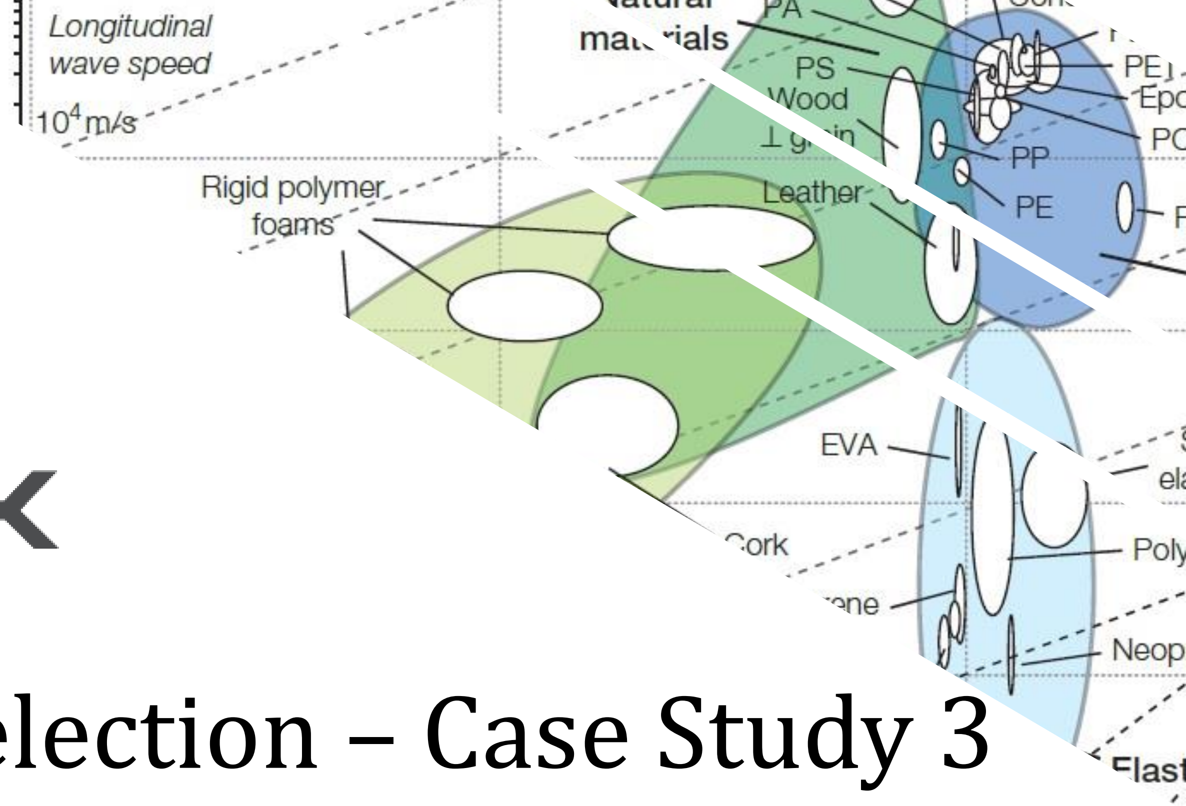


Materials Selection – Case Study 3
Eco-Properties and Composites

Professors:
Anne Mertens and Davide Ruffoni
Assistant:
Tommaso Maurizi Enrici

Mechanical Properties Case Studies

- *Mistakes*
- ***Case Study 21: Composite Materials for flexible conductors and percolation***
- ***Case Study 22: Composite Materials for connectors that don't relax their grip***
- *Commercials*
- ***Case Study 23: Eco-Audit selection on a Glass Bottle***
- ***Case Study 23': Eco-Audit selection on a PET Bottle***
- ***Case Study 24: Combined Eco-Audit selection (CES 2009)***
- ***Case Study 25: Eco-Audit selection on an Iron***
- ***Case Study 26: Eco-Audit selection on a Family Car***
- ***Case Study 27: Eco-Audit selection on an Portable space heater***

Mistakes

Mistakes

- *Instructions:*

Call the pdf file like that:

***Group** X _ 1 key word_Responsible name*

Mail Object :

SELECTION1819

PLEASE

Remember: the bibliography research is not a list of materials used, but a presentation of the topic, characteristics, environment and problems!!!!

Université de Liège

Faculté des sciences appliquées

Materials selection : Research work.

Prof. J. Lecomte-Beckers

[redacted]

Année académique 2016-2017

le 29 novembre 2016

Mistakes

MECA0462-2 - Materials selection

[redacted]

Professeur : J. Lecomte-Beckers et Professeur D. Ruffoni

Assistant : T. Maurizi-Enrici

[redacted] **Groupe** [redacted]

1er Master Ingénieur civil aérospatial

Année académique 2017 – 2018

Mistakes

ênegreen8

1

Mistakes

2 Exercice 1 : Colonnes du Parthénon

Le but de cet exercice est de sélectionner un matériau au meilleur prix pour construire les colonnes du Parthénon.

2.5.3 Rejet de CO_2

Pour affiner la recherche, la quantité de dioxyde de carbone émise peut être utilisée pour sélectionner le meilleur matériau. Celle-ci est fournie par CES pour chaque matériau dans la section des propriétés écologiques. L'empreinte en émission de CO_2 est reprise dans la Tab.1. Il peut être remarqué, dans ce tableau, que les empreintes en rejet de CO_2 sont minimales pour le béton.

Matériau	Béton	Ciment	Marbre	Calcaire	Contre-plaqué	Bois dur	Bois doux
CO_2 [kg/kg]	$0,01$	$0,9$	$0,13$	$0,0147$	$0,79$	$9,82$	$0,36$

TABLE 1 – Émission de CO_2 pour les matériaux repris à la Fig.7.

Mistakes

Materials Selection

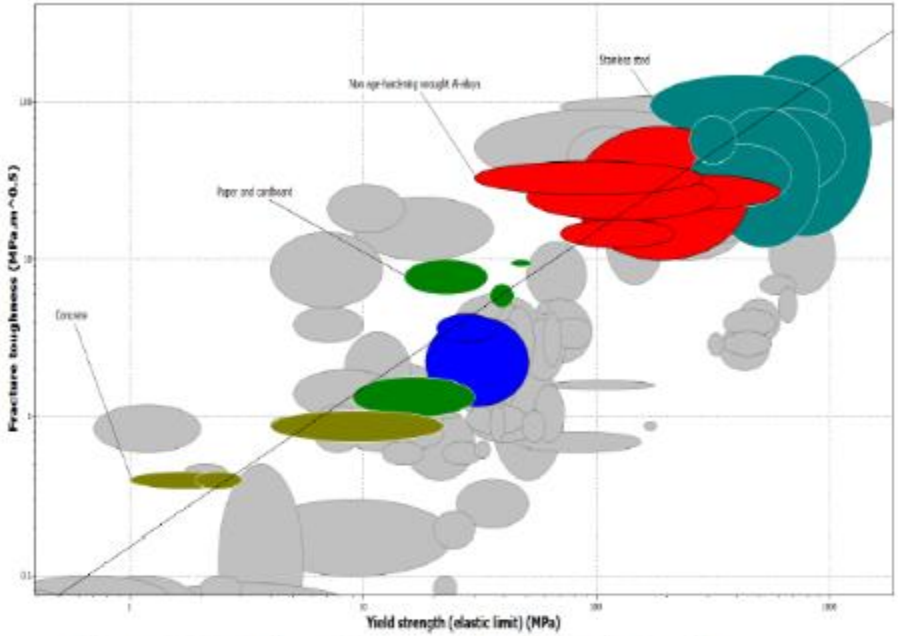


FIGURE 11 – Sélection des matériaux maximisant à la fois les index M_1 et M_2 permettant d'obtenir une canette résistante et peu chère.

Show: Pass all Stages

Rank by: Stage 2: Performance Index

Name	Stage 2: In...
Non age-hardening wrought ...	0.357
Paper and cardboard	0.345
Stainless steel	0.234
Concrete	0.229
Hardwood: oak, along grain	0.201
Cast Al-alloys	0.106
Low carbon steel	0.105
Cement	0.100

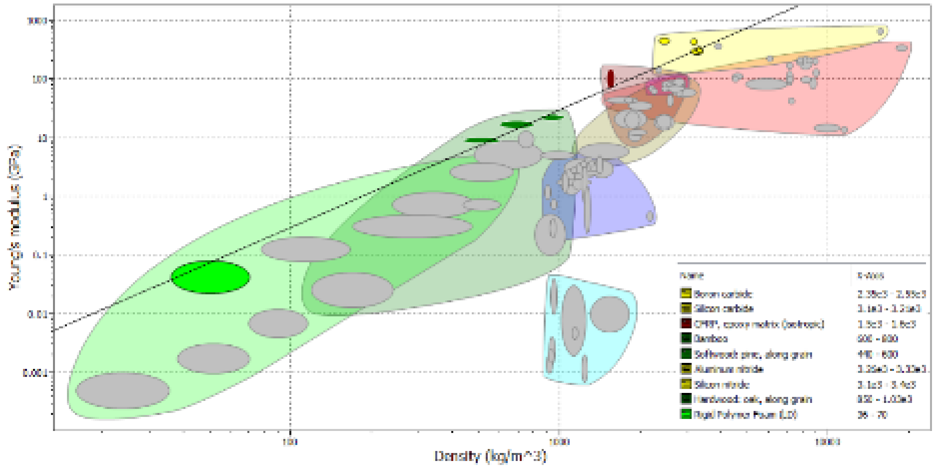
FIGURE 12 – Liste des éléments maximisant à la fois les index M_1 et M_2 permettant d'obtenir une canette résistante et peu chère.

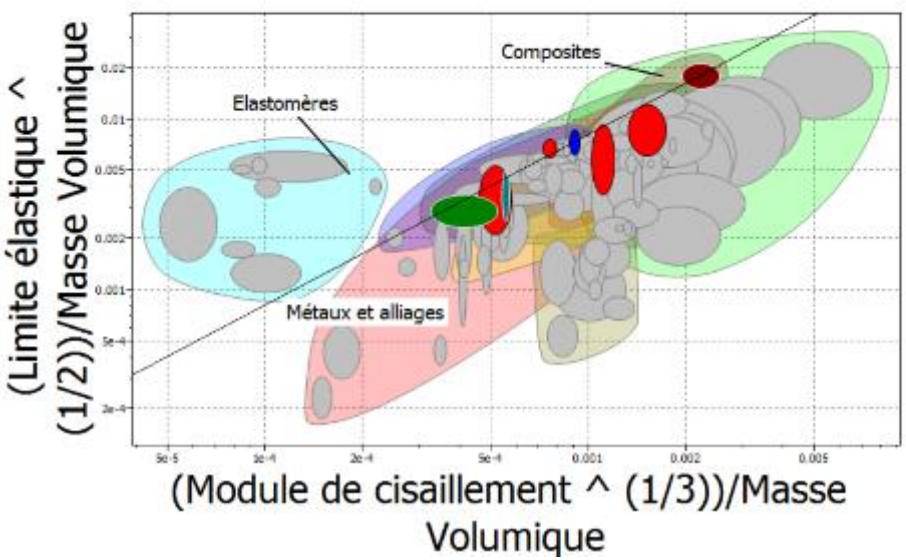
3.4 Conclusion

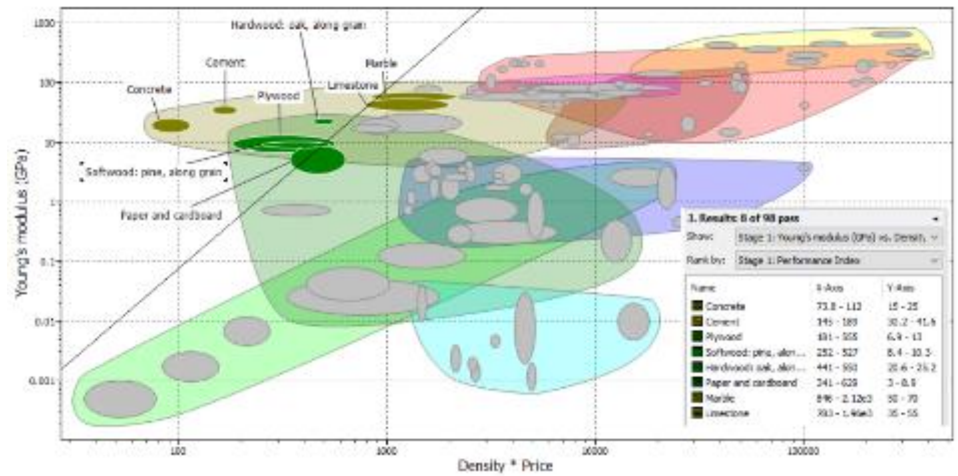
On remarque que, même si de nombreux matériaux peuvent a priori remplir les critères énoncés pour remplir la fonction de canette, certains d'entre eux devront être écartés

Université de Liège -10- Groupe 6

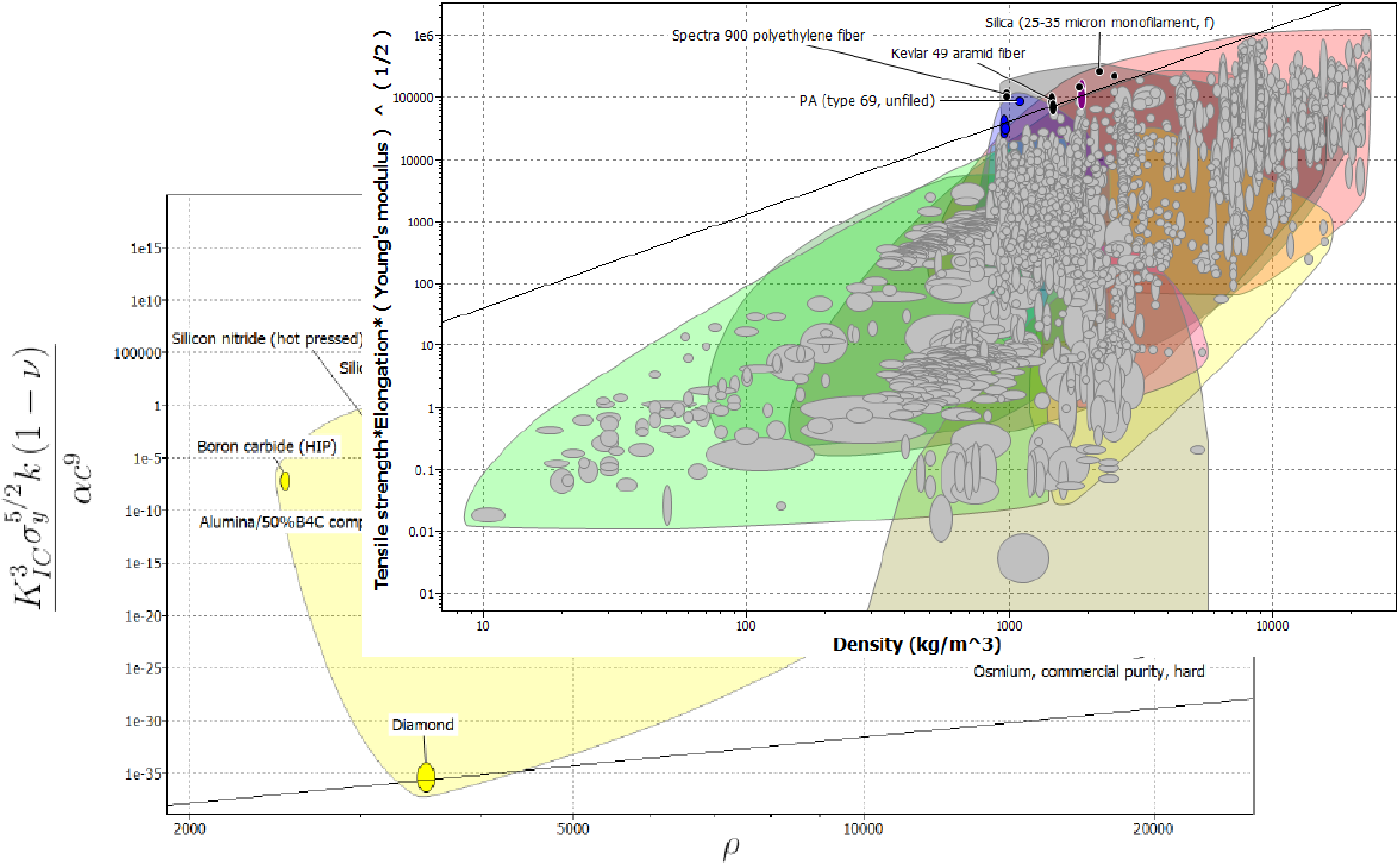
Mistakes


Young's modulus (GPa)
Density (kg/m^3)
Boron carbide
Silicon carbide
Bamboo
Aluminum nitride
Silicon nitride
Hardwood: oak, along grain


Composites
Elastomères
Métaux et alliages
(Limite élastique ^ (1/2))/Masse Volumique
(Module de cisaillement ^ (1/3))/Masse Volumique


Hardwood: oak, along grain
Cement
Concrete
Plywood
Marble
Limestone
Softwood: pine, along grain
Paper and cardboard
Young's modulus (GPa)
Density * Price

Mistakes



Silica (25-35 micron monofilament, f)
Spectra 900 polyethylene fiber
Kevlar 49 aramid fiber
PA (type 69, unfiled)
Tensile strength*Elongation* (Young's modulus) ^ (1/2)
Density (kg/m^3)
Silicon nitride (hot pressed)
Boron carbide (HIP)
Alumina/50%B4C comp
Diamond
Osmium, commercial purity, hard
$\frac{K_{IC}^3 \sigma_y^{5/2} k (1-\nu)}{\alpha c^9}$
ρ

