MICROWAVE DISHES CONTAINERS

Selecting Materials and Process

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1. Introduction

Microwave dishes principal applications:

- Fast food
- Reheating food

Common materials:

- Polymers such as PP and PE
- Polymer foams of PS
- Traditional glass and ceramic dishware

2. Function

Principal function :

- Contain food heated by microwaves

Microwave oven :

- Microwave: radiation of 2.45 GHz through the food
- Water, fat and other substances in the food absorb energy from the microwaves in a process called dielectric heating

3. Objectives

Choice of materials and process

- Scenario 1
  Disposable microwave dishes
  → very cheap

- Scenario 2
  Reusable dishes
  → cost less critical
  → very good resistance to fresh water

4. Constraints

- Minimal microwave absorption Z ε

  → Minimal dielectric constant ε

  → Minimal power factor Z

- Minimal thickness to limit absorption
- Stiff and strong enough to cope with ordinary handling loads
- Support service temperature of about 100° C
- Good thermal insulation for handling and keep dishes hot

4. Constraints

- Estimation of mechanical properties required

$$\delta = \frac{Fw^3}{384EI} \quad \text{with} \quad I = \frac{wt^3}{12} \quad \Rightarrow \quad E = \frac{Fw^3}{384I\delta}$$

$$\sigma = \frac{Ftw}{16I} = \frac{3F}{4t^2}$$

Numerical application :

F = 10 N

δ = 10 mm

w = 200 mm

t = 2 mm

$\Rightarrow$

E = 156.25 MPa

σ = 1.875 MPa

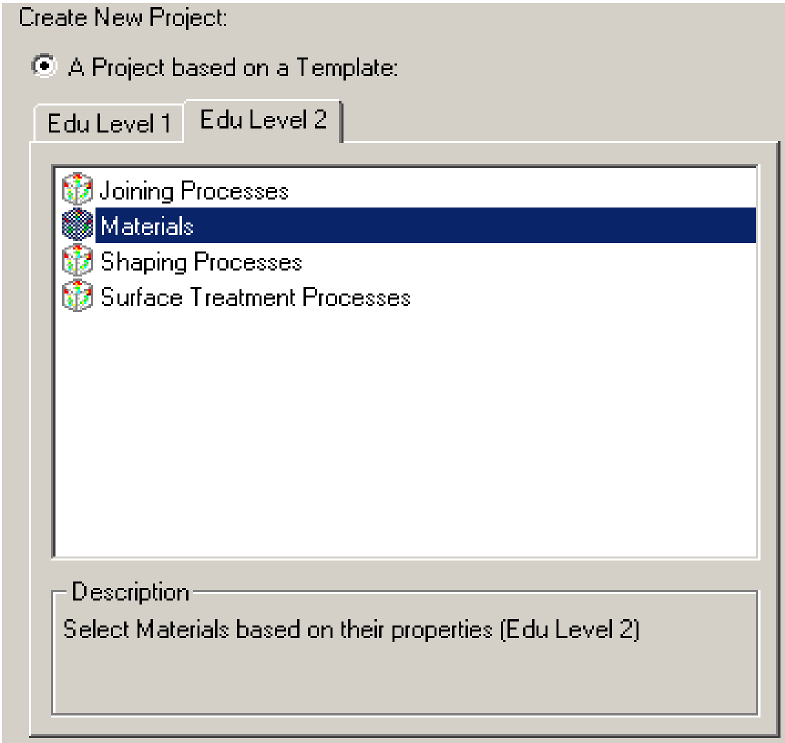
5. Free variables

- Choice of materials
- Choice of process

6. Approach - Scenario 1

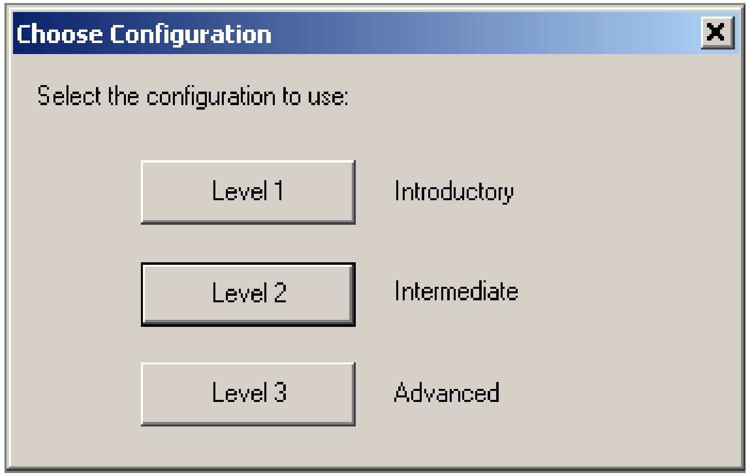
Selection data :

