Science: Alcoa Kitts Green – Teacher Guide

Context

The Aluminium Company of America (Alcoa) is one of the world's largest producers of aluminium, and manufacturers of aluminium products. They are involved in all major areas of the production and manufacturing process, from mining, refining and smelting through to fabrication and technology development. The recycling of aluminium also makes up a significant part of the company's activities.

The Alcoa manufacturing plant at Kitts Green, Birmingham, produces high quality, flat rolled aluminium. This material has a wide range of uses from types of packaging such as aluminium foil and drinks cans, to sheet metals for commercial transportation and the construction industry.

Understanding the physical and chemical behaviours of aluminium, its compounds and alloys underpins much of the work done at the plant. The foundry produces a range of different aluminium alloys, each with unique tensile properties making them suited to different uses. The most common alloys involve combinations of magnesium and silicon, though many other elements including copper, zinc, and manganese are used. These often improve the alloy's strength, hardness, yield, and/or corrosion resistance when compared to pure aluminium.

Objectives

The virtual field trip to Alcoa Kitts Green and the associated learning activities can be used to support the following learning objectives:

- Understand real-world techniques for testing material properties, and gain a greater knowledge of a range of scientific professions (*Key Stage 3 and 4 National Curriculum for Science*)
- Know that ultrasound waves are partially reflected at boundaries which allow them to be used for non-invasive imaging *(GCSE Physics)*
- Understand that metals such as aluminium, are derived from ore, and can be recycled *(GCSE Chemistry)*
- Understand the physical and chemical properties of aluminium, and the impact of creating alloys on the material properties (*Key Stage 3 National Curriculum for Science, GCSE Chemistry)*
- Know the force-extension relationship for materials, and the linear response for elastic deformation (*Key Stage 3 National Curriculum for Science, GCSE Physics)*

Learning activities

Students could:

- Conduct an experiment to investigate the relationship between load and extension for a variety of materials. Plot graphs of the results, identifying Young's Modulus for elastic deformation, the yield strength, and the ultimate strength of the materials. Fine gauge metal wires can be used where they respond sufficiently to load, and where suitably sensitive measurement devices are accessible.

  (Supporting resources: Load-extension graph PowerPoint) **Download Here**

- Annotate a screenshot of the ultrasonic testing equipment to explain how ultrasound is used to detect defects in metal slabs. They could then answer the question: why is ultrasound used in these tests?

  (*Supporting resources: Ultrasound worksheet and PowerPoint*) **Download Here**

- Use sample ultrasound data to determine the thickness of aluminium sheets and plot the results for a test scan.

  (*Supporting resources: Ultrasound worksheet and PowerPoint*) **Download Here**

- Sort the stages of the aluminium recycling process into the correct order and match them to their descriptions.

  (*Supporting resources: Aluminium recycling process cards*) **Download Here**

- Investigate the material and chemical properties of aluminium: magnetism, corrosion/oxidisation, strength, hardness, density. Students should then list as many aluminium products as they can think of. What are the properties of aluminium that make it a suitable material for each of these products?
- Careers activity: Create a table with two columns. In the first column, list the job role of each of the people introduced during the virtual field trip. In the second column, list the education and training that supported each person in achieving their job role.

Key questions

- How does the load placed on different materials affect their extension?
- What does elastic deformation mean? What does plastic deformation mean?
- How does ultrasonic non-destructive testing work and why is it used?
- How is the depth and position of a fault calculated from an ultrasound signal?
- What are the physical and chemical properties of aluminium? Which properties make aluminium suitable for different products?
- Describe how aluminium is recycled and turned into ingots. What role does recycled aluminium play in Alcoa's business?

Keywords

Keyword	Definition
aluminium	A non-ferrous metal element extracted from bauxite clay through electrolysis.
alloy	A mixture of two or more metals, normally giving properties that are better than the pure metal.

corrosion	The process by which metals react with other elements in the environment to form stable compounds, either as oxides or hydroxides.
dross	Scum that forms on the surface of molten metal as a result of impurities.
eddy current separator	A device which uses magnetic fields to separate non-ferrous metals.
elastic deformation	A temporary, self-reversing change in the shape of an object caused by an applied force.
ingot	A solid block of metal made by casting molten metal.
load	An applied force.
metallurgist	A scientist specialising in the physical and chemical behaviours of metals, their compounds, and their alloys.
non-ferrous metal	Metals that do not contain iron, and are not magnetic. Examples are aluminium, copper, lead and tin.
oxidise	Chemically react with oxygen to form compounds.
plastic deformation	A permanent change in the shape of an object caused when the applied load exceeds the yield strength.
strain	The amount an object is deformed, divided by the original length of the object.
stress	The force per unit area applied to an object.
ultrasonic non-destructive testing	An inspection method that uses ultrasonic sound waves to detect defects in a material.
ultrasound	High frequency sound waves used for imaging.
ultimate strength	The maximum stress a material can take without failing.
yield point	The stress at which a material begins to deform plastically, rather than elastically.
Young's modulus	A measure of the amount a material will deform (by extension) when a force is applied. It is also known as the modulus of elasticity.