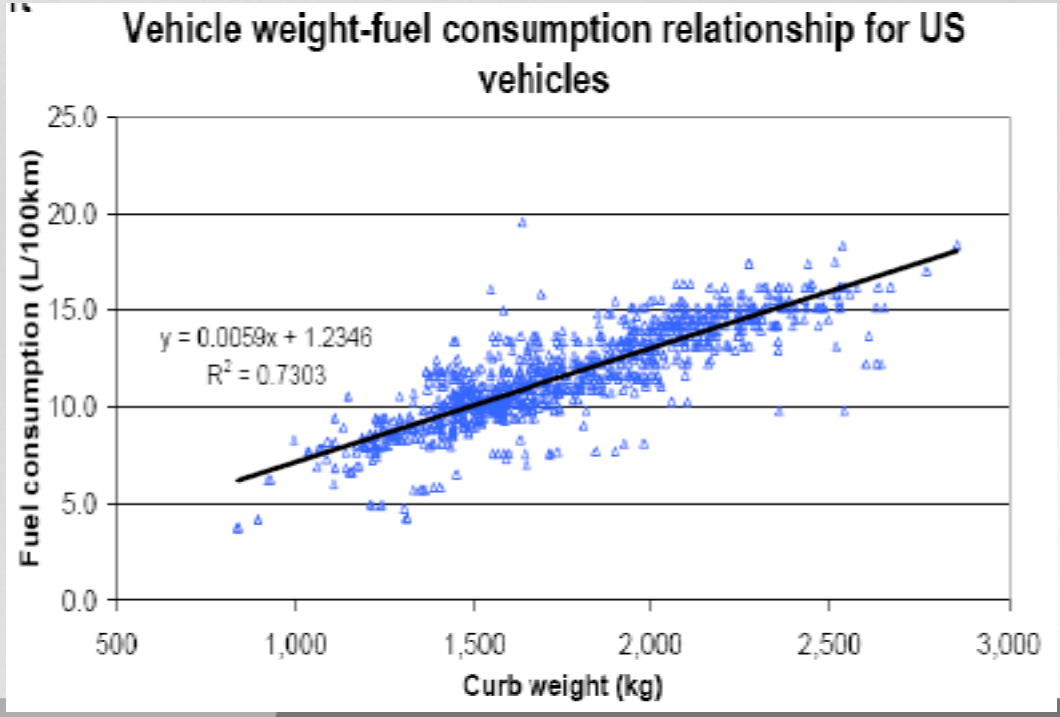
Dynamic response and energy absorption of foam

Yang An

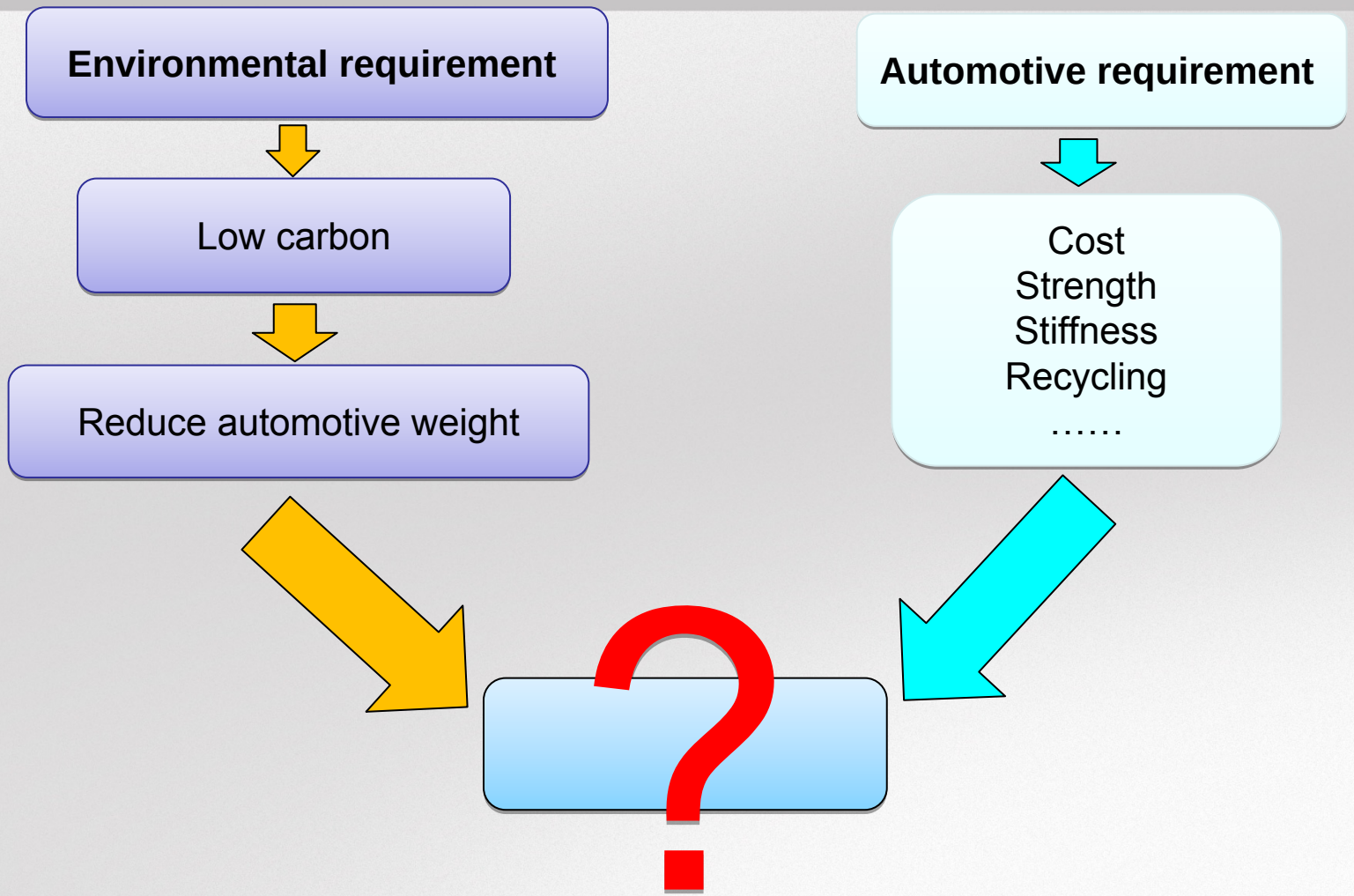
Project objectives

- One of the things I believe is absolutely necessary to get under control with a sports car, or with any car, is weight. Weight is the big enemy of all characteristics apart from ride.