Edu Level 2 - Materials



Configuration :

Level 2 - Intermediate



6. Approach – Scenario 1

Choice of materials :

Stage 1 - Limit Stage

Mechanical properties

	Minimum	Maximum	
Young's modulus	0.15625		GPa
Shear modulus			GPa
Bulk modulus			GPa
Poisson's ratio			
Yield strength (elastic limit)	1.875		MPa
Tensile strength			MPa

Thermal properties

Thermal conductor or insulator?

- ☐ Good conductor
- ☐ Poor conductor
- ☑ Poor insulator
- ☑ Good insulator

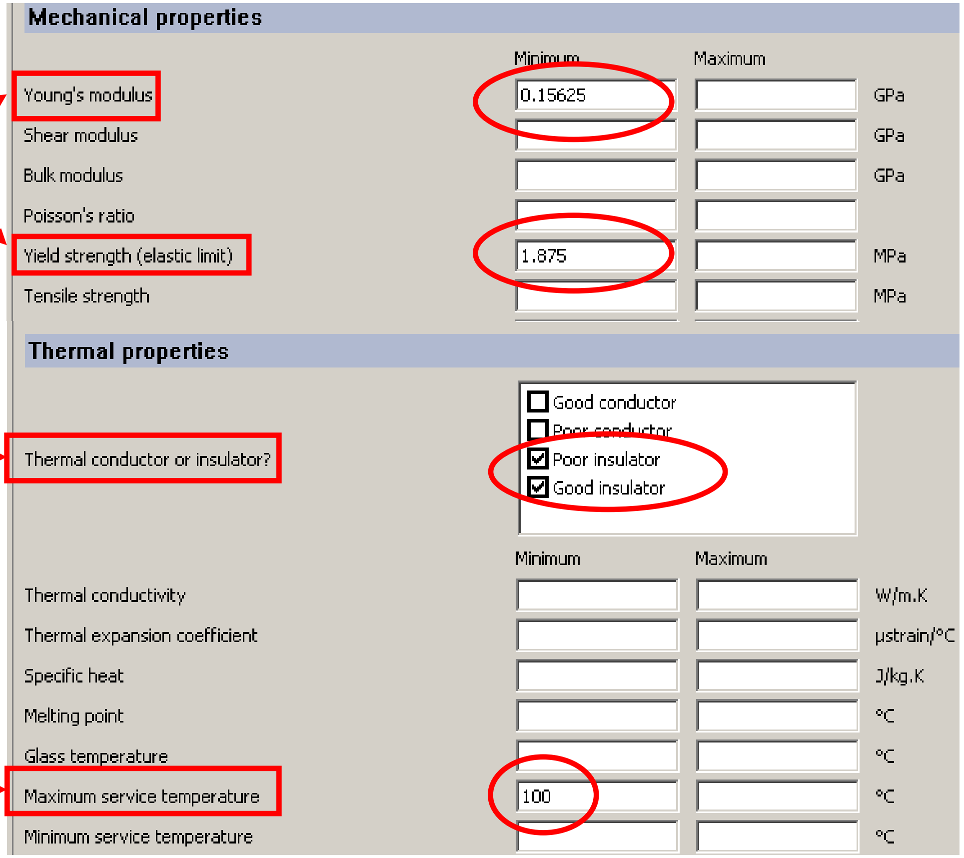
	Minimum	Maximum	
Thermal conductivity			W/m.K
Thermal expansion coefficient			µstrain/°C
Specific heat			J/kg.K
Melting point			°C
Glass temperature			°C
Maximum service temperature	100		°C
Minimum service temperature			°C

