ANALYSIS OF A COMPOSITE CYLINDER SUBJECTED TO BLAST LOADING

BY
KARTHIK DOPPALA

OBJECTIVE OF ANALYSIS:

- ANALYZING THE IMPACT OF A BLAST ON OPEN CYLINDER COMPOSITE MODELS
  - SHELL ELEMENT MODEL
  - SOLID ELEMENT MODEL

ANSYS-LS DYNA:

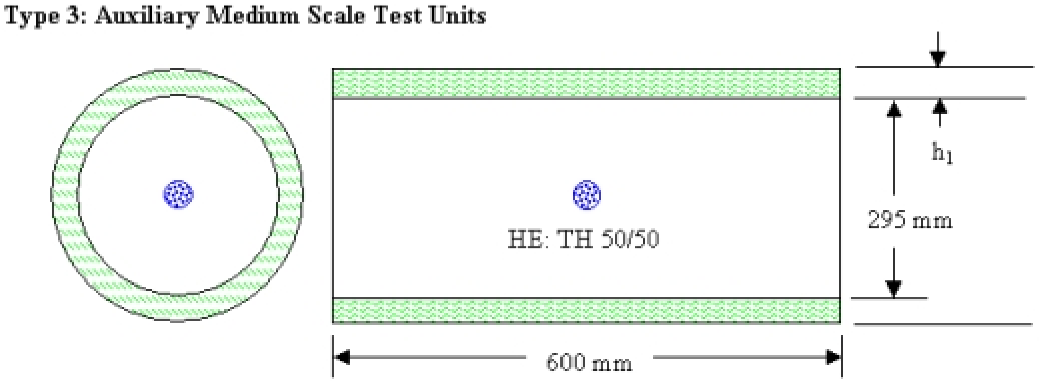
WHY DO WE NEED COMPOSITE MATERIAL IN OUR ANALYSIS?

- HIGH RATIO OF STIFFNESS TO WEIGHT

COMPOSITE USED IN THE ANALYSIS:

- BASALT PLASTIC

MODEL OF THE COMPOSITE CYLINDER(WITH DIMENTIONS):


Type 3: Auxiliary Medium Scale Test Units
HE: TH 50/50
h1
295 mm
600 mm

MODELING PROCEDURE:

❖ELEMENT TYPE
❖REAL CONSTENTS
❖MATERIAL TYPE

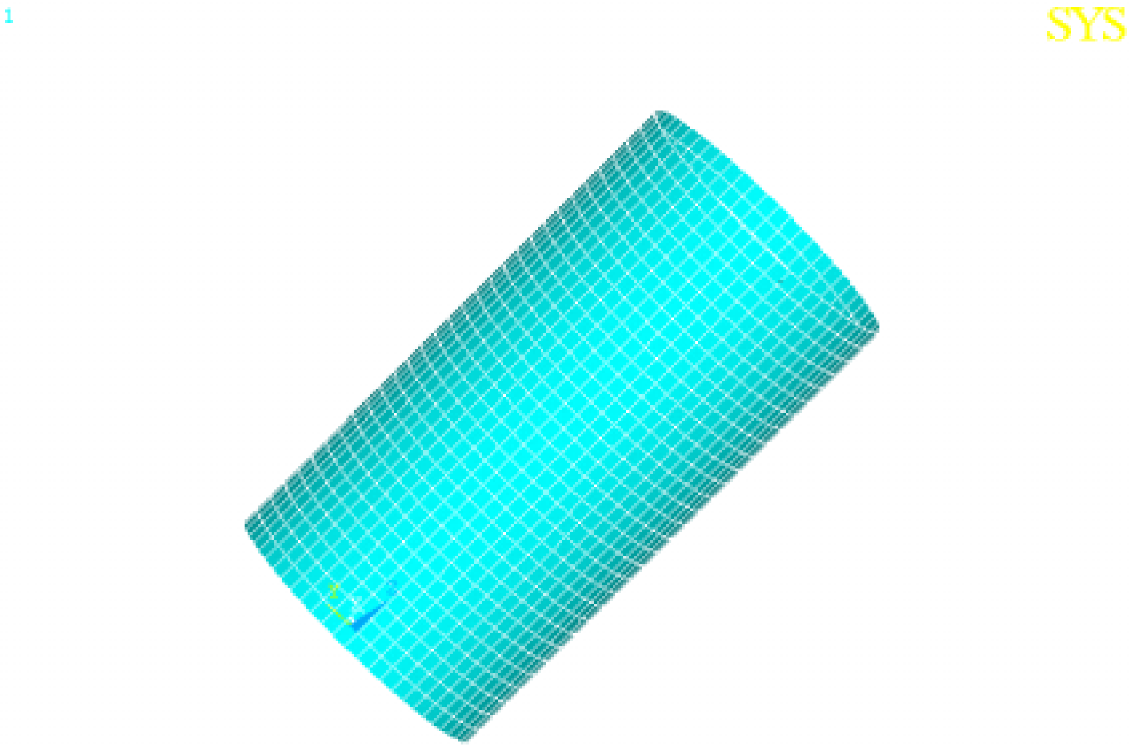
THE OVER ALL COMPOSITE PROPERTIES IN X-Y DIRECTIONS:

Ex=21.44Gpa
Ey=14.75Gpa
Ez=14Gpa
Gxy=10.35Gpa
Gyz=3Gpa
Gxz=3Gpa
Vxy=0.463
Vxz=0.3
Vyz=2.06E3Kg/m3

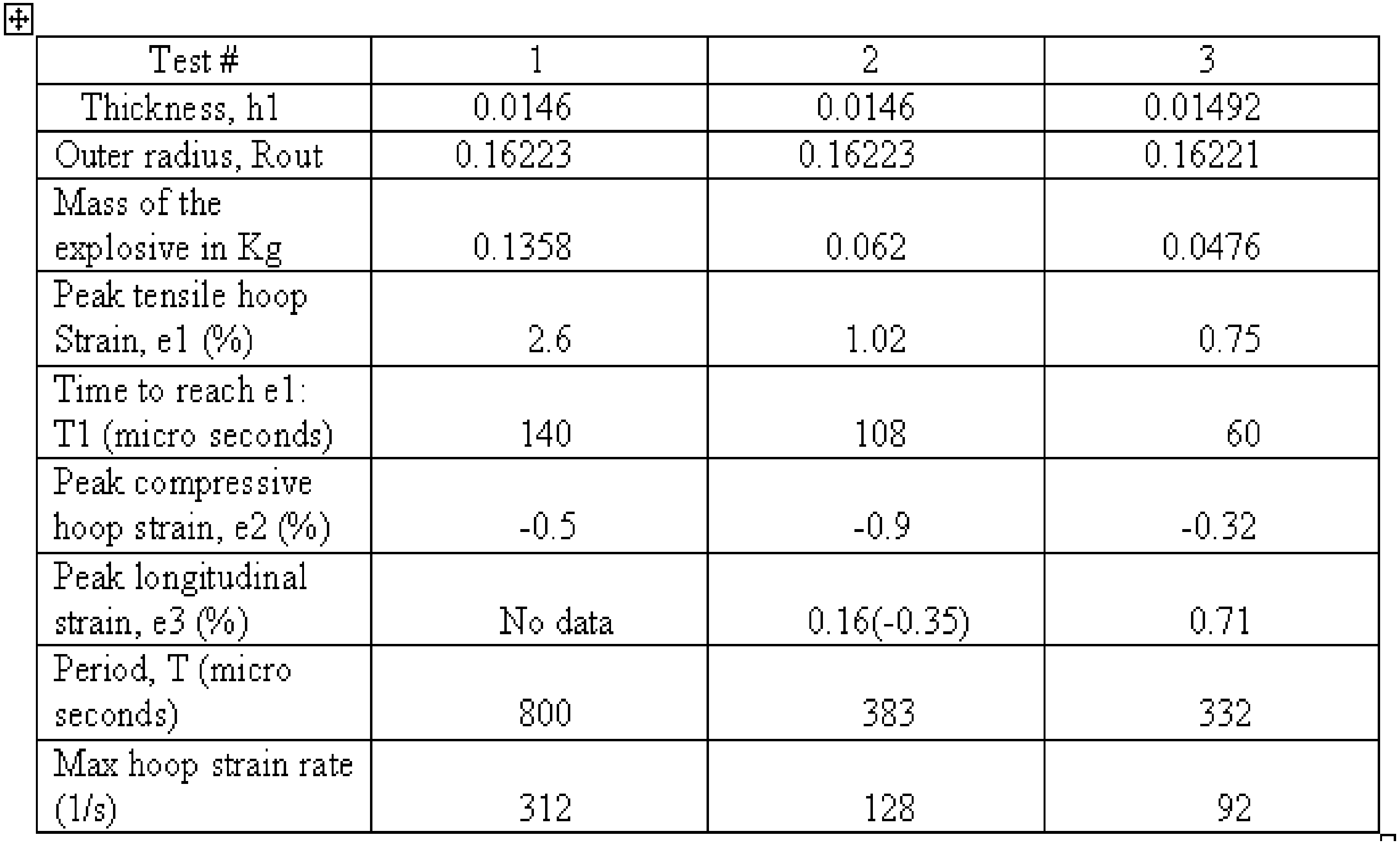
THICKNESSES OF THE THREE CYLINDERS USED:

- 1st cylinder –0.015meters
- 2nd cylinder -0.015meters
- 3rd cylinder – 0.015meters

CYLINDER MODEL(SHELL ELEMENTS) WITH MESH:



EXPERIMENTAL RESULTS:



Test #	1	2	3
Thickness, h1	0.0146	0.0146	0.01492
Outer radius, Rout	0.16223	0.16223	0.16221
Mass of the explosive in Kg	0.1358	0.062	0.0476
Peak tensile hoop Strain, e1 (%)	2.6	1.02	0.75
Time to reach e1: T1 (micro seconds)	140	108	60
Peak compressive hoop strain, e2 (%)	-0.5	-0.9	-0.32
Peak longitudinal strain, e3 (%)	No data	0.16(-0.35)	0.71
Period, T (micro seconds)	800	383	332
Max hoop strain rate (1/s)	312	128	92

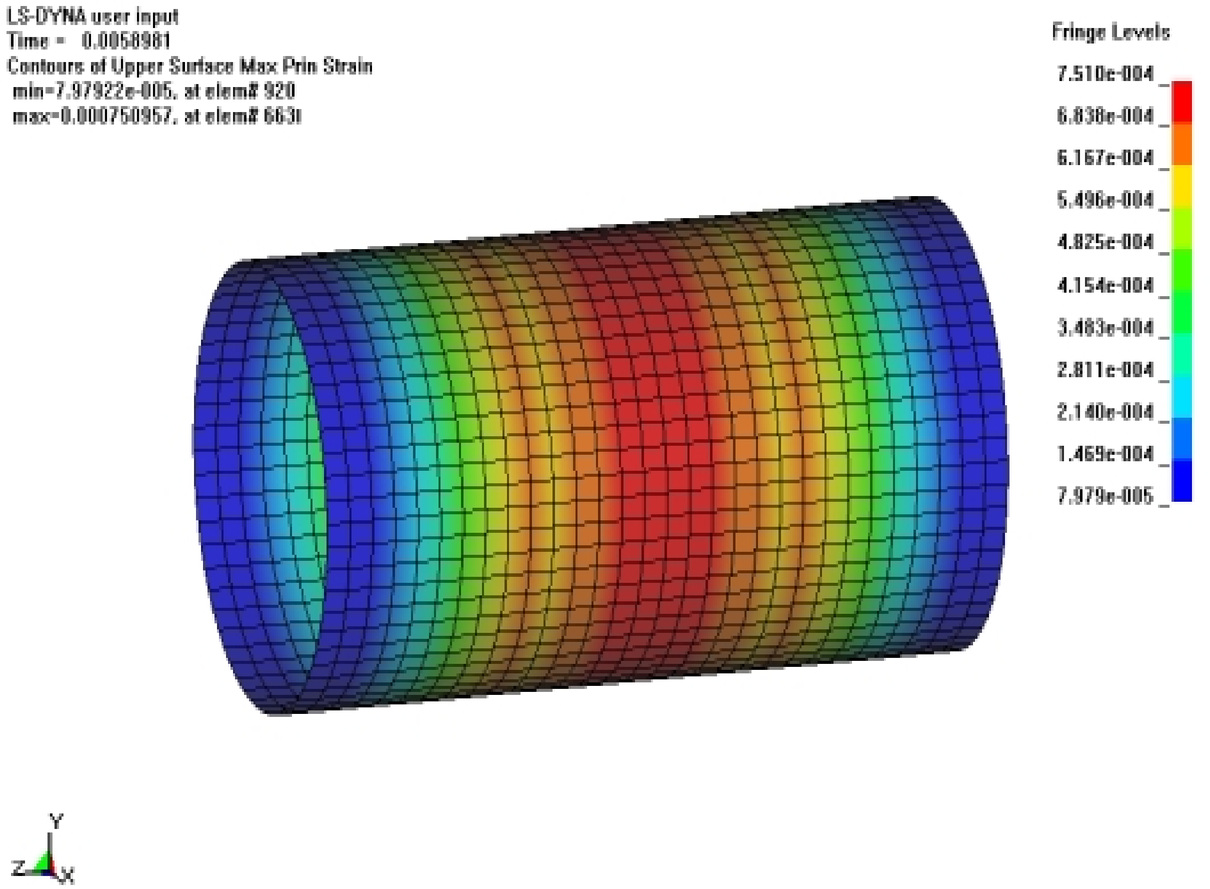
BLAST LOADING:

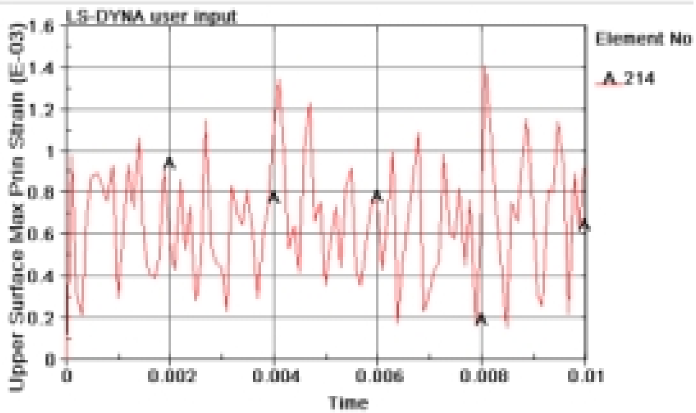
- CONWEP FUNCTION
- CARDS USED
  - -SET SHELL GENERATE
  - -LOAD SHELL SET
  - -LOAD BLAST

MASS OF EXPLOSIVE USED IN THE CYLINDERS:

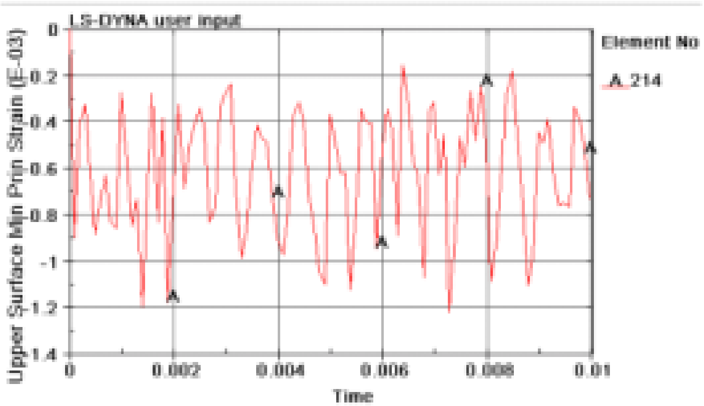
CYLINDER 1- 0.153454
CYLINDER 2- 0.07006
CYLINDER 3- 0.053788

SIMULATED MODEL OF CYLINDER(SHELL ELEMENTS) 1 AND ITS RESULTS:


LS-DYNA user input
Time = 0.0058981
Contours of Upper Surface Max Prin Strain
min=7.97922e-005, at elem# 920
max=0.000750957, at elem# 6631
Fringe Levels
7.510e-004
6.838e-004
6.167e-004
5.496e-004
4.825e-004
4.154e-004
3.483e-004
2.811e-004
2.140e-004
1.469e-004
7.979e-005
Y
Z
X