Mistakes

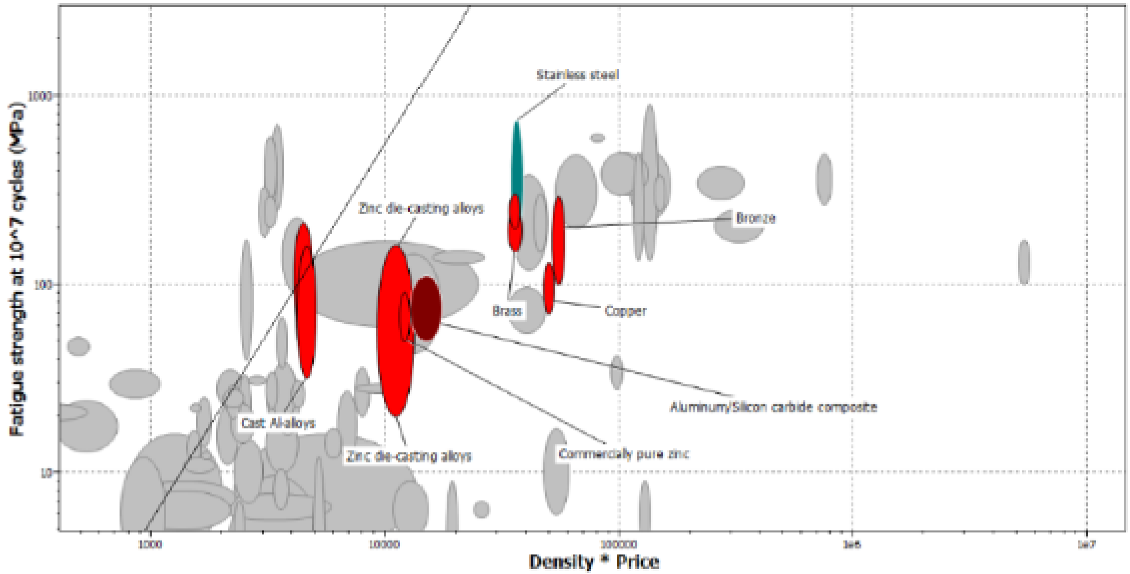


FIGURE 8 – Diagramme d'Ashby obtenu pour une hélice en eau douce

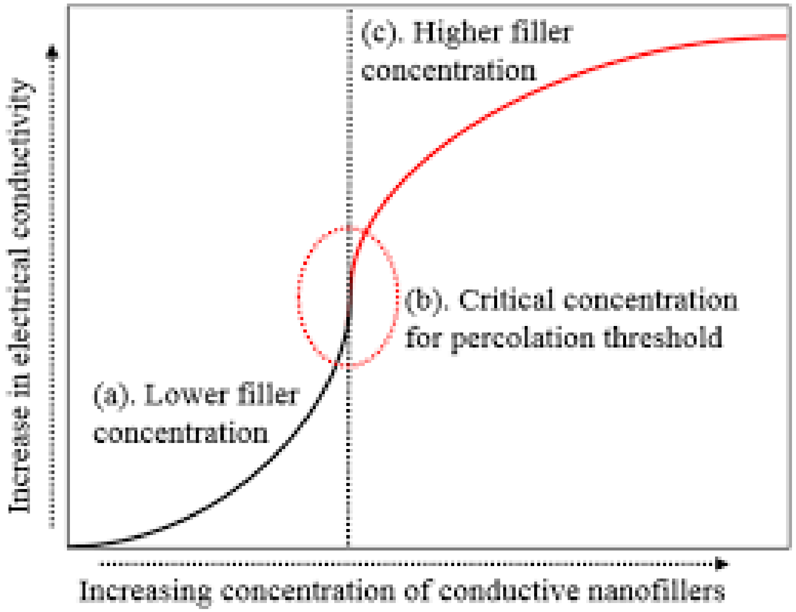
Name	Stage 2: Index
Bronze	7,14e5
Stainless steel	6,91e5
Commercially pure titanium	5,55e5
Brass	4,98e5
Copper	4,85e5
Aluminum/Silicon carbide composite	1,29e5
Commercially pure zinc	9,93e4
Zinc die-casting alloys	8,34e4
Age-hardening wrought Al-alloys	4,68e4
Cast Al-alloys	3,89e4

FIGURE 9 – Matériaux obtenus pour une hélice en eau douce

Composite Materials

Case Study 21:
Composite Materials for
Flexible conductors and percolation

Objective	• Moldable
Constraints	• Low Young's modulus to allow conformation • Low resistivity to permit conduction ($\rho e < 1000\ \mu\Omega.cm$)
Free Variables	• Choice of matrix, reinforcement, configuration, and volume fraction

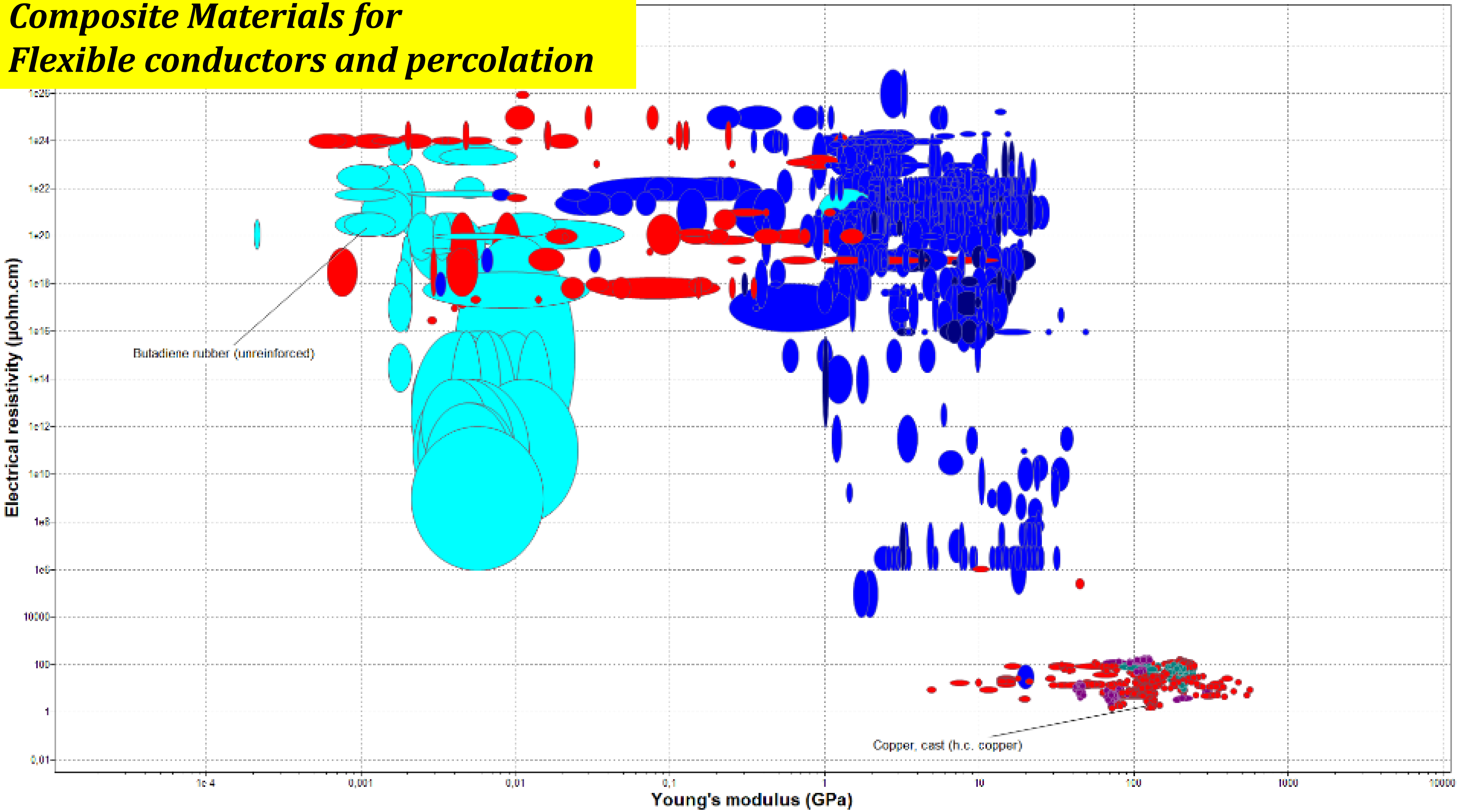


For bulk conduction we need connectivity: The array first becomes a conductor when a single trail of contacts links one surface to the other, that is, when the volume fraction f of the conducting spheres reaches the percolation threshold fc. Percolation problems are easy to describe but difficult to solve.

<u>You can try at home to insert spheres!</u>

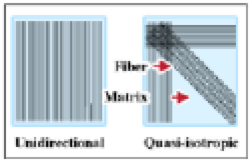
Composite Materials

Case Study 21:
Composite Materials for
Flexible conductors and percolation



Composite Materials

Continuous fiber (UD & QI)



Predicts the performance of continuous fiber reinforced materials

Unidirectional = alligned fiber lay-up [0°]
Quasi-isotropic = multi-axial lay-up [0°/+45°/-45°/90°]s

Assumptions:
- Uniform reinforcement distribution
- Perfect interfacial bonding
- Material is fully dense

Fiber orientation: Unidirectional

Source Records

Matrix: Butadiene rubber (unreinforced)

Fiber: Copper, cast (h.c. copper)

Model Variables

Enter values or range of values. For example, 1; 3; 8 or 1-8.

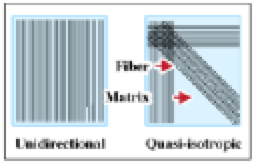
Fiber volume fraction: 1 - 50 % Number of values: 6

Record Naming

Matrix: Rubber

Fiber: Copper Uni

Continuous fiber (UD & QI)



Predicts the performance of continuous fiber reinforced materials

Unidirectional = alligned fiber lay-up [0°]
Quasi-isotropic = multi-axial lay-up [0°/+45°/-45°/90°]s

Assumptions:
- Uniform reinforcement distribution
- Perfect interfacial bonding
- Material is fully dense

Fiber orientation: Quasi-isotropic

Source Records

Matrix: Butadiene rubber (unreinforced)

Fiber: Copper, cast (h.c. copper)

Model Variables

Enter values or range of values. For example, 1; 3; 8 or 1-8.

Fiber volume fraction: 1 - 50 % Number of values: 6

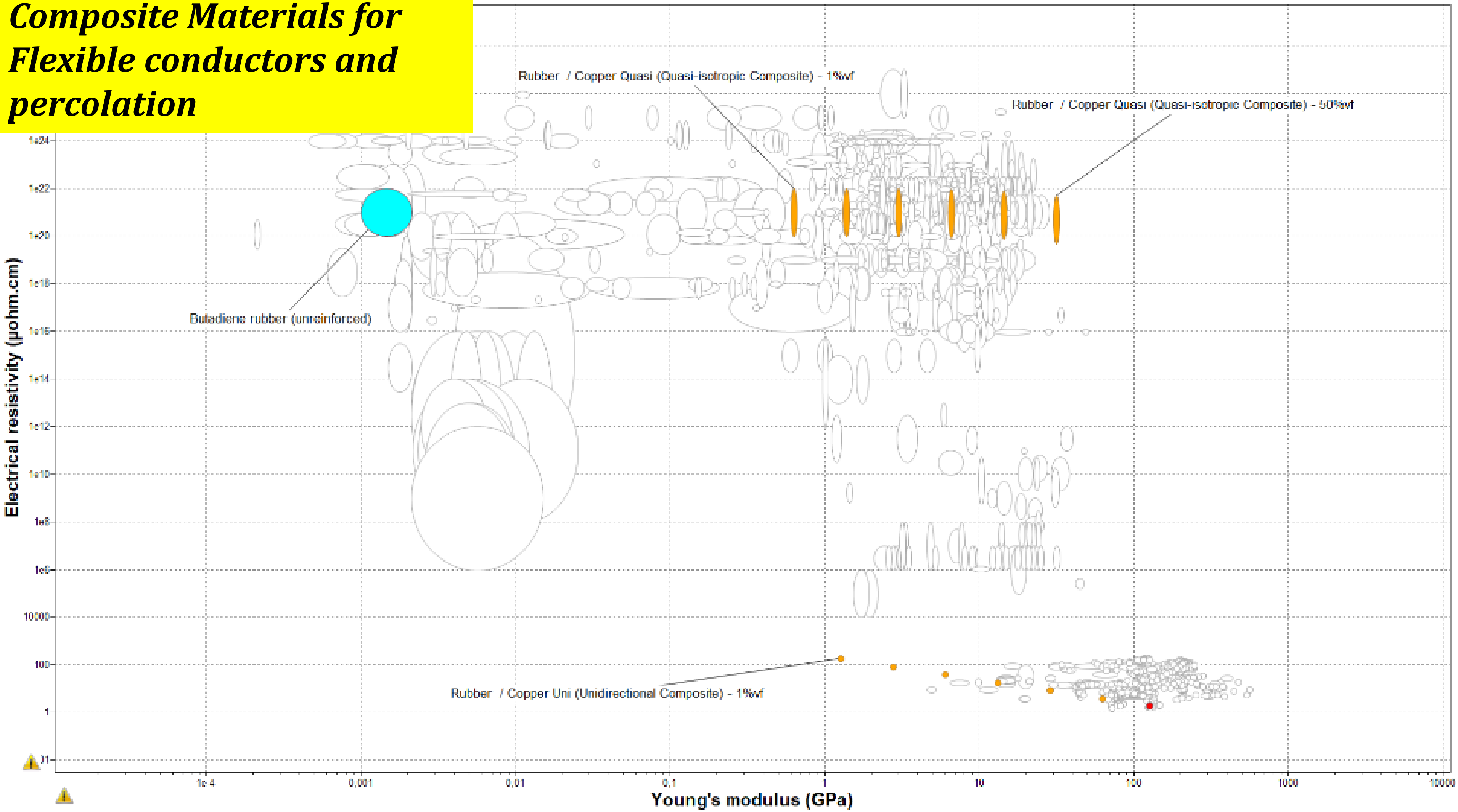
Record Naming

Matrix: Rubber

Fiber: Copper Quasi

Composite Materials

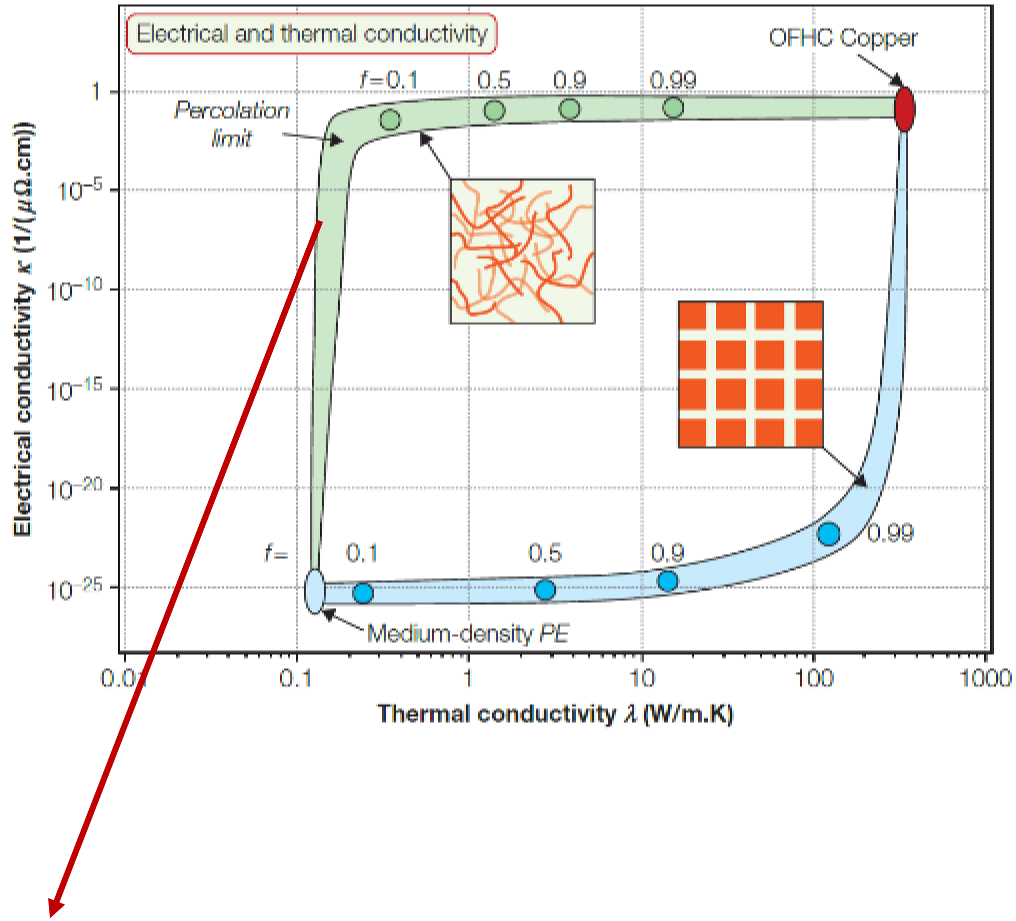
Case Study 21: Composite Materials for Flexible conductors and percolation



Composite Materials

Case Study 21:
Composite Materials for
Flexible conductors and percolation

Materials that are good electrical conductors are always good thermal conductors too. Copper, for example, excels at both. Most polymers, by contrast, are electrical insulators (meaning that their conductivity is so low that for practical purposes they do not conduct at all), and as solids go they are also poor thermal conductors—polyethylene is an example.