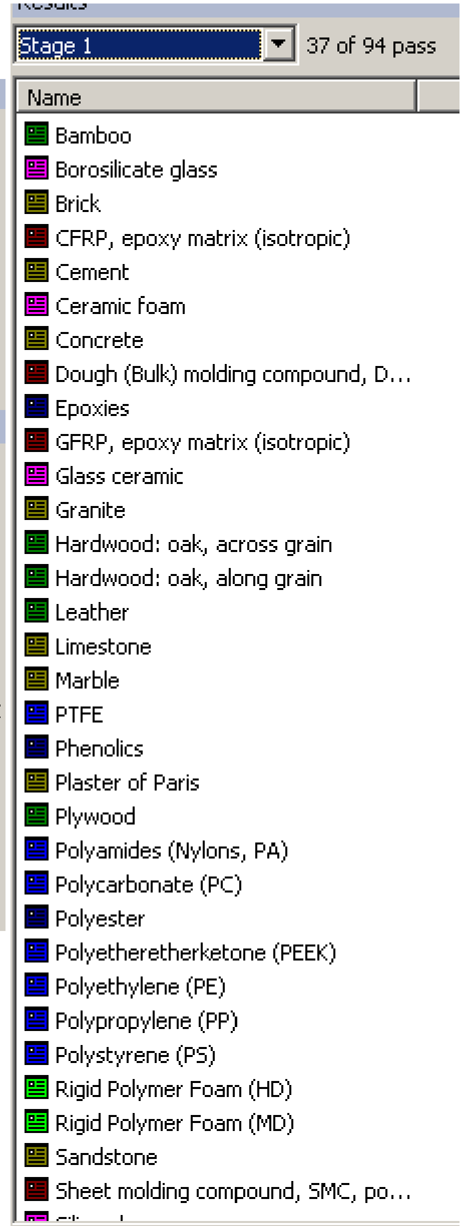
6. Approach – Scenario 1

Calculated values

Can be taken & keep dishes hot

Water boiling





6. Approach – Scenario 1

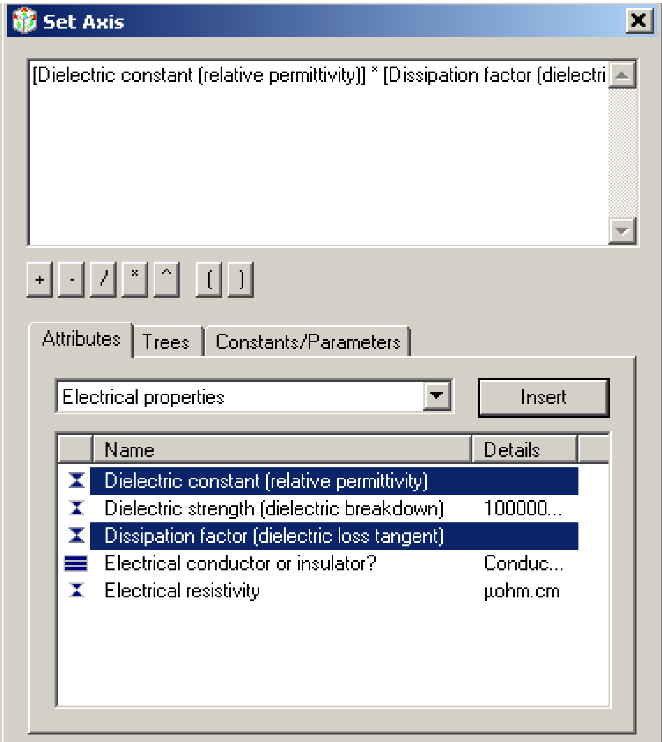
Choice of materials :