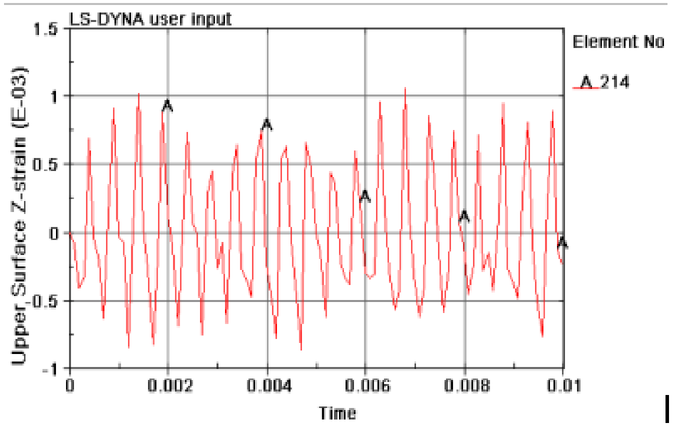


Tensile hoop strains at various intervals of time



Compressive hoop strains at various intervals of time

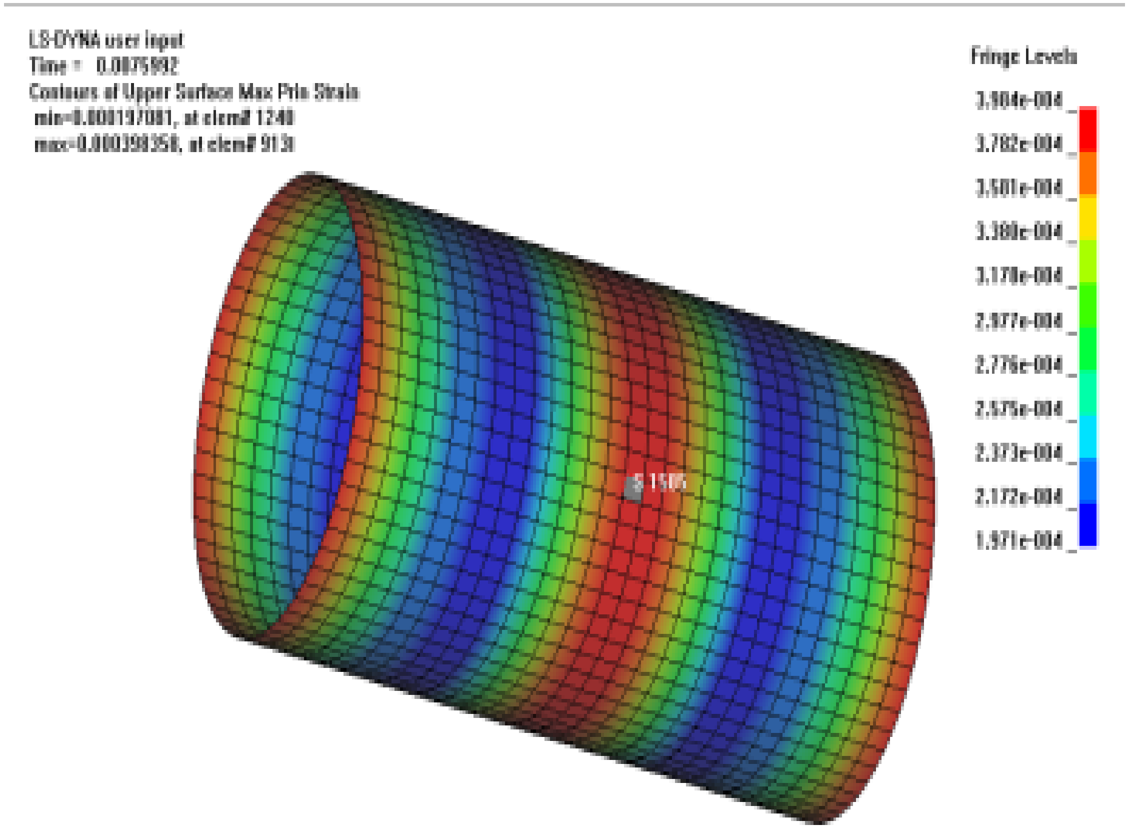
Peak tensile hoop strain, e1 (%)	1.4
Time taken to reach e1, T1	8098 micro seconds
Maximum hoop strain sate	28.62
Peak compressive hoop strain, e2 (%)	-0.12
Time period	109micro seconds



Longitudinal strains at various intervals of time

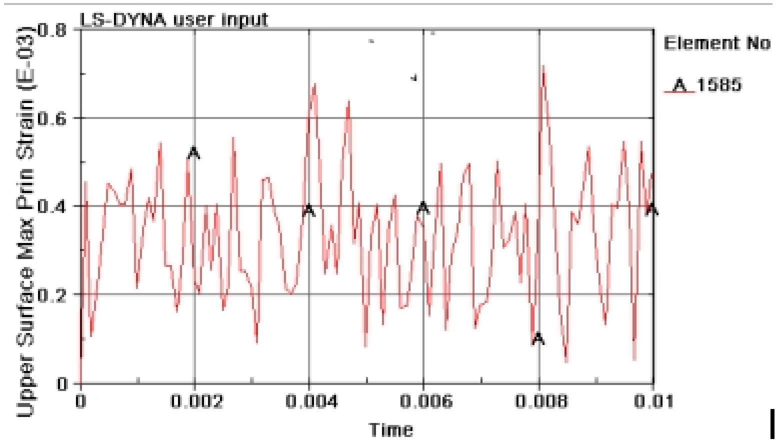
Peak longitudinal strain,e3(%)	0.106

SIMULATED MODEL OF CYLINDER 2(SHELL ELEMENTS)AND ITS RESULTS:

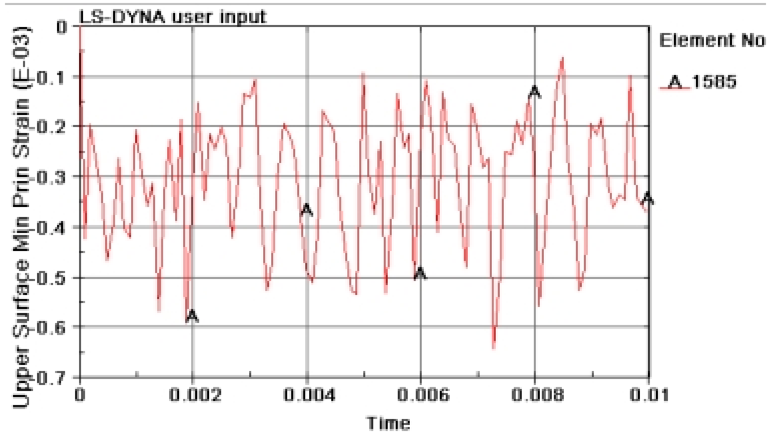


LS-DYNA user input
Time = 0.0075992
Contours of Upper Surface Max Prin Strain
min=0.000197081, at elem# 1240
max=0.000398358, at elem# 913

Fringe Levels
3.984e-004
3.782e-004
3.581e-004
3.380e-004
3.178e-004
2.977e-004
2.776e-004
2.575e-004
2.373e-004
2.172e-004
1.971e-004