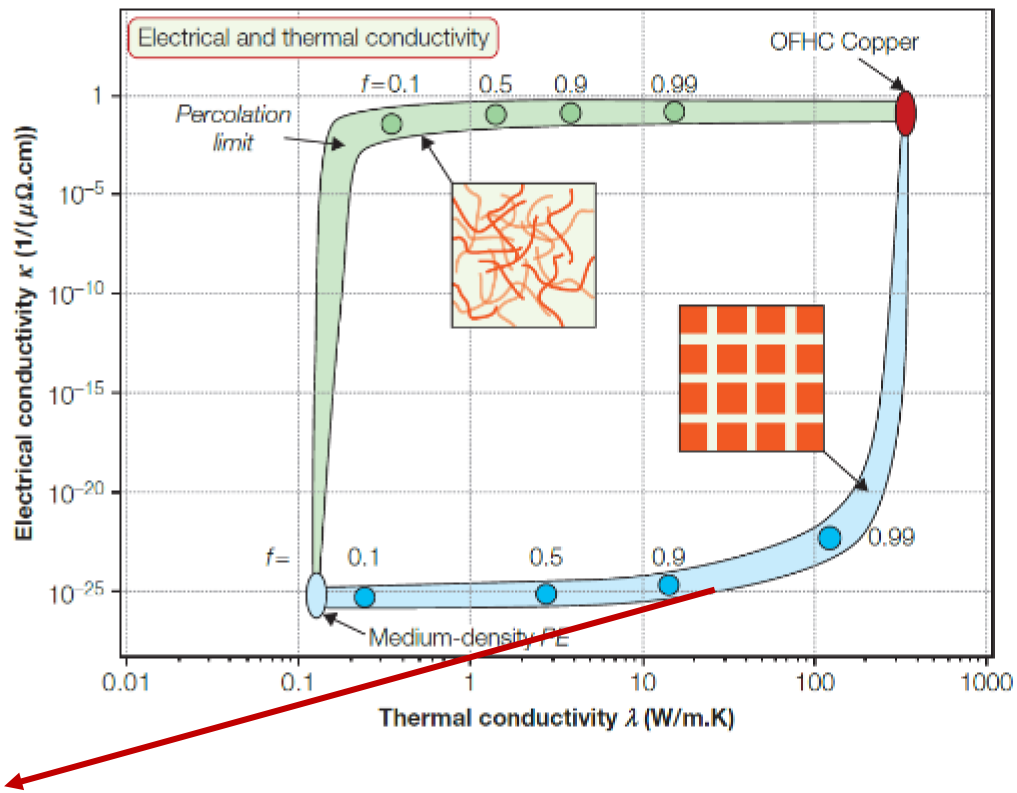


$$\tilde{\kappa}_1 = f\,\kappa_{cu} + (1-f)\,\kappa_{PE}$$

$$\tilde{\lambda}_1 = \lambda_{PE}\left(\frac{\lambda_{Cu} + 2\lambda_{PE} - 2f(\lambda_{PE} - \lambda_{Cu})}{\lambda_{Cu} + 2\lambda_{PE} + f(\lambda_{PE} - \lambda_{Cu})}\right)$$

Composite Materials

Case Study 21:
Composite Materials for
Flexible conductors and percolation

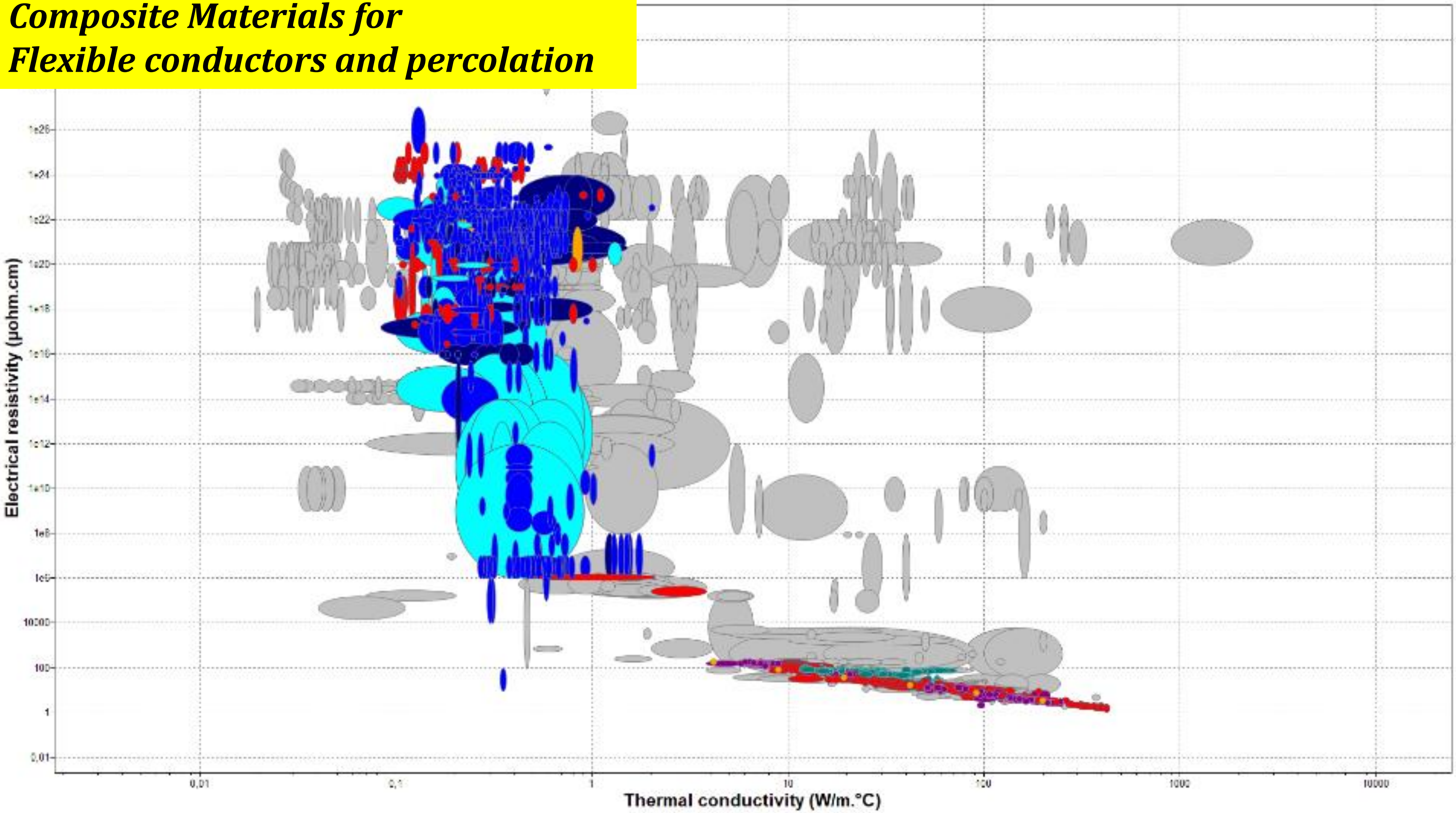


$$\widetilde{\kappa}_2 = \left(\frac{f}{\kappa_{Cu}} + \frac{(1-f)}{\kappa_{PE}} \right)^{-1}$$

$$\widetilde{\lambda}_2 = \left(\frac{f}{\lambda_{Cu}} + \frac{(1-f)}{\lambda_{PE}} \right)^{-1}$$