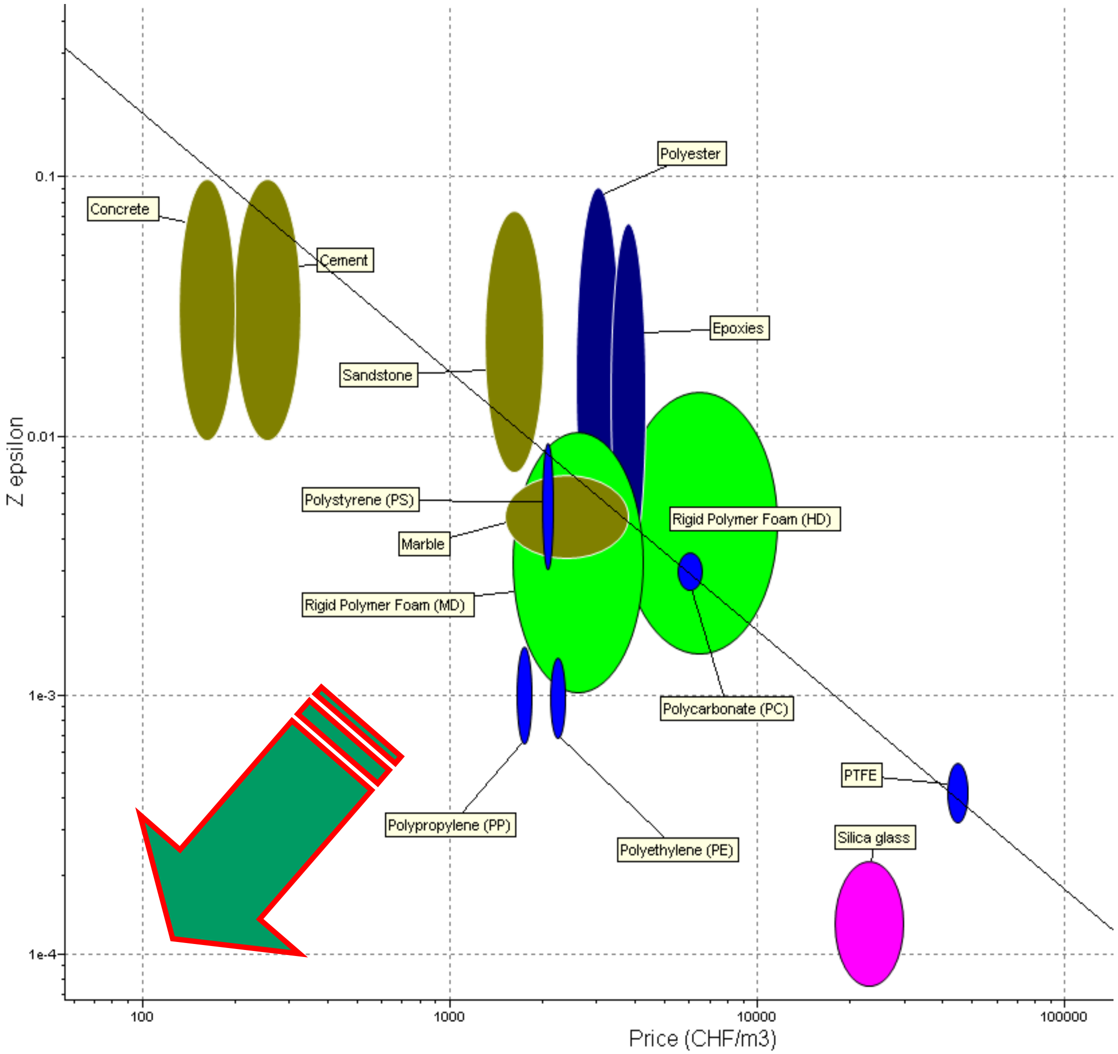
Stage 2 – Graph Stage

Z ε

vs

Price [m^3]