---------- J. Main, Aston Martin



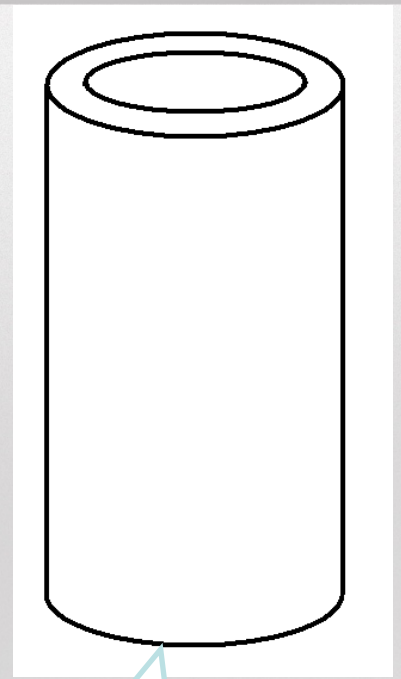
Project objectives



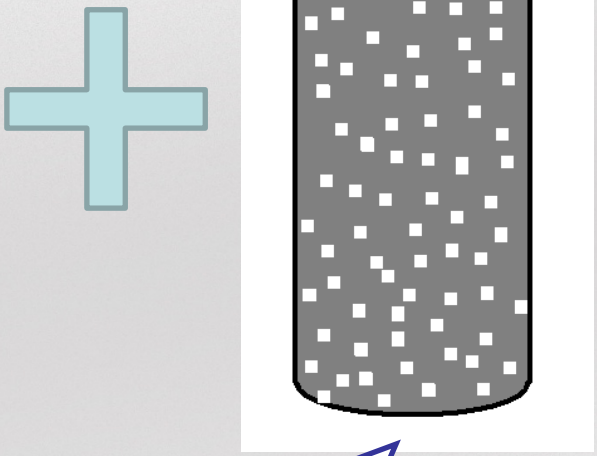
Overviews

- How to choose metal foam core tube
  - Metal tube
    - Material
    - Section shape
    - Thickness and length
  - Metal foam
    - Material
    - Porosity
    - Cell types
    - Cell shape
    - Cell size
  - Metal tube + Metal foam core
    - Interaction force between outer metal tube and inner metal foam core

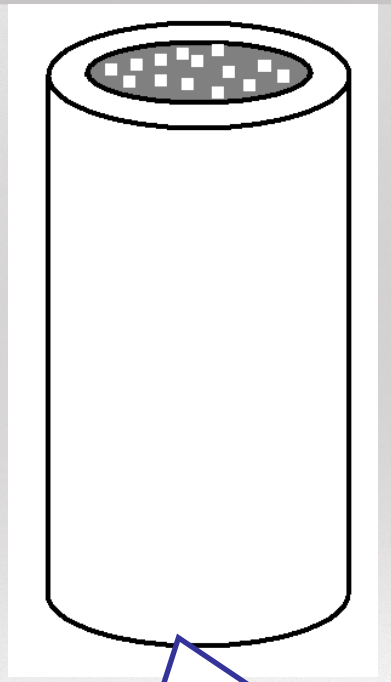
Research questions



Tube: High stress, high stiffness



Foam: High energy absorbability, low density



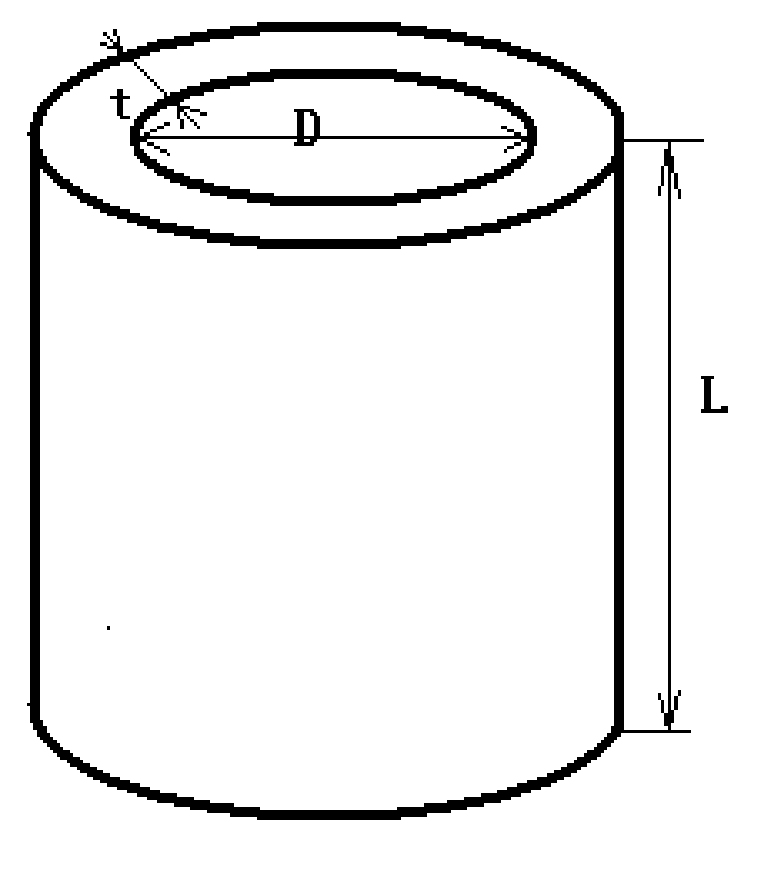
Metal tube with foam core:

?

