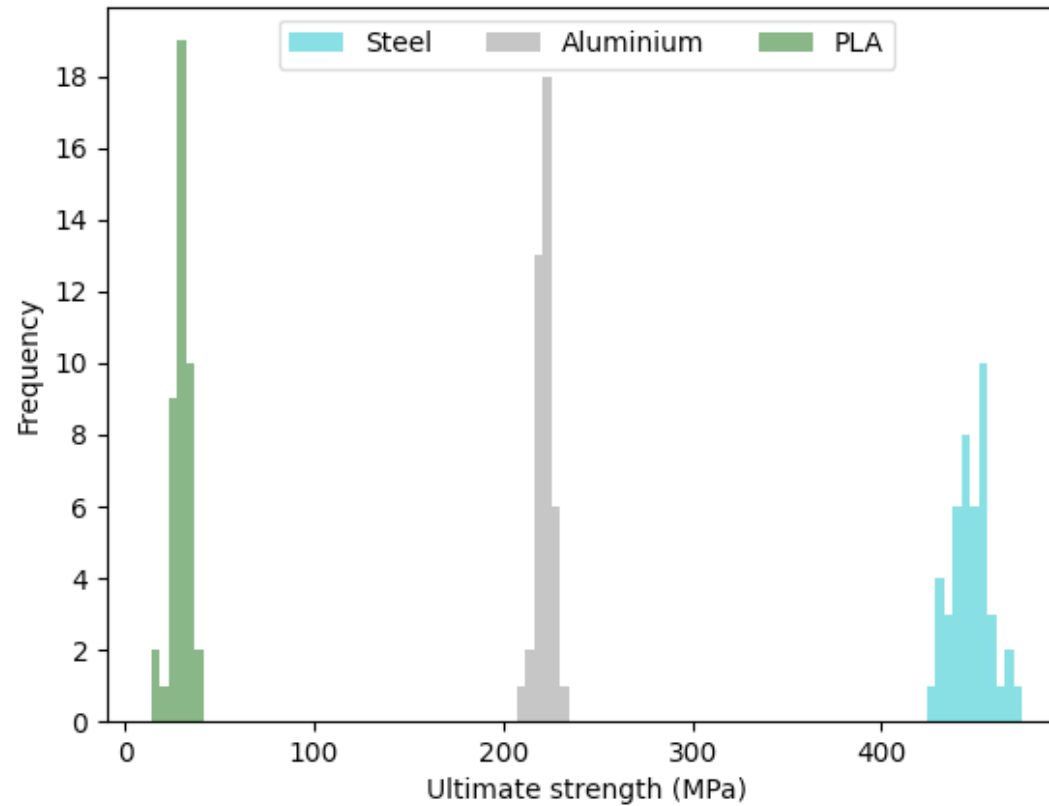


Statistics and Variability from your Mechanical Laboratory

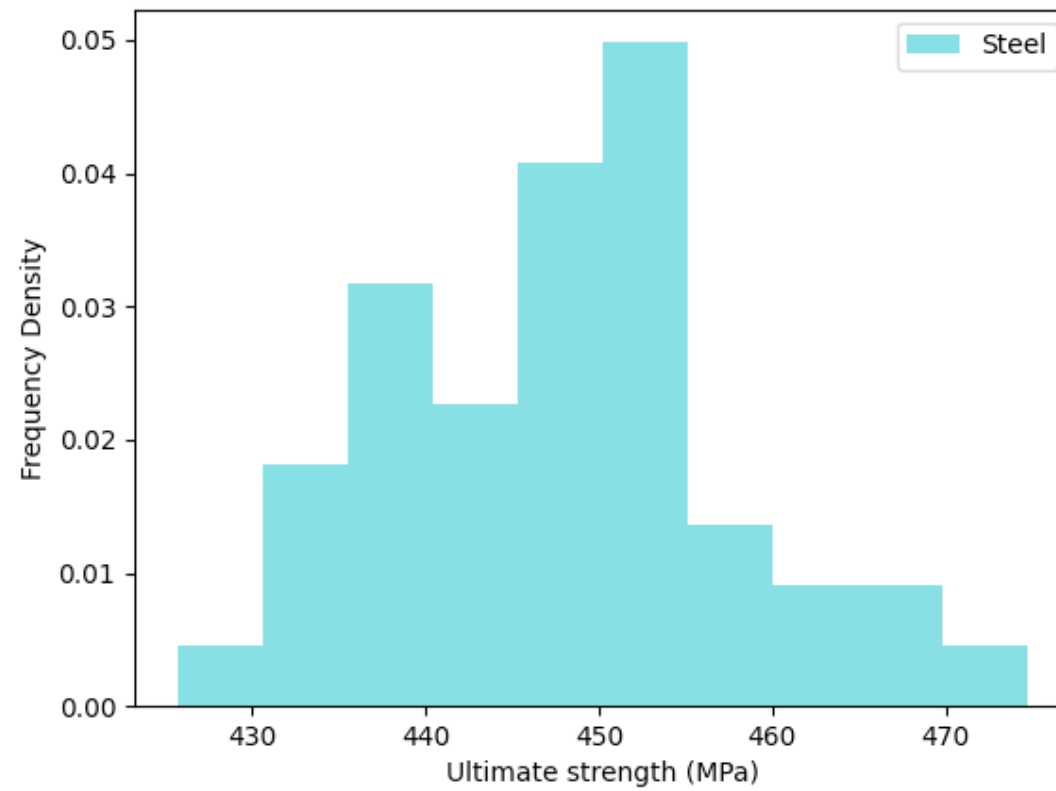
Materials 2, 2025