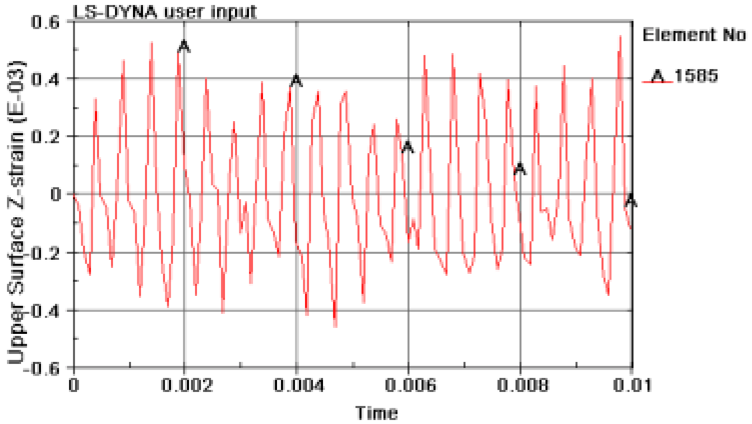


Graph showing the tensile hoop strains at various intervals of time



Graph showing the compressive hoop stresses at various time intervals

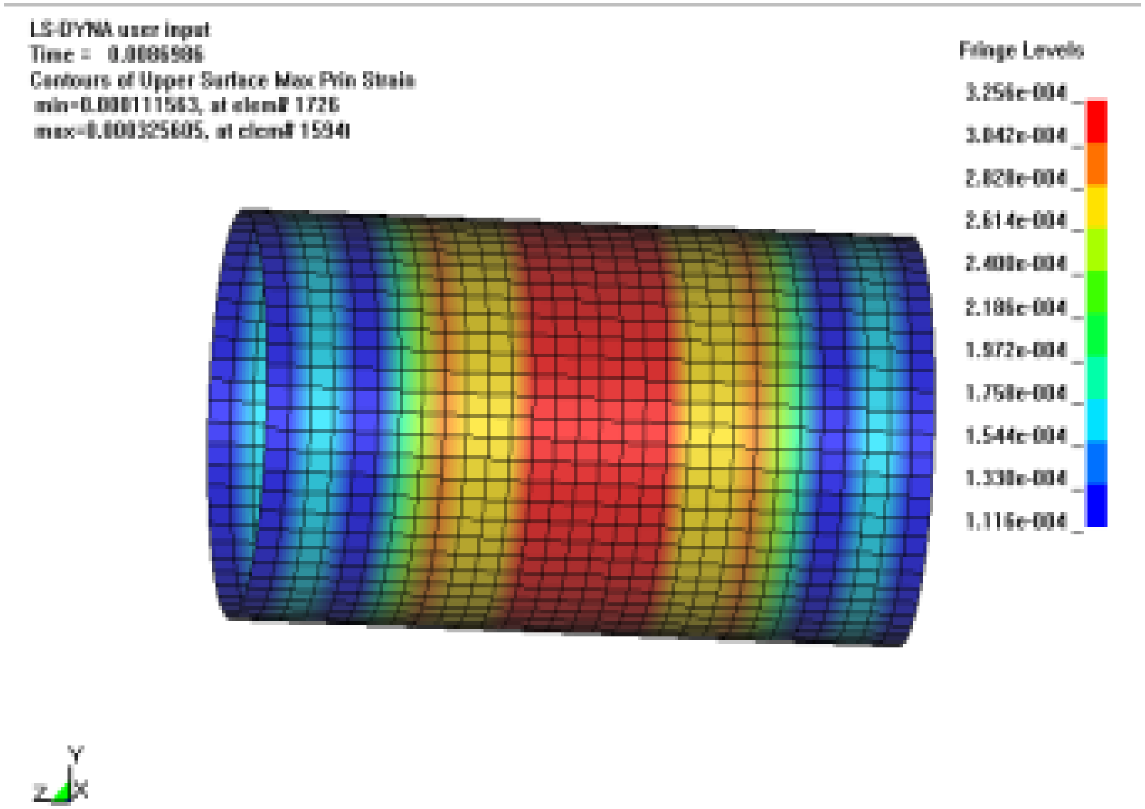
Peak tensile hoop strain, e1 (%)	0.71
Time taken to reach e1,T1	8097 micro seconds
Maximum hoop strain sate	14.9
Peak compressive hoop strain, e2 (%)	-0.06
Time period	71 micro seconds

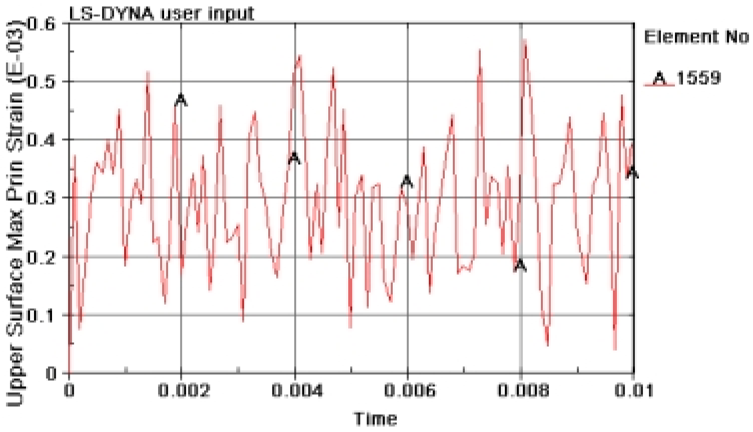


Graph showing longitudinal hoop strains at various intervals of time

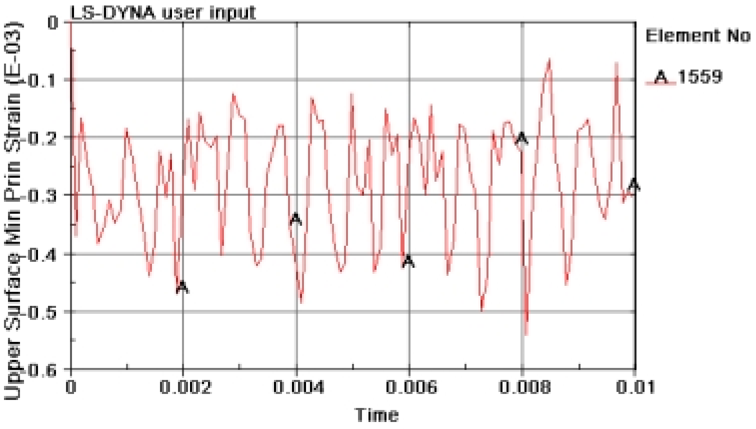
Peak longitudinal strain, e3 (%)	0.05

SIMULATED MODEL OF CYLINDER 3(SHELL ELEMENTS) AND ITS RESULTS:


LS-DYNA user input
Time = 0.0086986
Contours of Upper Surface Max Prin Strain
min=0.000111563, at elem# 1726
max=0.000325605, at elem# 1594l
Fringe Levels
3.256e-004
3.042e-004
2.828e-004
2.614e-004
2.400e-004
2.186e-004
1.972e-004
1.758e-004
1.544e-004
1.330e-004
1.116e-004
Y
Z
X

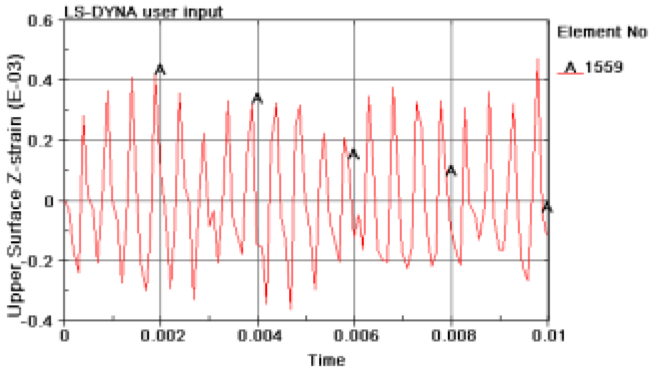


Graph showing the tensile hoop strains at various intervals of time.



Graph showing the compressive hoop stresses at various time intervals

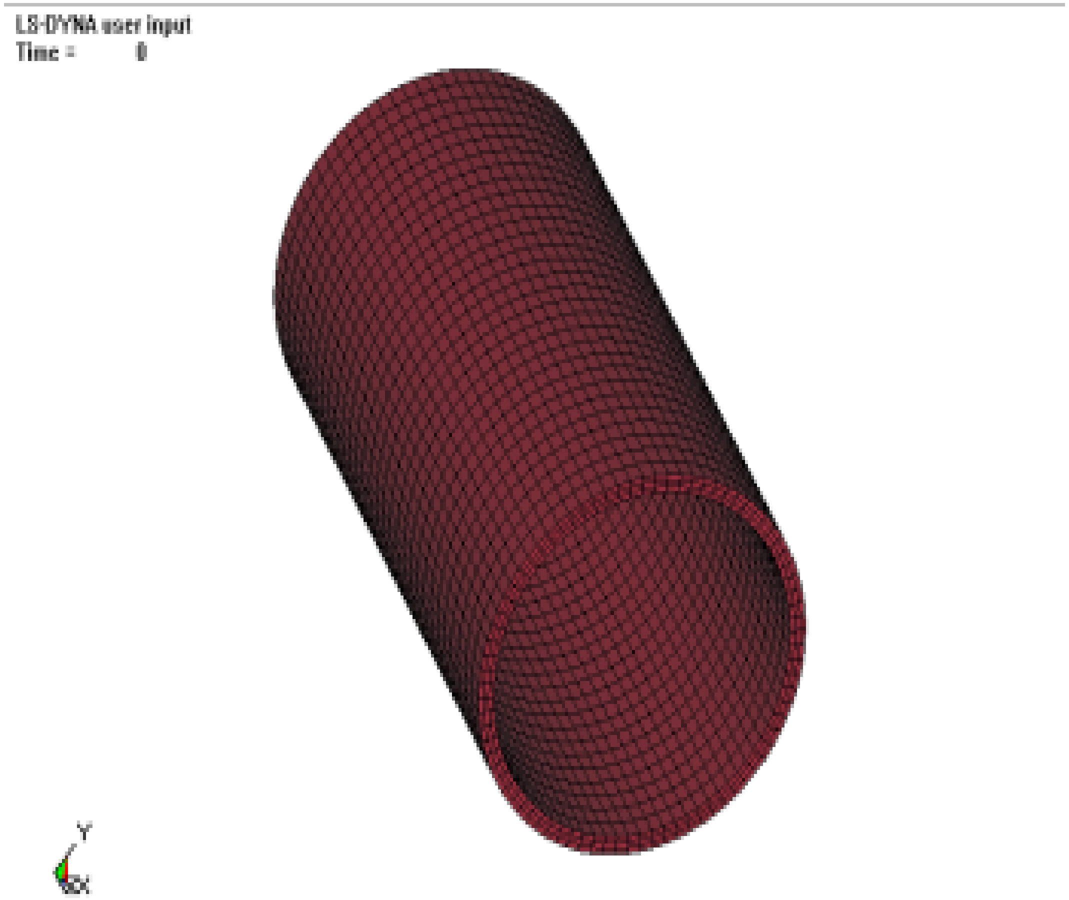
Peak tensile hoop strain, e1 (%)	6.1
Time taken to reach e1,T1	8097micro seconds
Maximum hoop strain sate	12.5
Peak compressive hoop strain, e2 (%)	-0.05
Time period	104micro seconds