Overviews

- Methodology
  - FE model
  - Experiment
- Material
  - Aluminium foams
  - Aluminium tubes
- Test
  - Compress testing
  - Bending testing

Samples



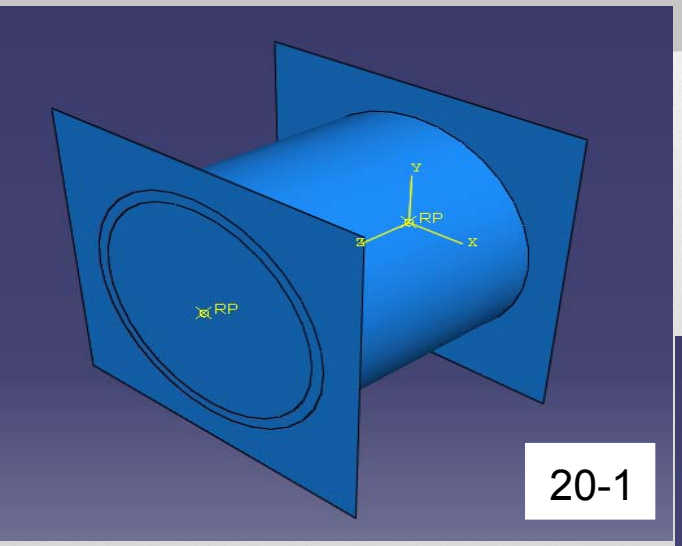
Two layer tube	
Outer layer	Inner layer
Aluminium Alloy 6063	Aluminium Foam

- *D=50mm*
- *T=2, 3, and 5 mm*
- *L= 50, 100, 200 and 400 mm*

Material Properties and Interactions

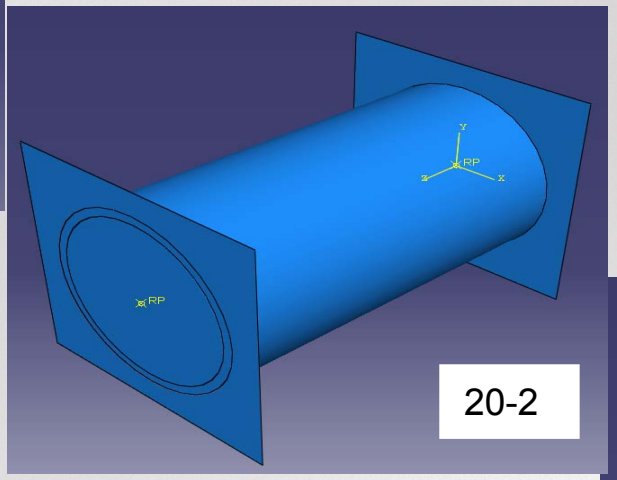
- Material properties
  - **Characteristics of Al alloy**
    - Young's modulus: E=68.9GPa
    - Yield Stress: σ=160MPa
    - Poisson's ratio: v=0.33
  - **Characteristics of Al foam**
    - Close-cell
    - Porosity: 90%
- Interactions
  - Tie connection
  - Constraint connection

