Alloys – where are they used?
Alloys – where are they used?
Alloys – where are they used?
Alloys – where are they used?
Alloys – where are they used?

- Potential energy in elastic band:

\[ E = \frac{1}{2} kx^2 = \frac{1}{2} Fx = \frac{1}{2} \times 10 \times 0.1 = 0.5 \text{ J} \]
Alloys – where are they used?

- Potential energy in elastic band:
  
  \[ E = \frac{1}{2} kx^2 = \frac{1}{2} Fx = \frac{1}{2} 10 \times 0.1 = 0.5 \text{ J} \]

- Kinetic energy in handgun bullet:
  
  \[ E = \frac{1}{2} mv^2 = \frac{1}{2} 0.005 \times 400^2 = 400 \text{ J} \]
Alloys – where are they used?

• Potential energy in elastic band: \[ E = \frac{1}{2} kx^2 = \frac{1}{2} Fx = \frac{1}{2} \times 10 \times 0.1 = 0.5 \text{ J} \]

• Kinetic energy in handgun bullet: \[ E = \frac{1}{2} mv^2 = \frac{1}{2} \times 0.005 \times 400^2 = 400 \text{ J} \]

• Potential energy in enormous band: \[ E = \frac{1}{2} kx^2 = \frac{1}{2} Fx = \frac{1}{2} \times 100 \times 10 = 500 \text{ J} \]
Alloys – where are they used?
Jet engine: commercial jet
Aircraft fuel efficiency over the past 50 years

Fuel burn relative to Comet Engine Cruise Fuel Consumption

Aircraft Fuel Burn Per Seat

Jet engine: turbine discs
Certification – fan blades & birds!

- **Small bird**: Number based on area of front of engine, maximum 16, mass 55 - 110g (e.g. starlings)

- **Medium bird**: Number based on area of front of engine, maximum 10, mass 0.7 kg (e.g. seagull)

- **Large bird**: 1 bird, mass at least 1.8 kg at speeds up to 2500ms⁻¹
Designing a new alloy – what is required?

- Fracture toughness
- Yield strength
- Processibility
- Cost
- Density
- Fatigue life
- Corrosion resistance
- Oxidation resistance
- Creep
- Required properties for new alloy

Yield strength

Cost

Density

Fatigue life

Corrosion resistance

Oxidation resistance

Creep

Required properties for new alloy

Fracture toughness

Processibility
Types of property models

• For efficient development, predictions must take seconds or less
  ✗ Experimental data (weeks/months)
  ✓ Neural networks (nano/micro seconds)

• Combine estimates of individual properties to give overall probability of success
Multidimensional design space

and 4 different manufacturing processes
Predicted material

- Processed according to model predictions
- Property assessment underway
Conclusions: why natural sciences & materials?

- Union of different sciences that encourages analysis with a variety of techniques – analytical, numerics, and experiments
- Close connection to real-world problems
- Strong academic funding and well-paid industrial jobs