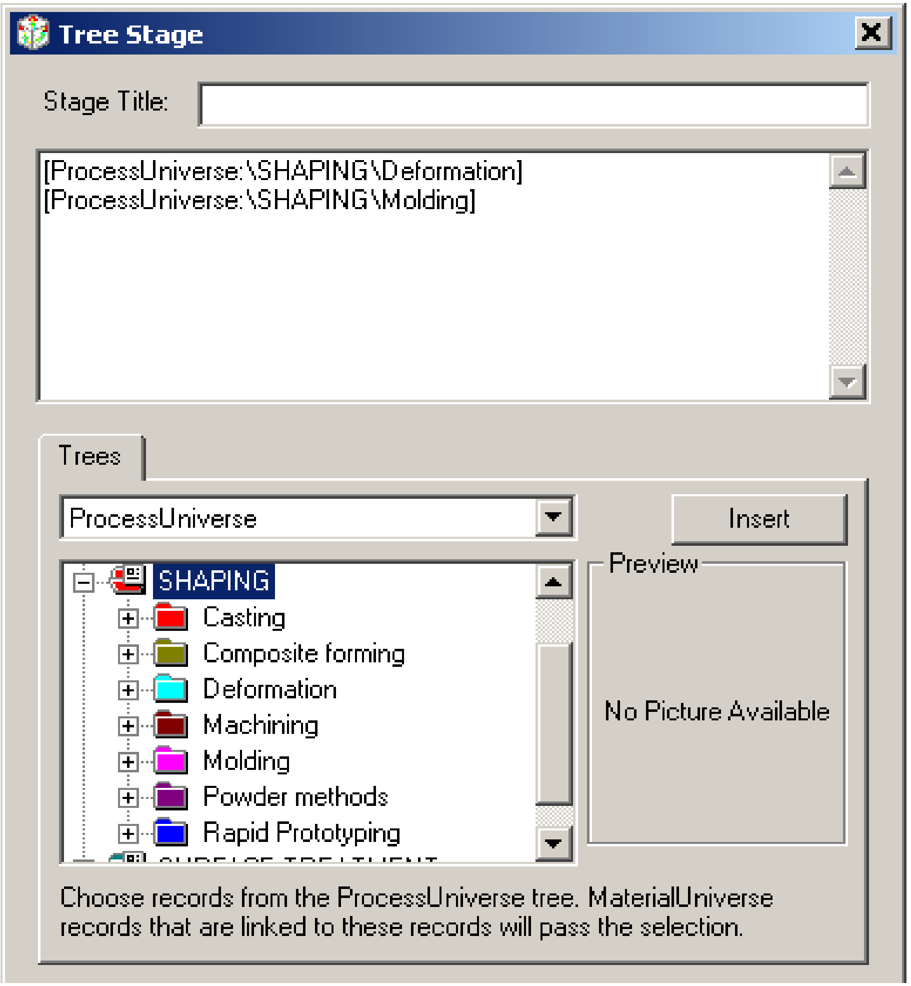


6. Approach – Scenario 1

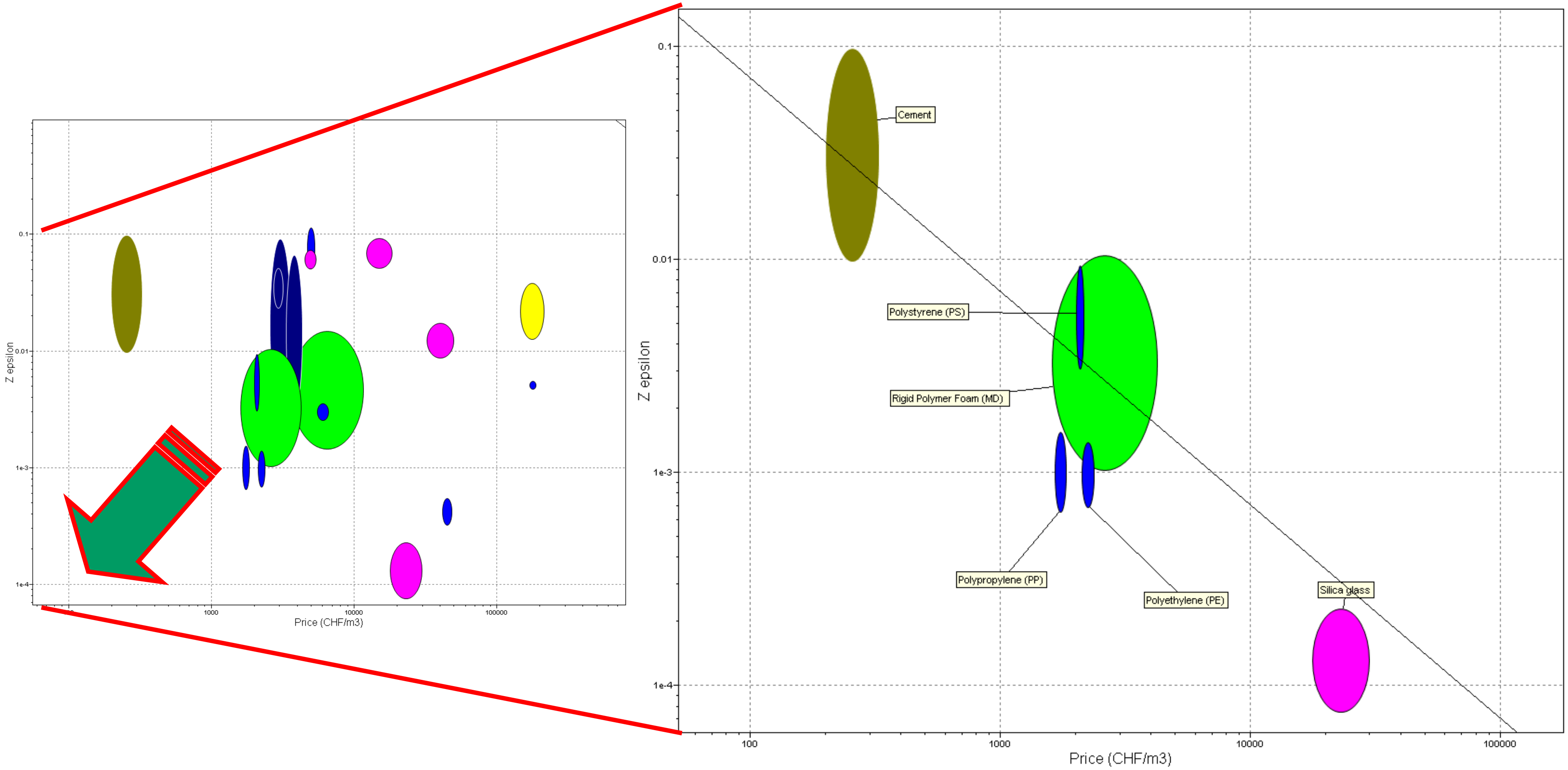
Choice of process :