Finite Element Models



20-1

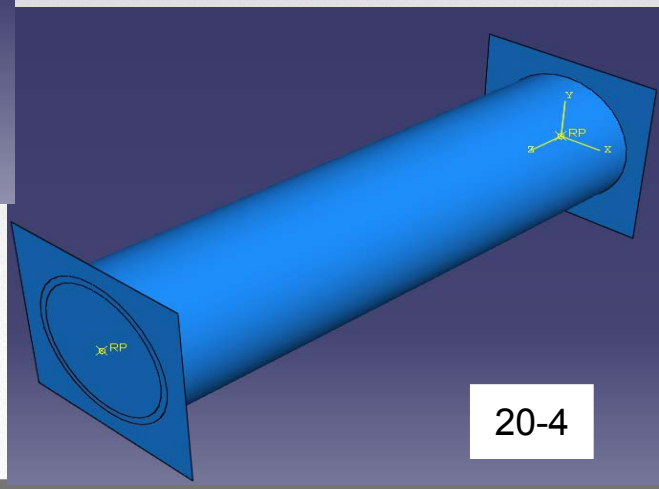
t = 2 mm
L = 50 mm



20-2

t = 2 mm
L = 100 mm

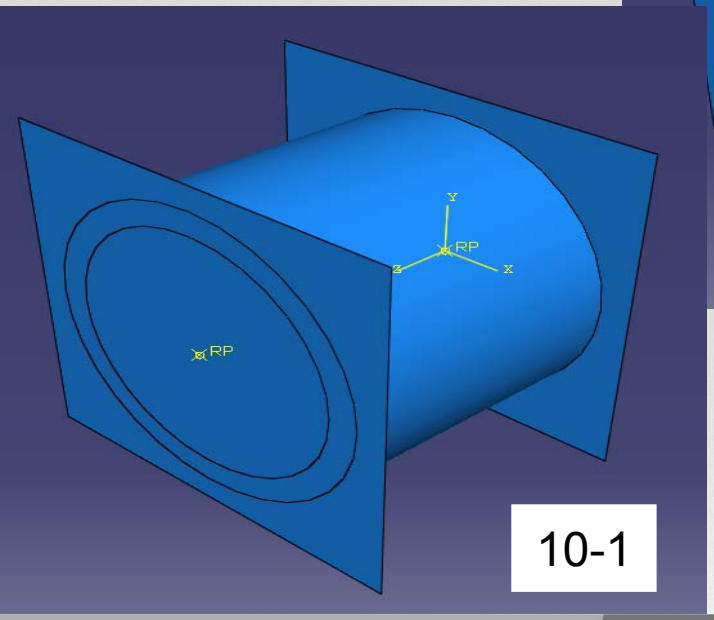
t = 2 mm
L = 200 mm



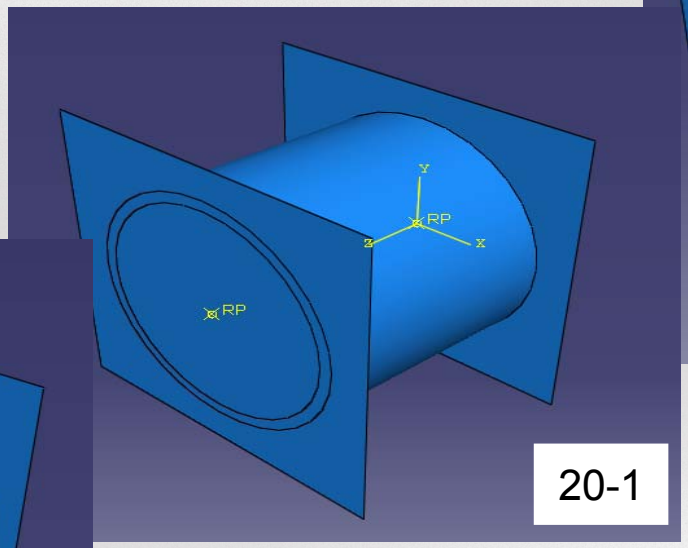
20-4

Finite Element Models

t = 5 mm
L = 200 mm

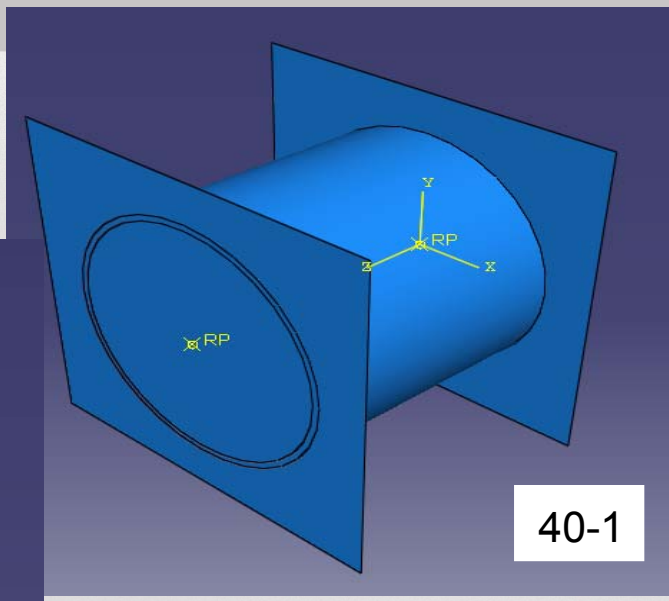


10-1



20-1

t = 3 mm
L = 200 mm



40-1

t = 2 mm
L = 200 mm

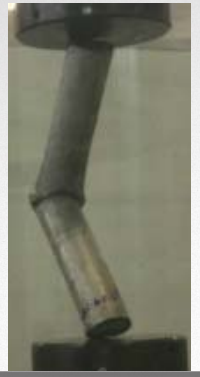