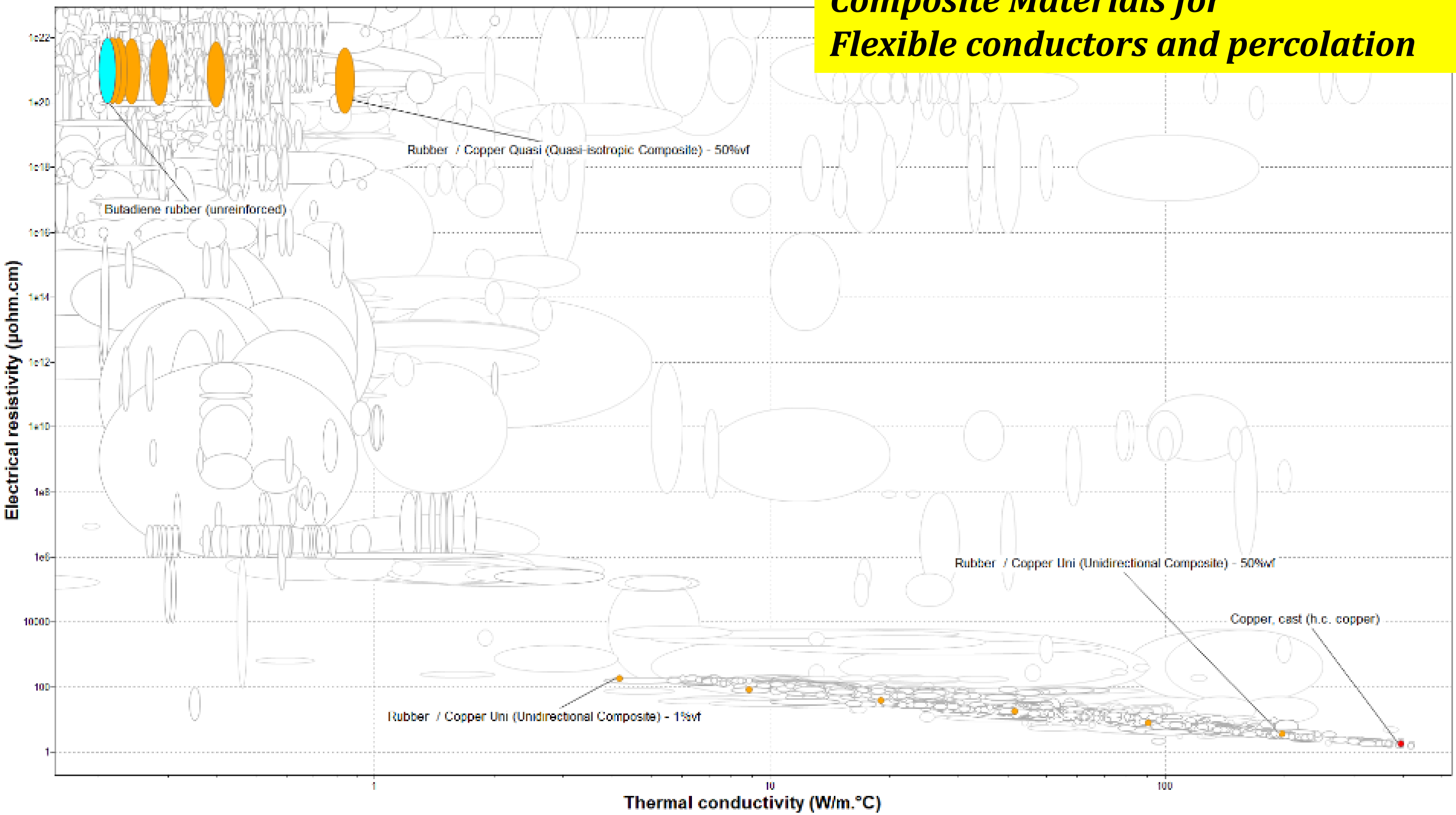
Composite Materials

Case Study 21:
Composite Materials for
Flexible conductors and percolation



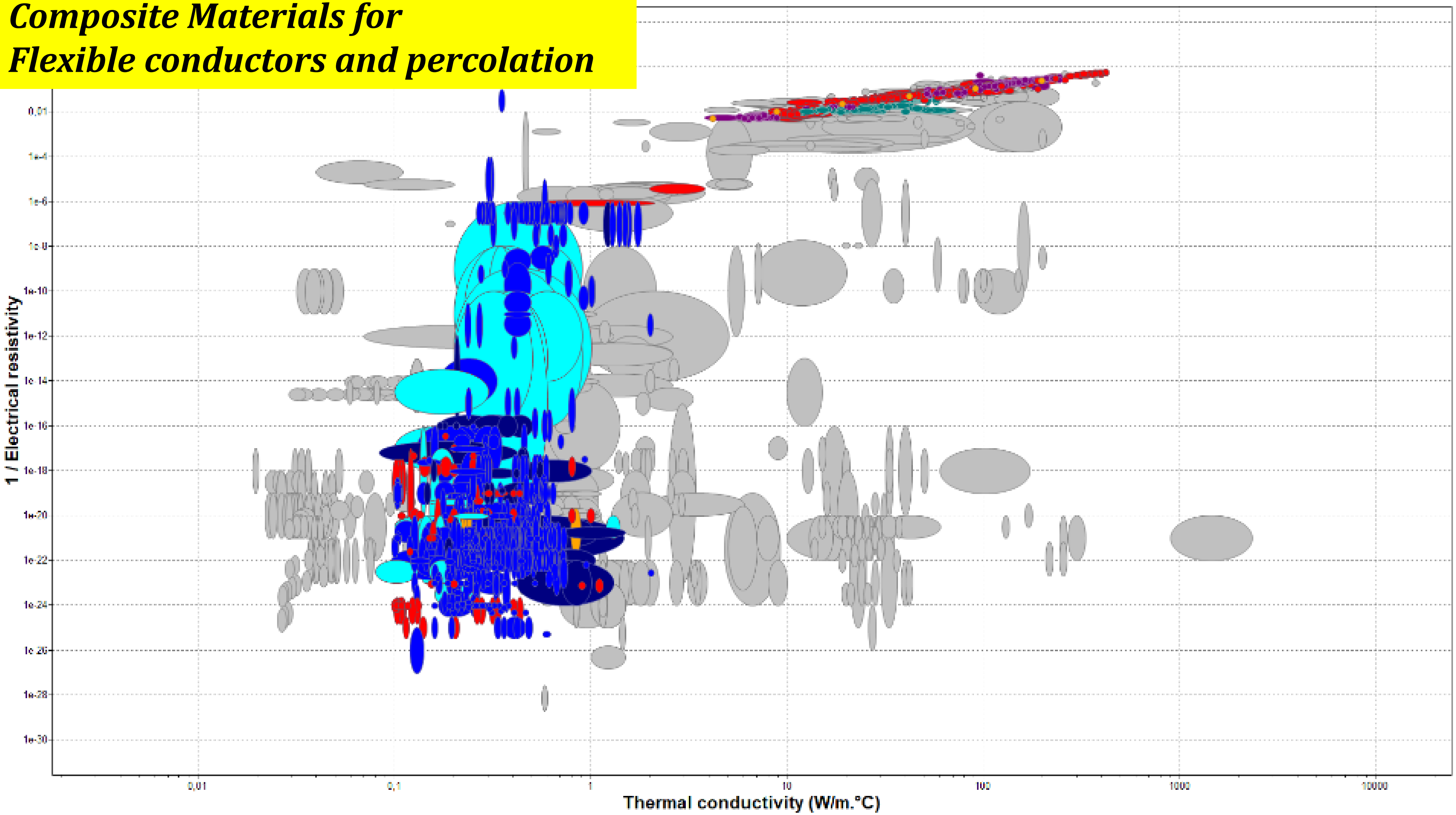
Composite Materials

Case Study 21:
Composite Materials for
Flexible conductors and percolation

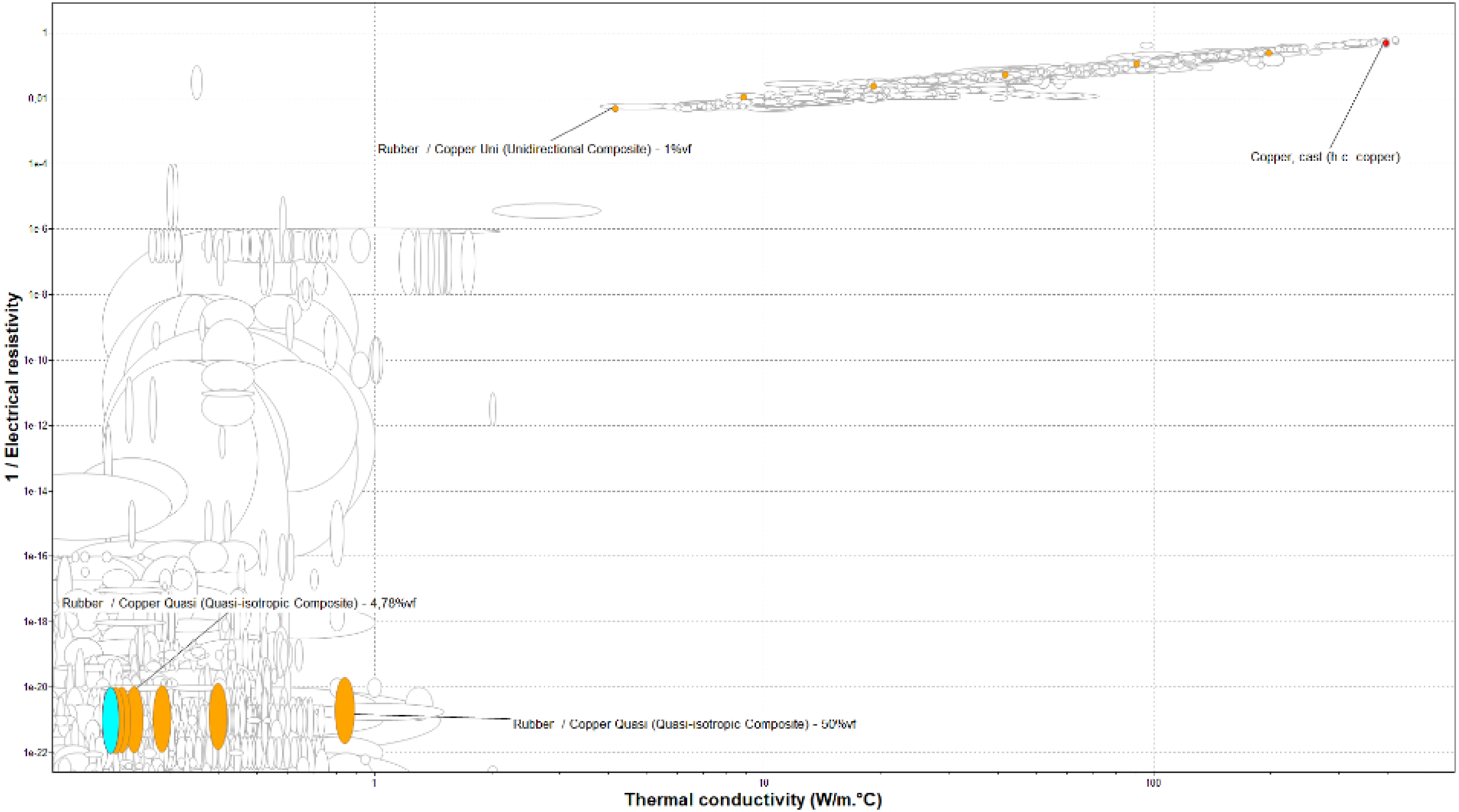


Composite Materials

Case Study 21:
Composite Materials for
Flexible conductors and percolation



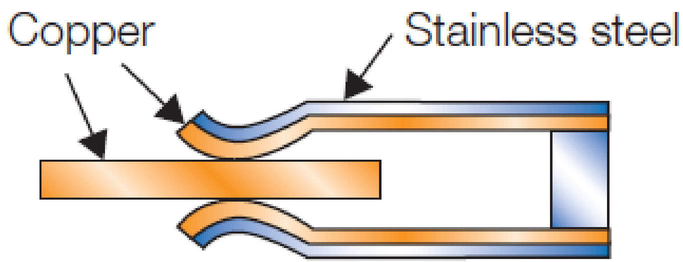
Composite Materials



Composite Materials

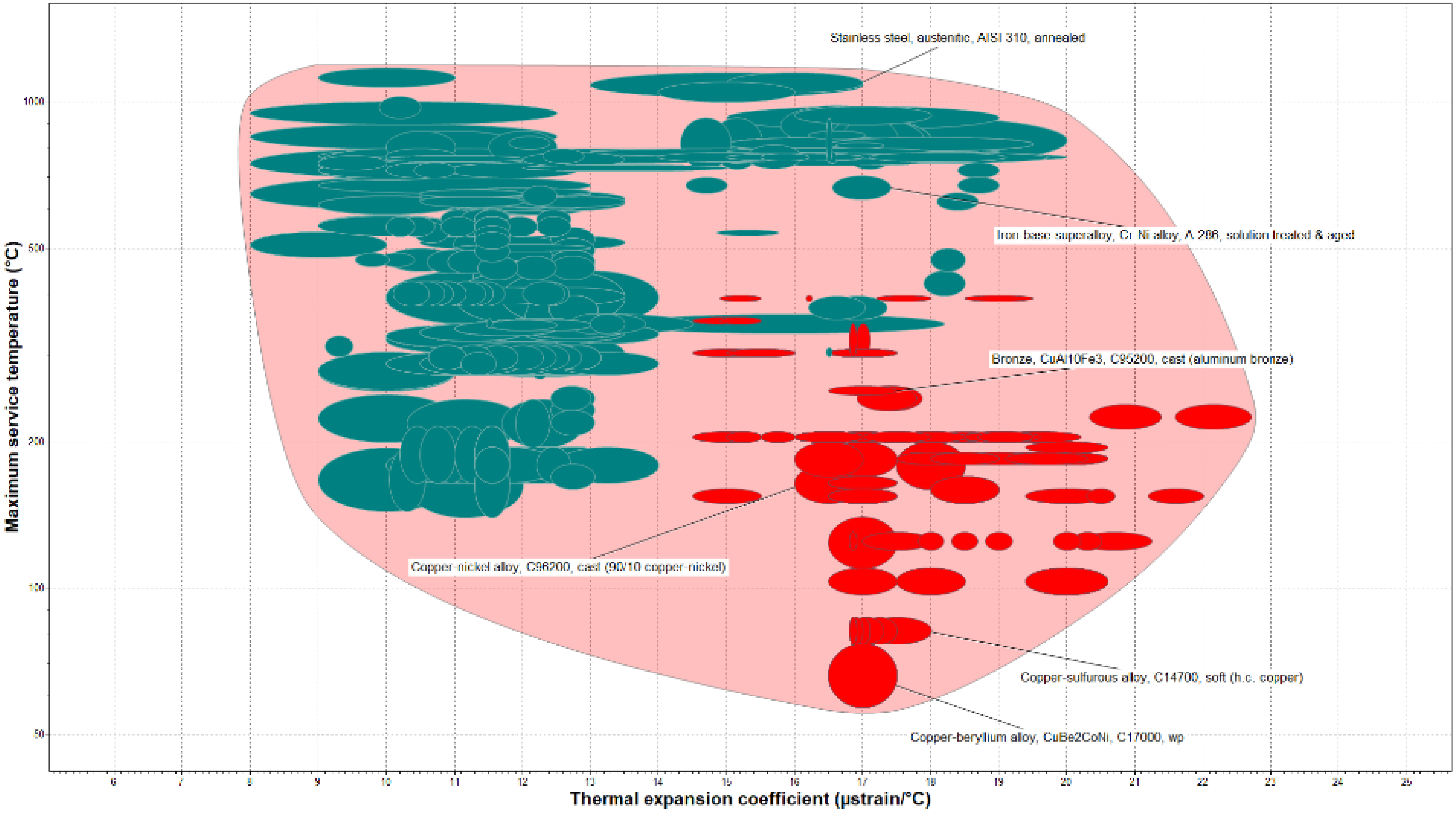
Case Study 22:
Composite Materials for Connectors that don't relax their grip

Objective	• Minimize distortion problems
Constraints	• Provide good electrical connection • Maintain clamping force at 200°C for life of vehicle
Free Variables	• Material 1 and 2; their relative thicknesses



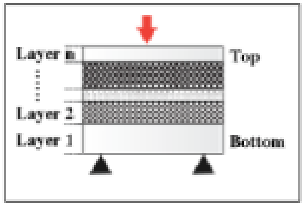
There are kilometers of wiring in a car. The transition to drive-by-wire control systems will increase this further. Wires have ends; they don't do much unless the ends are connected to something. The connectors are the problem: They loosen with time until, eventually, the connection is lost. Car makers, responding to market forces, now design cars to run for at least 300,000 kilometers and last, on average, 10 years. The electrical system is expected to operate without servicing for the lifetime of the car. Its integrity is vital: You would not be happy in a drive-by-wire car with loose connectors. With increasing instrumentation on engine and exhaust systems, many of the connectors get hot; some have to maintain good electrical contact at temperatures up to 200°C.

Composite Materials



Composite Materials

2-layer



Predicts the performance of multi-layer laminates, combining diffferent materials and layer thicknesses

Assumptions:
- Perfect interfacial bonding between layers
- Load is applied to upper surface
- In bending, no shear deflection occurs

Source Records

Layer 2 (top)	Stainless steel, austenitic, AISI 316L
Layer 1 (bottom)	Copper-nickel alloy, CuNi30Mn1Fe, C71500, half hard (70/30 copper-nickel)

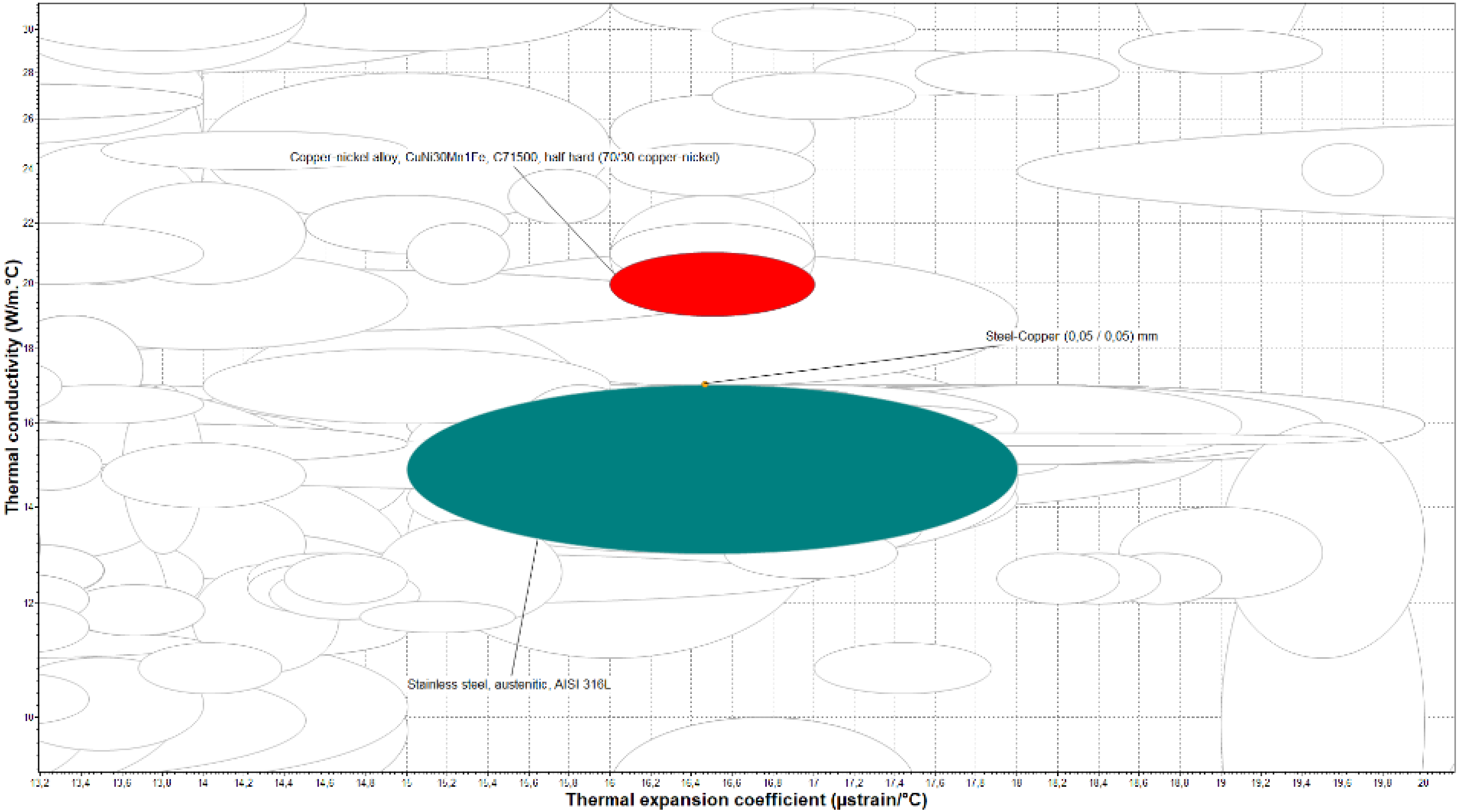
Model Parameters

Thickness layer 2 (top)	0,05	mm
Thickness layer 1 (bottom)	0,05	mm

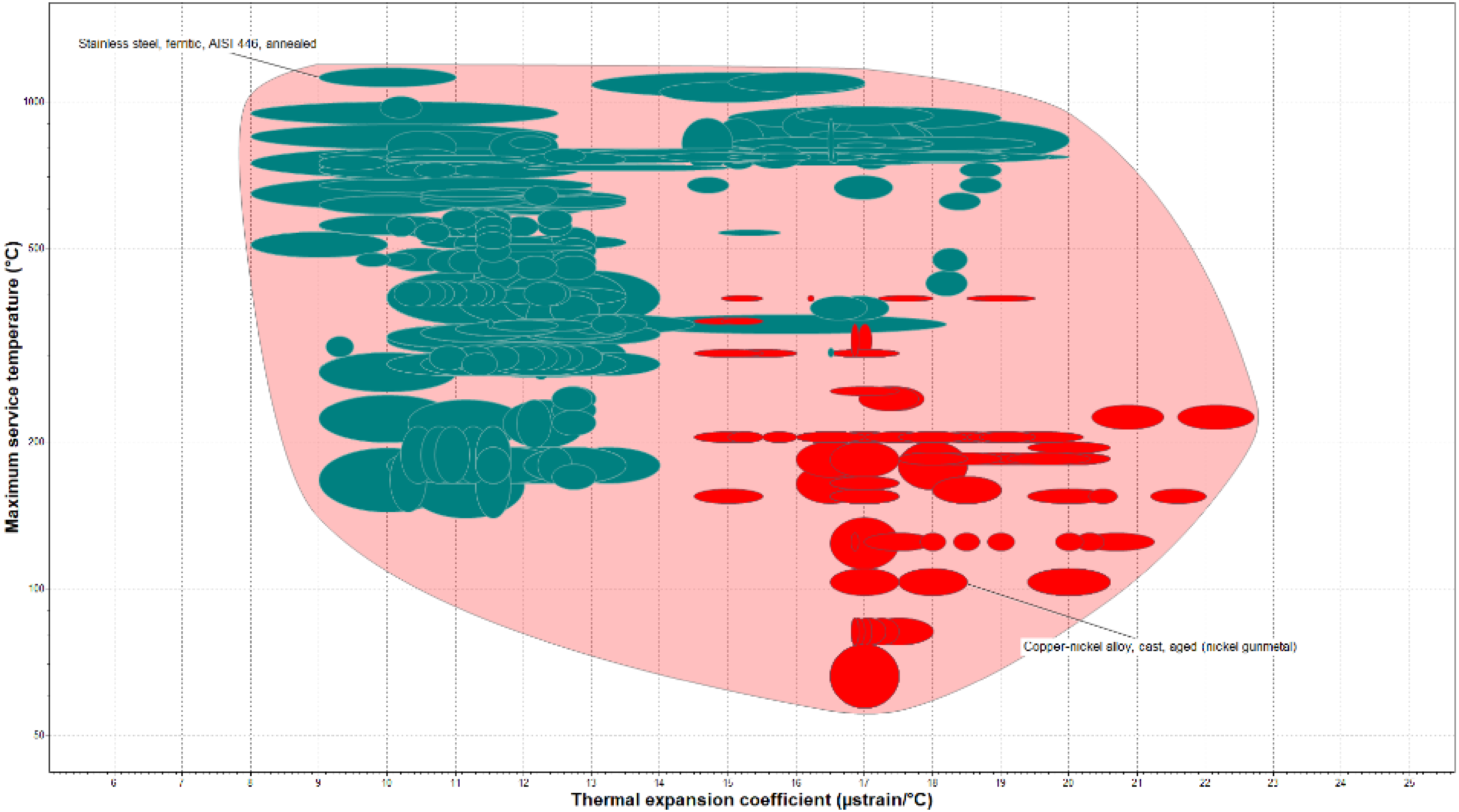
Record Naming

Layer 2	Steel
Layer 1	Copper

Composite Materials

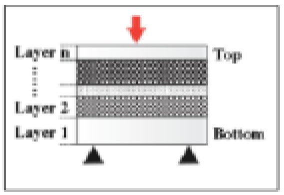


Composite Materials



Composite Materials

2-layer



Predicts the performance of multi-layer laminates, combining diffferent materials and layer thicknesses

Assumptions:

- Perfect interfacial bonding between layers
- Load is applied to upper surface
- In bending, no shear deflection occurs

Source Records

Layer 2 (top)	Stainless steel, ferritic, AISI 446, annealed
Layer 1 (bottom)	Copper-nickel alloy, cast (nickel gunmetal)