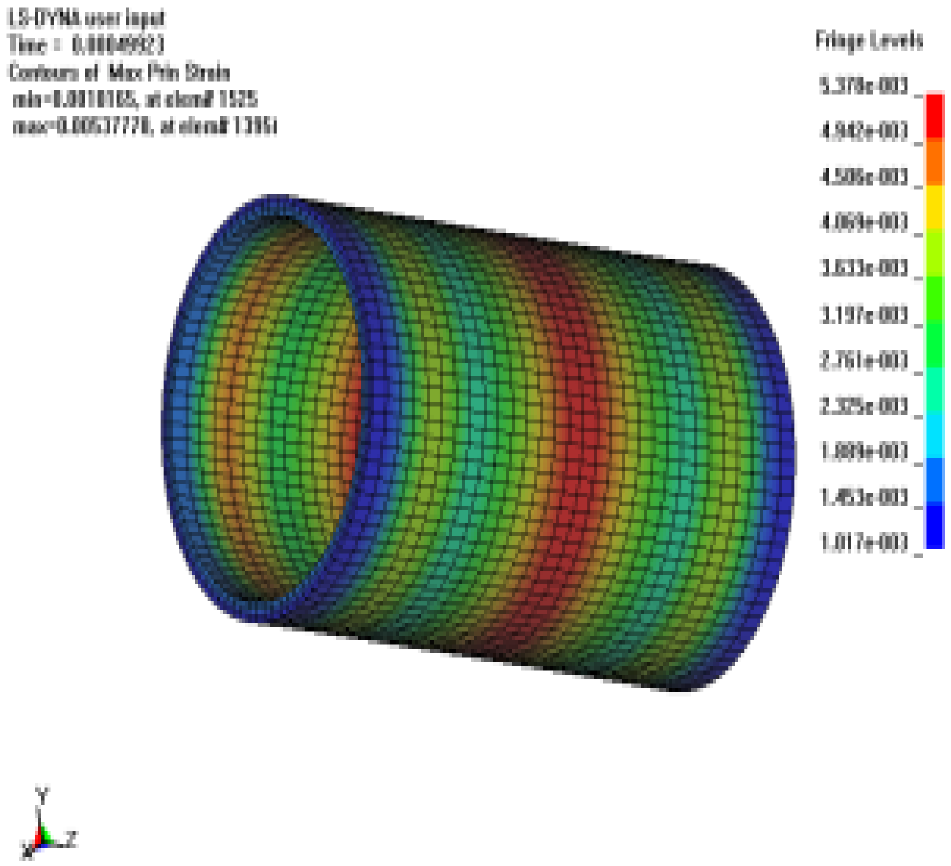
Graph showing longitudinal strain at various intervals of time

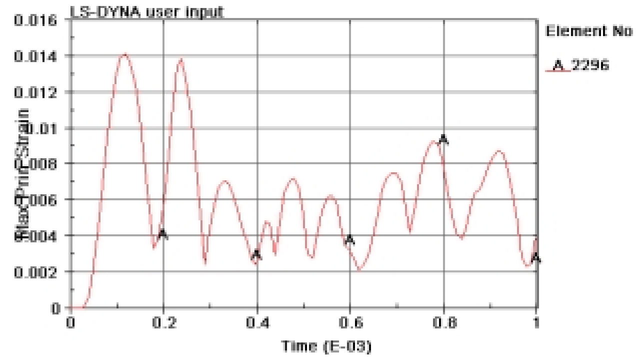
Peak longitudinal strain, e3 (%)	0.04

CYLINDER MODEL(SOLID ELEMENTS) WITH MESH:

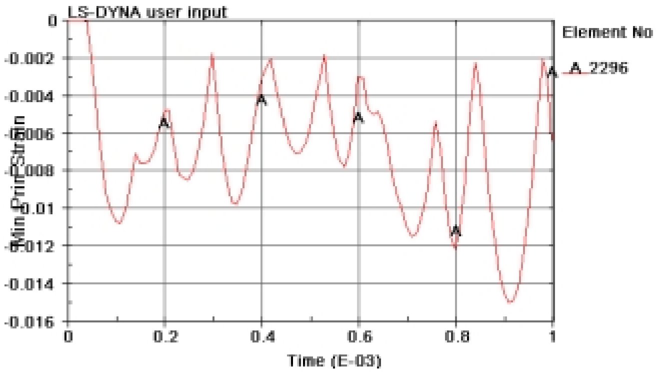

LS-DYNA user input
Time = 0
Y
X

SIMULATED MODEL OF CYLINDER 1(SOLID ELEMENTS) AND ITS RESULTS:


LS-DYNA user input
Time = 0.00049923
Contours of Max Prin Strain
min=0.0010165, at elem# 1525
max=0.00537778, at elem# 13951
Fringe Levels
5.378e-003
4.942e-003
4.506e-003
4.069e-003
3.633e-003
3.197e-003
2.761e-003
2.325e-003
1.889e-003
1.453e-003
1.017e-003
Y
Z
X

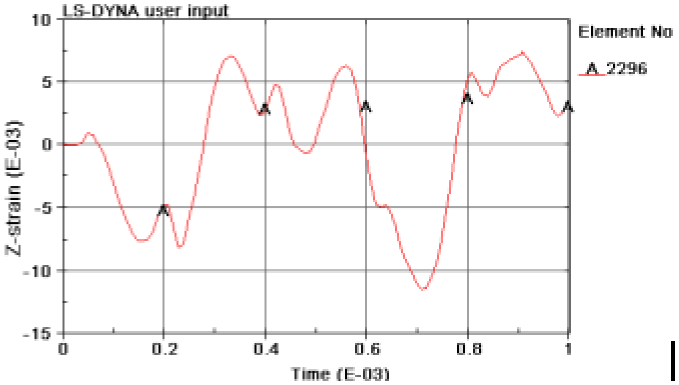


Tensile hoop stresses at various intervals of time



Compressive stresses at various intervals of time

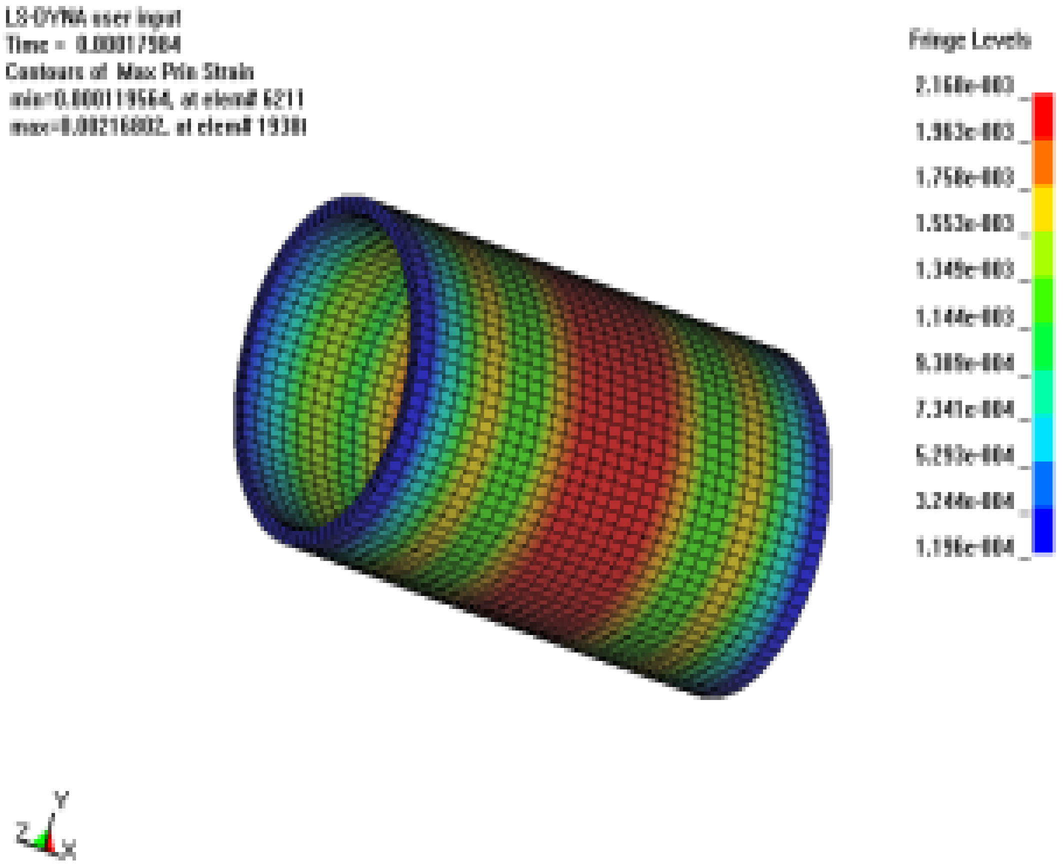
Peak tensile hoop strain, e1 (%)	1.41
Time taken to reach e1, T1	119.6 micro seconds
Maximum hoop strain rate	356
Peak compressive hoop strain, e2 (%)	-1.49
Time period	70 micro seconds

