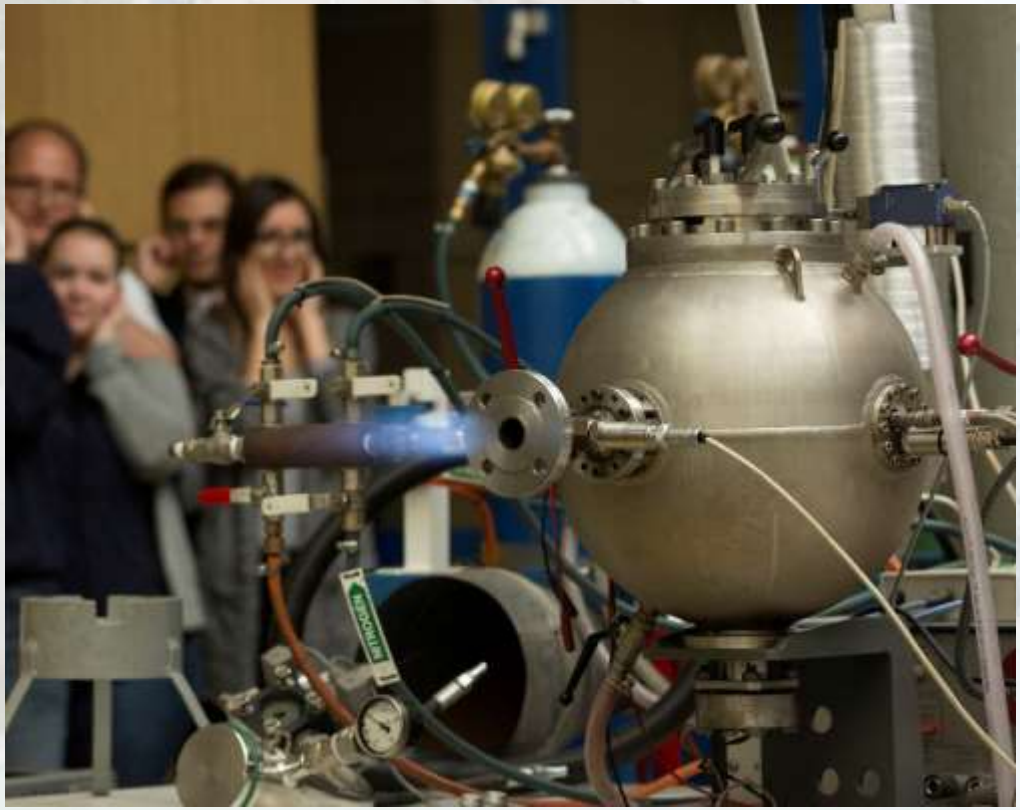
UNIVERSITY OF MISKOLC
FACULTY OF MECHANICAL ENGINEERING AND INFORMATICS



NON-CONVENTIONAL REINFORCED EPS AND ITS NUMERICAL EXAMINATION

The CCUV4 Workshop in Lodz

Máté Petrik PhD, assistant professor
mate.petrik@uni-miskolc.hu

FACULTY OF MECHANICAL ENGINEERING AND INFORMATICS

PLASTIC STRAWS

Visegrad Fund

FACULTY OF MECHANICAL ENGINEERING AND INFORMATICS

- EU restrictions on certain single-use plastics
- from 3 July 2021, single-use plastic plates, cutlery, straws, balloon sticks and cotton buds cannot be placed
- plastic straws: tubular structures, relatively good buckling behave
- how can we reuse this?