Compression deformation

Tube only

Tube with foam core

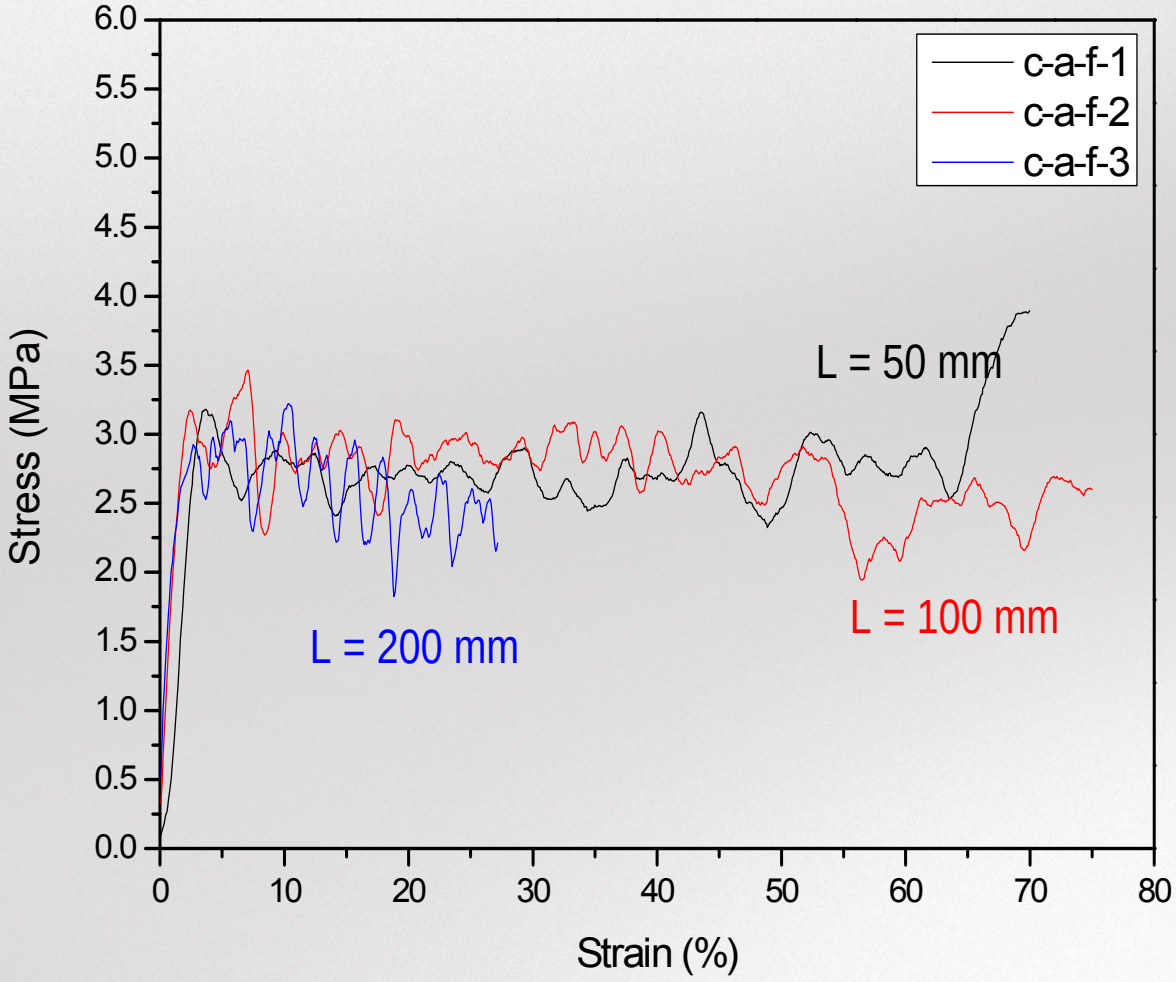
Compression deformation

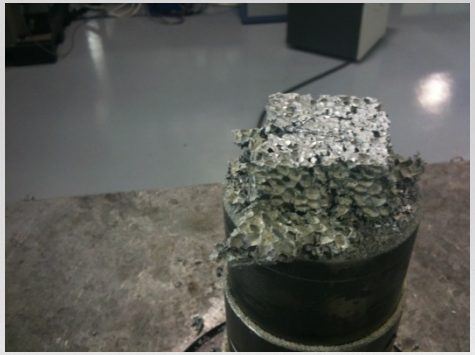
Tube only



Tube with foam core

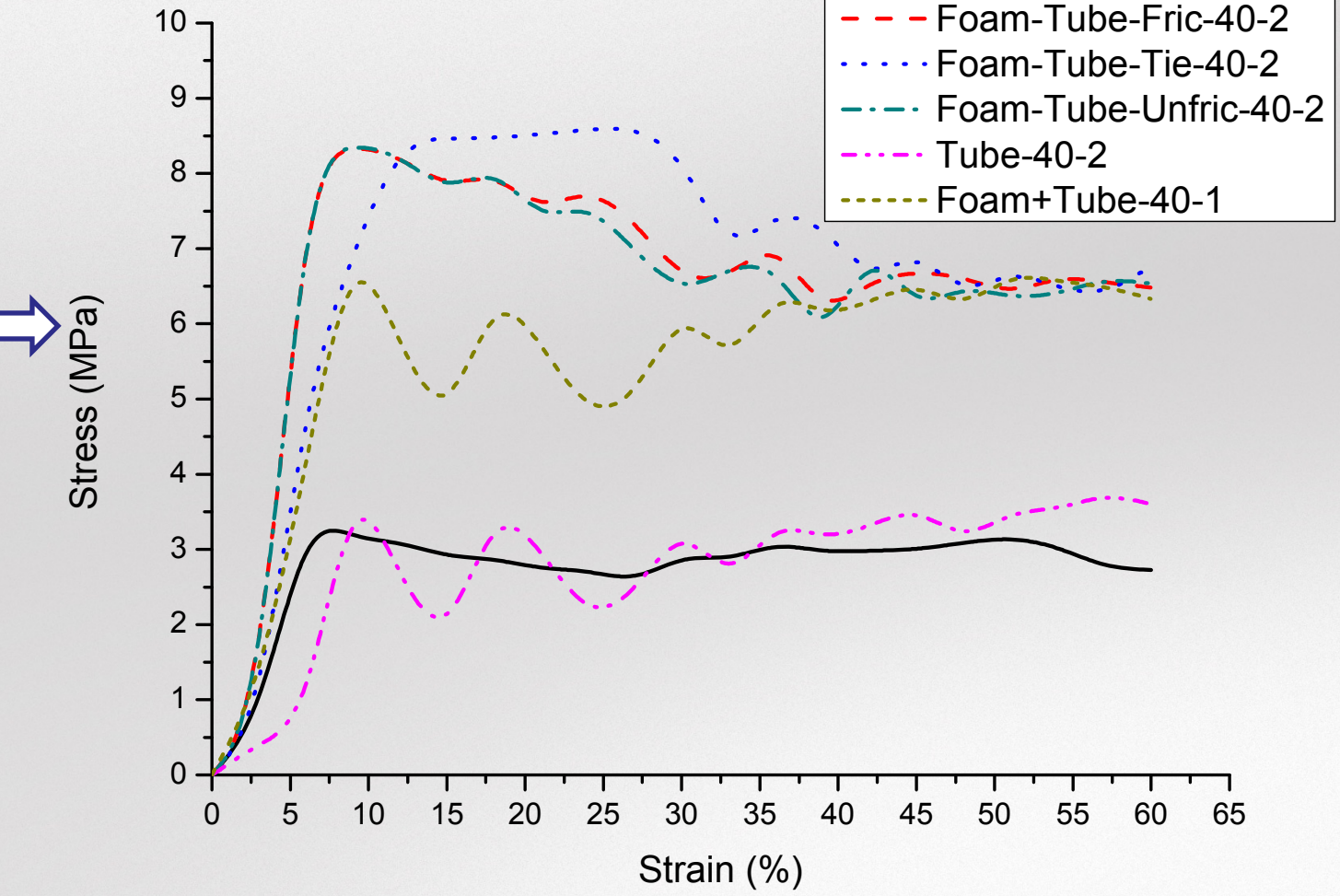
Compression deformation





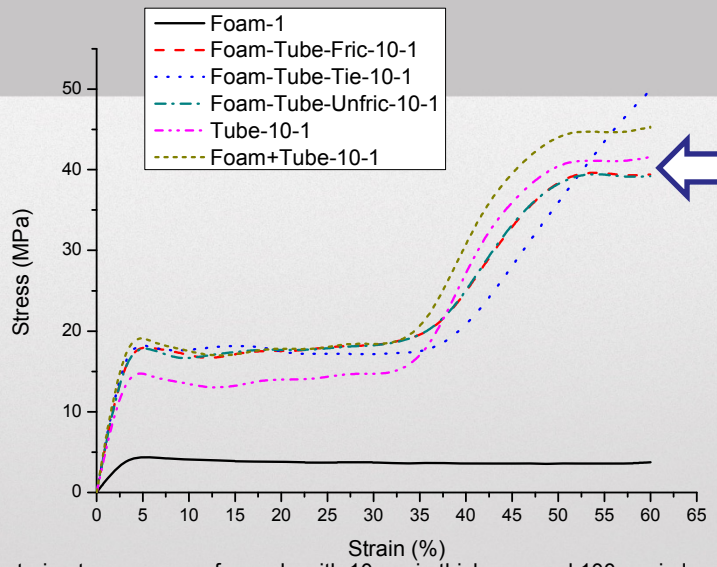
Results

D=100
t=2.5
L=200



The strain-stress curves of samples with the thickness of 2.5mm and the length of 200mm