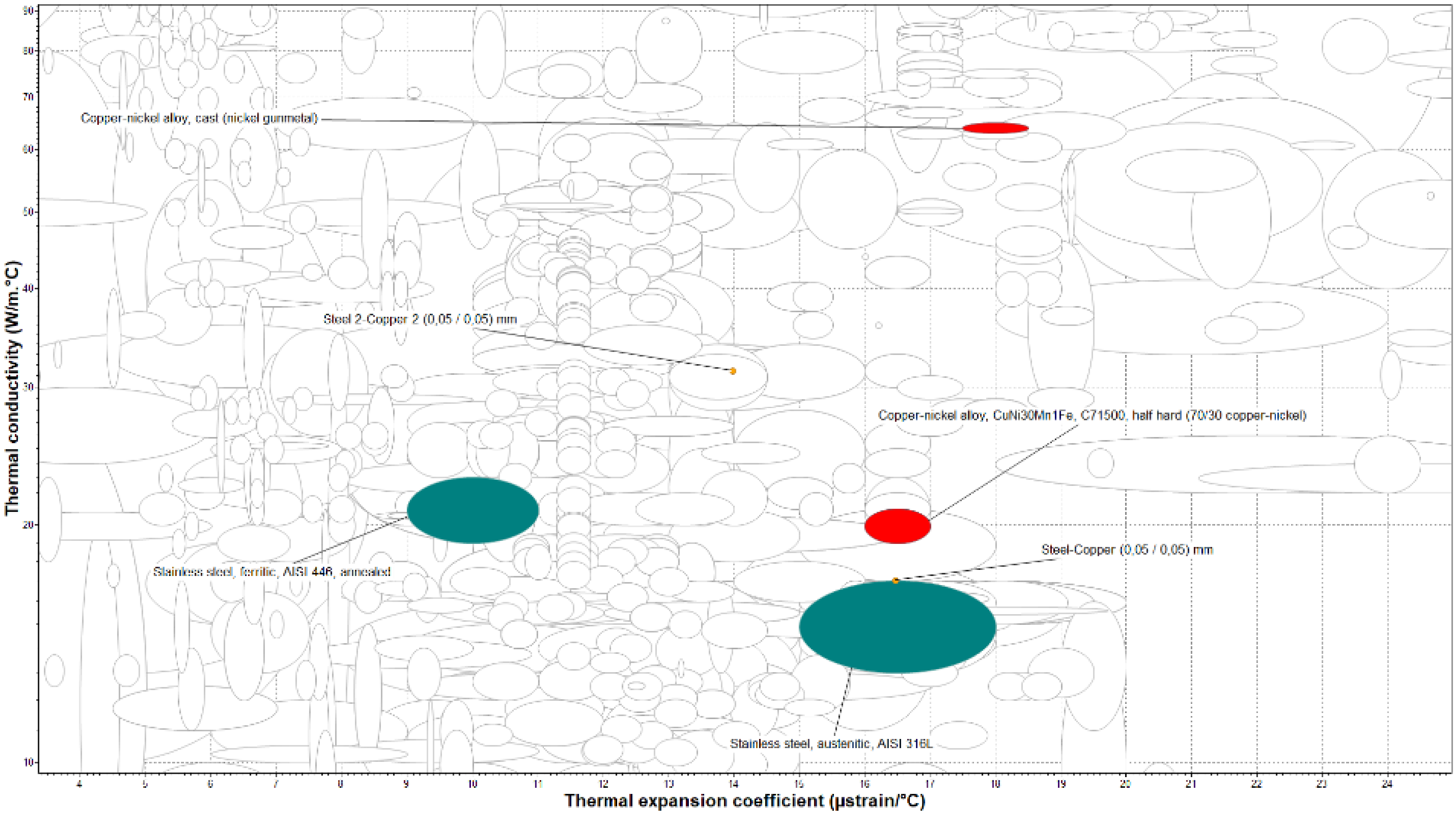
Model Parameters

Thickness layer 2 (top)	0,05	mm
Thickness layer 1 (bottom)	0,05	mm

Record Naming

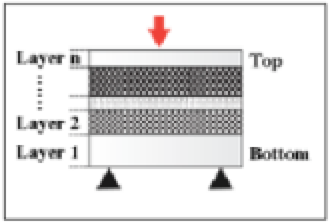
Layer 2	Steel 2
Layer 1	Copper 2

Composite Materials



Composite Materials

2-layer



Predicts the performance of multi-layer laminates, combining diffferent materials and layer thicknesses

Assumptions:
- Perfect interfacial bonding between layers
- Load is applied to upper surface
- In bending, no shear deflection occurs

Source Records

Layer 2 (top)	Stainless steel, ferritic, AISI 446, annealed
Layer 1 (bottom)	Copper-nickel alloy, cast (nickel gunmetal)

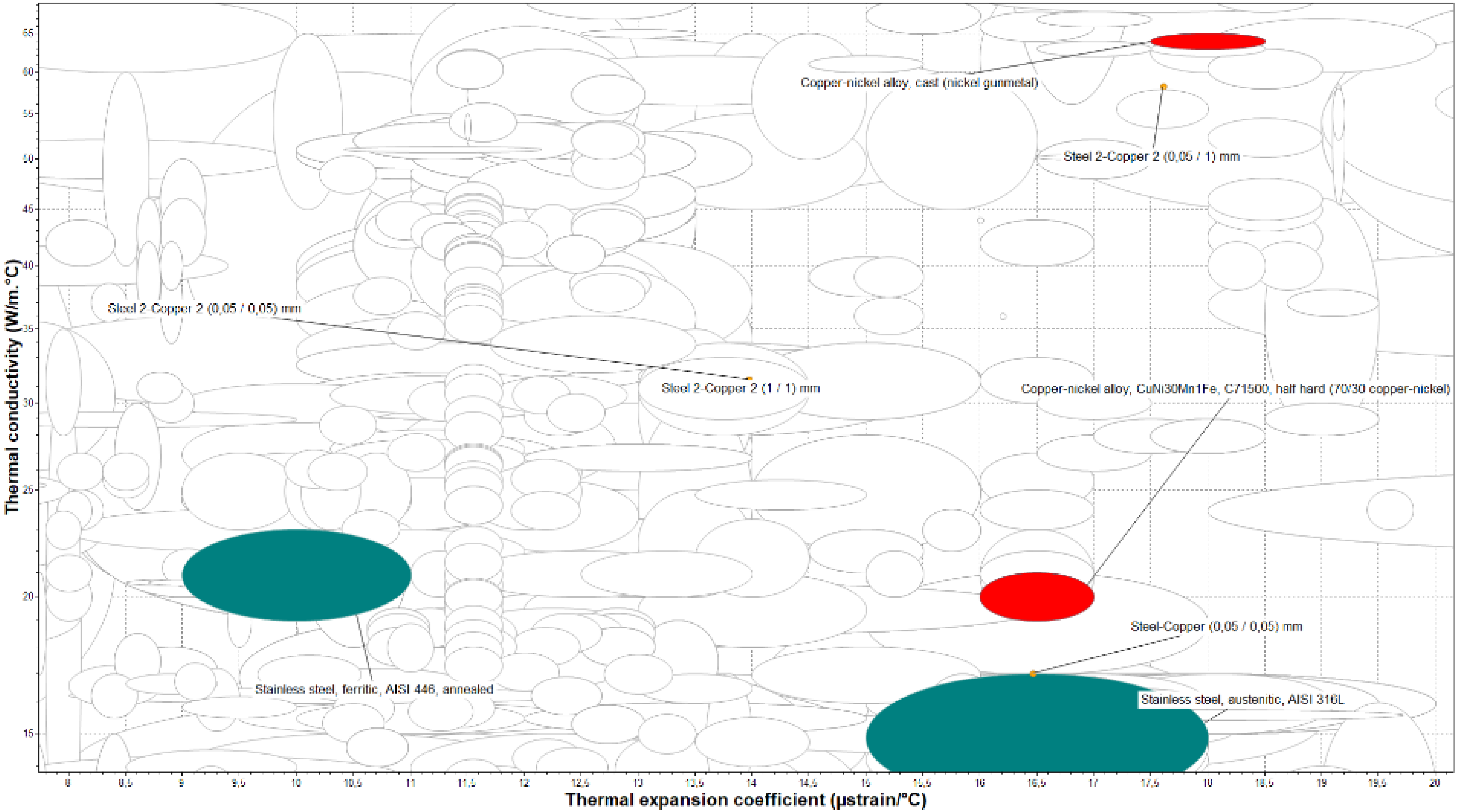
Model Parameters

Thickness layer 2 (top)	0,05	mm
Thickness layer 1 (bottom)	1	mm

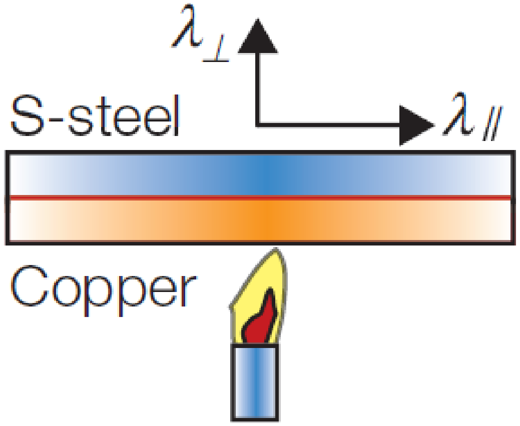
Record Naming

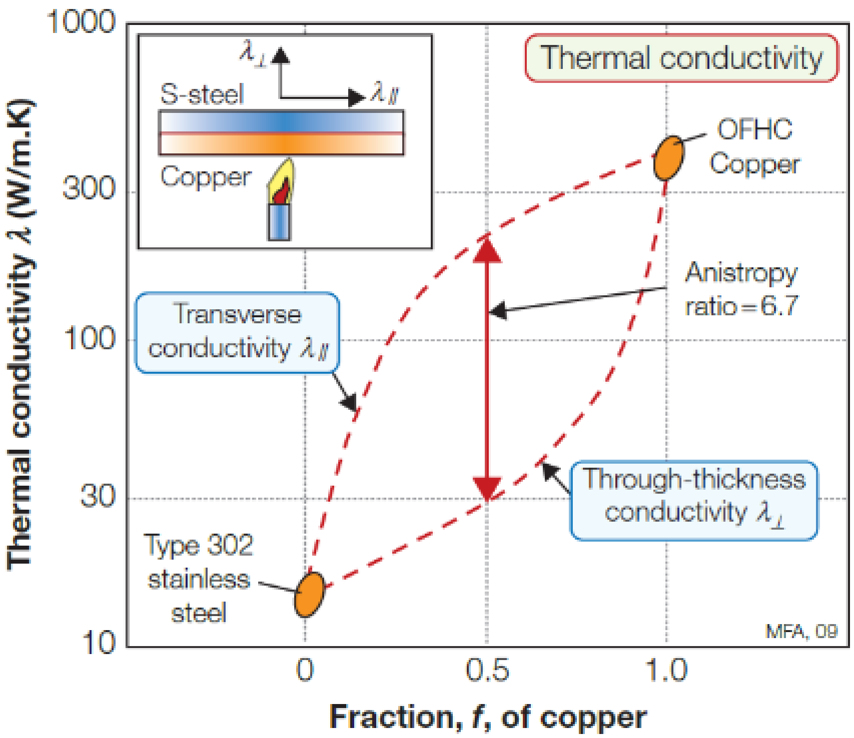
Layer 2	Steel 2
Layer 1	Copper 2

Composite Materials



Composite Materials





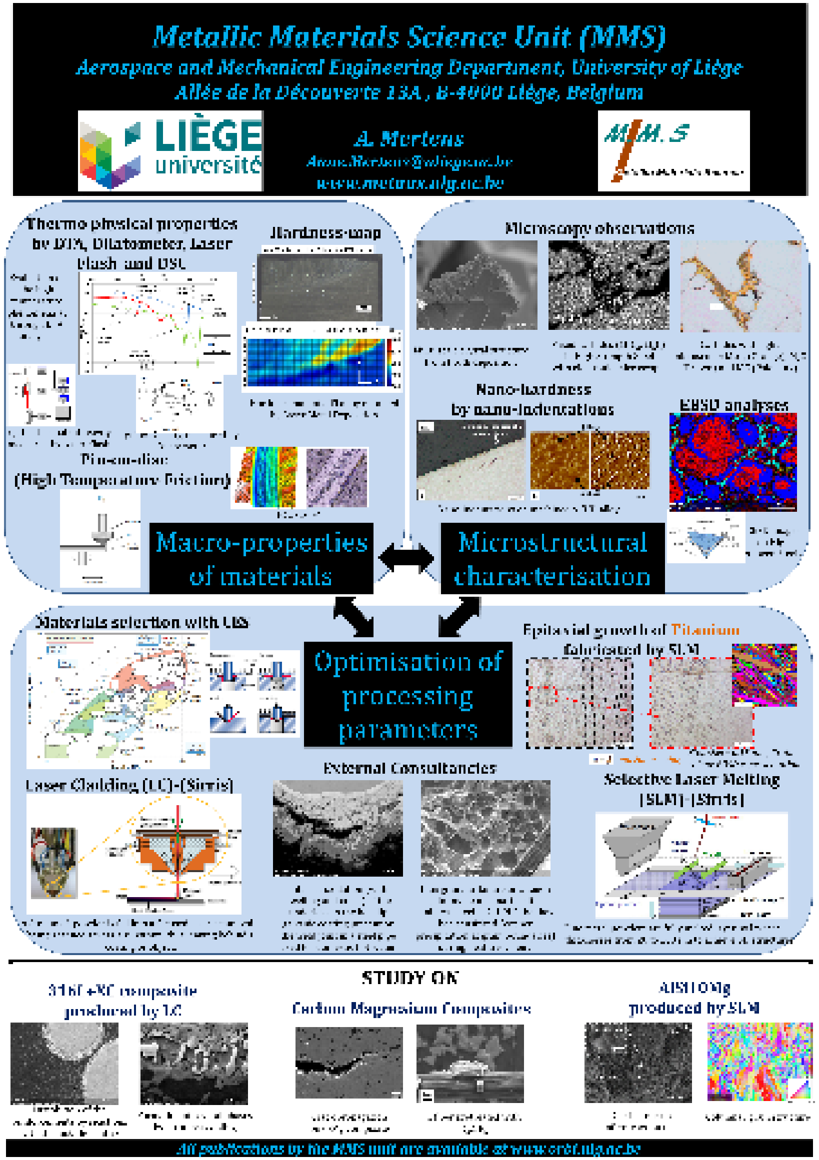
$$\tilde{\lambda}_{//} = f\,\lambda_1 + (1-f)\lambda_2$$

$$f = t_1/(t_1 + t_2)$$

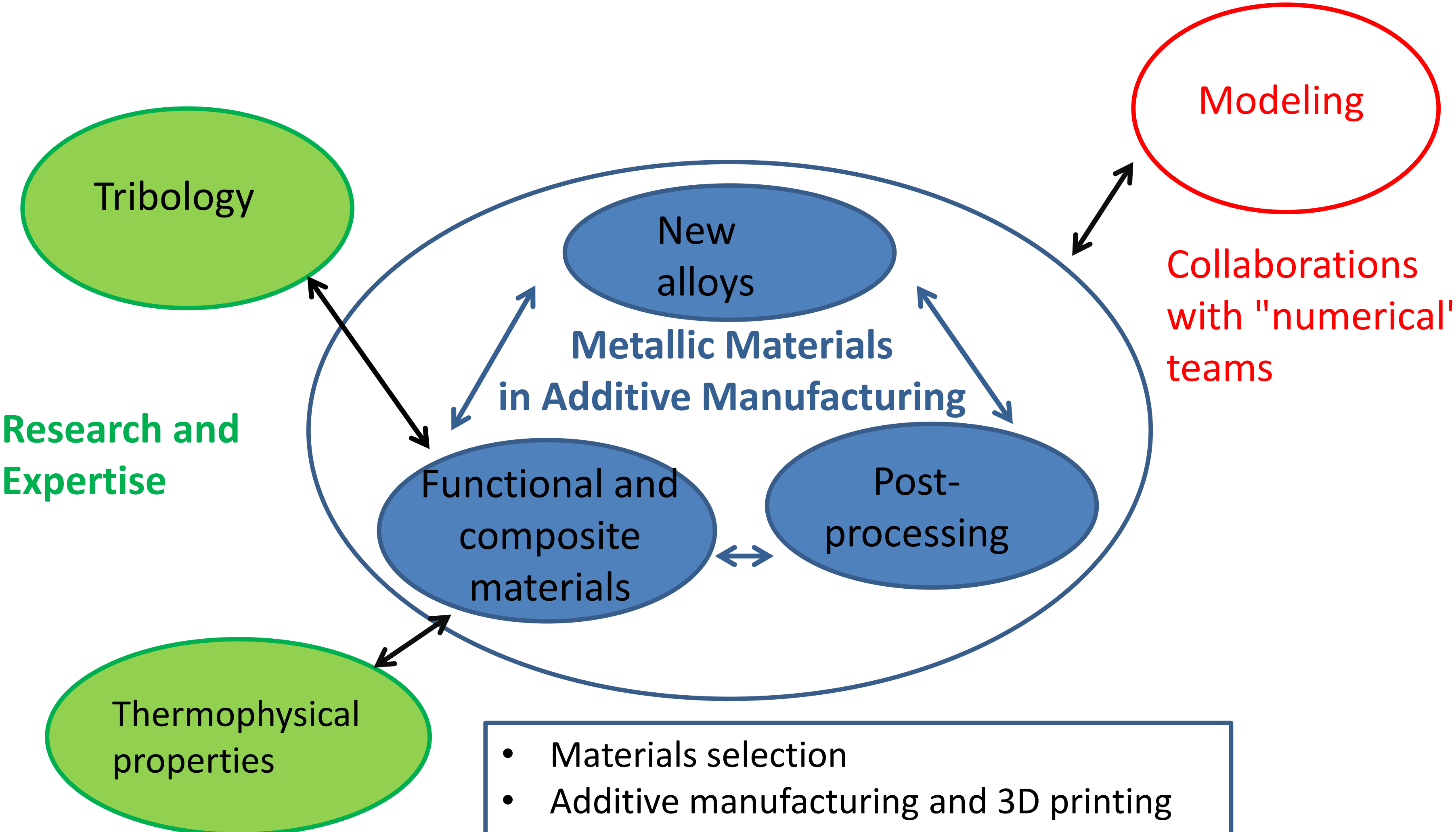
$$\tilde{\lambda}_{\perp} = \left(\frac{f}{\lambda_1} + \frac{(1-f)}{\lambda_2}\right)^{-1}$$

