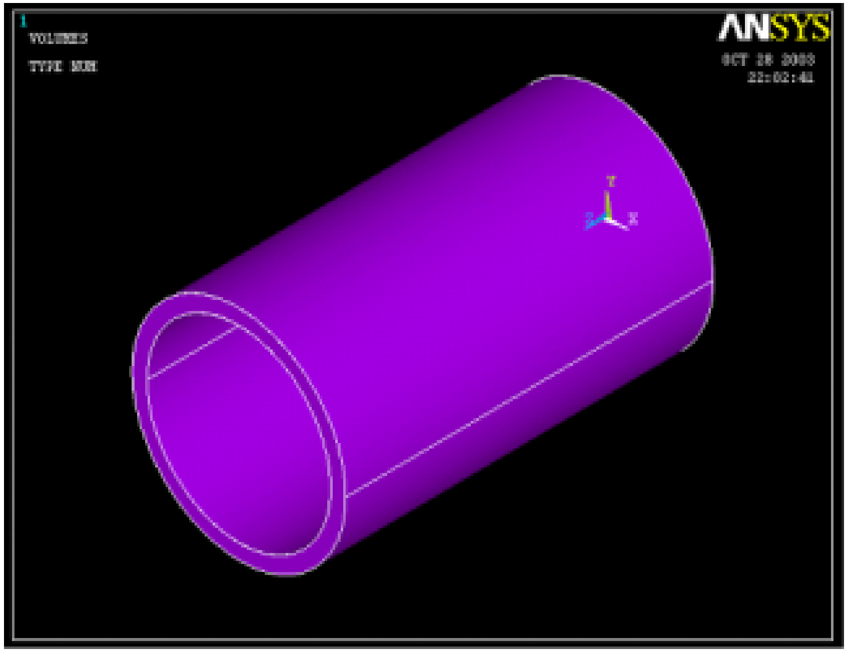
- Peak Tensile Strain in the circumferential direction: ϵ_1
- Peak Compressive Strain in the circumferential direction: ϵ_2
- The time to reach the peak tensile strain in the circumferential direction: τ_1
- Peak Tensile and Compressive Strain in the longitudinal direction: ϵ_3
- Radial oscillation fundamental tone period: T
- The peak circumferential strain rate: $d\epsilon_1/d\tau$

Modeling

- The model,open ended cylinder is modeled using Ansys.
- The outer diameter of the cylinder is 86.1mm and the inner diameter is 75 mm
- There is inner steel liner of 1 mm thickness



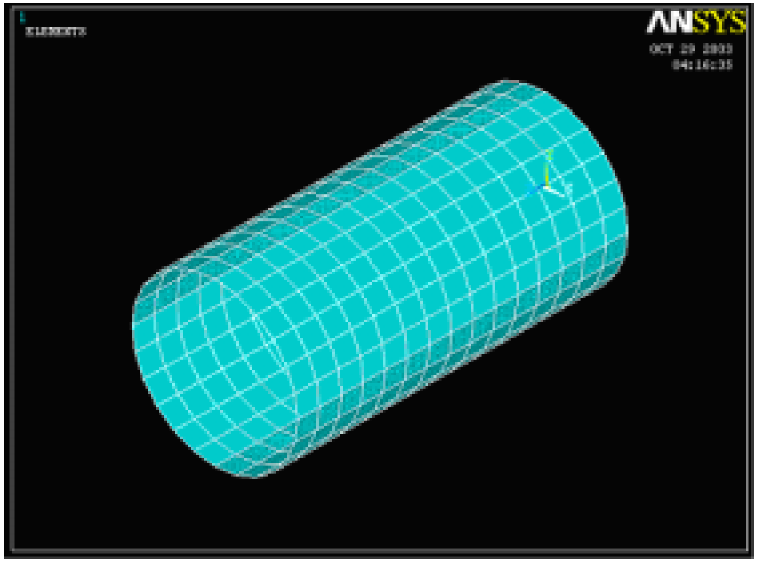
Ansys Model



Meshing Technique

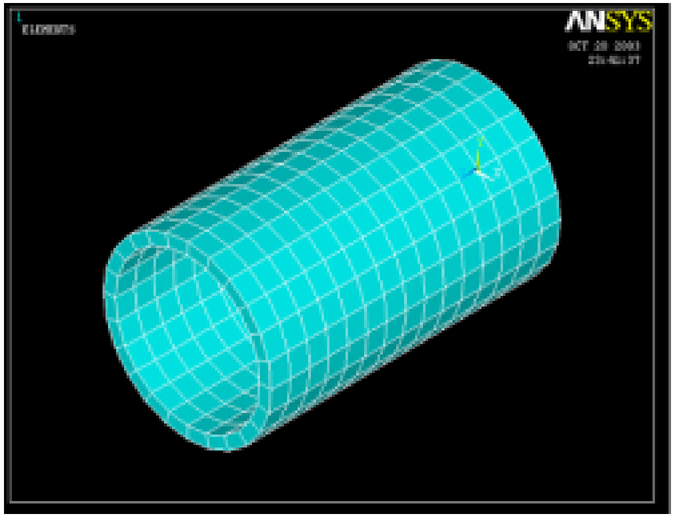
- The model was simulated for two different environments.
- First with composite cylinder meshed as solid elements and inner steel liner as shell elements.
- Second, with both composite cylinder and inner steel liner as solid elements.