Stage 3 – Tree Stage

- Deformation
- Molding

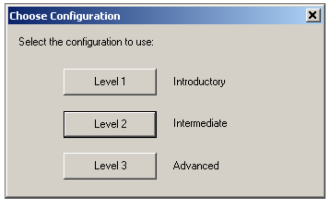


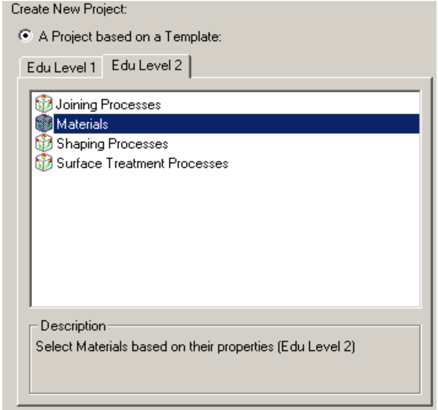
6. Results – Scenario 1



- The best one is Polypropylene (PP), but generally Rigid Polymer Foam (MD) and Polystyrene (PS) are used for disposable microwave dishes containers
- Ribs can be added to the geometrical design to increase mechanical resistance

6. Approach – Scenario 2





From scenario 1 :

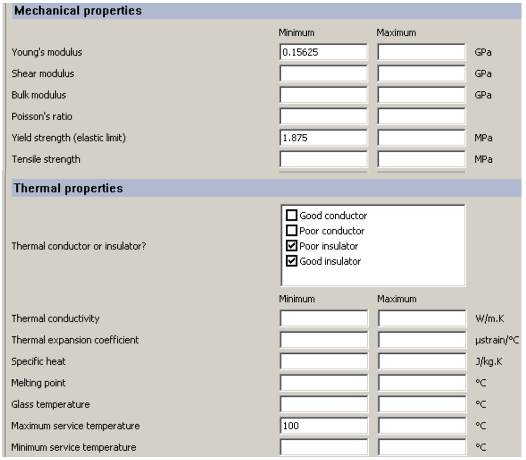
- Same data selection & configuration

  Edu Level 2 - Materials - Intermediate

- Same choice of process

  Molding

  Deformation



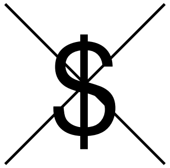
Added constraint :

Limit added to stage 1: very good resistance to fresh water

Analysis :

The price is less critical

The mechanical durability is more critical



6. Approach – Scenario 2

Choice of materials :

