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| **Which Material and Why?** | | |
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| Selecting materials based on their properties | | |
| **Subjects:** Design and Technology,Engineering  **Approx. time:** 60 - 80 minutes |  | **Key words / Topics**   * alloy * aluminium * creep resistance * corrosion resistance * material properties * strength to weight ratio * toughness * thermal resistance |
| **Suggested Learning Outcomes** |  |  |
| * To know the main categories and properties of engineering materials. * To understand how the properties of materials affect how they are used. * To be able to select appropriate materials for an aerospace engineering application. | | |
| **Introduction** |  |  |
| This is one of a set of resources produced in conjunction with the engineering company Arconic. The resources are designed to support teaching of key engineering concepts at both key stage 3 and key stage 4, including the new GCSE in Engineering. This resource focusses on selecting appropriate materials for an aerospace application.  When selecting materials for engineering applications, their properties must be considered. This ensures that that they are fit for purpose. | | |
| **Purpose of this activity**  In this activity, learners will use their knowledge of properties to select an appropriate main material for the fan blades of a turbojet engine. They will learn about properties such as toughness, thermal resistance and creep resistance. It will build understanding of how to apply this knowledge when selecting a material for a real engineering application.  This could be used as a one-off main lesson activity, as part of a wider unit of work focussing on material properties and selection, or as part of a scheme on aircraft design using all of the resources developed in association with Arconic. | | |
| **Activity** |  | **Teacher notes** |
| **1. How turbojet engines work (5 - 10 mins)**  Teacher to outline how a turbojet aircraft engine works. Discuss the purpose of the fan blades in the engine.  **2. Material properties (10 mins)**  Introduce the material properties needed for a turbojet fan blade in an aircraft engine. For example:   * thermal resistance * toughness * creep resistance * corrosion resistance * strength to weight ratio   Ask learners to write down the meaning of each of the properties and self/peer asses their responses against the answers given in the teacher PowerPoint.  **3. Material research and selection (20 - 30 mins)**  Show learners the available materials for producing a turbojet fan blade – both suitable and unsuitable. For example:   * Cast iron * Aluminium * Aluminium alloy * Acrylic * Plywood * Structural concrete   Explain that some of these are more appropriate for this application than others! Learners to then research the properties of each material and select, with justification, the material that they would use for the application.  **4. Presentation (20 - 30 mins)**  Learners to prepare a short presentation to the class to show their findings. This could include:   * The material selected and why its properties make it suitable. * Other factors, such as cost, environmental impact and machinability of the selected material. * Information about the materials not selected and why they were unsuitable.   If time allows learners could present this during the lesson, or in a subsequent lesson. |  | This activity can be completed as individuals or in small groups.  **Available materials**  Suggested examples have been given that cover different types and categories of materials from the relevant GCSE specifications. However, the teacher may wish to alter this list to reflect materials that learners have been using/studying. Some materials shown are clearly inappropriate for this application - it is up to the learners to explore them and explain why.  Arconic produce aluminum alloys for this purpose as they have the required properties and are also more cost-effective to produce compared to the alternatives.  **Researching properties**  Learners will need access to appropriate textbooks or the internet for researching the properties of materials.  For example:   * Hodder GCSE Engineering 9-1 * Hodder GCSE Design and Technology 9-1 * Collins Design and Technology All-in-One Revision and Practice   **Presentation**  Learners could use PowerPoint or other visual aids to assist in making their presentation. These could also be placed on the school VLE or network drive for use as revision aids.  Additional lesson time may need to be allocated so that all learners can show their presentations to the class. |
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| **Differentiation** |  |  |
| **Basic** |  | **Extension** |
| Provide the properties of materials on a separate sheet that lower ability learners can refer to when making their selections.  Allow the use of cue cards or a short script when learners are making their presentation to the class. |  | Expand the list of potential materials to be considered.  Identify and explain the most suitable materials for other sections of the aircraft, such as the wings and fuselage.  Research new materials that are being developed for use on these applications, such as aluminum-lithium alloys. |
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| **Resources** |  | **Required files** icon-docicon-pdficon-ppt |
| * Projector/Whiteboard * Textbooks and/or internet access * Presentation software |  | icon-ppt Which material and why Teacher Presentation  icon-pdf Which material and why Learner Handout |
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| **Additional websites** |  |  |
| The following websites can be used for additional background information or to aid with the activity:   * **NASA – How a jet engine works:** Explanation as to how a jet engine functions. <https://www.grc.nasa.gov/www/k-12/UEET/StudentSite/engines.html> * **Arconic website – Aerospace:** Introduction to the work that Arconic does in developing materials for aerospace applications. <https://www.arconic.com/global/en/what-we-do/aerospace.asp> * **Technology Student –** Properties of materials: Explanation of some of the main properties of different materials. <http://www.technologystudent.com/joints/matprop1.htm> * **Aluminium Association - Aluminium alloys:** Explanation of what is manet by aluminum alloys, and how they created. <http://www.aluminum.org/resources/industry-standards/aluminum-alloys-101> | | |
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| **Related activities (to build a full lesson)** |  |  |
| **Starters**   * Identify the properties of materials needed for use in aerospace applications, such as a jet engine.   **Main**   * ACTIVITY: Which material and why? * Present findings to the class. | | **Plenary**   * Peer/self assessment of presentations made. * Reflection on Objectives and PLT skills used |
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| **The Engineering Context** film |
| Material properties and how they affect selection is required learning as part of both the new Design and Technology and Engineering 9-1 GCSE courses.  The knowledge gained can also be used when selecting materials for future product and system designs. |

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| **Curriculum links** | |
| **England: National Curriculum**  Design & Technology   * KS3 1a, 1e, 3a, 4a | **Northern Ireland: Curriculum**  Technology & Design   * KS3 Knowledge, understanding and skills: Manufacturing – selecting and using materials fit for purpose. * Objective 2: Explore technical inventions and designs that have met a social need cost-effectively. * Learning Outcomes - research and manage information effectively to investigate design issues, using Mathematics and ICT where appropriate. * communicate effectively in oral, visual (including graphic), written, mathematical and ICT formats showing clear awareness of audience and purpose. |
| **Scotland: Curriculum for Excellence**  Technologies   * TCH 4-01a, 4-05a, 4-10a | **Wales: National Curriculum**  Design and Technology   * KS3 Range: Designing: 2 * Resistant Materials: 10, 15 |
| **GCSE D&T**  AQA D&T   * 3.1.3, 3.1.6, 3.2.1, 3.2.5, 3.3.7   Edexcel D&T   * 1.4.2, 1.8, 1.9, 1.10, 1.12, 2.2, 2.3   Eduqas D&T   * 2.1 Core: 9, 10, 11, * 2.1 Metals: 1, 2   OCR D&T   * 2.1a i, 5.1, 5.2 | **GCSE Engineering**  AQA Engineering   * 3.1.1 |
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| **Assessment opportunities** | | |
| Regular questioning throughout the activity, formal teacher and self/peer assessment of final presentations. | | |
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| **Personal, learning & thinking skills (PLTS)** | | |
| * Independent enquirer * Creative thinker * Self-manager * Effective participator * Team worker * Reflective learner | | |