Possible Master Thesis Topics

M.M.S
Metallic Materials Science



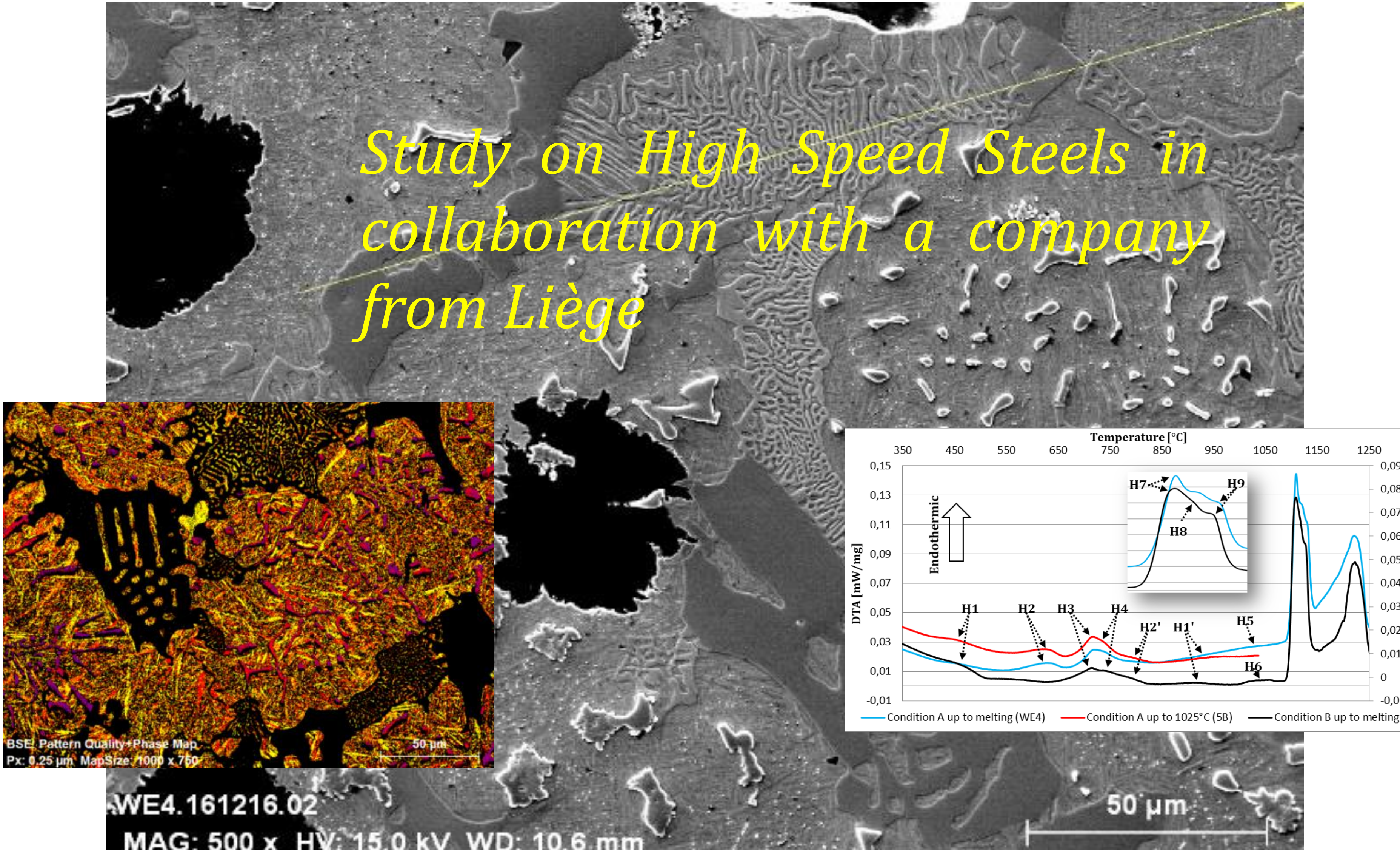
Possible Master Thesis Topics



- Materials selection
- Additive manufacturing and 3D printing
- Physics of Materials
- (Engineering of metallic materials)

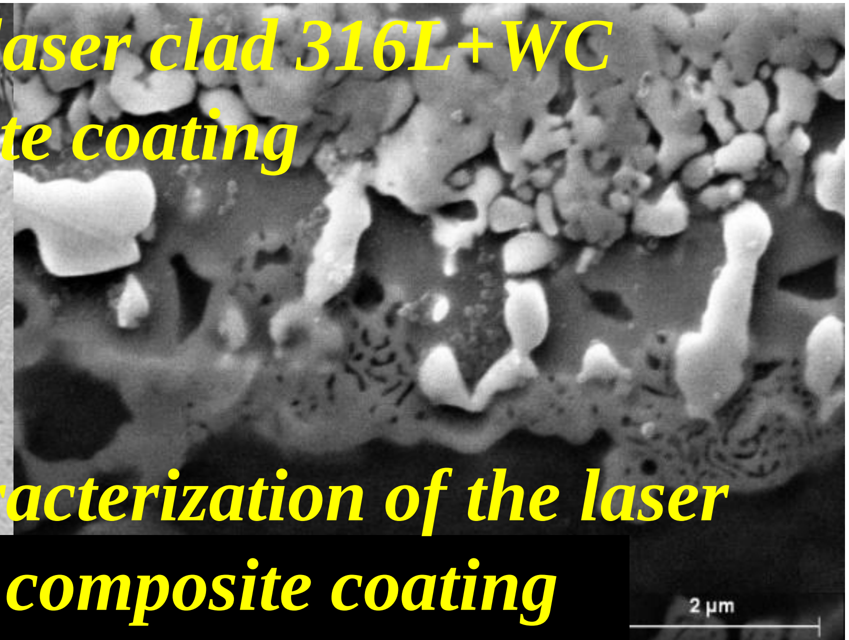
Possible Master Thesis Topics

Study on High Speed Steels in collaboration with a company from Liège



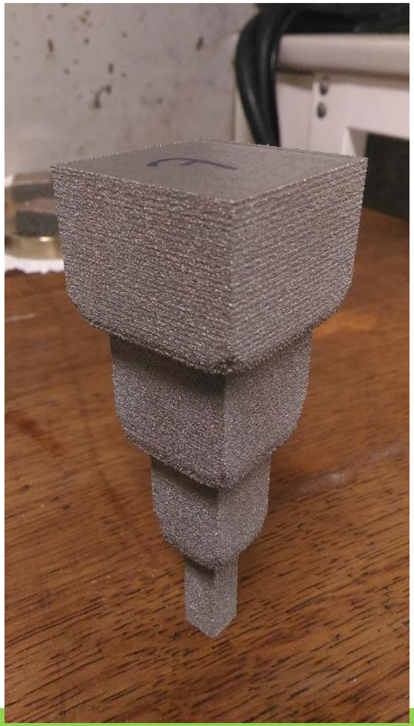
Possible Master Thesis Topics

Wear behavior of laser clad 316L+WC composite coating



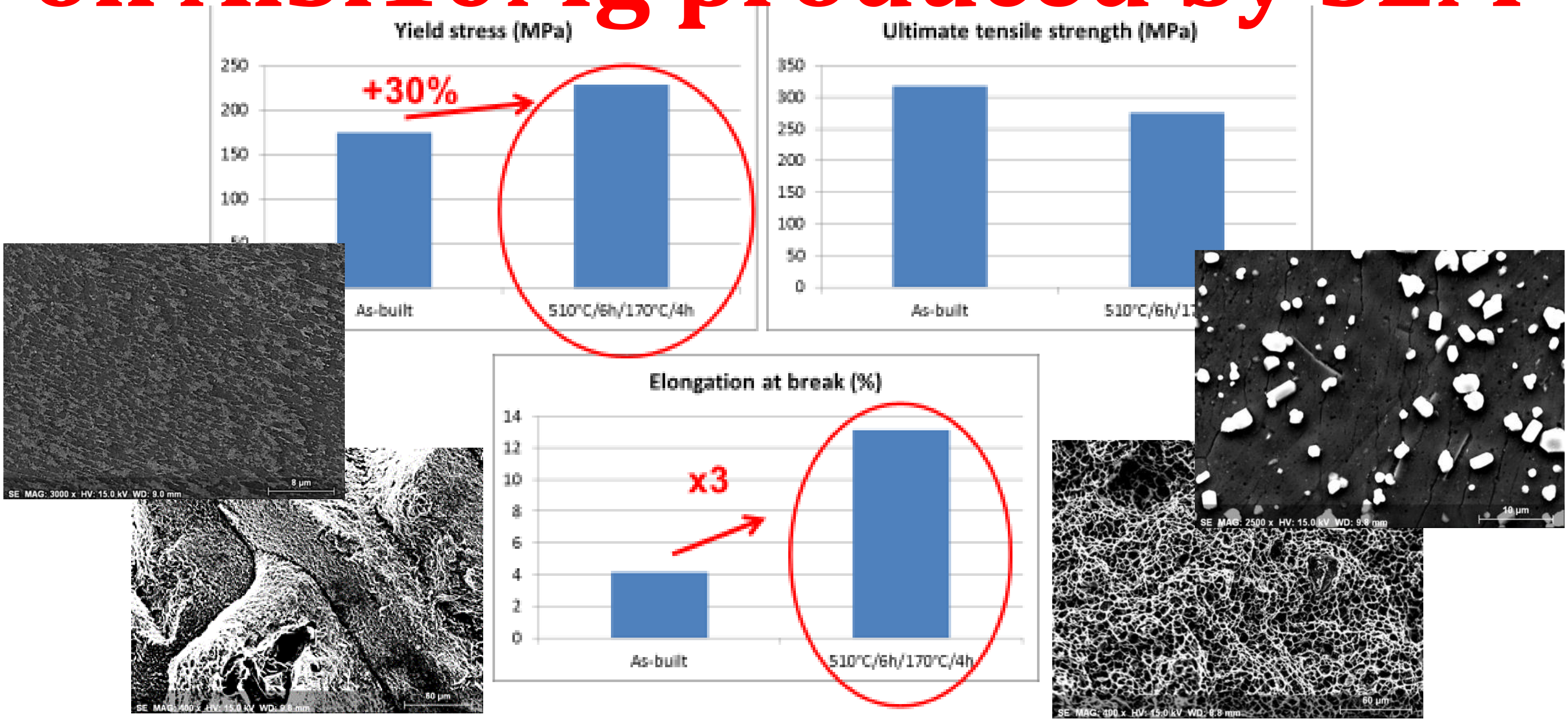
Microstructural characterization of the laser clad 316L+SiC composite coating

Microstructure changes during process in Ti6Al4V (EBM-Additive Manufacturing)



Possible Master Thesis Topics

Post-processing procedures on AlSi10Mg produced by SLM



Theoretical parenthesis : Cement (Portland)

- *Clay* $\xrightarrow{500°C}$ $H_2O+Fe_2O_3+Al_3O_3+SiO_2$
- *Limestone* $\xrightarrow{900°C}$ $CaO + CO_2$

- ***Components***

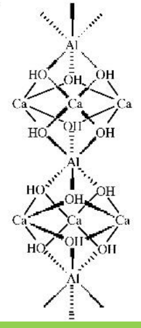
• *Celite*	$3CaO \cdot Al_2O_3$	C_3A	*Aluminate – 20% by weight*	***Setting***
• *Brownmillerite*	$4CaO \cdot Al_2O_3 \cdot Fe_2O_3$	C_4AF		
• *Belite*	$2CaO \cdot SiO_2$	C_2S	*Silicate - 80% by weight*	***Hardening***
• *Alite*	$3CaO \cdot SiO_2$	C_3S		

Setting – fast exothermic hydration

$C_3A + 3CaSO_4 \cdot 2H_2O$ (from Gypsum addition) $+ 32H_2O \longrightarrow C_3A \cdot 3CaSO_4 \cdot 32H_2O$

Aluminate reaction is immediate and gypsum is added to slow it down

(a)



<u>*Ettringite*</u>
<u>*15-20% of final volume*</u>

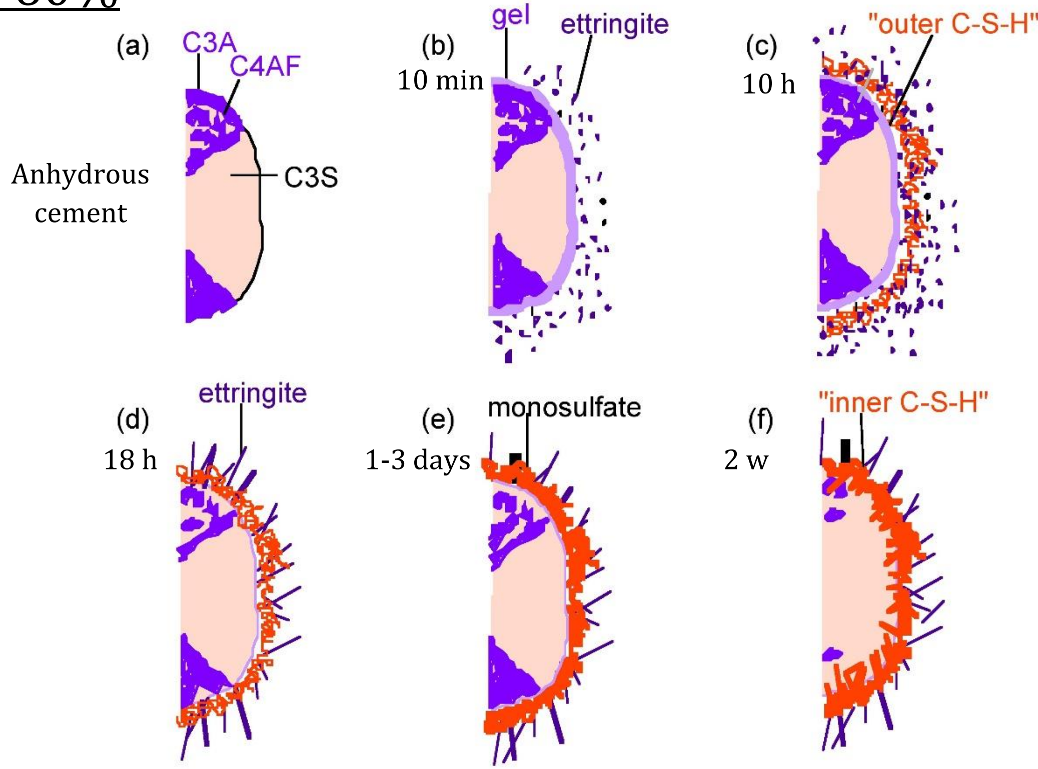
Theoretical parenthesis : Cement (Portland)

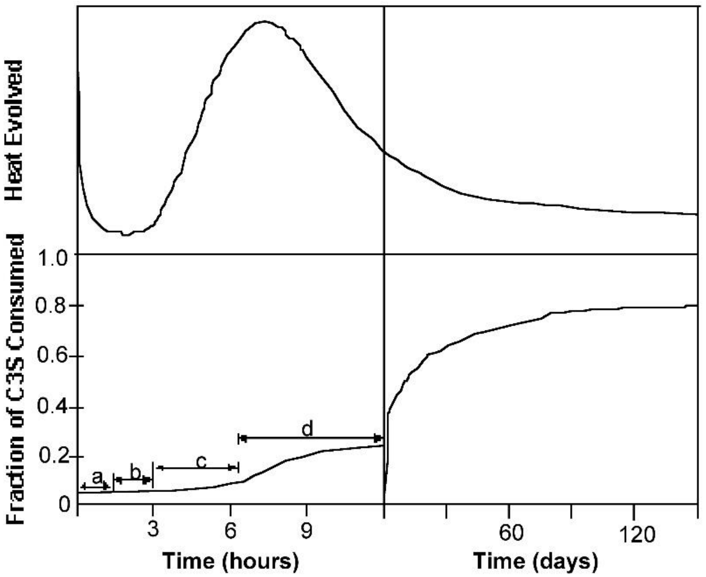
Hardening – slow hydration

$$2C_3S + 7H_2O \longrightarrow CSH \cdot 3Ca(OH)_2$$
$$2C_2S + 5H_2O \longrightarrow CSH \cdot Ca(OH)_2$$

Rigid calcium-silicate hydrate gel, C–S–H 50-60%

Portlandite or Calcium hydroxide 20-25%



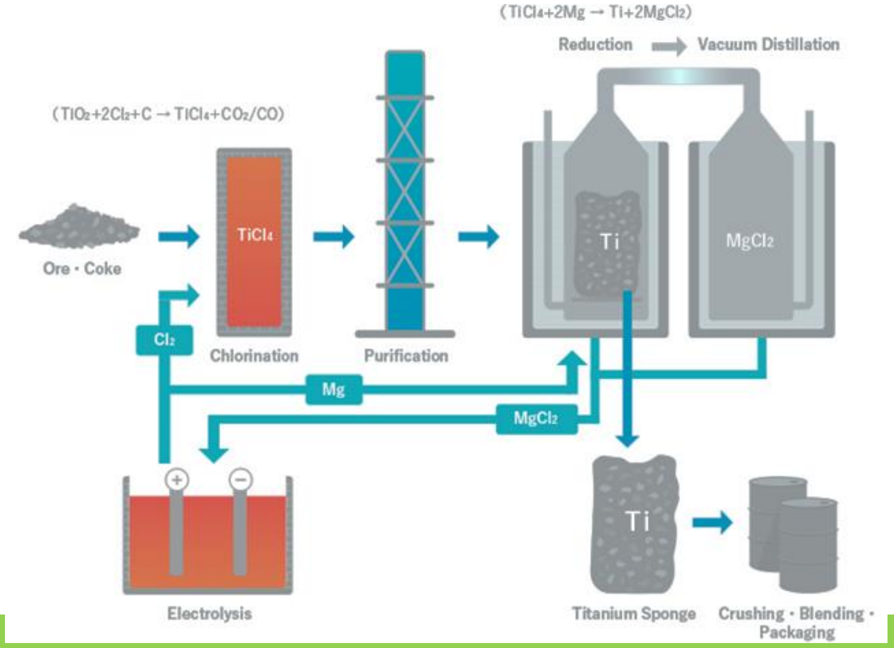


Theoretical parenthesis : Titanium

- *Discovered in the 1790*
- *Nowadays the main Ti ores are rutile (TiO_2) and ilmenite ($FeTiO_3$)*
- *Main rutile mines are Brazil, meanwhile ilmenite mines are in South Africa, India, USA, Norway e Australia*

- **Titanium extraction – Kroll process**

1. The ore rutile (impure titanium(IV) oxide) is heated with chlorine and coke at a temperature of about 1000°C.
2. $TiCl_4$ can be reduced using either magnesium or sodium.
3. Titanium(IV) chloride vapor is passed into a reaction vessel containing molten magnesium in an argon atmosphere, and the temperature is increased to about 1000°C. The reduction process is very slow, taking about 2 days, followed by several more days of cooling.