Meshed Model



The model showing meshing of shell elements

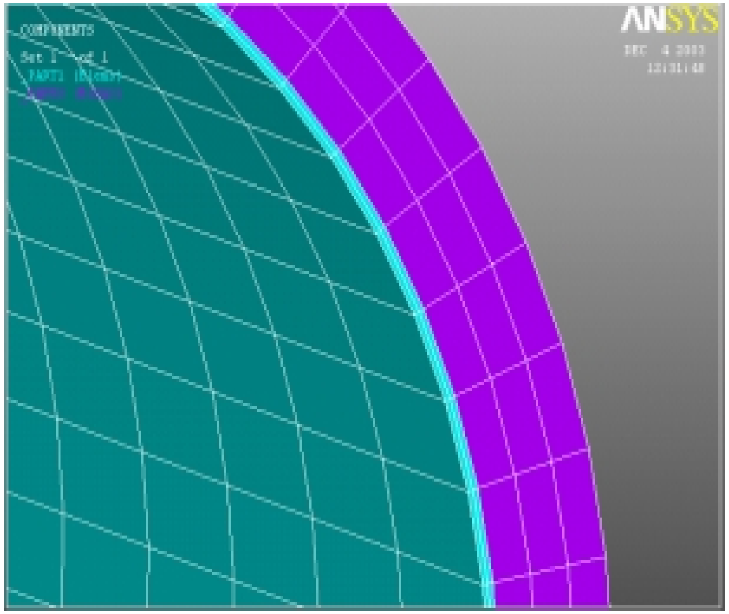
Meshed Model



Meshed model showing uniform square grid containing both shell and solid elements

Improved Mesh

- The mesh is remeshed for more elements in the thickness direction,to see the impact of blast on the outer cylinder.
- There are three elements in the thickness direction.



Material properties

Element Type	Material Models	Material Properties
Solid 164 (outer composite cylinder)	Linear Orthotropic	E_x = 15.44 GPa E_z (thickness direction) = 14 GPa **E_y = 48.54 GPa** **G_{xy} = 6.645 GPa** **G_{yz} = 3 GPa** **G_{xz} = 3 GPa** **ν_{xy} = 0.098** **ν_{xz} = ν_{yz} = 0.3** Density = 2.06 g/cm^3
Shell 163(Inner Steel Liner)	Linear Isotropic	Density = 7850 kg/m^3 E=200Gpa ν=0.3

NOTE:

The SI units were used consistently throughout the input deck: Length [m], Mass [kg], Time [ms], Density [kg/m^3], Modulus [GPa] and Strength [GPa]

Control cards
For Environment - 1

- In order to model the blast effects in Ls-dyna,conwep function is used.
- Following three control cards are essential to invoke conwep function:**LOAD__BLAST ,LOAD_ SEGMENT or LOAD_SHELL or and LOAD_SEGMENT_SET.**

Control cards (contd.)

```
*LOAD_BLAST
$ WGT XBO YBO ZBO TBO IUNIT ISURF
$---+----1----+----2----+----3----+----4----+----5----+----6----+----7-
---+----8
   0.05198         0         0      0.15         0         2         2
```

```
*LOAD_SHELL_SET
$(Defines which shell to apply *LOAD_BLAST)
$---+----1----+----2----+----3----+----4----+----5----+----6----+----7-
---+----8
$      SID      LCID         SF         AT
       999        -2         -1          0
```

```
*SET_SHELL_LIST_GENERATE
$---+----1----+----2----+----3----+----4----+----5----+----6----+----7-
---+----8
$      SID       DA1        DA2        DA3        DA4
       999
         1       768
```

Control Cards For Environment -2

- The control cards used in case of both solid elements are LOAD__BLAST , LOAD_ SEGMENT and LOAD_SEGMENT_SET.

- LOAD_SEGMENT is obtained by applying pressure on the surface on which the blast will be created, this is done in hyper mesh .