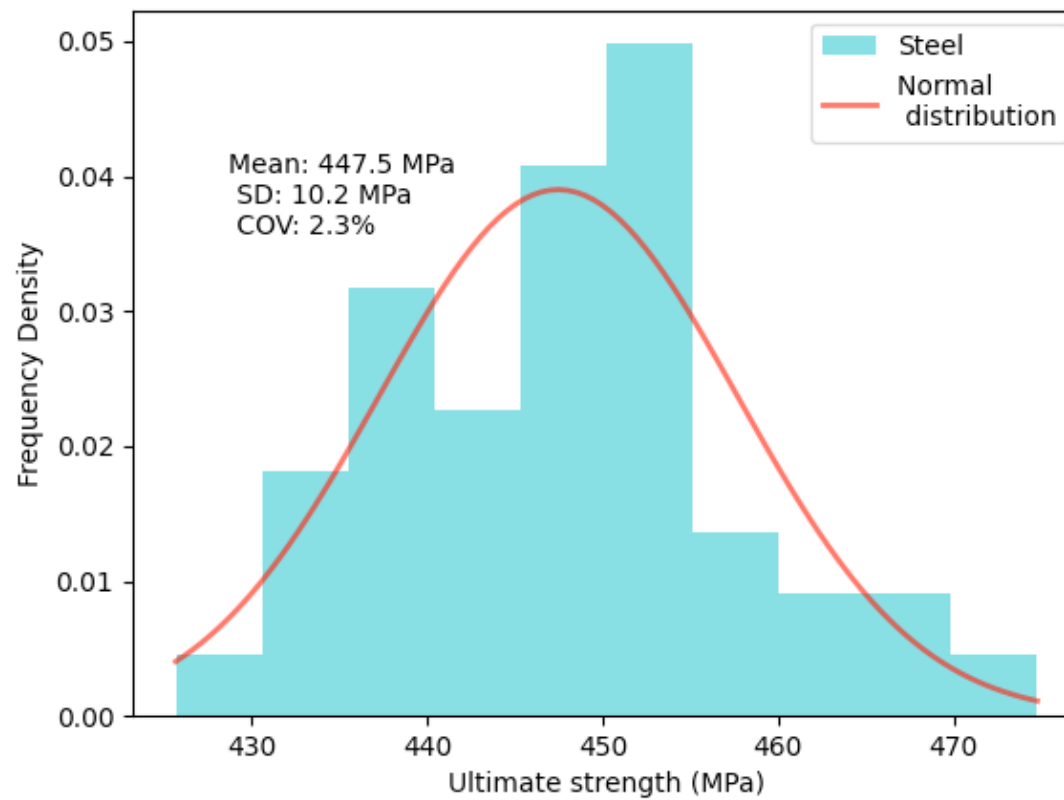
Histogram: measured strength



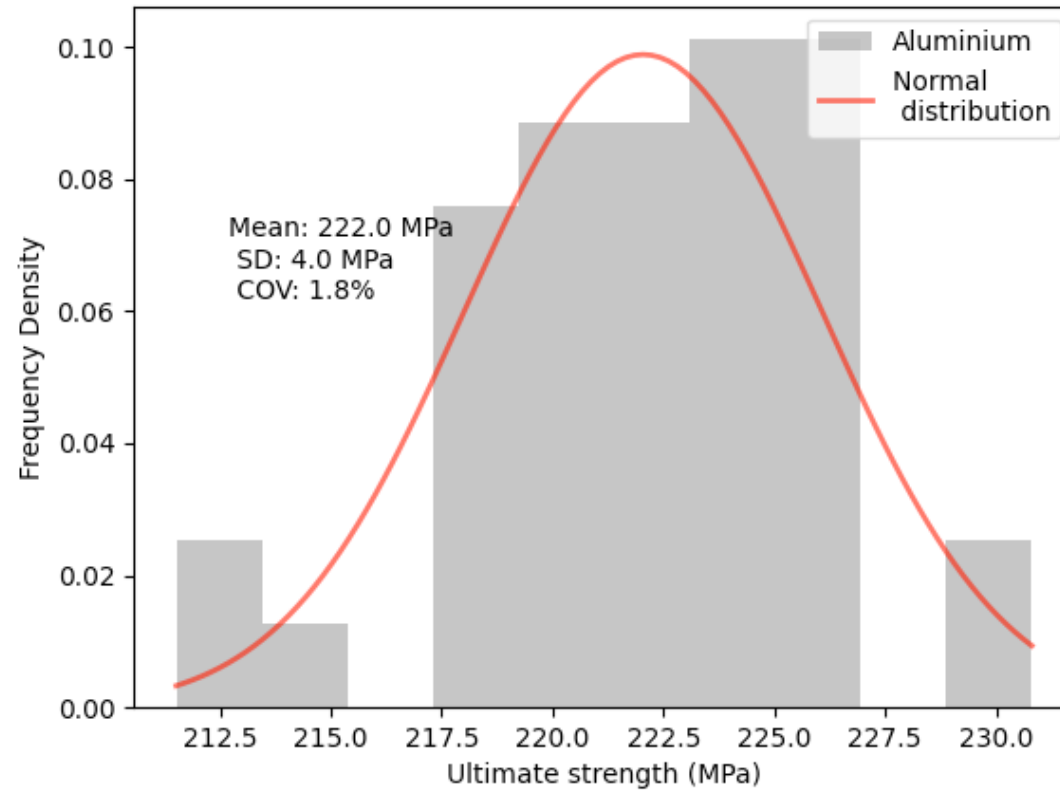
Histogram: Steel



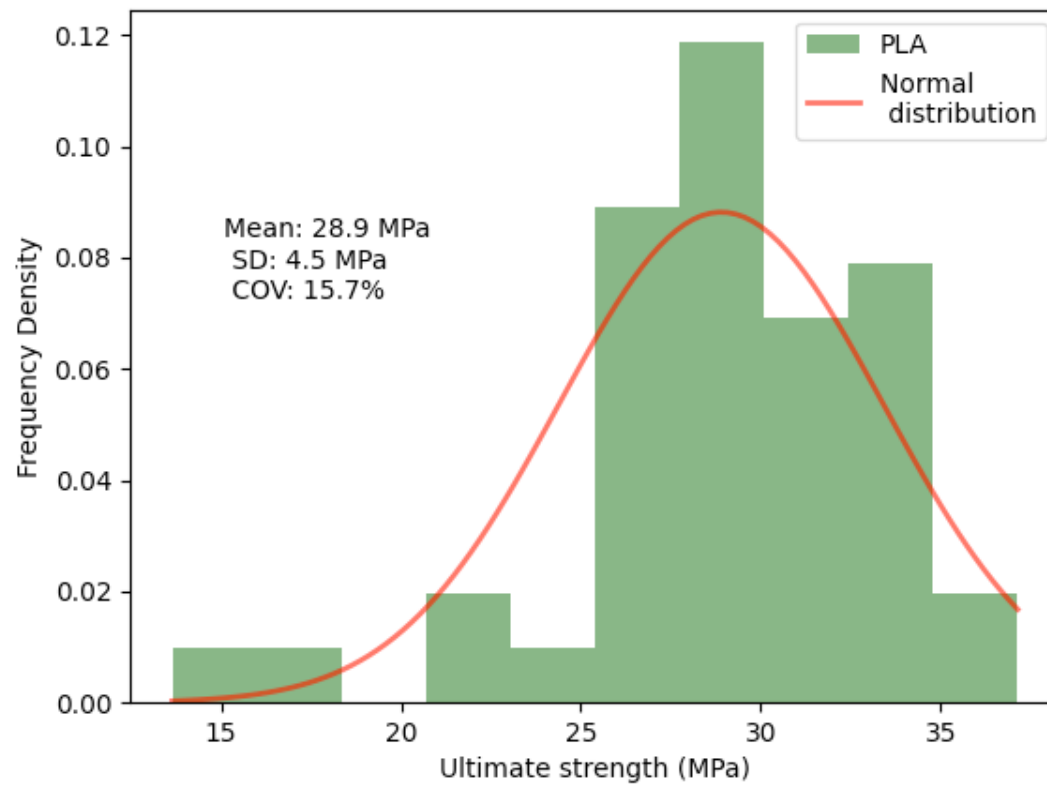