Theoretical parenthesis : Titanium

$$TiO_2 + 2Cl_2 + 2C \xrightarrow{1000°C} TiCl_4 + 2CO$$

$$TiCl_4 + 2Mg \xrightarrow{1000°C} Ti + 2MgCl_2$$

Titanium sponge

- When it is cool, the reaction mixture is crushed, and dilute hydrochloric acid is added to react with any excess magnesium to form more magnesium chloride. All the magnesium chloride dissolves in the water, and the remaining titanium is processed further to purify it.

Warning for all engineers

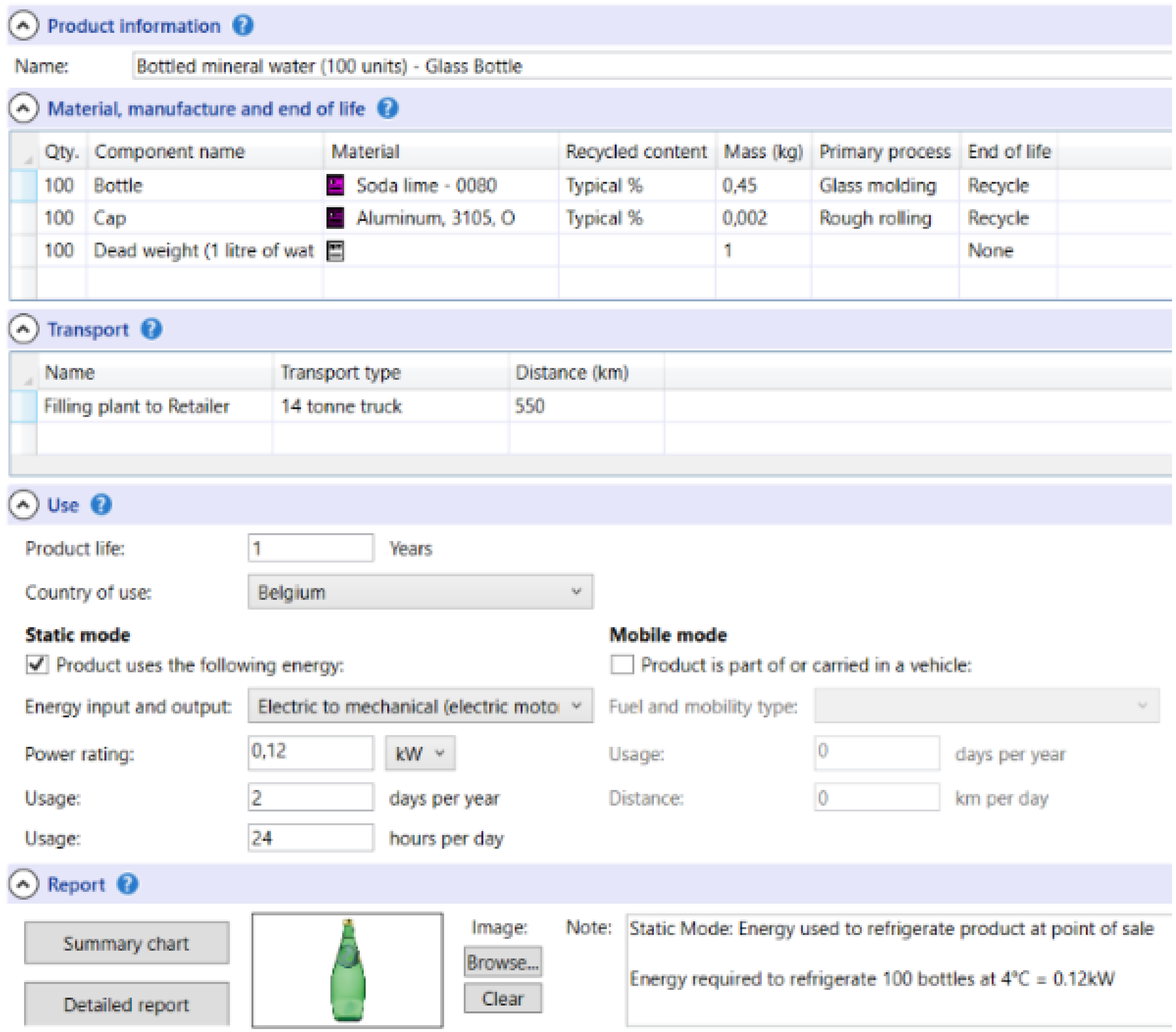
- Traces of oxygen or nitrogen in the titanium tend to make the **metal brittle**. The reduction has to be carried out in an inert argon atmosphere rather than in air.
- Titanium is made by a batch process. In the production of iron, for example, there is a continuous flow through the Blast Furnace. Iron ore and coke and limestone are added to the top, and iron and slag removed from the bottom. This is a very efficient process.
- With titanium, however, you make it one batch at a time. Titanium(IV) chloride is heated with sodium or magnesium to produce titanium. The titanium is then separated from the waste products, and an entirely new reaction is set up in the same reactor. This is a slow and inefficient way of doing things

Eco-Audit

Eco-Audit

Case Study 23: Eco-Audit selection on a Glass Bottle

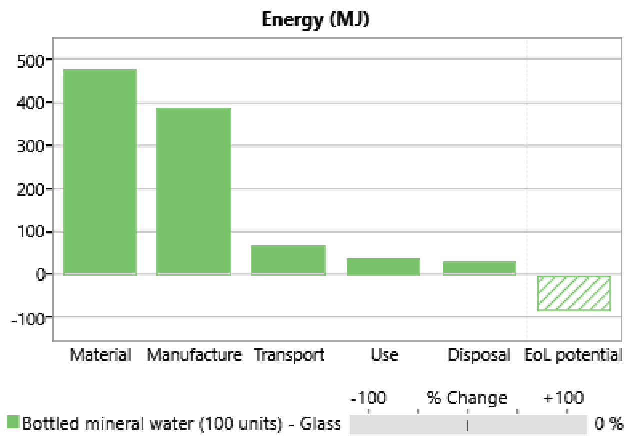
Evaluate the <u>eco-impact</u> of a product

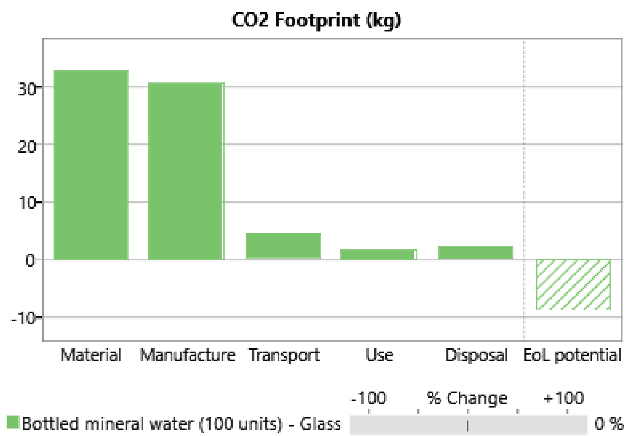


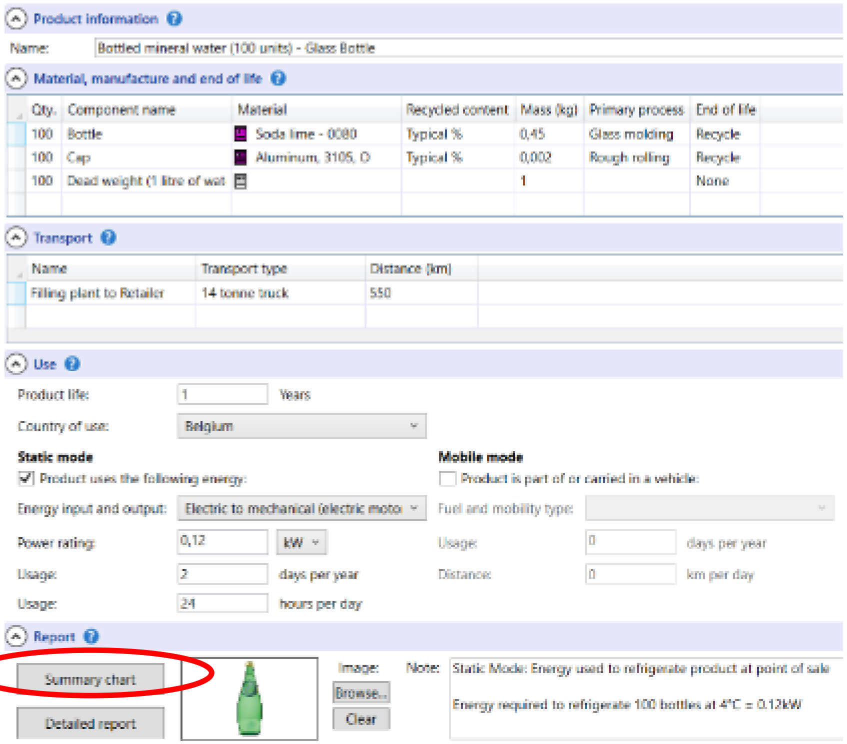
Evaluate:
Transport
Static use

Eco-Audit

Case Study 23: Eco-Audit selection on a Glass Bottle





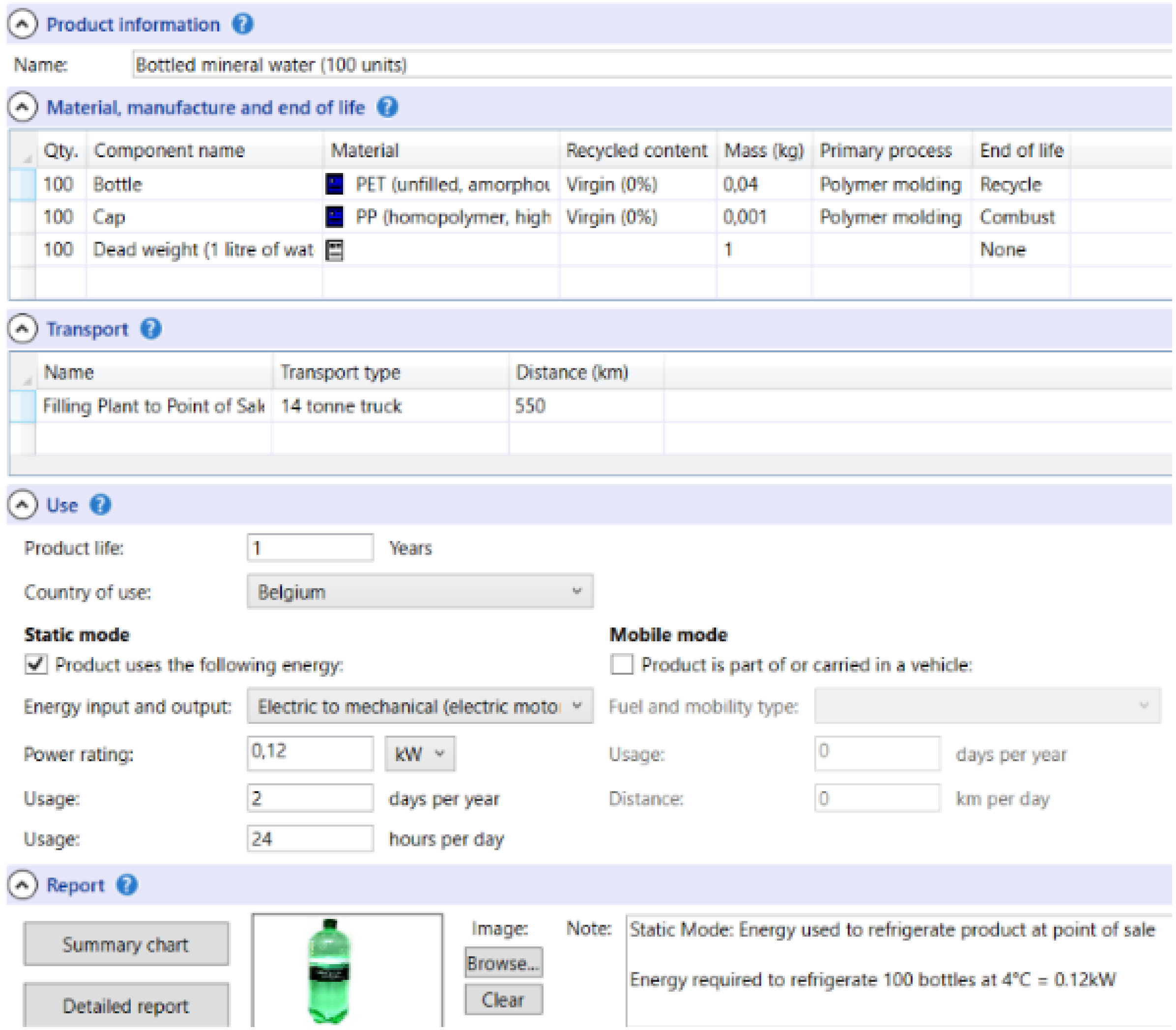


Eco-Audit

Case Study 23': Eco-Audit selection on a PET Bottle

Evaluate the <u>eco-impact</u> of a product

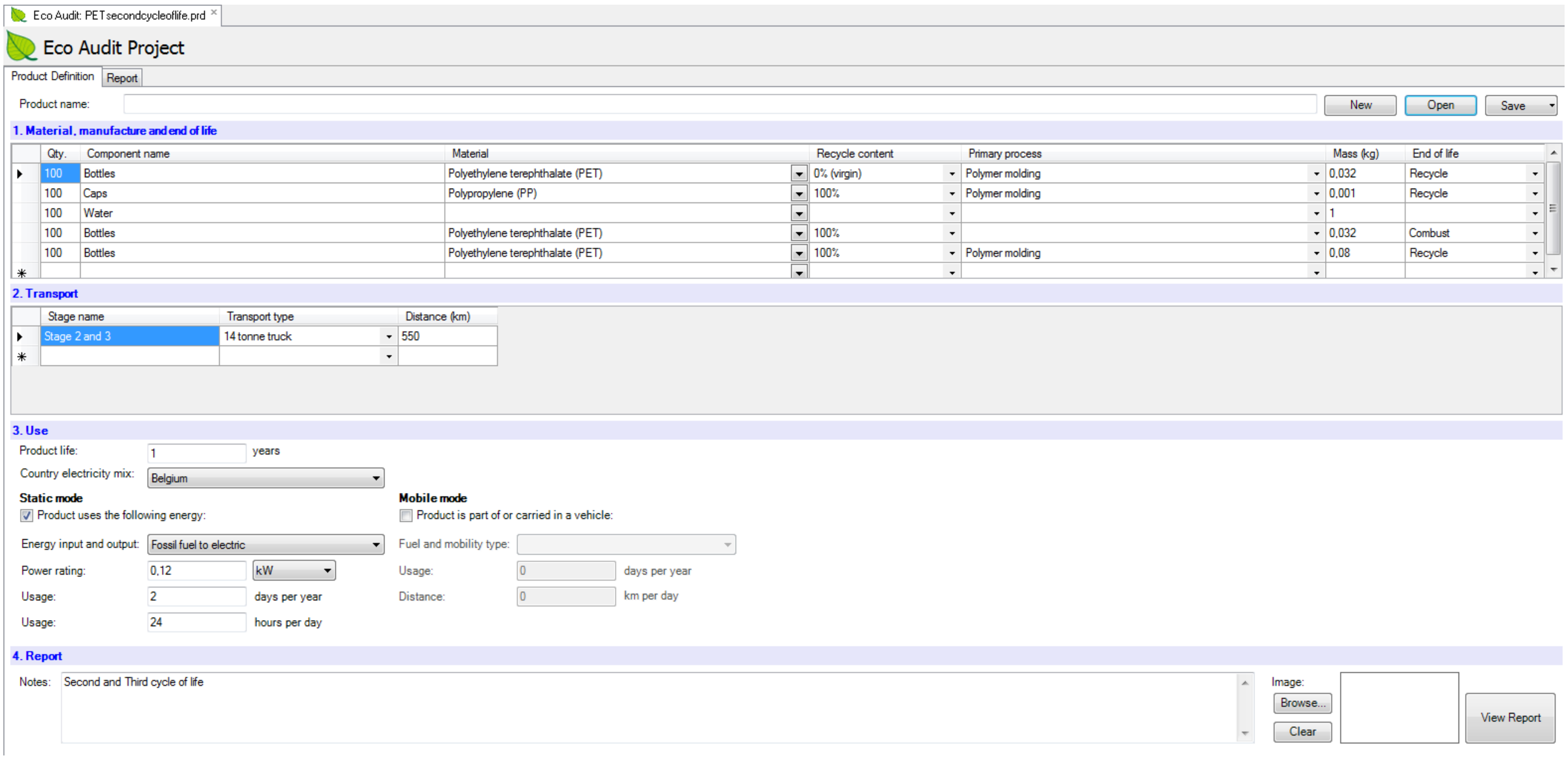
Evaluate:
Transport
Static use



Case Study 24:
Combined Eco-Audit selection (CES 2009)