Load Segment

Denotes the segment on which pressure is applied.

```
*LOAD_SEGMENT
        -2    -1.000     0.000         2         1        15        16
        -2    -1.000     0.000      2028      2027         1         2
         -         -         -         -         -         -         -

         -         -         -         -         -         -         -

         -         -         -         -         -         -         -

        -2    -1.000     0.000       784       783      2000      1999
        -2    -1.000     0.000      2055       784      1999      1953
```

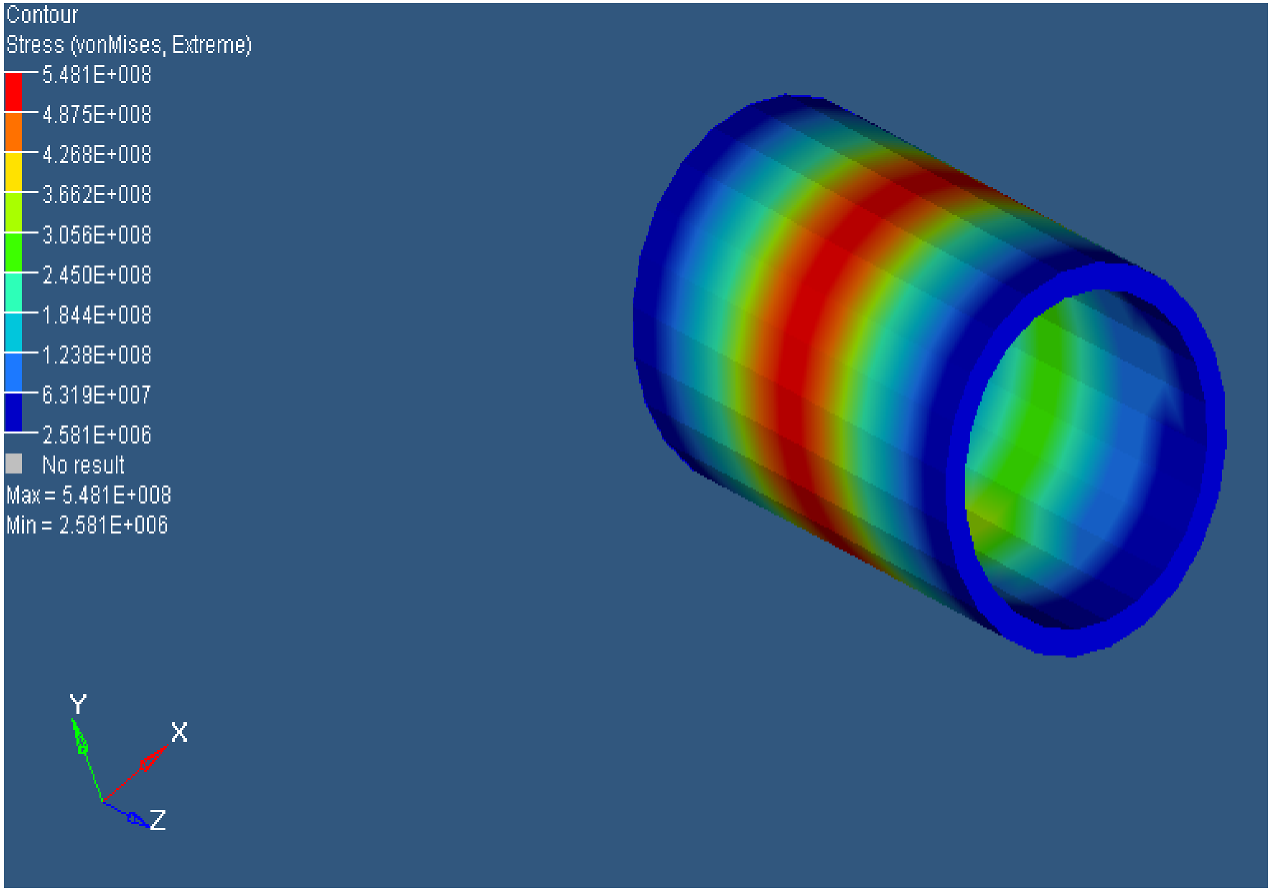
Blast Card

```
*LOAD_BLAST
$      WGT        XBO        YBO        ZBO        TBO      IUNIT      ISURF
    .05198          0          0       0.15          0          2          2
$      CFM        CFL        CFT        CFP
```

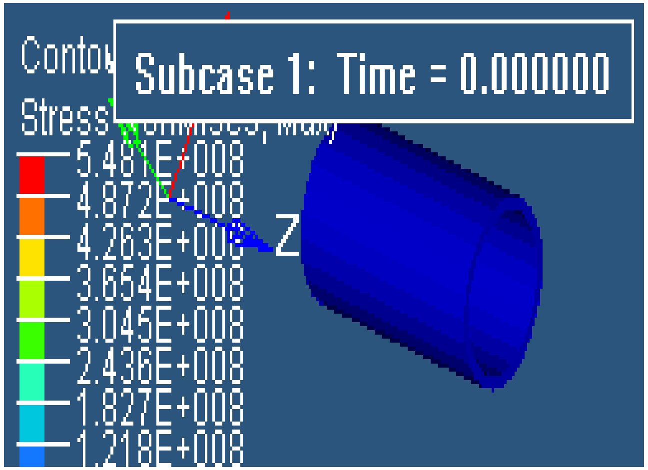
Blast Material

- The actual blast material used is a combination of HE & TH
- TNT equivalent of HE is =Correction factor*mass of HE
- Correction Factor used =1.13
- Mass of HE = 46.0 grams

