Pearson BTEC Level _ Higher Nationals in Engineering (RQF)

Unit 9: Material, Properties & Testing

Unit Workbook 3

in a series of 4 for this unit

Learning Outcome 3

Testing Techniques

Contents

INTRODUCTION

Explore the testing techniques to determine the physical properties of an engineering material.

- *Testing Techniques:*
  - Destructive and non-destructive tests used to identify material properties.
  - The influence of test results on material selection for a given application.
  - Most appropriate tests for different categories of materials.
  - Undertaking mechanical tests on each of the four material categories for data comparison and compare results against industry recognised data sources, explain reasons for any deviation found.

GUIDANCE

This document is prepared to break the unit material down into bite size chunks. You will see the learning outcomes above treated in their own sections. Therein you will encounter the following structures;

Purpose Explains *why* you need to study the current section of material. Quite often learners are put off by material which does not initially seem to be relevant to a topic or profession. Once you understand the importance of new learning or theory you will embrace the concepts more readily.

Theory Conveys new material to you in a straightforward fashion. To support the treatments in this section you are strongly advised to follow the given hyperlinks, which may be useful documents or applications on the web.

Example The examples/worked examples are presented in a knowledge-building order. Make sure you follow them all through. If you are feeling confident then you might like to treat an example as a question, in which case cover it up and have a go yourself. Many of the examples given resemble assignment questions which will come your way, so follow them through diligently.

Question Questions should not be avoided if you are determined to learn. Please do take the time to tackle each of the given questions, in the order in which they are presented. The order is important, as further knowledge and confidence is built upon previous knowledge and confidence. As an Online Learner it is important that the answers to questions are immediately available to you. Contact your Unit Tutor if you need help.

Challenge You can really cement your new knowledge by undertaking the challenges. A challenge could be to download software and perform an exercise. An alternative challenge might involve a practical activity or other form of research.

Video Videos on the web can be very useful supplements to your distance learning efforts. Wherever an online video(s) will help you then it will be hyperlinked at the appropriate point.

Specific heat is defined as the amount of heat per unit mass required to raise the temperature by one degree Celsius. It is normally found by something known as the ‘drop method’, whereby a defined mass of the material, at a known elevated temperature is added to a known mass of water, again at a known temperature and then determining the equilibrium temperature of the resulting mixture. By measuring the heat absorbed by the water and container, the specific heat can be figured out.

Thermal expansion is simply the expansion due to heat and is simply measured linearly as the change of a material’s unit length as a result of a one-degree temperature change. As this is such a small change in temperature, the expansion changes tend to be very small and are measured on a microscopic scale.

1.1.3 Electrical Testing

Some materials are clearly better examples of electrical conductors, such as metals, whereas other material groups tend to act as electrical insulators, polymers usually act in this way. The effect of heat on thermal conductivity differs between different material groups, as a metal warms the flow of electrons is interfered with and, as such the conductivity decreases. Conversely, in a material which is an electrical insulator, when heat is applied, the electrical conductivity actually increases. As a general rule, it is important to note that the electrical conductivity of both insulators and conductors is not greatly affected by small changes in temperature. There are some exceptions, such as Silicon, Carbon and Geranium, which is why these materials are known as semiconductors. They act as insulators at absolute zero but are good conductors at room temperature and beyond.

The **conductivity** of a material is measured by passing an electric current through a known volume of test material and determining its resultant resistance. The current must be known, and the voltage kept at a constant, while the conductivity is calculated as a reciprocal of total resistance.

1.1.4 Corrosion, Radiation & Biological Testing

The environment in which a material is placed can have huge effects on the material behaviour and properties, as such, many mechanical, thermal and electrical tests are conducted on materials before, during and after exposure to a controlled environment. Corrosion testing is used to assess materials within a specific environment or their reaction to a specific environmental attack. Corrosion in metals often comprises of electrons being removed leading to the formation of a more stable compound, usually in the form of rust. Galvanic corrosion occurs in metals where two dissimilar metals are placed in a solution, whilst in electrical contact with each other, this form of corrosion can occur in seawater or even in the presence of rain and fog.

Corrosion testing is used to find out how materials perform in the presence of electrolytes, the actual testing may involve completely immersing in seawater or exposure to sea-fog. The material is subjected to this hostile environment for a set period of time, removed and visually examined. This test material may then be subject to a mechanical test in order to obtain quantitative data, alternatively mechanical tests may be conducted within the hostile environment to obtain results over time.

A **radiation test** is conducted by subjecting the test material to a known radiation source, for a pre-determined amount of time. Commonly, traditional mechanical tests are then carried out to discover the nature of any changes as a function of time. Materials can be tested for changes due to exposure to several different types of radiation, such as electromagnetic, x-ray, gamma-ray, atomic exposure, radio-frequency waves, even just simple sunlight exposure. Any radiation exposure almost always has an adverse effect on

1.2 Influence of Test Results

The importance of materials testing cannot be underestimated, it contributes a huge amount of information, which is critical for designers, engineers and production staff alike. Firstly, and quite simply, some material tests are part of a design and manufacture process, they are a regulatory requirement from authorising bodies and internal company quality procedures. Secondly, materials testing provides information on which material is the most appropriate for a specified application, if an application demands a material to conduct electricity it is pointless to specify an electrical insulator material for that purpose. Thirdly, even once a product has been manufactured testing may still be carried out to evaluate how this product is performing and potentially, this may improve future designs. Lastly, materials testing can prove that a manufacturing, production or treatment process has been successful in maintaining material properties at a specified level.