- https://environment.ec.europa.eu/topics/plastics/single-use-plastics/eu-restrictions-certain-single-use-plastics_en

THERMAL INSULATIONS

- EPS: expanded polystyrene
  - closed-cell structure
  - rigid
  - low density (10-20 kg/m^3)
- XPS: extruded polystyrene
  - also closed cell structure
  - but improved surface roughness and higher stiffness
  - reduced thermal conductivity
  - higher density (45-50 kg/m^3)
- difference in water absorption
  - EPS has a lot of open channel, water and ice may cause damage
  - XPS also not waterproof and vapor proof

OUR GOAL

Visegrad Fund

FACULTY OF MECHANICAL ENGINEERING AND INFORMATICS

- produce reinforced EPS material
  - cheaper than XPS
  - at least equal physical and thermal properties, than XPS
- reinforcment materials:
  - plastic straws → good choice
  - wheat and straw from agriculture → bad choice

PRODUCTION METHODS OF EPS AND XPS

Visegrad Fund

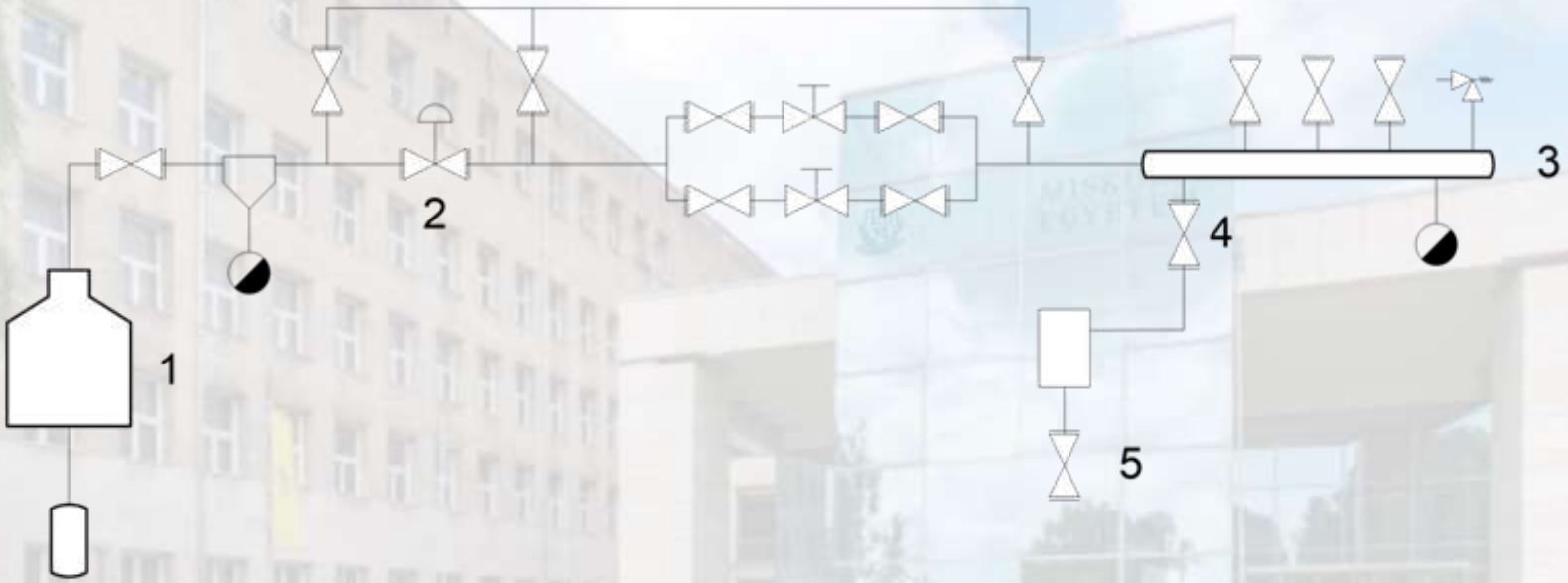
FACULTY OF MECHANICAL ENGINEERING AND INFORMATICS

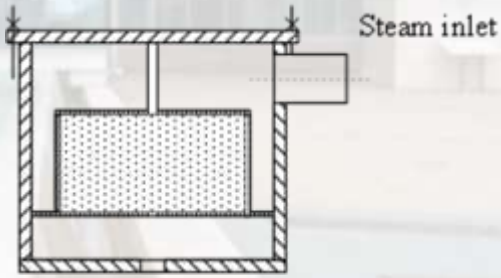
	EPS	XPS
Material	Polystyrene foam	
Production method	Polystyrene beads ↓ Heat (steam) Blowing agents (pentane, carbon dioxide) Expantion to foam ↓ Cut to size	Solid polystyrene crystals ↓ Additives, foaming agents Extrusion ↓ High temperature, high pressure Continuous press ↓ Cooled down Foam → cut to size
Structure	Closed cells	Completely closed cells
Density, kg/m^3	13,5	50
Pressure resistance, kPa	70	100-690