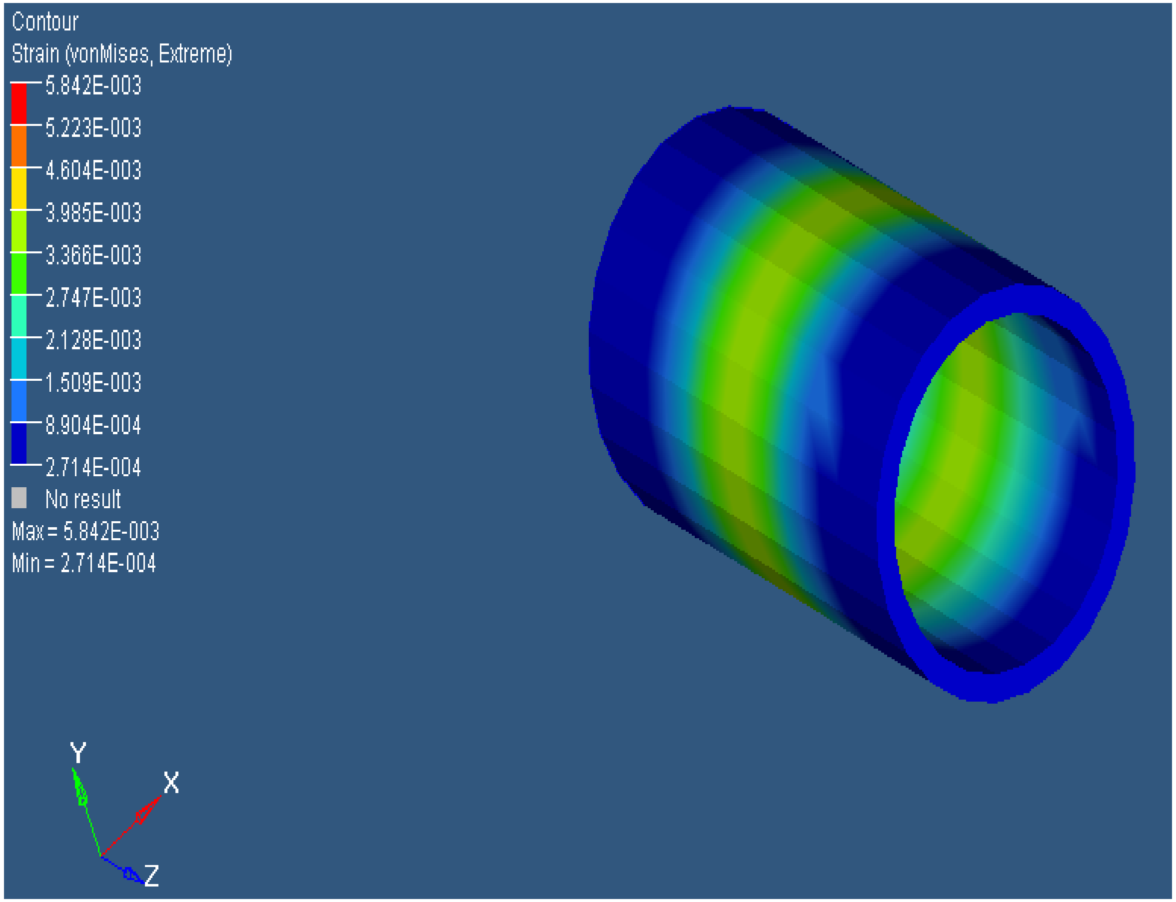
Stress Contours Enivronment-1



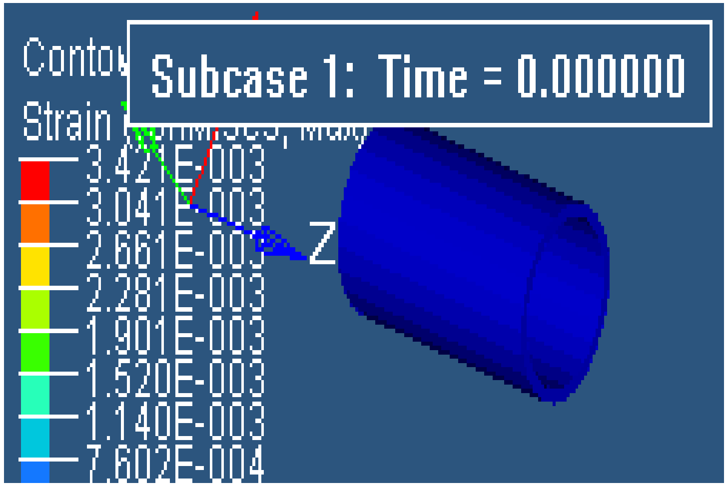
Stress Contours Enivronment-1



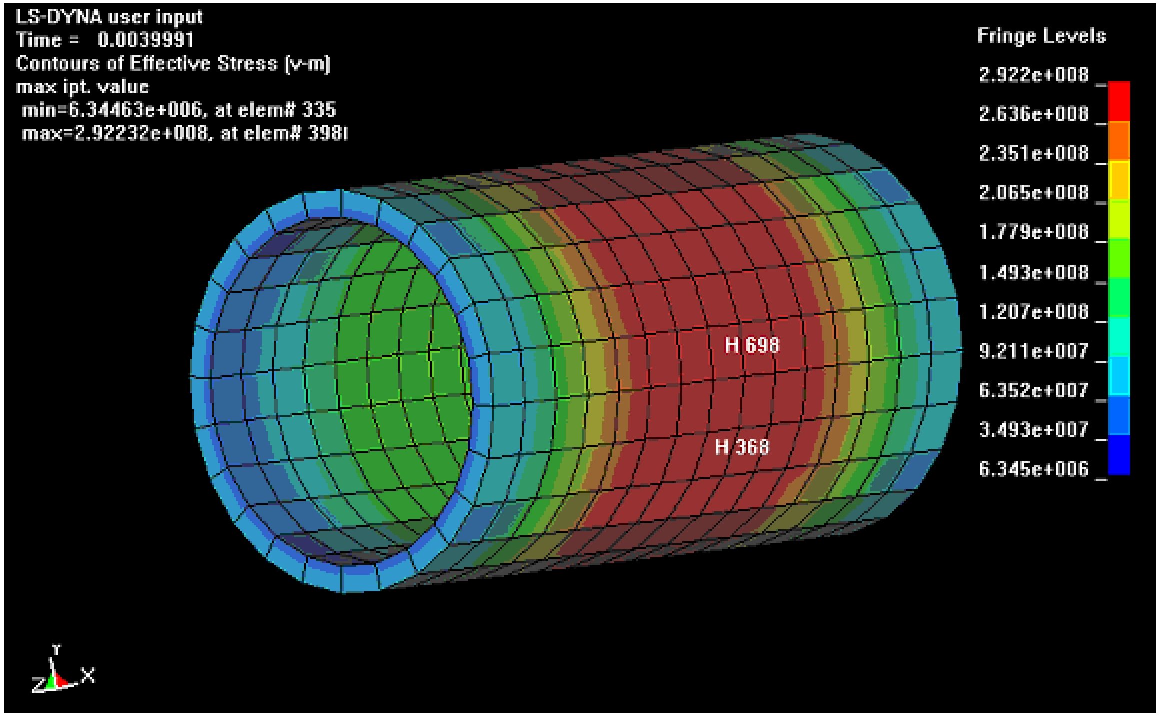
Strain Contours Enivronment-1



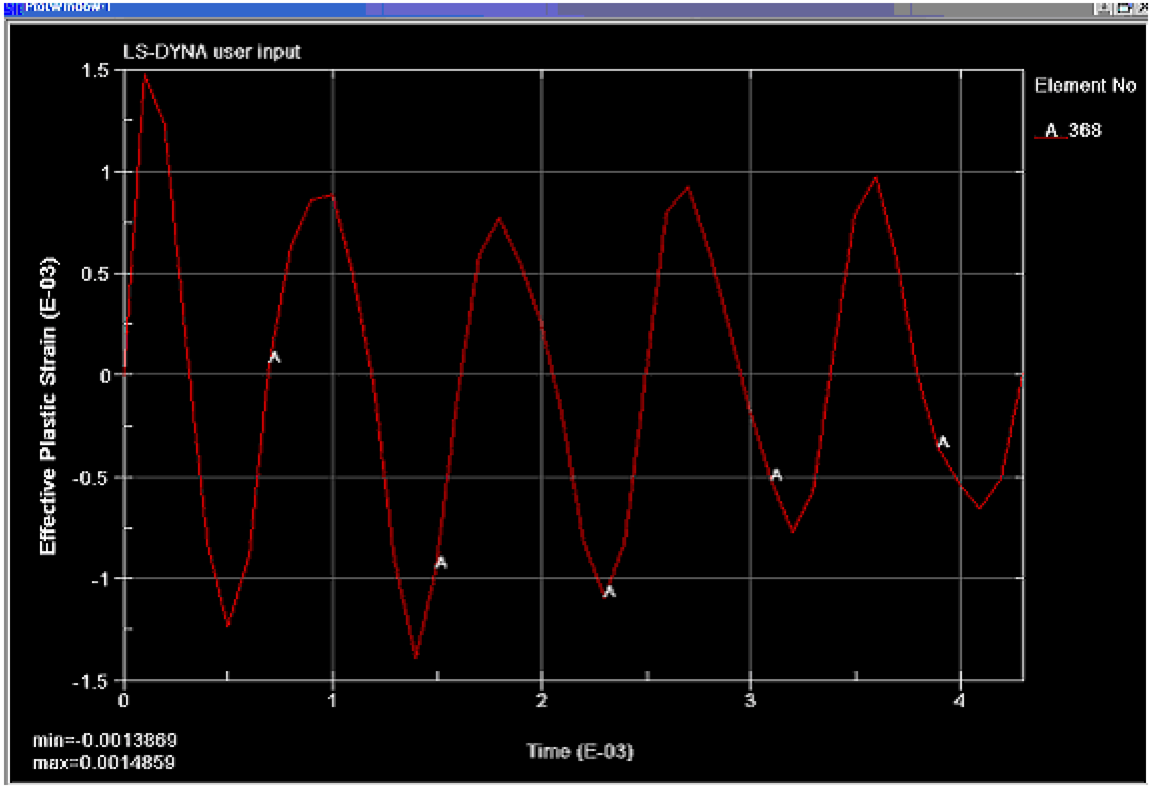