Histogram: Steel



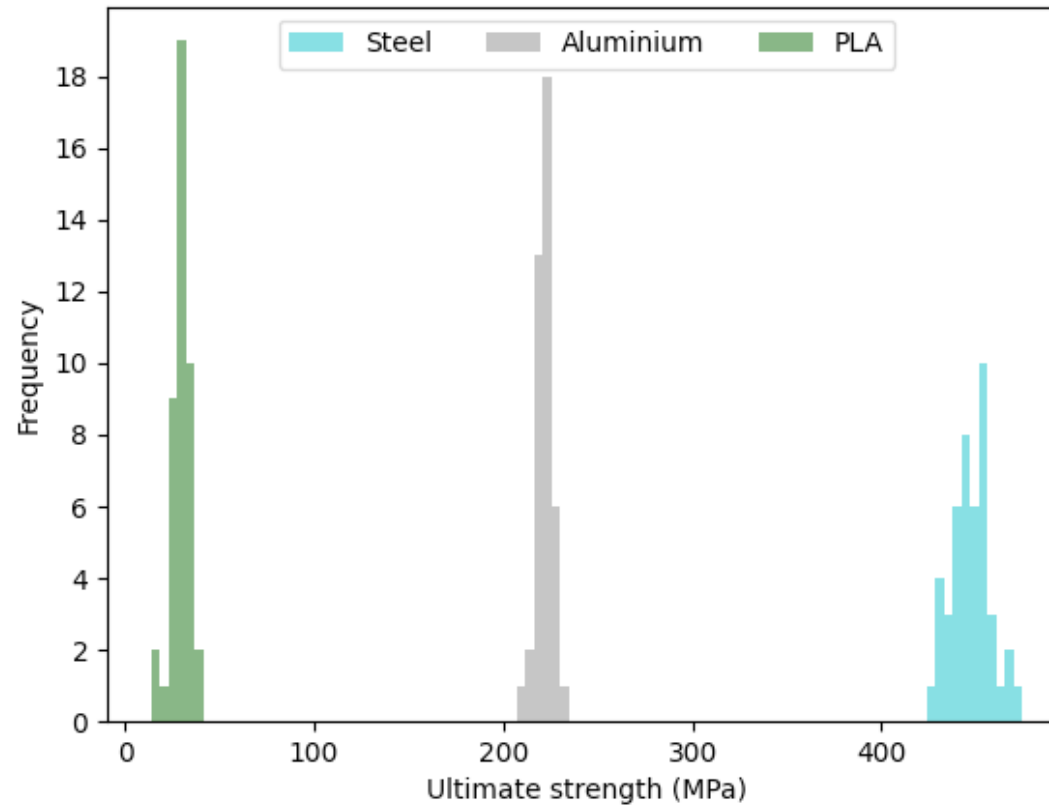
Histogram: Steel



Histogram: 3D printed PLA



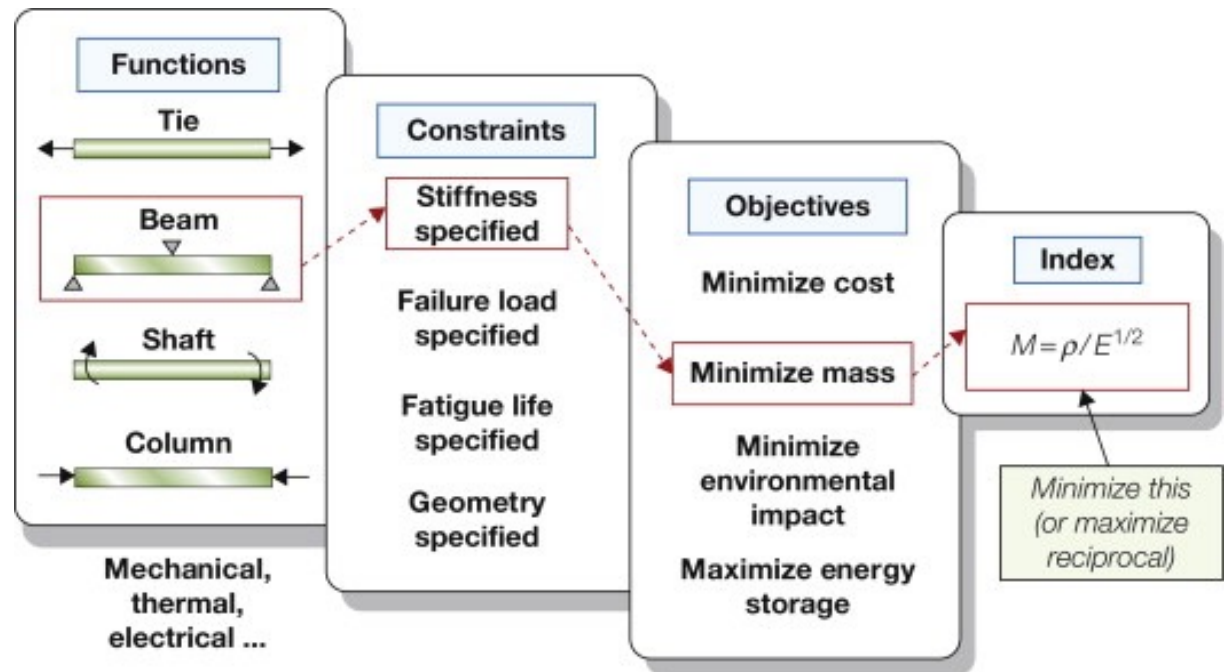
Histogram: measured strength



Materials 2: Granta and Materials Selection

Tom Reynolds

Performance Indices (Ashby, 2011)



Defining the problem: what properties matter?

Thermal insulation for buildings



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Defining the problem: what properties matter?