OWN METHOD FOR EPS PRODUCTION

Visegrad Fund

FACULTY OF MECHANICAL ENGINEERING AND INFORMATICS





Steam system used for EPS production:
1: Boiler, 2: Control valve, 3: Steam header, 4: Valve, 5: Throttle valve

EXPERIMENTS

Visegrad Fund

FACULTY OF MECHANICAL ENGINEERING AND INFORMATICS

Specimen ID	Additive Material	Density (kg/m³)
Specimen 1	none	87.2
Specimen 2	2 g natural wheat straw	79.9
Specimen 3	none	87.2
Specimen 4	2 g natural wheat straw	87.6
Specimen 5	5 pieces Ø12 mm PE straw	96.9
Specimen 6	5 pieces Ø12 mm PE straw	95.9
Specimen 7	5 pieces Ø12 mm PE straw	125.21
Specimen 8	5 pieces Ø12 mm PE straw	129.9
Specimen 9	7 pieces Ø8 mm PE straw	96.9
Specimen 10	7 pieces Ø8 mm PE straw	104.9
Specimen 11	7 pieces Ø8 mm PE straw	121.6

COMPRESSION TEST

- Mechanical test

1—pressing machine,

2—force measuring cell,

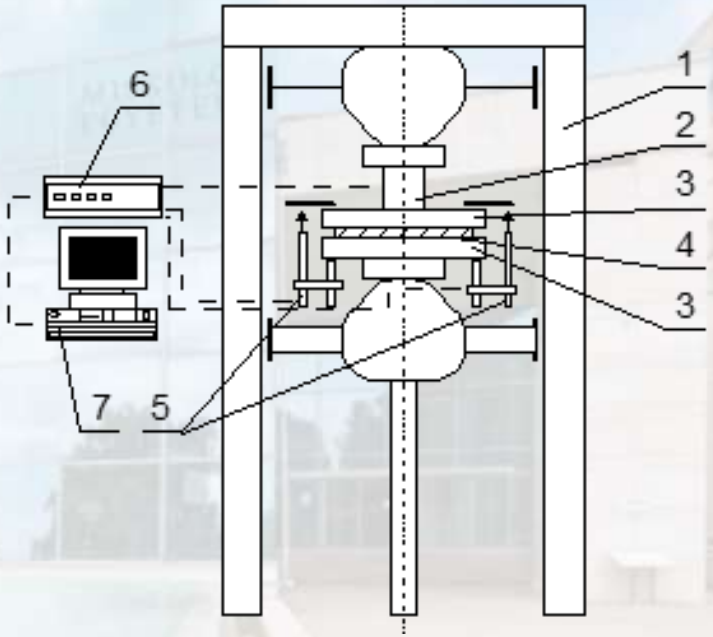
3—clamping structure,

4—tested specimen,

5—displacement transmitter,

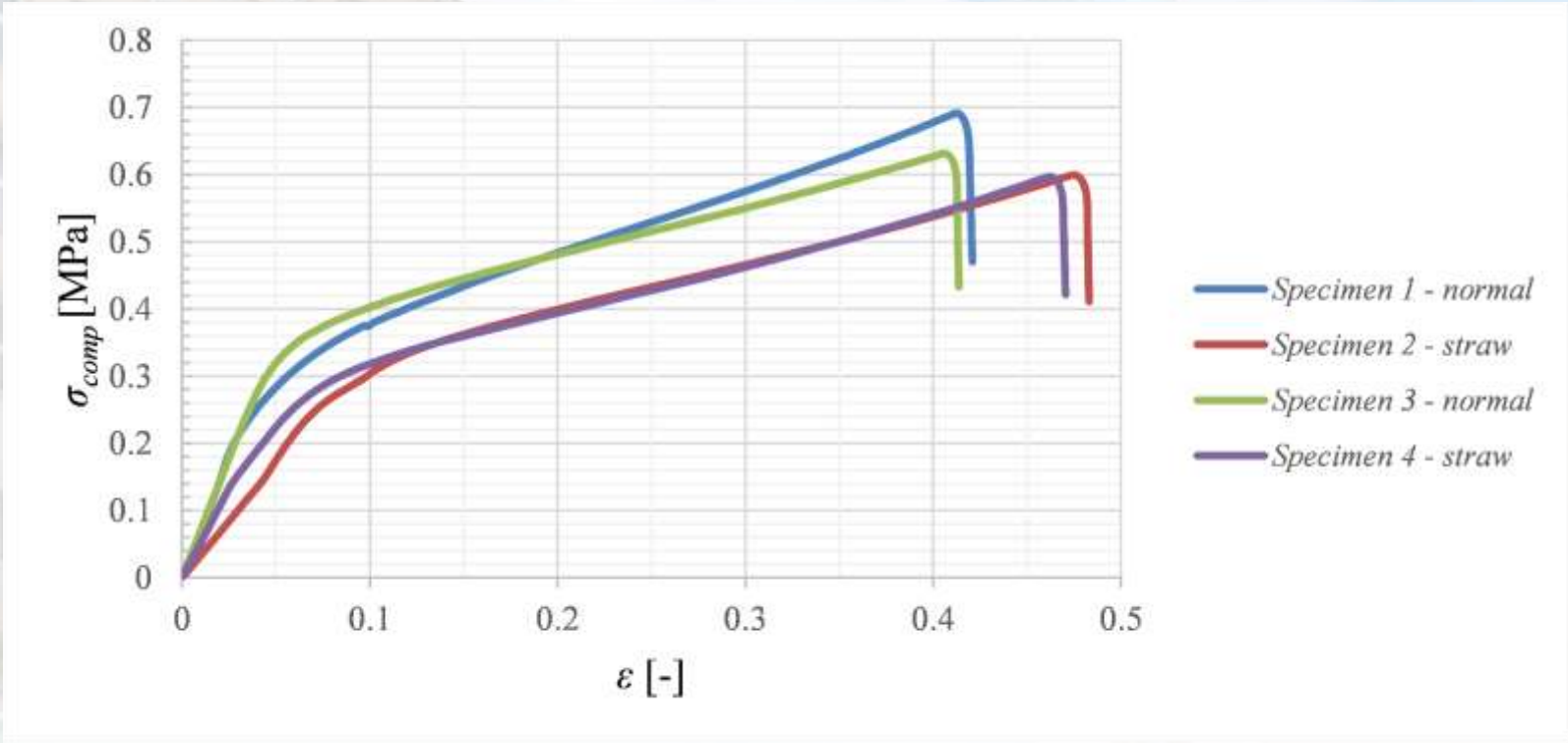
6—Quantum X A/D measurement data collector,