Strain Contours Enivronment-1



Effective Strain Enivronment-1



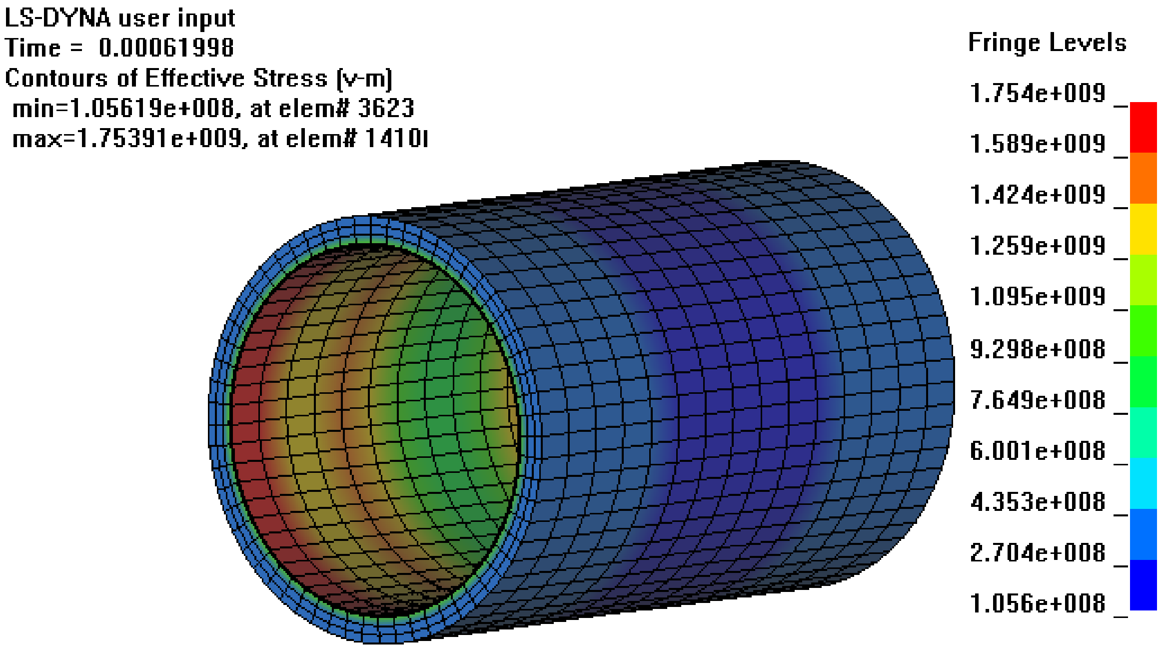
Strain Vs Time



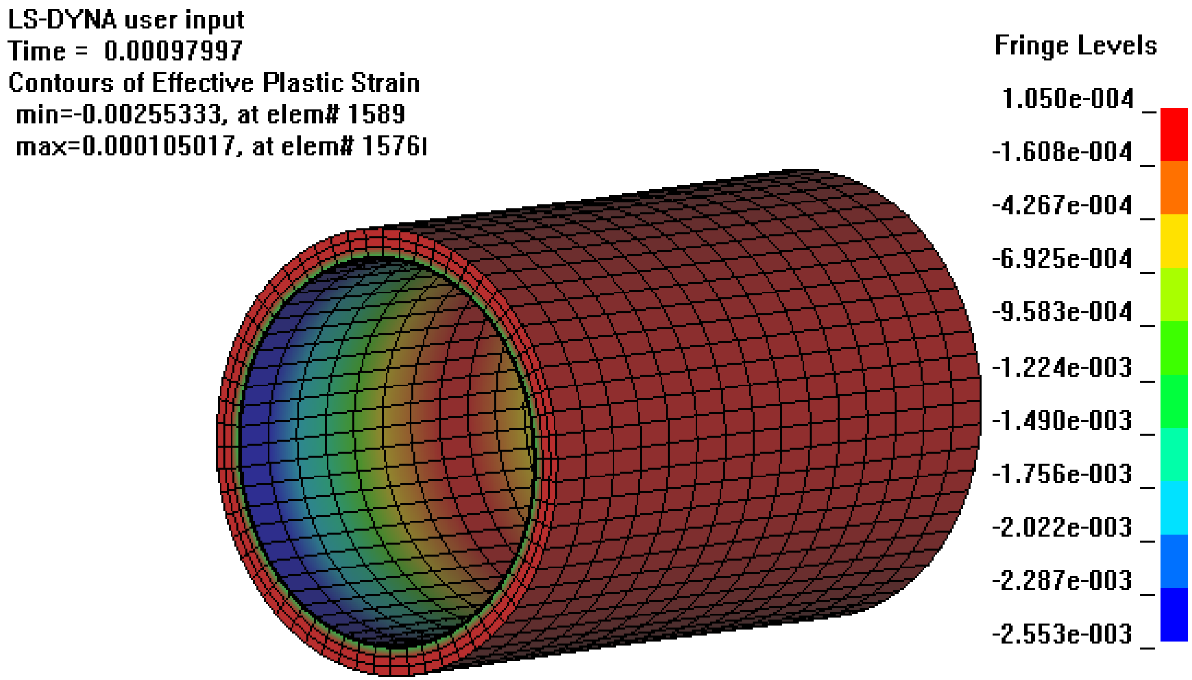
Results Enivronment-1

Test Parameters	Experimental Results	Ls-dyna Results
Comp. Thick. h_i [mm	6.6	6.6
M_{HE} [g]	46.0	51.98(with scale factor = 1.13)
Peak Tensile Hoop Strain ε_1 [%]	2.9	0.44
Time to Reach ε_1: τ_1 [μs]	43.2	99.27
Peak Comp. Hoop Strain ε_2 [%]	-1.4	-0.139
Peak Long. Strain, ε_3 [%]	1.85	3.88
Period, T [μs]	112	400.17
Max. Hoop Strain Rate [1/s]	891	769