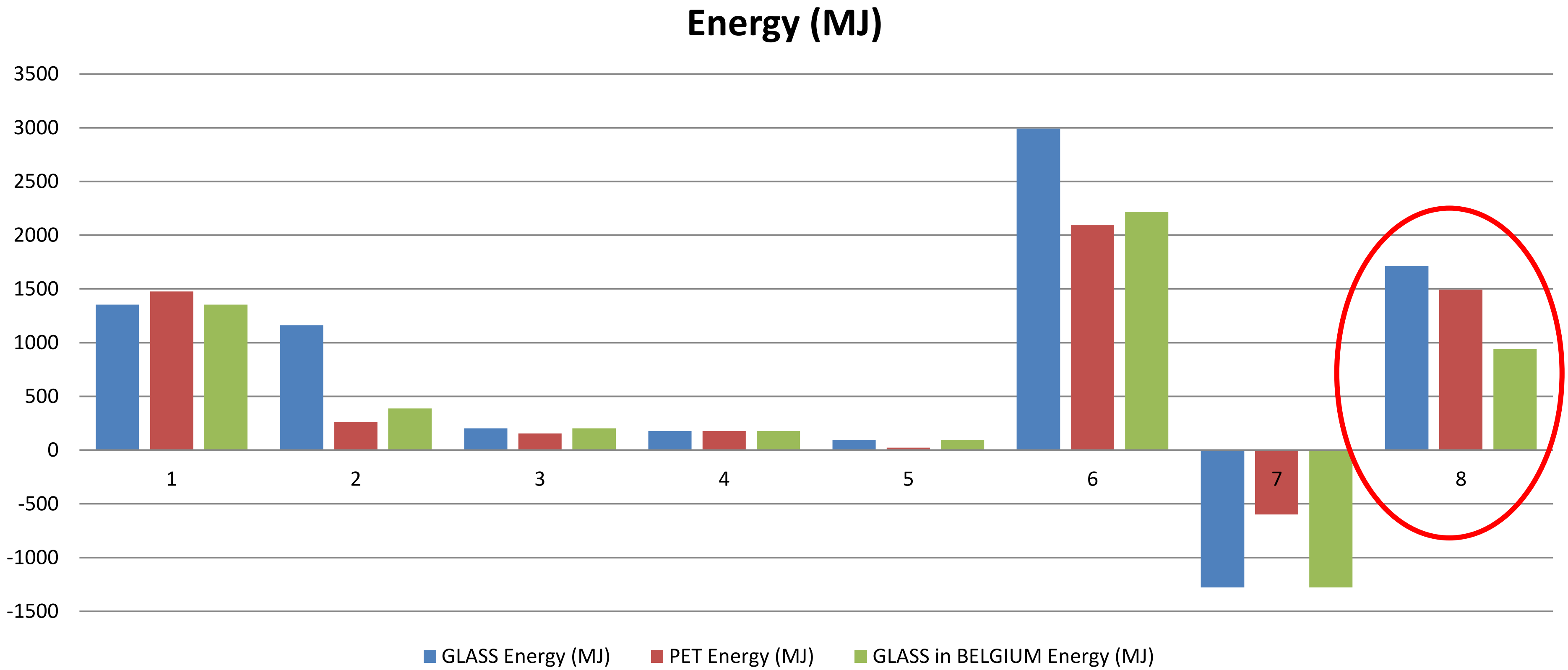
Case Study 24:
Combined Eco-Audit selection (CES 2009)

Data=
100 Bottles in 3 recycling life cycles (considered 1 kg of water)
Considered Transport and Use (*the use depending to the object change his impact*)
Country: Belgium



Case Study 24: Combined Eco-Audit selection (CES 2009)

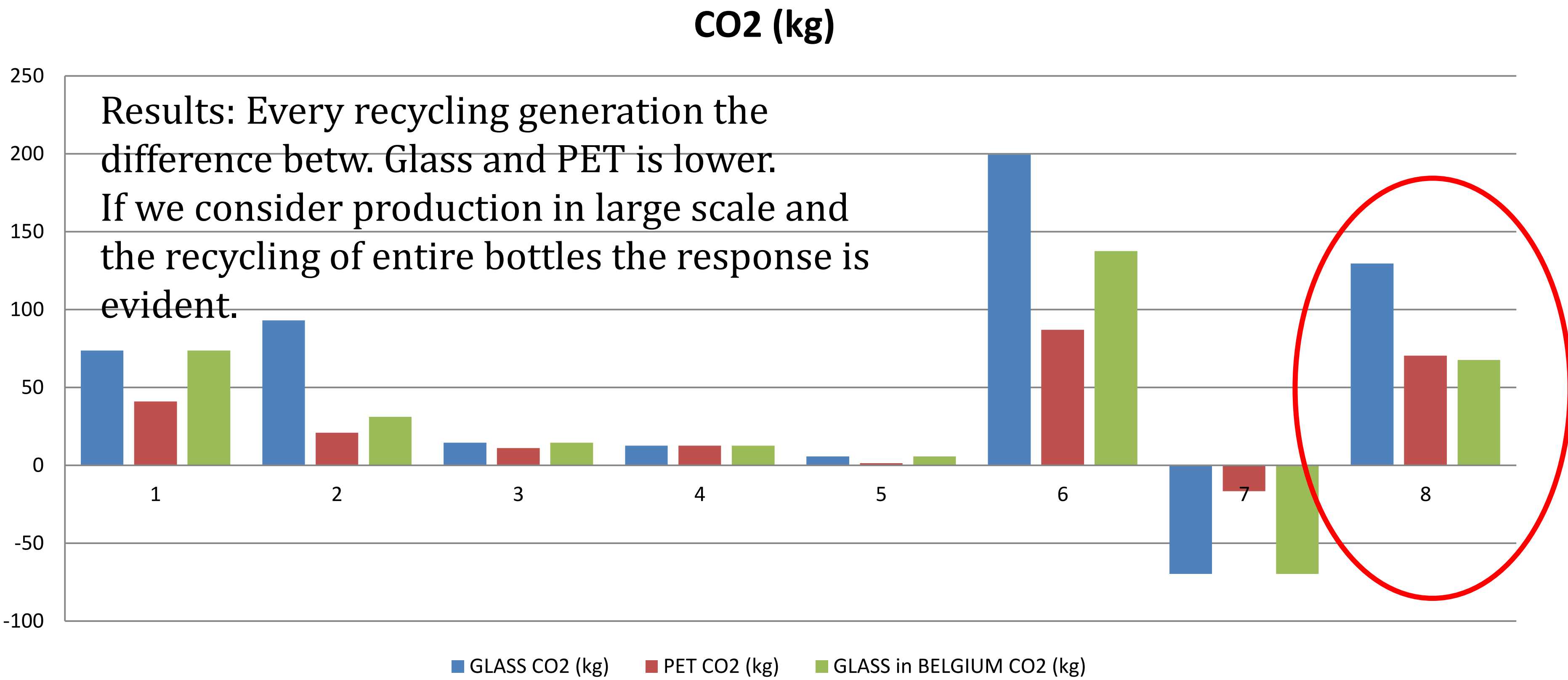
		GLASS	PET	GLASS in BELGIUM
	Phase	Energy (MJ)	Energy (MJ)	Energy (MJ)
1	Material	1354,08323	1475,55609	1354,083228
2	Manufacture	1162,35162	262,163425	388,4996677
3	Transport	203,643	155,72425	203,643
4	Use	177,737143	177,737143	177,7371429
5	End of life (collection & sorting)	94,92	21,89	94,92
6	Total	2992,735	2093,07091	2218,883039
7	End of life (collection & sorting)	-1279,52098	-598,953162	-1279,520976
8	Final Total	1713,21402	1494,11775	939,3620632



Case Study 24:
Combined Eco-Audit selection (CES 2009)

		GLASS	PET	GLASS in BELGIUM
	Phase	CO2 (kg)	CO2 (kg)	CO2 (kg)
1	Material	73,6071374	41,0329314	73,60713742
2	Manufacture	92,988132	20,9730744	31,07997411
3	Transport	14,458653	11,0564218	14,458653
4	Use	12,6193371	12,6193371	12,61933714
5	End of life (collection & sorting)	5,6952	1,3134	5,6952
6	Total	199,36846	86,9951647	137,4603017
7	End of life (collection & sorting)	-69,7889211	-16,6647563	-69,78892107
8	Final Total	129,579539	70,3304084	67,6713806

Results: Every recycling generation the difference betw. Glass and PET is lower.
If we consider production in large scale and the recycling of entire bottles the response is evident.



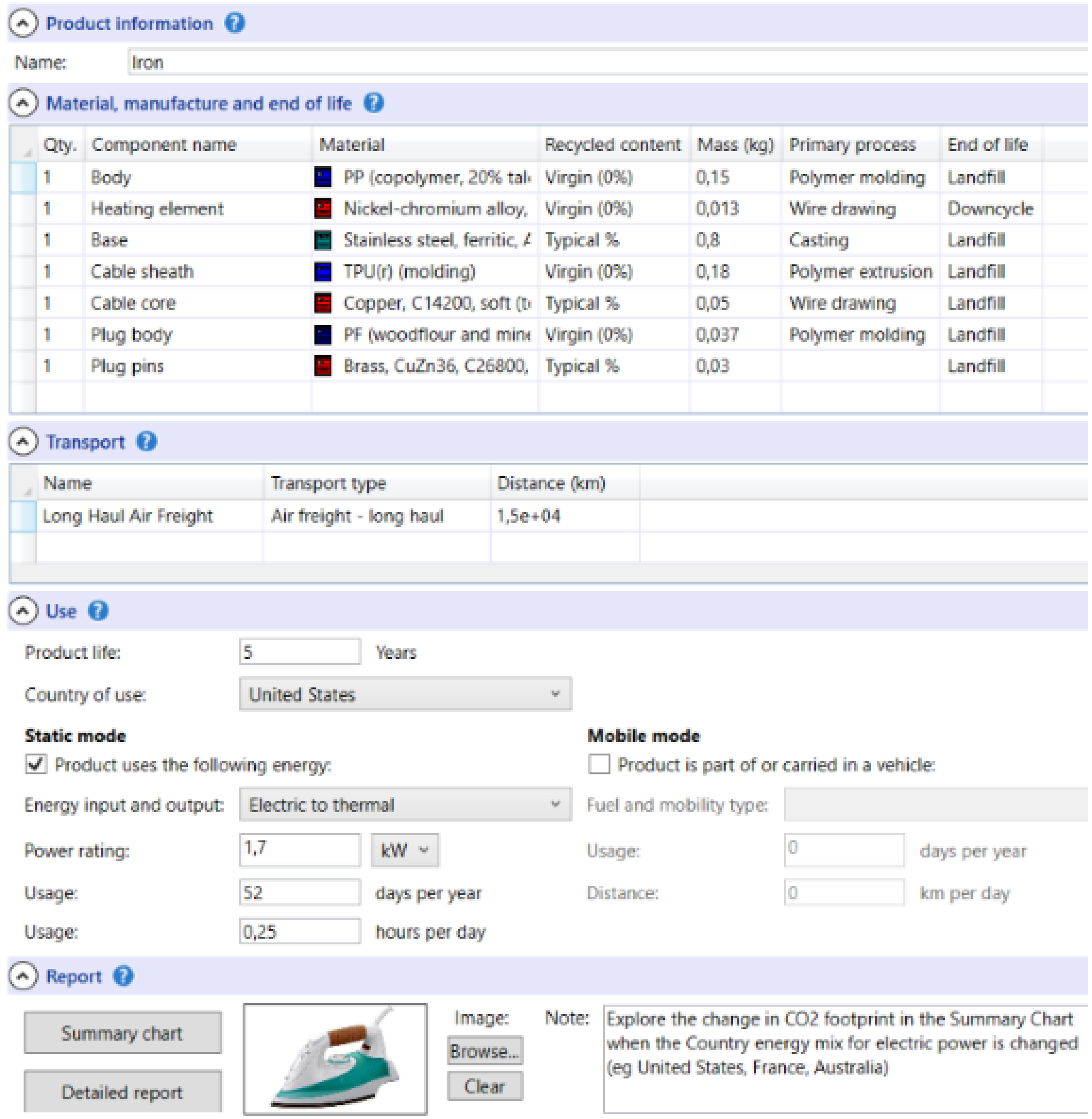
Case Study 24:
Combined Eco-Audit selection (CES 2009)

Eco-Audit

Case Study 25: Eco-Audit selection on an Iron

Evaluate the <u>eco-impact</u> of a product

Evaluate:
Transport
Static use



Product information

Name: Iron

Material, manufacture and end of life

Qty.	Component name	Material	Recycled content	Mass (kg)	Primary process	End of life
1	Body	PP (copolymer, 20% tal	Virgin (0%)	0,15	Polymer molding	Landfill
1	Heating element	Nickel-chromium alloy,	Virgin (0%)	0,013	Wire drawing	Downcycle
1	Base	Stainless steel, ferritic, A	Typical %	0,8	Casting	Landfill
1	Cable sheath	TPU(r) (molding)	Virgin (0%)	0,18	Polymer extrusion	Landfill
1	Cable core	Copper, C14200, soft (t	Typical %	0,05	Wire drawing	Landfill
1	Plug body	PF (woodflour and mine	Virgin (0%)	0,037	Polymer molding	Landfill
1	Plug pins	Brass, CuZn36, C26800,	Typical %	0,03		Landfill

Transport

Name	Transport type	Distance (km)
Long Haul Air Freight	Air freight - long haul	1,5e+04

Use

Product life: 5 Years

Country of use: United States

Static mode

☑ Product uses the following energy:

Energy input and output: Electric to thermal

Power rating: 1,7 kW

Usage: 52 days per year

Usage: 0,25 hours per day

Mobile mode

☐ Product is part of or carried in a vehicle:

Fuel and mobility type:

Usage: 0 days per year

Distance: 0 km per day

Report

Summary chart

Detailed report

Image: Browse... Clear

Note: Explore the change in CO2 footprint in the Summary Chart when the Country energy mix for electric power is changed (eg United States, France, Australia)

Eco-Audit

Case Study 26: Eco-Audit selection on a Family Car

Evaluate the <u>eco-impact</u> of a product

Evaluate:
Mobile use

Product information

Name: Family car

Material, manufacture and end of life

Qty.	Component name	Material	Recycled content	Mass (kg)	Primary process	End of life
1	Steel content	Low alloy steel, AISI 31	Typical %	850	Rough rolling	Recycle
1	Aluminium content	Aluminum, 355.0, perm	Typical %	438	Casting	Recycle
1	Thermoplastic content (PU	TPU(r) (molding)	Virgin (0%)	148	Polymer extrusion	Landfill
1	Thermoset content	Polyester (cast, rigid)	Virgin (0%)	93	Polymer molding	Landfill
1	Elastomer content	Butyl / Halobutyl rubbe	Virgin (0%)	40	Polymer molding	Landfill
1	Glass content	Borosilicate - 2405	Typical %	40	Glass molding	Recycle
1	Other metal content	Copper, C14200, hard (	Typical %	61	Extrusion, foil rolling	Recycle
1	Textile content	PE-LD (molding and ext	Virgin (0%)	47	Polymer extrusion	Landfill

Transport

Use

Product life: 10 Years

Country of use: World

Static mode

☐ Product uses the following energy:

Energy input and output:

Power rating: 0 kW

Usage: 0 days per year

Usage: 0 hours per day

Mobile mode

☑ Product is part of or carried in a vehicle:

Fuel and mobility type: Gasoline - family car

Usage: 250 days per year

Distance: 100 km per day

Report

Summary chart

Detailed report

Image: Browse... Clear

Note:

Eco-Audit

Case Study 27: Eco-Audit selection on an Portable space heater

Evaluate the <u>eco-impact</u> of a product

Evaluate:
Transport
Static use
Mobile use

Name: Portable space heater

Material, manufacture and end of life

Qty.	Component name	Material	Recycled content	Mass (kg)	Primary process	End of life
1	Heater casing	Carbon steel, AISI 1010,	Typical %	5,4	Extrusion, foil rolling	Downcycle
1	Fan	Carbon steel, AISI 1010,	Typical %	0,25	Extrusion, foil rolling	Downcycle
1	Air flow enclosure (heat sh	Stainless steel, ferritic, A	Typical %	0,4	Extrusion, foil rolling	Downcycle
1	Motor, rotor and stator	Cast iron, gray, flake gr	Typical %	0,13	Casting	Downcycle
1	Motor, wiring:conductors	Copper, C14200, soft (t	Typical %	0,08	Wire drawing	Downcycle
1	Motor, wiring: insulation	PE-HD (high molecular	Virgin (0%)	0,08	Polymer molding	Landfill
1	Connecting hose, 2 meter	Natural rubber (unreinf	Virgin (0%)	0,35	Polymer molding	Landfill
1	Hose connector	Brass, CuZn36, C26800,	Typical %	0,09	Extrusion, foil rolling	Downcycle
1	Other components	PC (low viscosity, moldi	Virgin (0%)	0,22	Polymer molding	Landfill
1	Gas canister			20		None

Transport

Name	Transport type	Distance (km)
South Korea Factory to US	Sea freight	1e+04
US Port to Point of Sale	32 tonne truck	600

Use

Product life: 3 Years

Country of use: World

Static mode

☑ Product uses the following energy:

Energy input and output: Fossil fuel to thermal, vented system

Power rating: 9,3 kW

Usage: 10 days per year

Usage: 2 hours per day

Mobile mode

☑ Product is part of or carried in a vehicle:

Fuel and mobility type: Diesel - light goods vehicle

Usage: 300 days per year

Distance: 85 km per day

Report

Summary chart

Detailed report

Image: Browse... Clear

Note: