The Materials Age

Gareth Conduit
The Stone age: 3.4 million BC – 2000 BC

1.9 million BC
Olduvai Gorge, Tanzania

1.2 million BC
Olduvai Gorge, Tanzania
The Bronze age: 2000 BC – 1000 BC

1400 BC
France

1200 BC
Britain
The Iron age: 1000 BC – 500 AD

900 BC
Iran

300 BC
Yorkshire
First Steel age: 500 AD – 1850 AD

900 AD Oxford

1200 AD Damascus
Second Steel age: 1850 AD – 1930 AD

1876
France

1906
Portsmouth
Modern materials: plastics
Modern materials: ceramics
Modern materials: composites
Modern materials: rubbers

- Potential energy in elastic band:

\[ E = \frac{1}{2} kx^2 = \frac{1}{2} Fx = \frac{1}{2} 10 \times 0.1 = 0.5 \text{ J} \]
Modern materials: rubbers

- 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:
  \[ E = \frac{1}{2} mv^2 = \frac{1}{2} 0.005 \times 300^2 = 225 \text{ J} \]
Modern materials: rubbers

- 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:
  \[ E = \frac{1}{2} mv^2 = \frac{1}{2} 0.005 \times 300^2 = 225 \text{ J} \]

- Potential energy in enormous band:
  \[ E = \frac{1}{2} kx^2 = \frac{1}{2} Fx = \frac{1}{2} 100 \times 5 = 250 \text{ J} \]
Modern materials: alloys
Jet engine: military jet
Jet engine: commercial jet
Jet engine: commercial jet

\[ E = \frac{1}{2} m v^2 = \frac{p^2}{2m} \]
Jet engine: turbine discs
Designing a new alloy – what is required?

- Fracture toughness
- Yield strength
- Processibility
- Corrosion resistance
- Oxidation resistance
- Creep
- Fatigue life
- Cost
- Density

Required properties for new alloy
Multidimensional design space

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and 4 different manufacturing processes
Selection of design space
Selection of design space
Automated sampling - parallel optimization

Optimal material

Suboptimal material
Predicted material
Predicted material
Predicted material
Predicted material
Conclusions: scientific

- Developed new algorithms to optimize a material’s properties
- Manufactured alloys fulfill physical criteria
Conclusions: why work in material sciences?

- 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