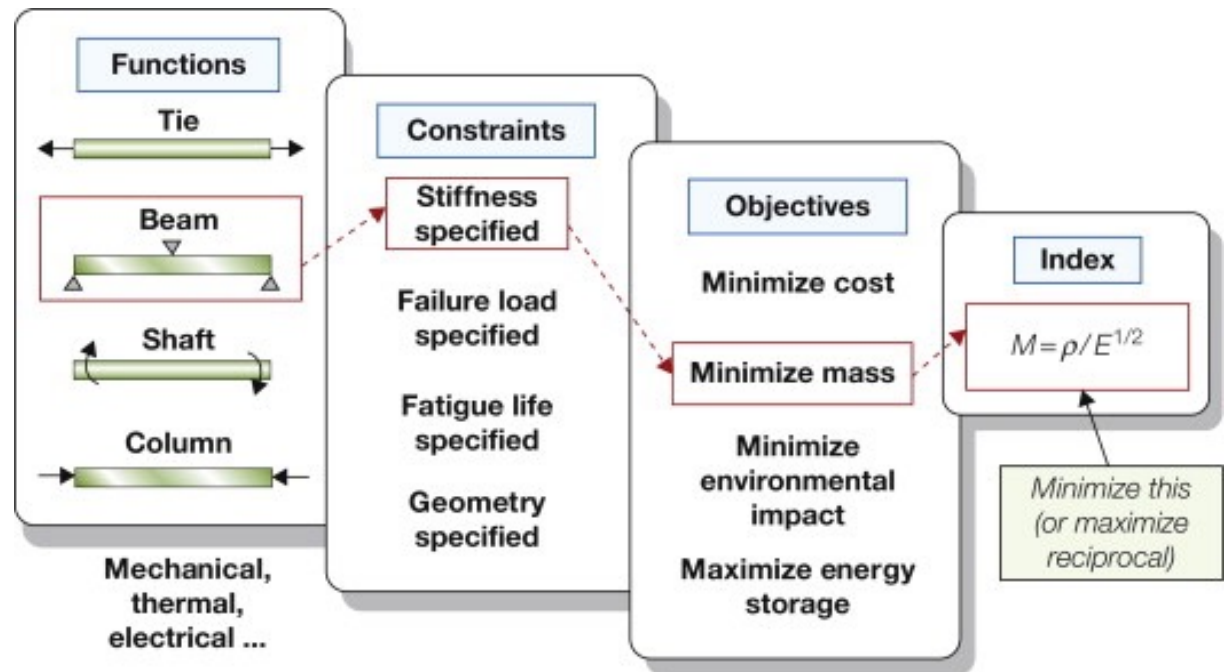
Thermal insulation for buildings

- Thermal conductivity
- Toxicity
- Flammability
- Embodied carbon
- Cost

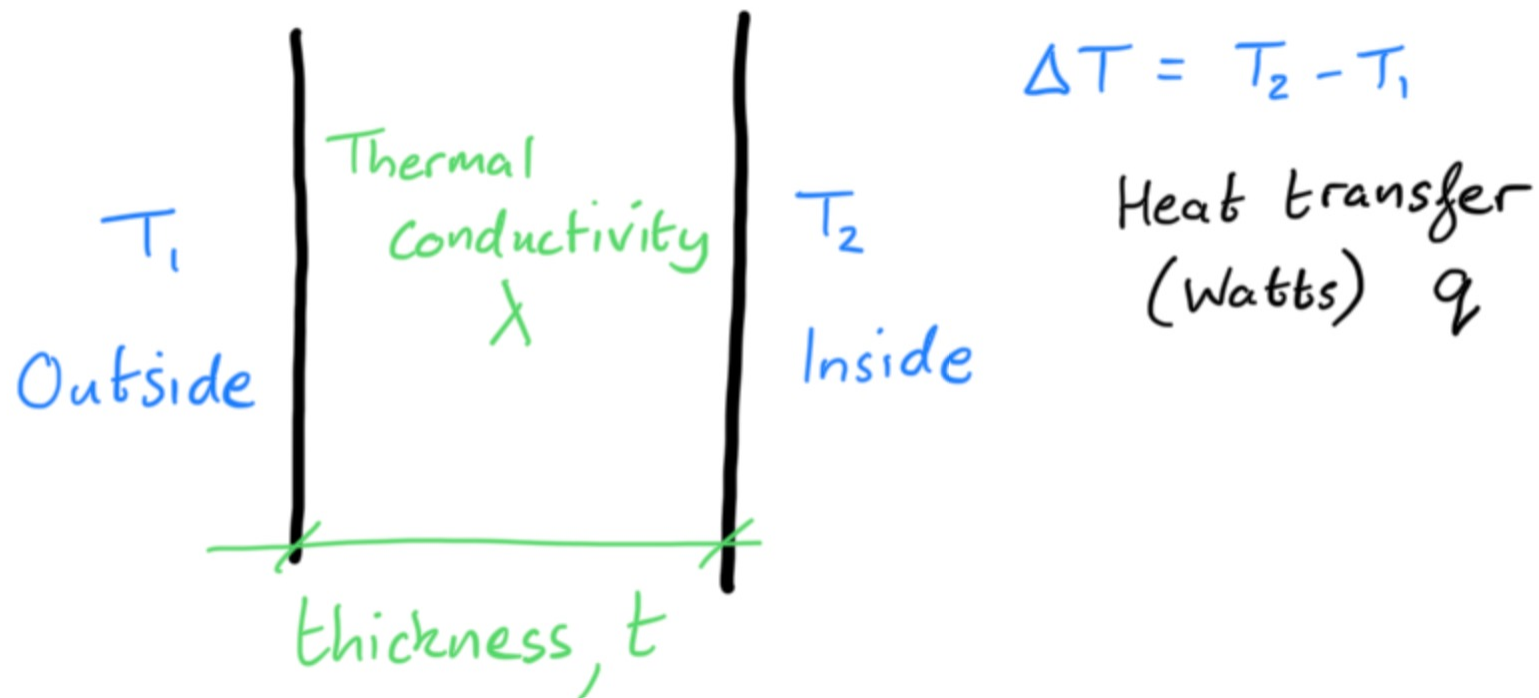


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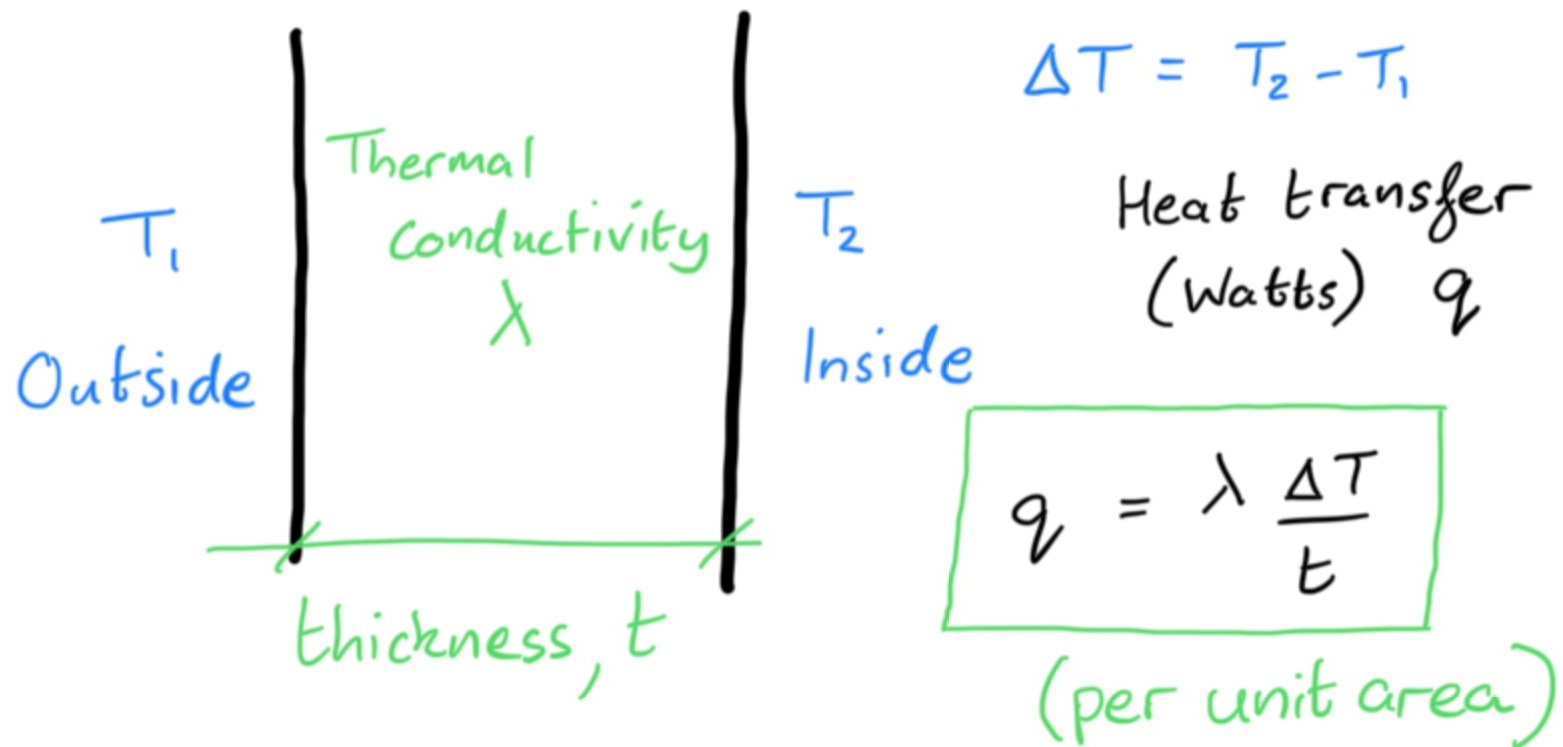
Performance Indices (Ashby, 2011)



Function: thermal insulation



Function: thermal insulation



Constraints

- Low heat flux
- Non-toxic
- Non-flammable

Fixed variables: area A of wall, temperature difference ΔT

Free variable: thickness t

Objective: minimize cost

Cost per unit area:

$$\mathcal{E} = \frac{cAt\rho}{A}$$

Cost per unit mass c

Thickness t

Density ρ

Area A

Performance metric

Low heat transfer: $1/q$

Low cost: $1/\mathcal{E}$

Combine into performance metric:

$$P = \frac{1}{q} \times \frac{1}{\mathcal{E}} = \frac{t}{\lambda \Delta T} \times \frac{1}{ct\rho}$$

