Level 3 - Unit 25 – Mechanical Behaviour of Metallic Materials

BTEC

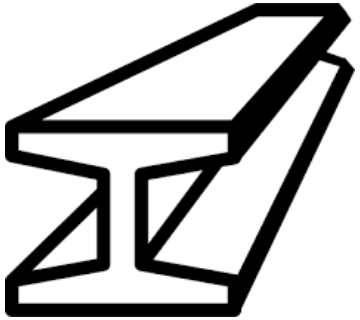
Knowledge Organiser

Metallurgy

Learners investigate and conduct tests on the mechanical properties of metals, consider suitable applications and explore failure modes to improve component design

Unit Overview

Selecting the most appropriate material and processing method for an engineered product or system is critical to ensure that it is fit for purpose. The materials used in the airframe of an aeroplane, car body pressings, cast components in domestic appliances and the 'T'-shaped electricity pylons (in the UK) all require careful selection and testing of appropriate metallic materials. In this unit, you will investigate and research the microstructures of ferrous and non-ferrous metallic materials, some of which will have been processed, for example heat treated. You will inspect the microstructures of the materials you are investigating. You will also undertake destructive and non-destructive tests on the materials and use the results of the experimentation and research to determine the mechanical properties of, and suitable applications for, the materials. Finally, you will examine the reasons why components have failed in service and consider possible design improvements that could prevent failure. As an engineer it is important to know about and understand the capabilities of a range of metallic materials to create products and systems that are suitable for application. This unit will help to prepare you for an apprenticeship or a technician-level role in industry. It will also help to prepare you for a range of higher education courses, such as a Higher National Diploma (HND) or a degree in any engineering discipline.



Learning Aim A

learners will investigate the microstructures of at least six unlabelled images of materials, which will comprise a mix of ferrous, non-ferrous and processed metallic materials. Learners' evaluation will involve comparing the material microstructure in each image with examples from an accredited data source and will include the impact that impurities and grain boundaries have on the mechanical properties. For example, for an image of steel learners may have identified impurities at grain boundaries, phases such as pearlite and cementite, equiaxed grains or elongated grains for a material that has been cold worked. Learners' observations will also be linked to the mechanical properties of the material, for example the elongated grain structure of wrought iron and the distribution of impurities, making for a laminated structure that improves the impact resistance. For each examined material learners' evidence will contain an equilibrium diagram marked up with phases, for example eutectic.

Learning Aims:

A Investigate the microstructures of metallic materials, the effects of processing on them and how these effects influence their mechanical properties

B Explore safely the mechanical properties of metallic materials and the impact on their in-service requirements

C Explore the in-service failure of metallic components and consider improvements to their design

Learning Aim C

learners will explore a range of given components that have failed in service after having been in use for significant periods of time. At least two components will have failed due to a mechanical fault and at least one other due to corrosion. Learners will undertake a visual inspection check of the corrosion and complete at least one mechanical test safely. The type of mechanical test(s) undertaken will depend on the components selected. It is expected that most learners will complete a hardness test, although some may also or instead complete a creep test.
Having investigated the various failure modes, learners will evaluate how to eliminate or mitigate the problem by thinking how to redesign the component, for example by specifying a larger fillet radius where there is a change of cross-section and by using a material that has a better operating performance at high temperature and stress levels, such as a titanium alloy.

Learning Aim B

learners will safely set up and correctly use mechanical tensile, impact and hardness test equipment and gather accurate results when completing destructive tests independently. They will test at least six prepared samples comprising unlabelled ferrous and non-ferrous materials, some of which will have been processed, for example work hardened. Learners will justify why they have selected the correct test for the mechanical property that they are measuring. For example, if they are testing a thin piece of metal it would invalidate the results to use a hardness test that has a high-impact force, because it will distort the metal and the indentation measurements will not be a true indication of surface hardness. Learners will also complete at least two non-destructive tests safely and accurately on metallic material samples. Learners will use a combination of the mechanical test results and accredited data sources to evaluate their results. The evaluation for the:

- tensile tests will include plot load–extension plot (stress–strain graphs) and provide key data, for example yield strength, tensile strength, Young's modulus, percentage elongation and reduction in area
- tensile and impact tests will include the condition of the fracture surface in terms of how crystalline it is
- hardness tests will make comparisons between measured hardness values and what is expected for the material
- non-destructive tests will include a report on the surface or internal condition of the given metallic materials.

Learners will present suitable realistic applications of where the tested materials might be used in service, for example appreciating that while high-strength alloy steel might be good for the passenger shell of a car, lower-strength, more malleable steel would be a better option for the front and rear crumple zones. Learners will also determine that there is often a trade-off between tensile strength, hardness and impact strength of materials.

Key Vocabulary

Carbon, grains, ductility, brittleness, tensile

Work Related Learning:

Gaining knowledge of how materials and their properties is key to working in any part of engineering

Numeracy links:

Metallurgy uses precise measurements through material testing to ensure material properties

SMSC and British Values

Understanding the importance that Metallurgycan have to solve critical issues in the world.