7—computer

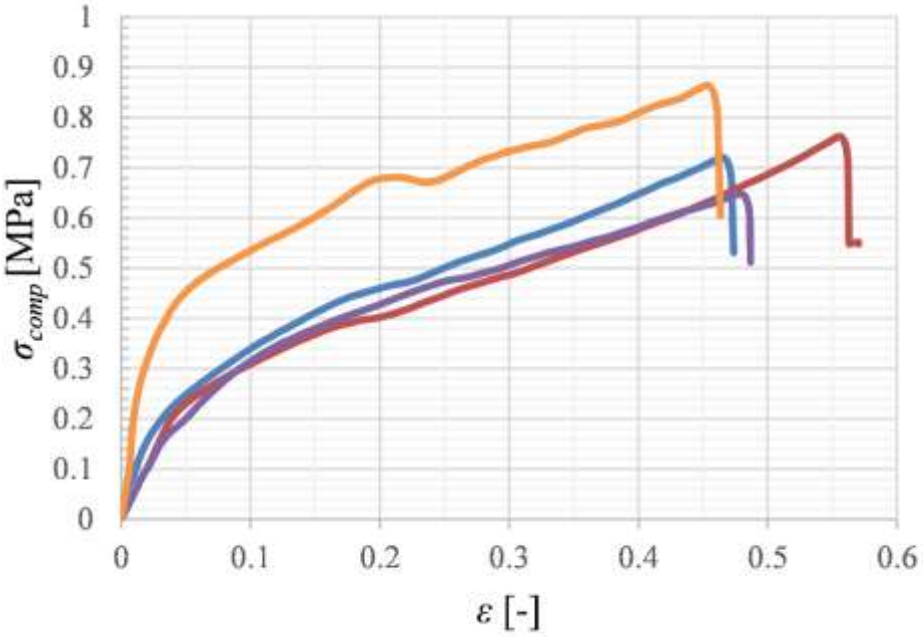


RESULTS

Visegrad Fund



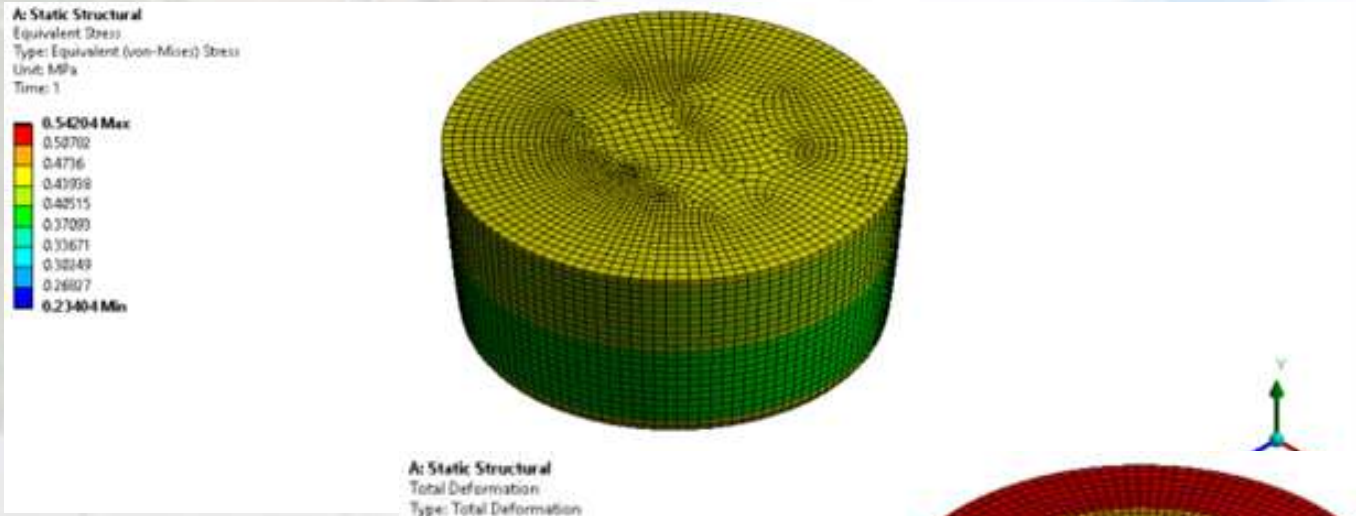
RESULTS

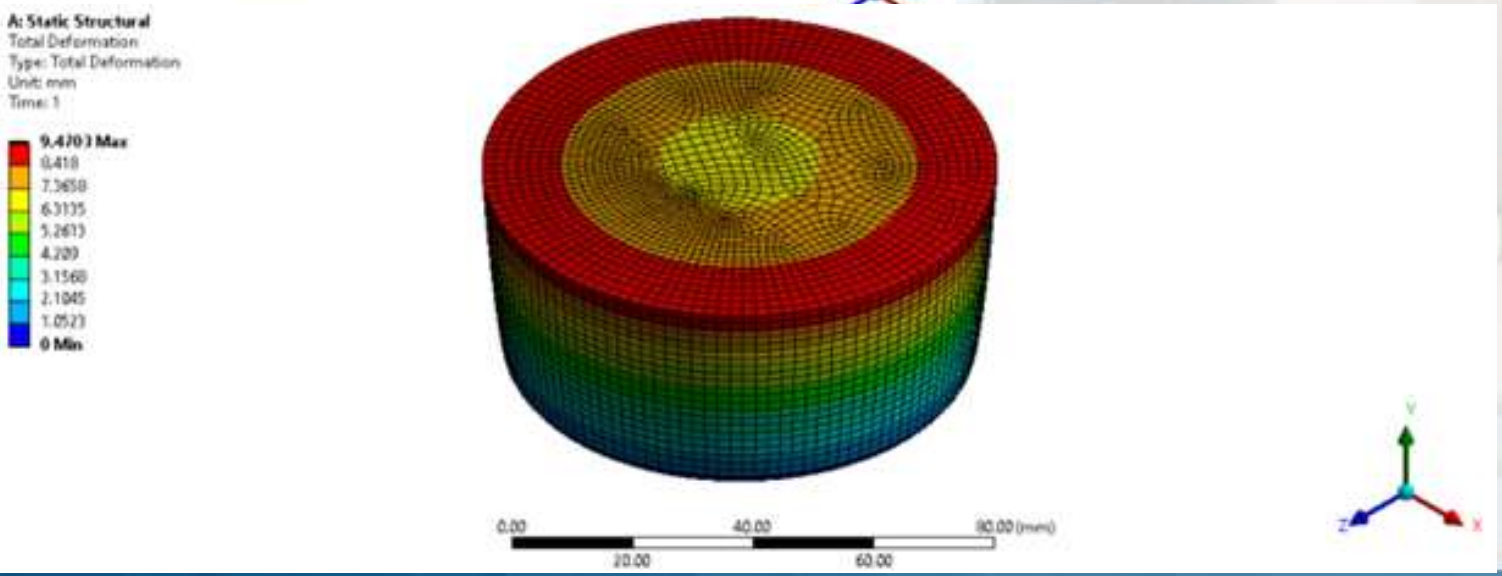

1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
σ_{comp} [MPa]
0
0.1
0.2
0.3
0.4
0.5
0.6
ε [-]
Specimen 5 - 5 big pc. straws
Specimen 6 - 5 big pc. straws
Specimen 7 - 5 big pc. straws
Specimen 8 - 5 big pc. straws
Specimen 5 - 5 big pc. straws
Specimen 6 - 5 big pc. straws
Specimen 7 - 5 big pc. straws
Specimen 8 - 5 big pc. straws