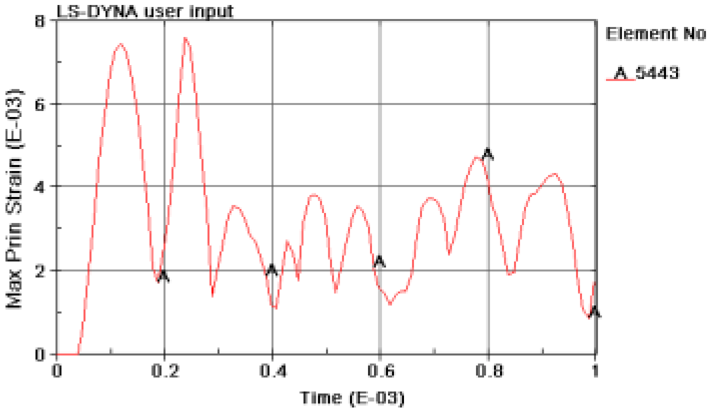


Longitudinal strains at different intervals of time

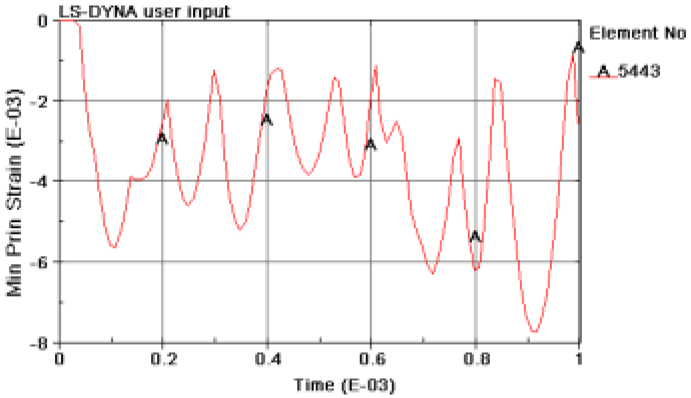
Peak longitudinal strain, e3 (%)	0.74

SIMULATED MODEL OF CYLINDER 2(SOLID ELEMENTS) AND ITS RESULTS:


LS-DYNA user input
Time = 0.00017584
Contours of Max Prin Strain
min=0.000119564, at elem# 6211
max=0.00216802, at elem# 19381
Fringe Levels
2.168e-003
1.963e-003
1.758e-003
1.553e-003
1.349e-003
1.144e-003
9.389e-004
7.341e-004
5.293e-004
3.244e-004
1.196e-004
Y
Z
X

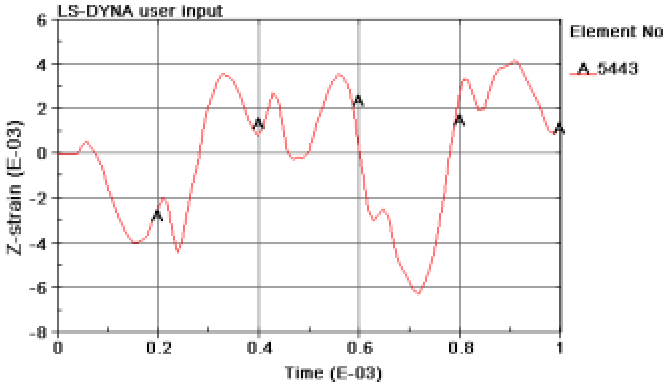


Tensile hoop strains at various time intervals



compressive strains at various time intervals

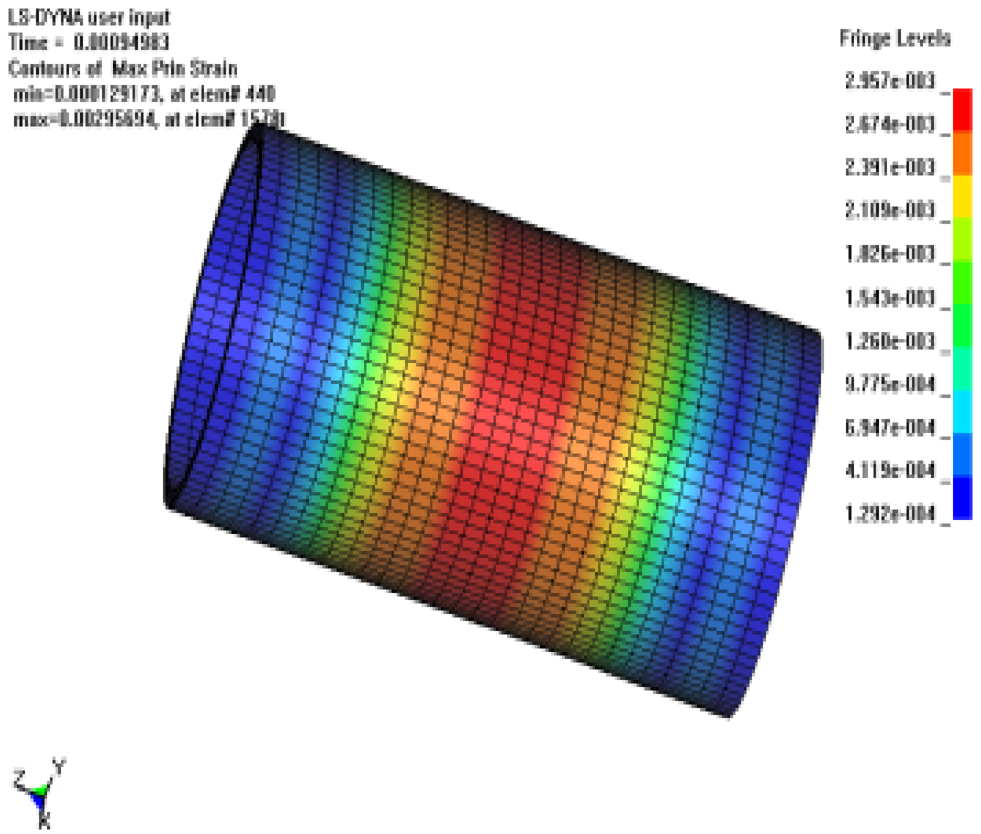
Peak tensile hoop strain, e1 (%)	0.76
Time taken to reach e1,T1	239.6 micro seconds
Maximum hoop strain rate	229
Peak compressive hoop strain, e2 (%)	- 0.7
Time period	93 micro seconds

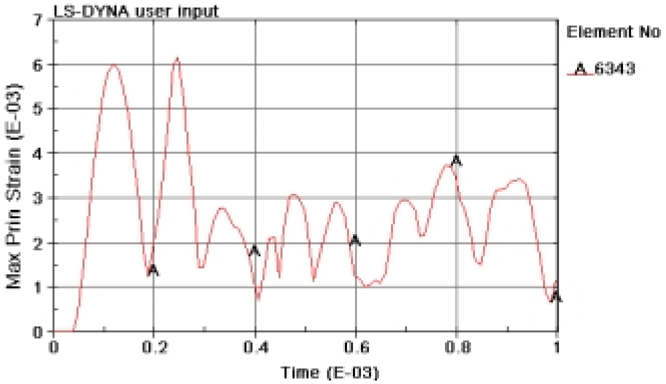


Longitudinal strains at various intervals of time

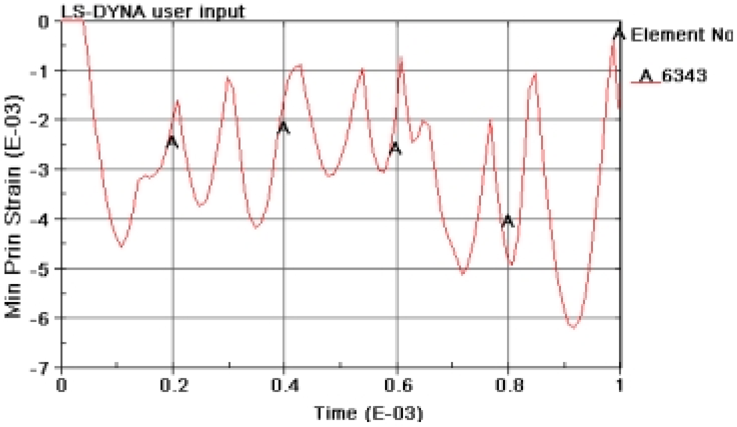
Peak longitudinal strain, e3 (%)	0.3

SIMULATED MODEL OF CYLINDER 3(SOLID ELEMENTS) AND ITS RESULTS:


LS-DYNA user input
Time = 0.00094983
Contours of Max Prin Strain
min=0.000129173, at elem# 440
max=0.00295694, at elem# 1578
Fringe Levels
2.957e-003
2.674e-003
2.391e-003
2.109e-003
1.826e-003
1.543e-003
1.260e-003
9.775e-004
6.947e-004
4.119e-004
1.292e-004
Z
Y
X

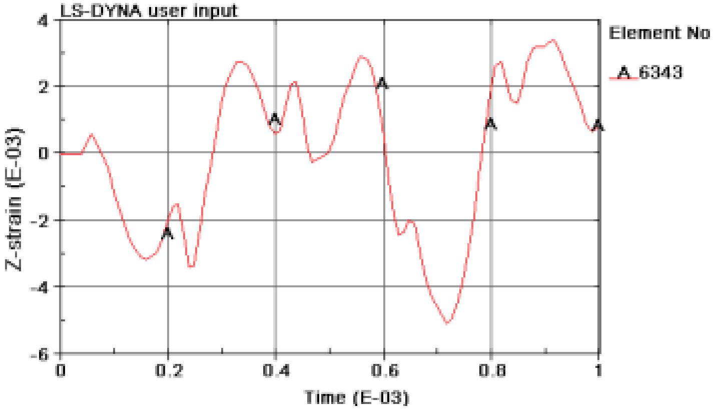


Tensile hoop strains at various time intervals



Compressive hoop stresses at various time intervals

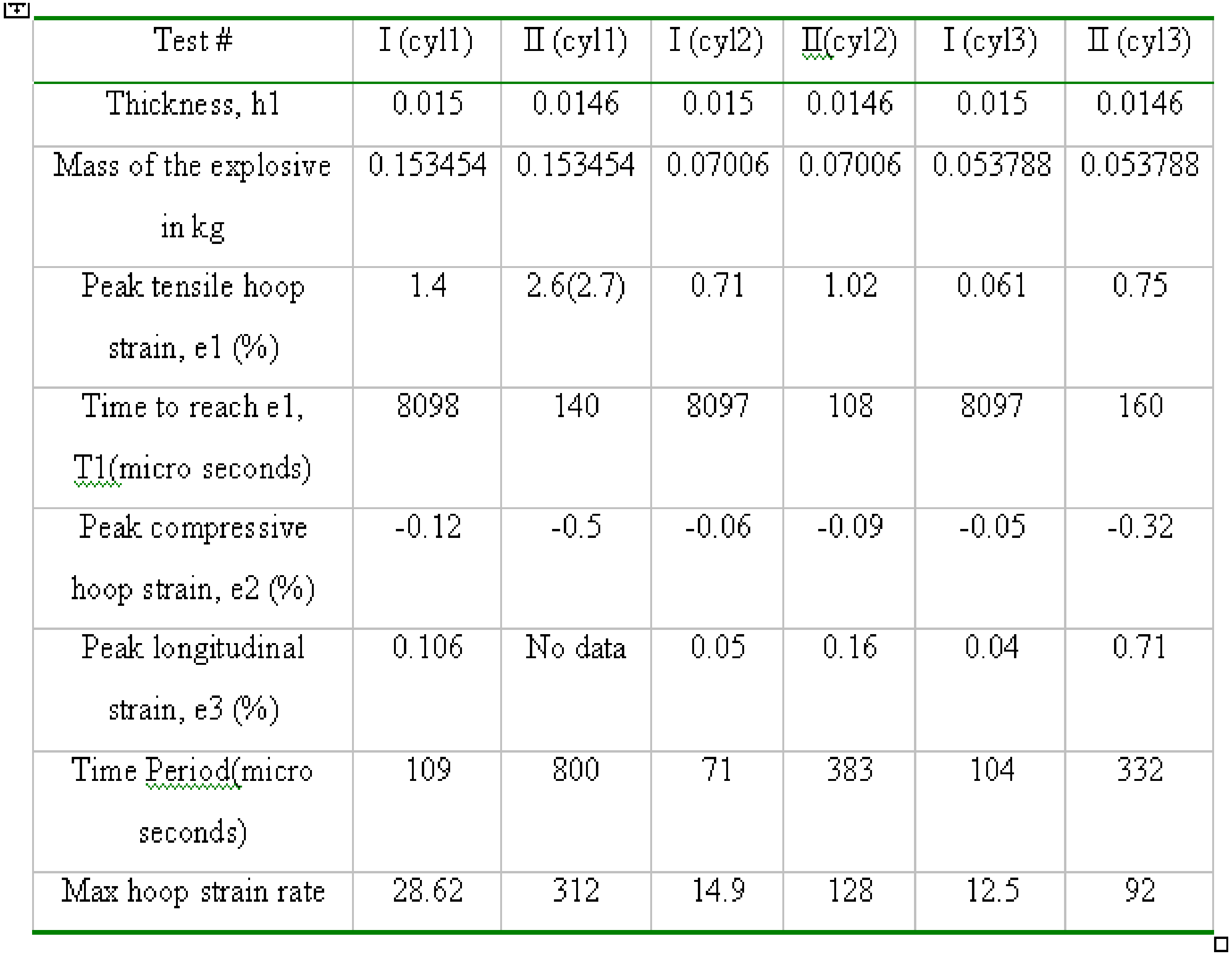
Peak tensile hoop strain, e1 (%)	0.61
Time taken to reach e1, T1	249.3 micro seconds
Maximum hoop strain rate	216
Peak compressive hoop strain, e2 (%)	- 0.61
Time period	94micro seconds



Longitudinal hoop strains at various intervals of time

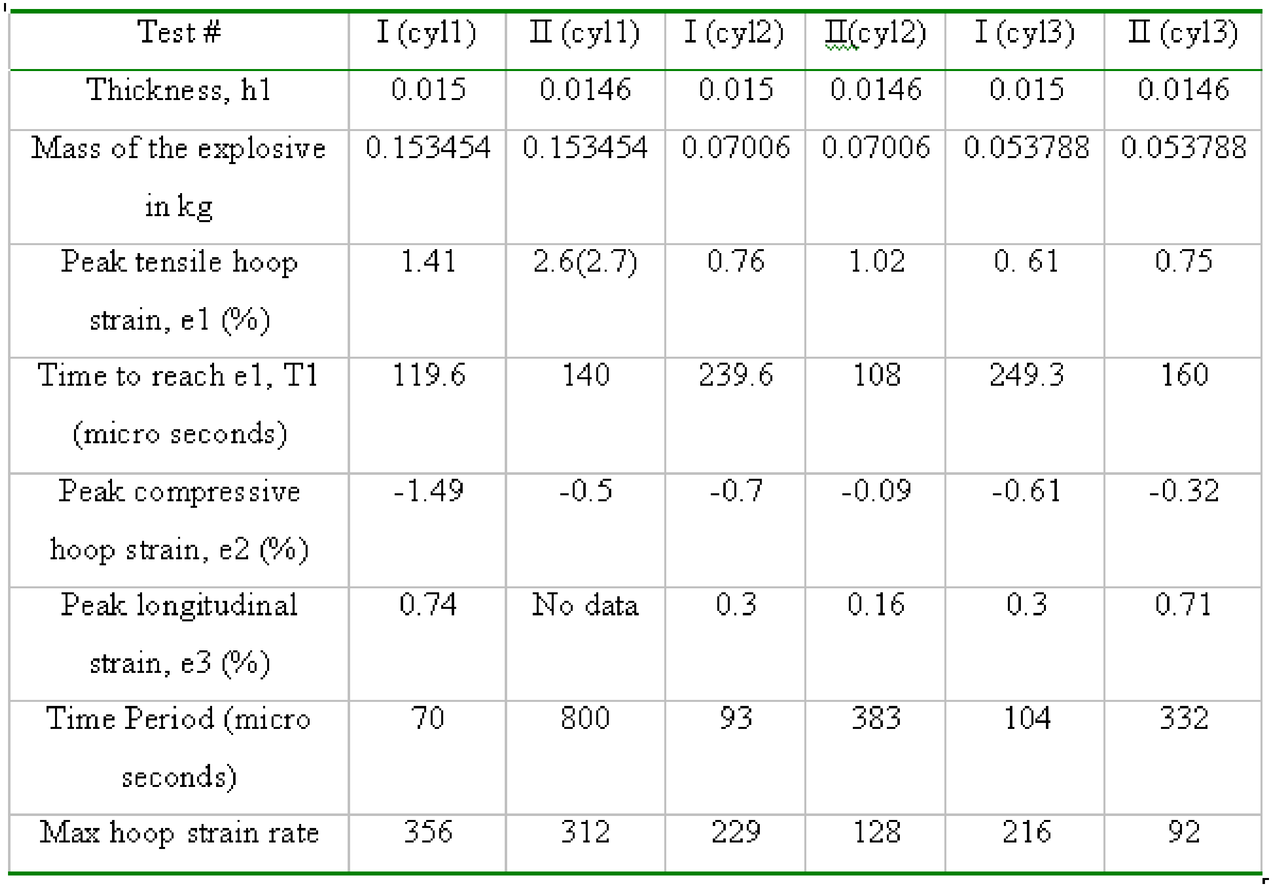
Peak longitudinal hoop strain, e3 (%)	0.3

COMPARISION OF THE SHELL MODEL RESULTS WITH THE EXPERIMENTAL RESULTS(COLUMN I REFERS TO THE RESULTS OF THE SHELL MODEL AND COLUMN II REFERS TO THE EXPERIMENTAL RESULTS):



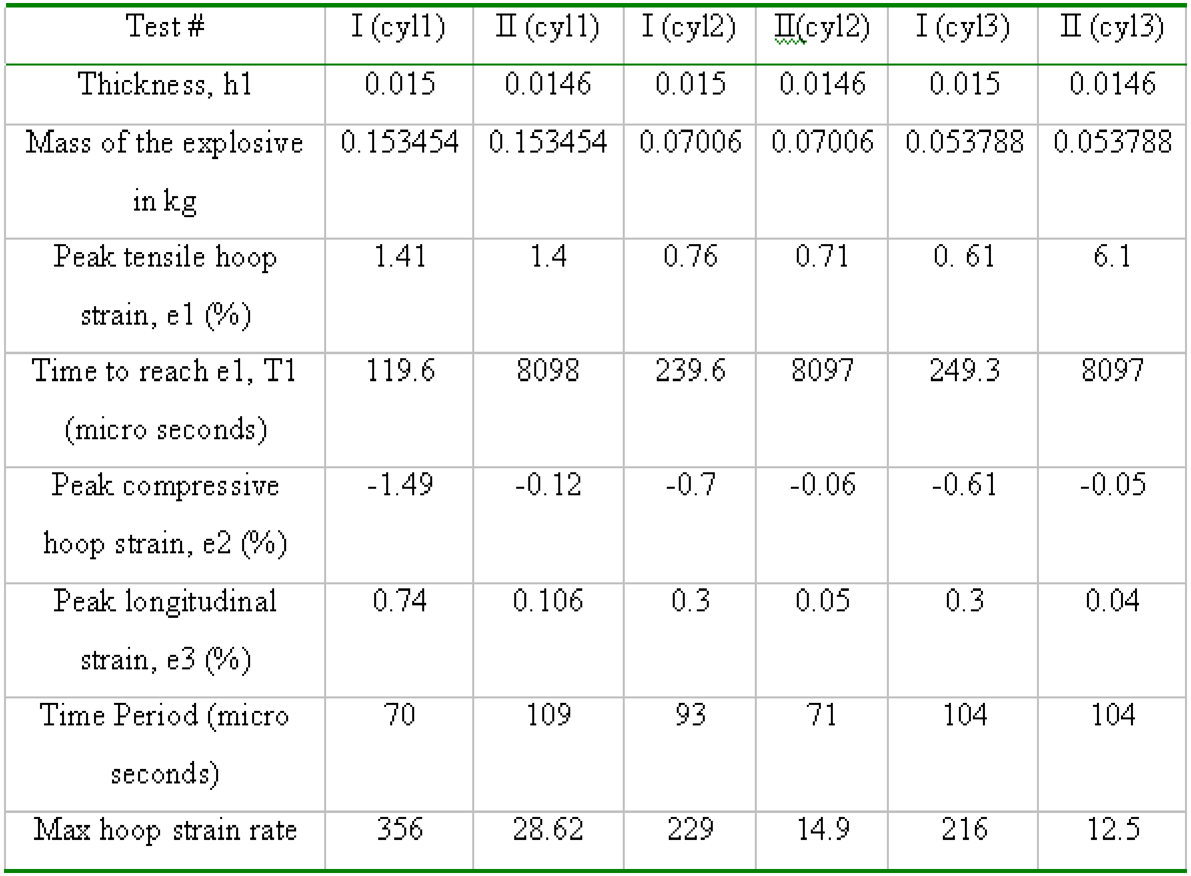
Test #	I (cyl1)	II (cyl1)	I (cyl2)	II(cyl2)	I (cyl3)	II (cyl3)
Thickness, h1	0.015	0.0146	0.015	0.0146	0.015	0.0146
Mass of the explosive in kg	0.153454	0.153454	0.07006	0.07006	0.053788	0.053788
Peak tensile hoop strain, e1 (%)	1.4	2.6(2.7)	0.71	1.02	0.061	0.75
Time to reach e1, T1(micro seconds)	8098	140	8097	108	8097	160
Peak compressive hoop strain, e2 (%)	-0.12	-0.5	-0.06	-0.09	-0.05	-0.32
Peak longitudinal strain, e3 (%)	0.106	No data	0.05	0.16	0.04	0.71
Time Period(micro seconds)	109	800	71	383	104	332
Max hoop strain rate	28.62	312	14.9	128	12.5	92

COMPARISION OF THE SOLID MODEL RESULTS WITH THE EXPERIMENTAL RESULTS(COLUMN I REFERS TO THE RESULTS OF THE SOLID MODEL AND COLUMN II REFERS TO THE EXPERIMENTAL RESULTS):



Test #	I (cyl1)	II (cyl1)	I (cyl2)	II(cyl2)	I (cyl3)	II (cyl3)
Thickness, h1	0.015	0.0146	0.015	0.0146	0.015	0.0146
Mass of the explosive in kg	0.153454	0.153454	0.07006	0.07006	0.053788	0.053788
Peak tensile hoop strain, e1 (%)	1.41	2.6(2.7)	0.76	1.02	0. 61	0.75
Time to reach e1, T1 (micro seconds)	119.6	140	239.6	108	249.3	160
Peak compressive hoop strain, e2 (%)	-1.49	-0.5	-0.7	-0.09	-0.61	-0.32
Peak longitudinal strain, e3 (%)	0.74	No data	0.3	0.16	0.3	0.71
Time Period (micro seconds)	70	800	93	383	104	332
Max hoop strain rate	356	312	229	128	216	92

COMPARISION OF THE SOLID MODEL RESULTS WITH THE SHELL ELEMENT RESULTS(COLUMN I REFERS TO THE RESULTS OF THE SOLID MODEL AND COLUMN II REFERS TO THE SHELL ELEMENT RESULTS):



Test #	I (cyl1)	II (cyl1)	I (cyl2)	II(cyl2)	I (cyl3)	II (cyl3)
Thickness, h1	0.015	0.0146	0.015	0.0146	0.015	0.0146
Mass of the explosive in kg	0.153454	0.153454	0.07006	0.07006	0.053788	0.053788
Peak tensile hoop strain, e1 (%)	1.41	1.4	0.76	0.71	0. 61	6.1
Time to reach e1, T1 (micro seconds)	119.6	8098	239.6	8097	249.3	8097
Peak compressive hoop strain, e2 (%)	-1.49	-0.12	-0.7	-0.06	-0.61	-0.05
Peak longitudinal strain, e3 (%)	0.74	0.106	0.3	0.05	0.3	0.04
Time Period (micro seconds)	70	109	93	71	104	104
Max hoop strain rate	356	28.62	229	14.9	216	12.5

CONCLUSIONS:

The results obtained from the analysis are varying from the experimental results; there is an error of about ten to twenty percent in the strain values. This is mainly because of the fact that CONWEP calculates the pressures at the nodes of the cylinder surface, over seeing the space, which lies between the point where the blast originates and the cylinder surface. The fluid present inside the cylinder has a considerable effect on the pressure, and in this case, the effect of air is not taken into consideration. The maximum hoop strains are approximately same for the shell and solid models but the time taken to reach e1 and the time period are deviating from the experimental values.

FUTURE SCOPE:

As described above, this is a fluid-structure interaction problem and this can be dealt with ALE analysis, which is an abbreviation for Arbitrary Lagrange Eularian.By using ALE analysis an attempt can be made to determine the effect of the fluid (present in side the cylinder) on the pressure exerted due to the blast loading.

REFERENCES:

1) ANSYS-LS DYNA USER'S GUIDE (http://www.oulu.fi/atkk/tkpalv/unix/ansys-6.1/content/Hlp_G_LsdTOC.html).
2) Russian Federal Nuclear Center VNIIEF Open Cylinders and AT595 Container Model Analysis Verification Plan.
3) ANSYS HELP MANUAL
LS DYNA MANUAL