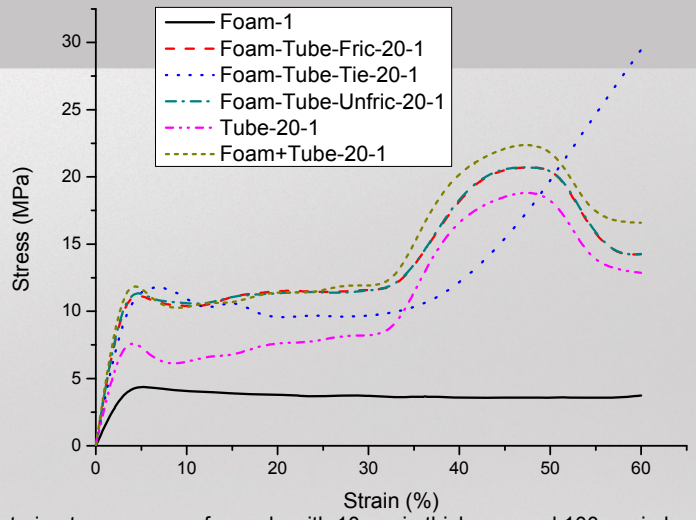
Results



D=50 mm
t=5 mm
L=200 mm

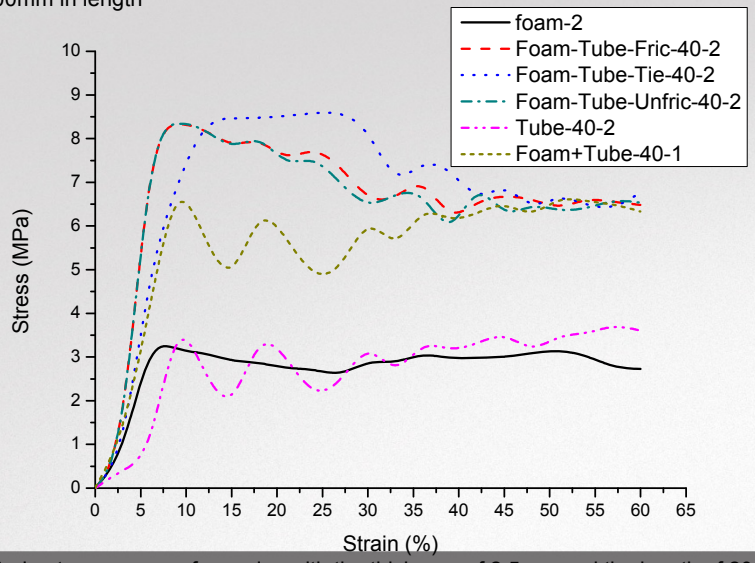
The strain-stress curves of sample with 10mm in thickness and 100mm in length

D=50 mm
T=3 mm
L=200 mm



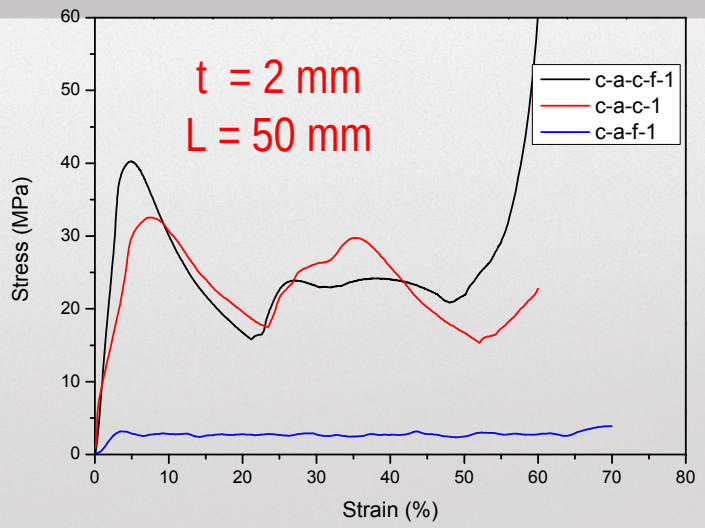
The strain-stress curves of sample with 10mm in thickness and 100mm in length

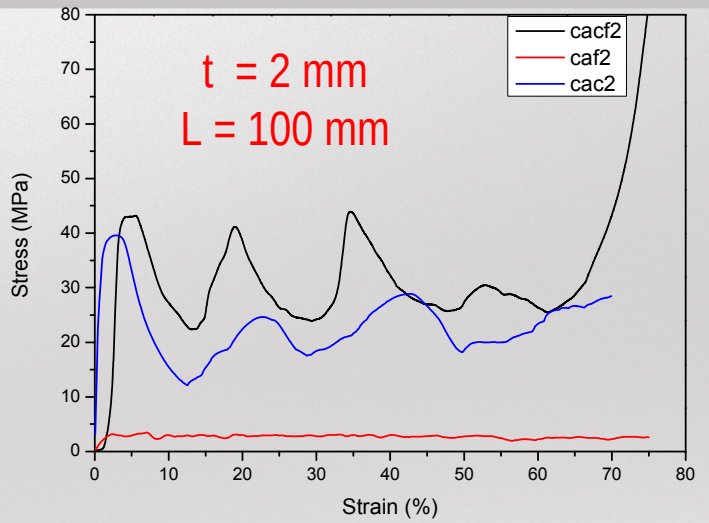
D=50 mm
t=1
L=200

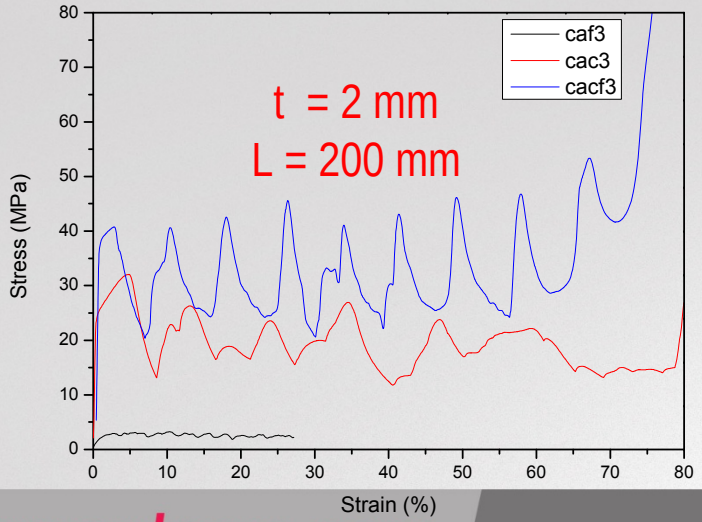


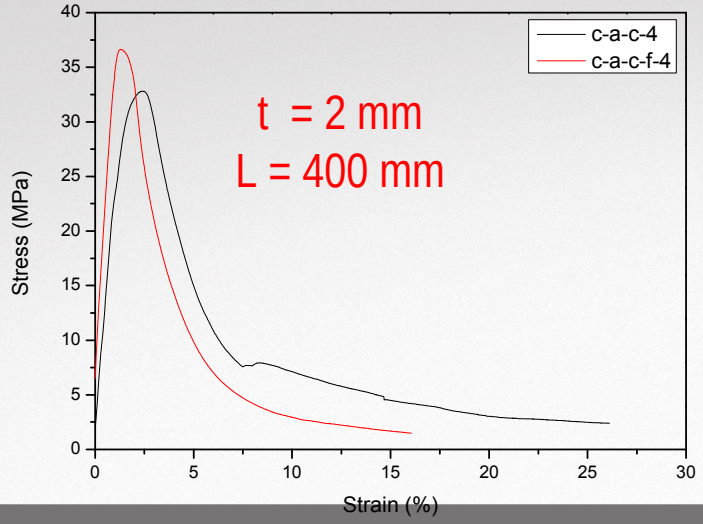
The strain-stress curves of samples with the thickness of 2.5mm and the length of 200mm