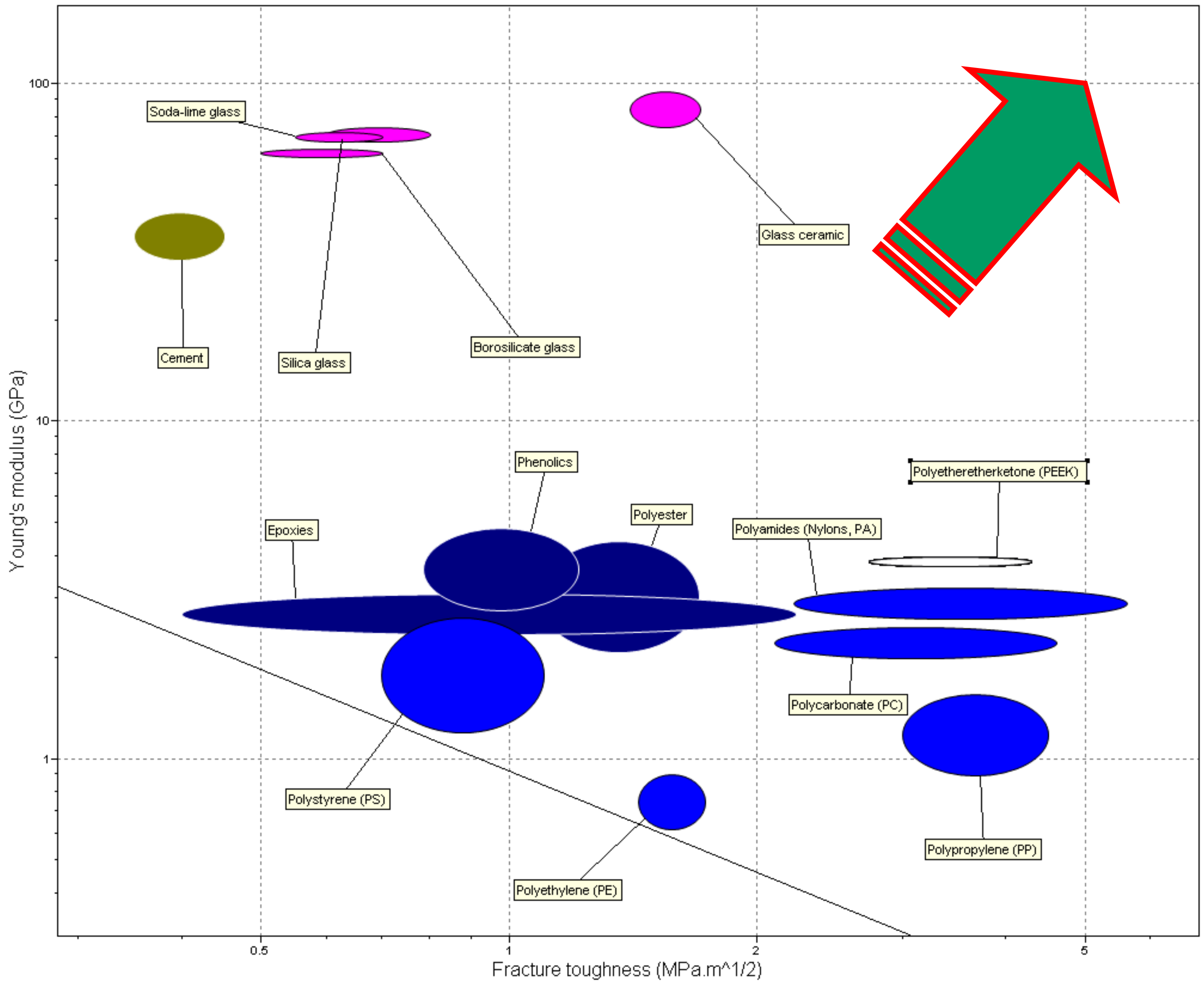
Stage 4 – Graph Stage

- Mechanical performances

Young modulus [GPa]