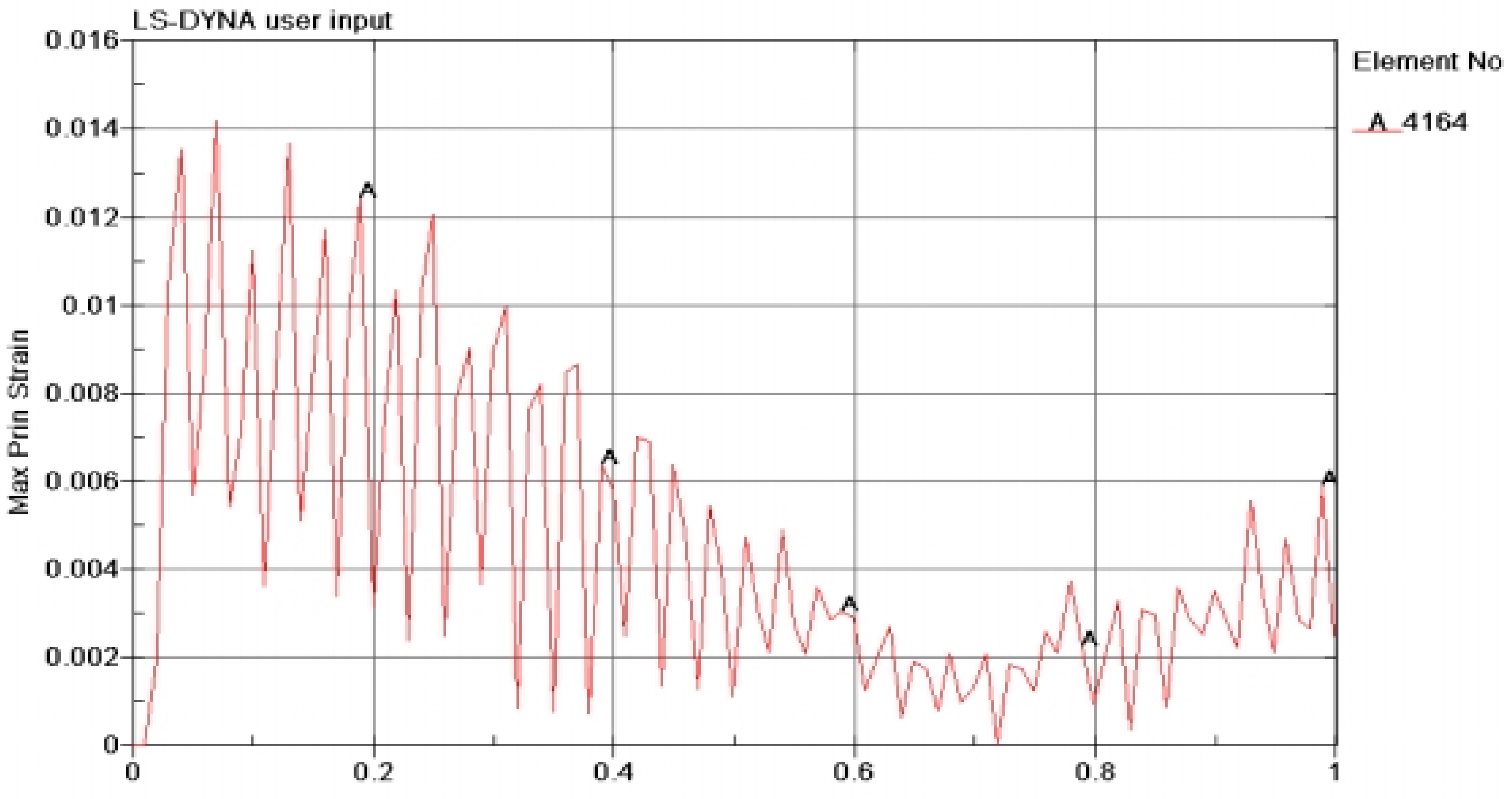
Stress contours



Plastic strain Environment-2



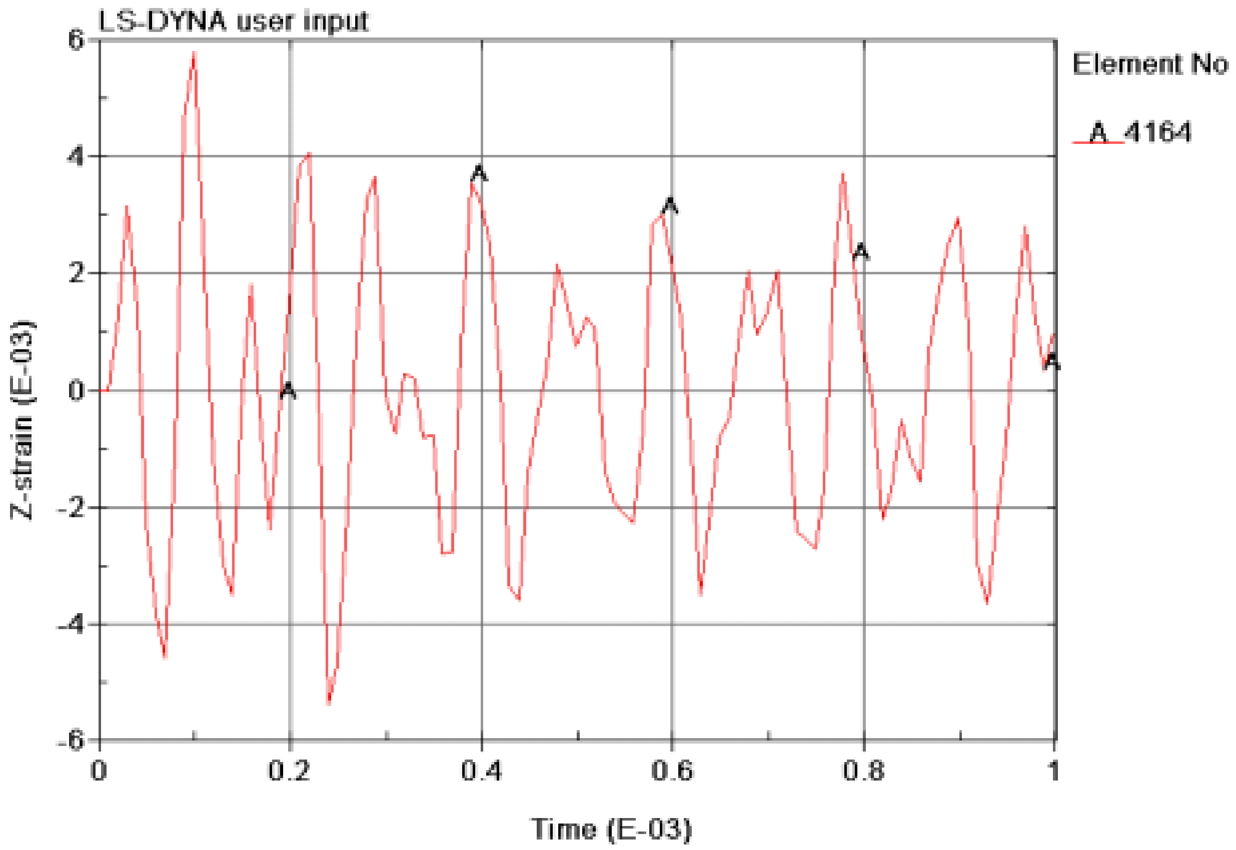
The plot for calculating peak Hoop tensile strain.



Results Enivronment-2

Test Parameters	Experimental Results	Ls-dyna Results (From Project 2,Refined Mesh)
Comp. Thick. h_1 [mm	6.1	6.1
M_{HE} [g]	46.0	51.98(with scale factor = 1.13)
Peak Tensile Hoop Strain ε_1 [%]	2.9	1.4231
Time to Reach ? 1: ε_1[? s]	43.2	69
Peak Comp. Hoop Strain ε [%]	-1.4	-1.6003
Peak Long. Strain, ε_3 [%]	1.85	0.584
Period, T [µs]	112	284
Max. Hoop Strain Rate [1/s]	891	662

Plot for peak longitudinal strain



Conclusions

- The results from the mesh with one component as solid elements and other as shell elements had huge deviations from experimental results.

- The mesh with both components as solid elements(Enivronment-2) gave more close results to experiments.

Conclusions cont'd

- Comparison of the experimental data and the computational data shows there is some discrepancies in the magnitude of the parameters under consideration.

- The reasons for such variation in results may be attributed to the discrepancy of conwep function in interpreting the TNT equivalent of HE.