FINITE ELEMENT ANALYSIS

Visegrad Fund

FACULTY OF MECHANICAL ENGINEERING AND INFORMATICS

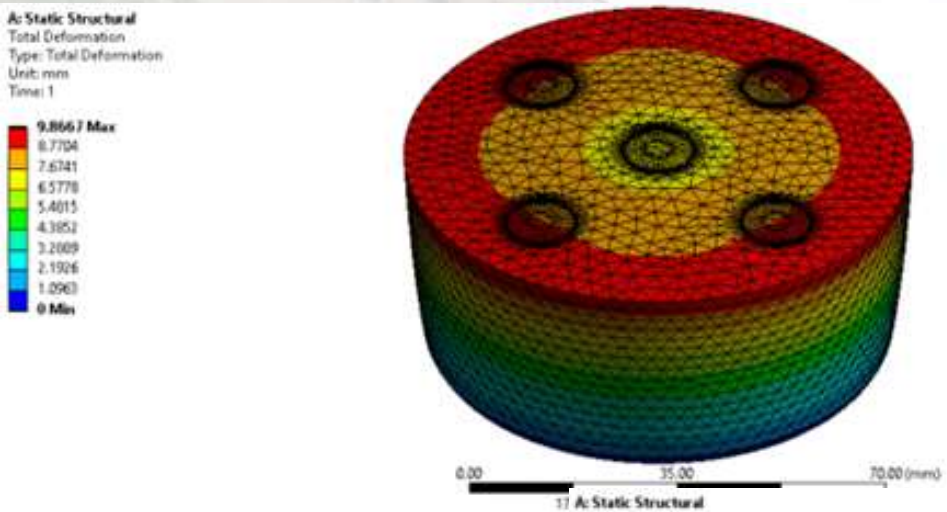


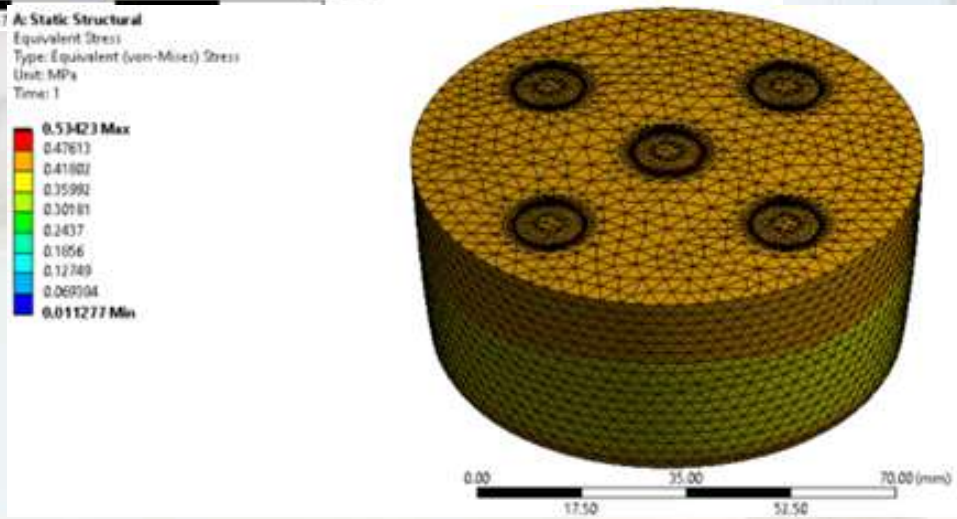


FINITE ELEMENT ANALYSIS

Visegrad Fund

FACULTY OF MECHANICAL ENGINEERING AND INFORMATICS





RESULTS FROM FEM

Visegrad Fund

FACULTY OF MECHANICAL ENGINEERING AND INFORMATICS

- bilinear hardening model suitable for the reinforced EPS material
- values:
  - Young's modulus: 8.1378 MPa
  - yield strength: 0.321 MPa
  - tangent modulus: 0.626 MPa
- differences between the measurements and analysis:
  - unbraced specimen: 8.42 mm measured and 8.3 mm simulates compression
  - stiffened specimen: 9.53 mm measured and 9.8 mm simulated compression
- thermal analysis:
  - with different CFD softwares, shows good correlation

SUMMARY

- recycling of plastic is a high proirity these days
- may have alternative or unconventional uses in various thermal insulation systems to increase strength
- we made experiments with different sizes and numbers of straws
- we proved that our idea was correct, the straws placed in the right direction increased the compressive strength of the EPS material
- future plans:
  - usage of more unconventional stiffiners
  - further development of production technology

University of Miskolc
Faculty of Mechanical Engineering and Informatics
Institute of Energy Engineering and Chemical Machinery
H-3515 MISKOLC-EGYETEMVÁROS

Máté Petrik PhD
assistant professor
mate.petrik@uni-miskolc.hu
+36 46 565 111 19/28
www.uni-miskolc.hu

LinkedIN profiles of the member of working group
Viktória Mikáczó PhD, Gábor Szepesi PhD, Zoltán Szamosi PhD, Zoltán Siménfalvi PhD, Máté Petrik PhD
Katalin Voith PhD