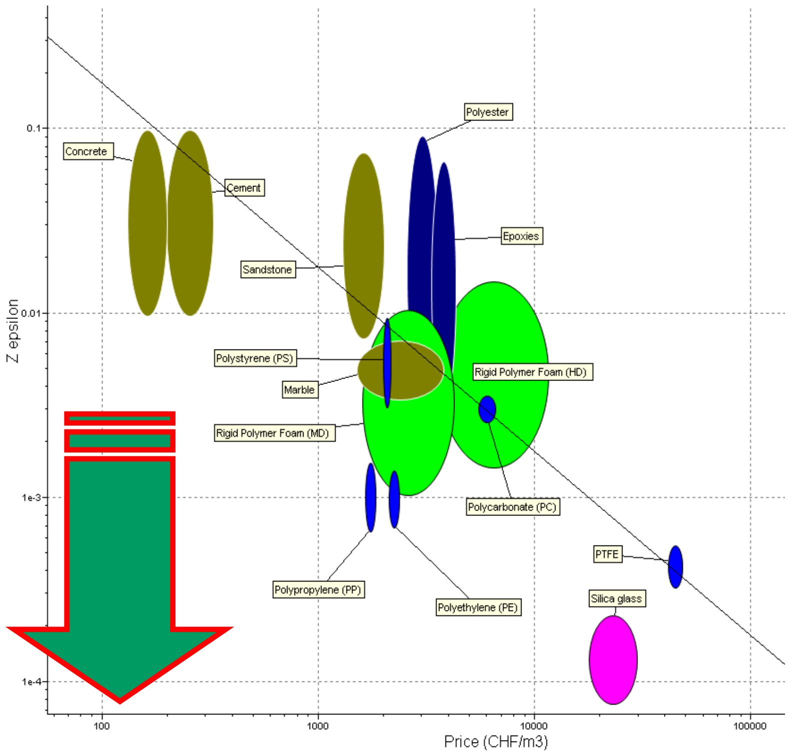
vs.

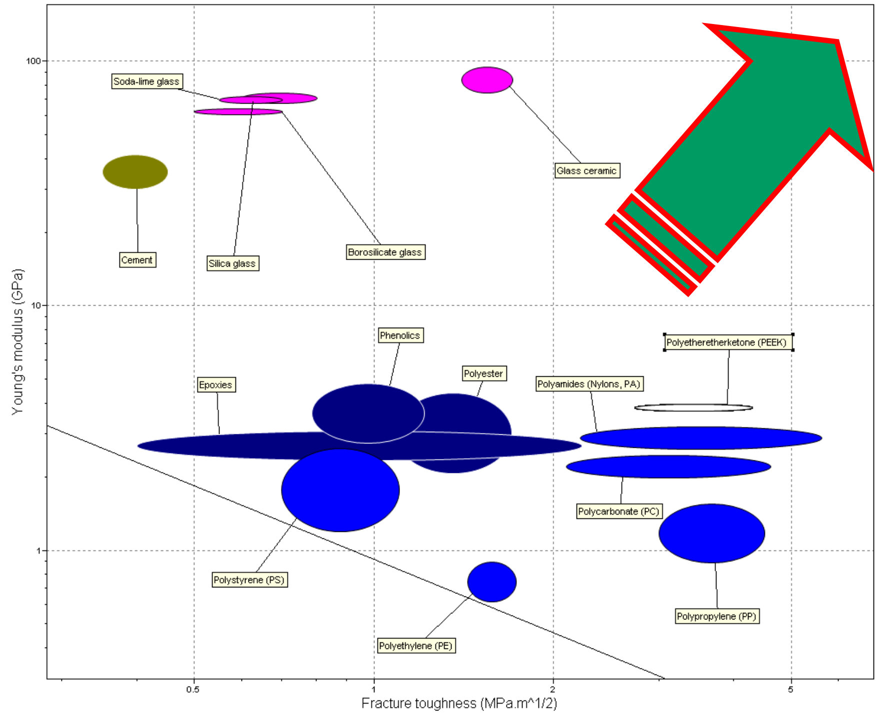
Fracture toughness [MPa/m$^{1/2}$]



6. Results – Scenario 2

For **reusable** microwave dishes containers





- The best material is Silica glass, but Polyethylene (PE) and Polypropylene (PP) are also very good
- Polystyrene (PS) is not good and polymer foams are avoided by the fresh water resistance limit stage

7. Conclusions

- Materials are partially the same for both scenario 1 and 2 (PP, PE) even if constraints change considerably
- There are always several possibilities for materials
- Not a big surprise – commonly used materials are the among the best
- Selected Processes help to limit materials (example cement)
- CES does not say much about food compatibility

➡ First approach for selecting the materials but further study necessary