Performance metric

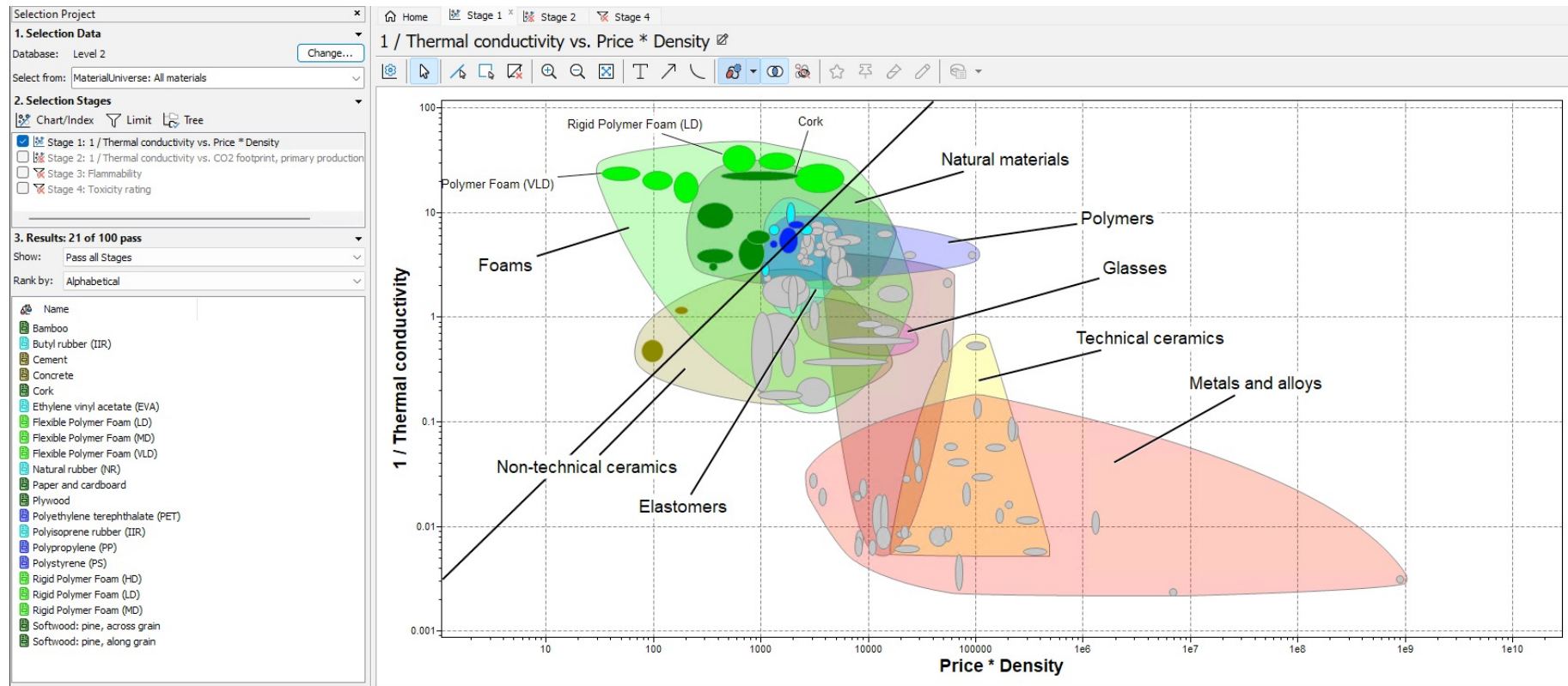
Low heat transfer: $1/q$

Low cost: $1/\epsilon$

Combine into performance metric:

$$P = \frac{1/\lambda}{c\rho} \times \frac{1}{\Delta T}$$

Granta software



Material-process matrix

WHAT Framework

Materials

- Classifications
- Properties
- Small scale structure (microstructure)
- Processing / manufacturing
- Applications

	Material class							
	Metals	Ceramics & glass				Polymers & Composites		
Process class	Ferrous, light, precious, other non-ferrous	Cementitious	Clay fired	Advanced/ engineering	Glass	Thermoplastics	Elastomers	Polymer matrix (thermoset) composites
Casting	✓	-	-	-	✓	-	-	-
Moulding	-	✓	✓	-	-	✓	✓	-
Deformation	✓	-	-	-	✓	-	-	-
Heat treatment	✓	-	✓	-	-	-	✓	-
Machining	✓	-	-	-	-	-	-	-
Composite forming	-	-	-	-	-	-	-	✓
Powder methods	-	-	-	✓	-	-	-	-
Special methods	-	-	-	✓	-	-	-	-

Applications

- Has this material been used for this application?
- Has it been used in an analogous application in another field?

WHAT Framework

Materials

- **Classifications**
- **Properties**
- **Small scale structure**
(microstructure)
- **Processing / manufacturing**
- **Applications**

Applications

WHAT Framework

Materials

- **Classifications**
- **Properties**
- **Small scale structure**
(microstructure)
- **Processing / manufacturing**
- **Applications**

- A conservative choice e.g. glass bottles, steel cans rejects the opportunity for innovation
- Examples where a new material has captured a market: plastic bottles, aluminium cans, polycarbonate eyeglass lenses
- It is important in the early stage of design, or of re-design, to examine all materials, not rejecting options merely because they are unfamiliar