Results


t = 2 mm
L = 50 mm
c-a-c-f-1
c-a-c-1
c-a-f-1
Stress (MPa)
Strain (%)

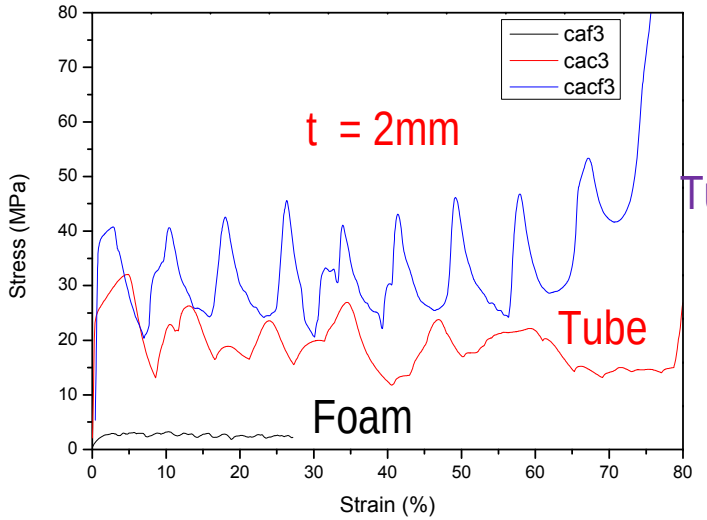

t = 2 mm
L = 100 mm
cacf2
caf2
cac2
Stress (MPa)
Strain (%)

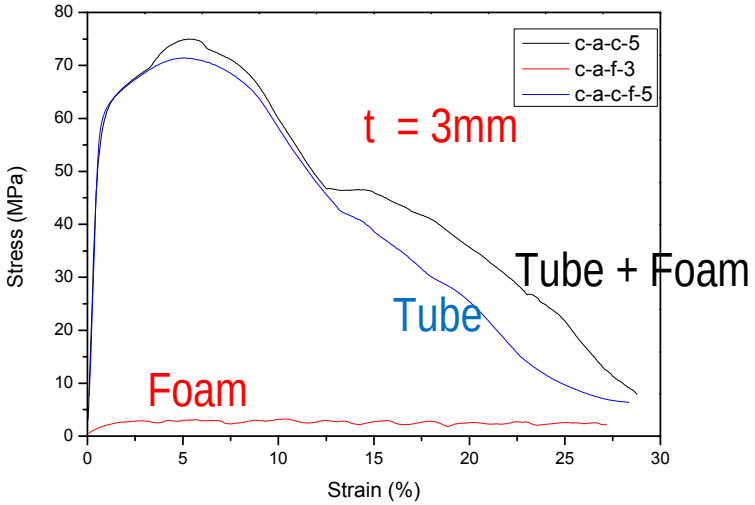

t = 2 mm
L = 200 mm
caf3
cac3
cacf3
Stress (MPa)
Strain (%)

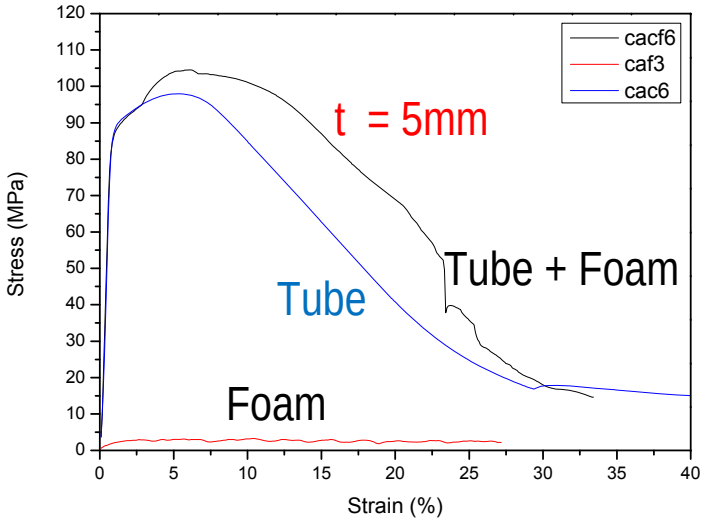

t = 2 mm
L = 400 mm
c-a-c-4
c-a-c-f-4
Stress (MPa)
Strain (%)

Results

L = 200 mm

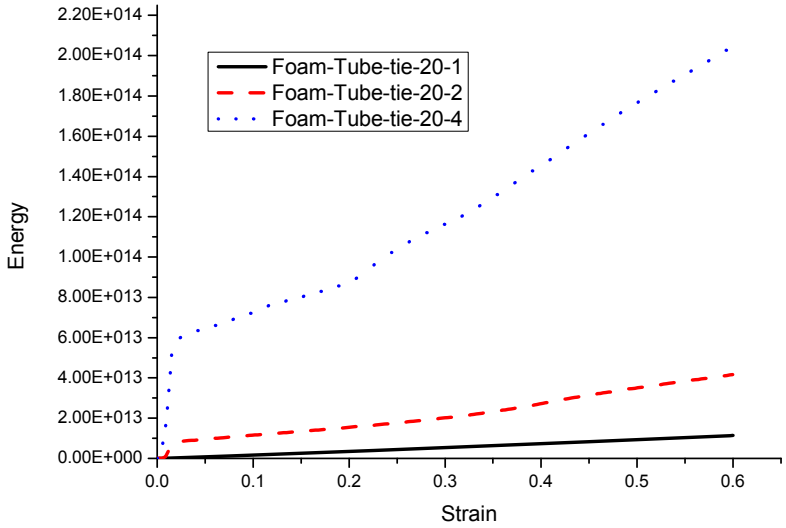




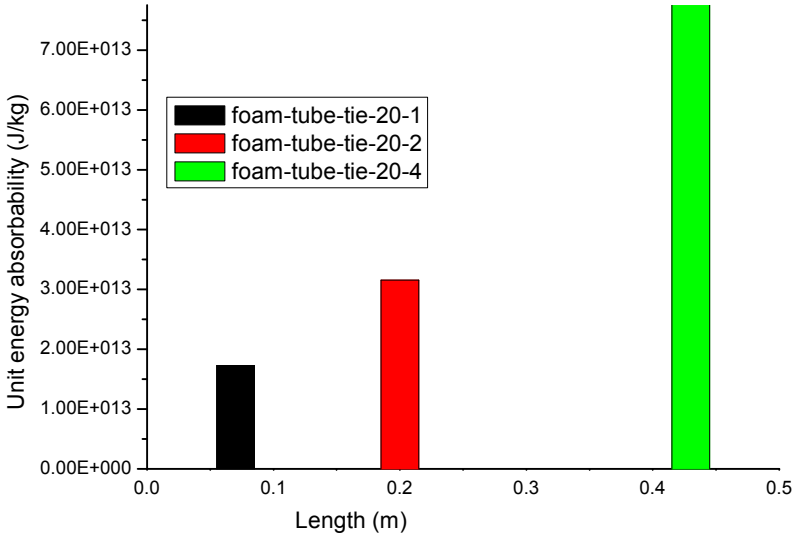


Results : Energy Absorbability

The sample with the longest length shows the highest energy absorbability



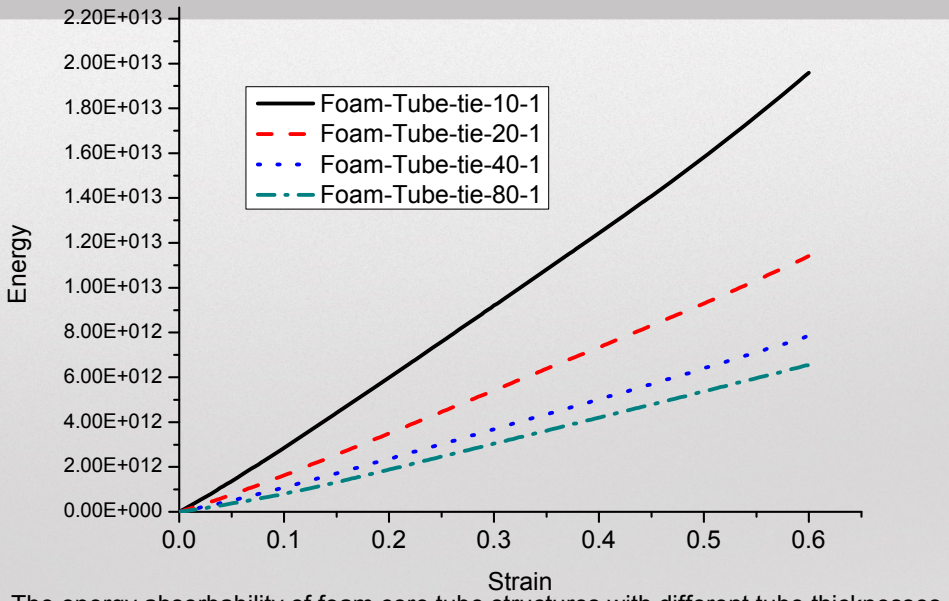
The energy absorbability of foam core tube structures with different lengths



The unit energy absorbability of foam core tube structures with different lengths

The unit energy absorbability of the foam core tube structures can be also increased by increasing the length of samples

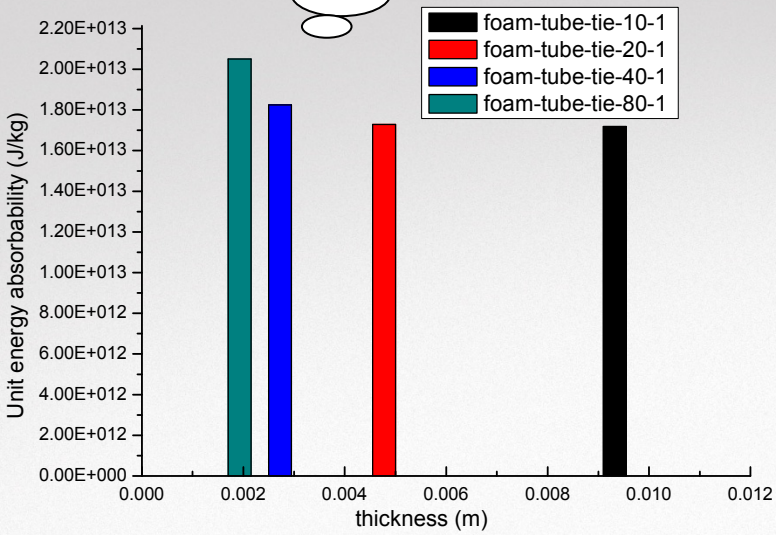
Results: Energy Absorbability



The energy absorbability of foam core tube structures with different tube thicknesses

The sample with the biggest thickness shows highest energy absorbability

Decreasing the thickness of tubes can increase the unit energy absorbability of the foam core tube structures



The unit energy absorbability of foam core tube structures with different tube thicknesses

Summary

- The foam core significantly affect the compression behaviour of tubes which include compression collapse mechanisms, stress-strain curves, Young's modulus and energy absorbability etc.
- When the length of composed structure
  - The plateau stress and yield stress do not have significantly changes, but the Young's modulus decrease
  - The strain energy absorbability increases
  - The unit strain energy absorbability (per weight) increases

Summary

- The metal tube also can affect the mechanical behaviours of composed tubes which include compression collapse mechanisms, stress-strain curves, plateau stress, yield stress and energy absorbability etc.
- When the diameters of tubes increase:
  - The plateau stress and yield stress increase
  - The strain energy absorbability increases
  - The unit strain energy absorbability (per weight) decreases

Thank you