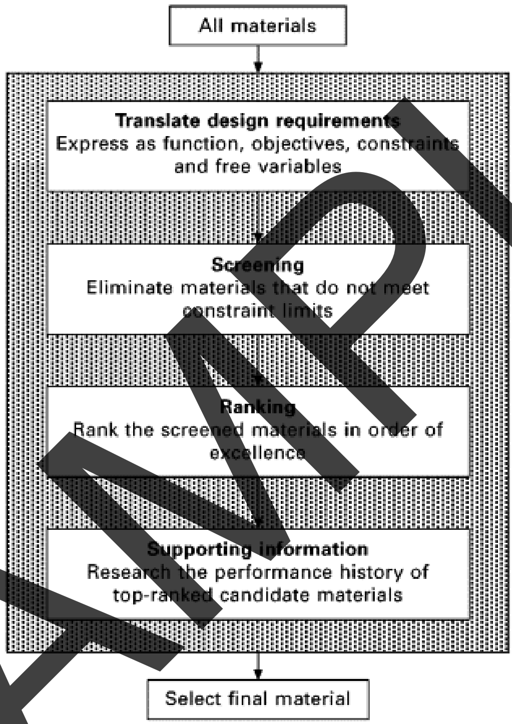

Figure 1.1: *Material Selection Process*

Based on test results, a shortlist of materials may be drawn-up. Final decisions often come down to ease of manufacture and associated costs. An example of the most suitable manufacturing processes based on quantities and material type can be seen below:

1.3 Mechanical Test Data

1.3.1 Metals

Performing a static tension/tensile test on a specimen of metal is a very common occurrence, there are standard setup parameters that must be adhered to in order to achieve accurate and viable results. Different governing bodies have their own sets of standards which companies comply with, usually depending on the country in which they operate. As an example, ASM International standards state that a typical specimen will be in the following form:

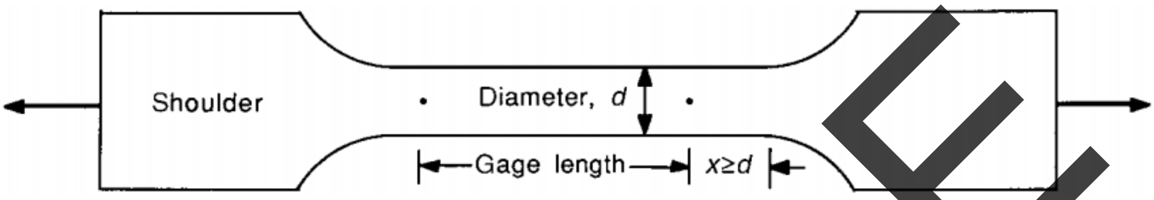

Figure 1.3: *Tensile Specimen Form*

These sets of standards then go on to specify the acceptable ways of holding the specimen, how much working space should be allowed, alignment parameters, even the standard environmental conditions and so on.

When a material undergoes a tensile test, it will experience different yield points, whereby it exhibits different behaviour phases: elastic, plastic and rupture. This behaviour can be represented graphically and is often seen in the following format:

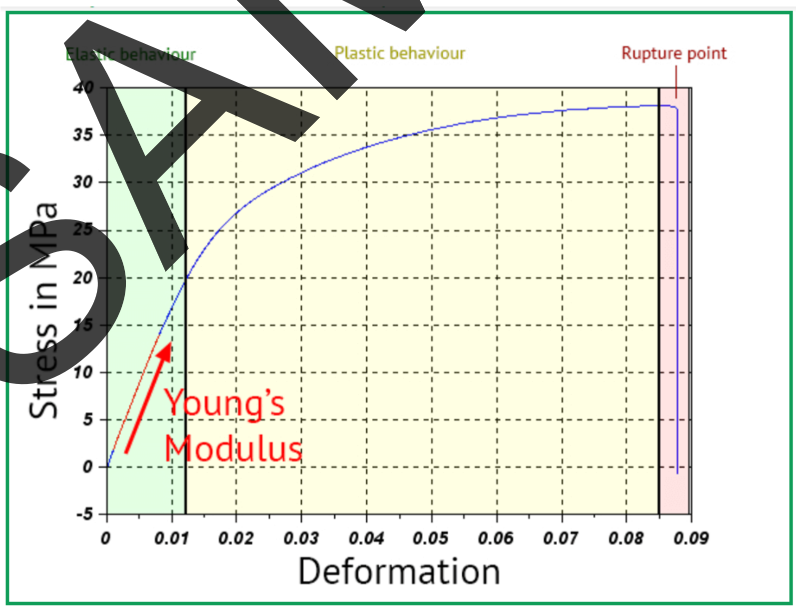

Figure 1.4: *Yield Points, Plotted*

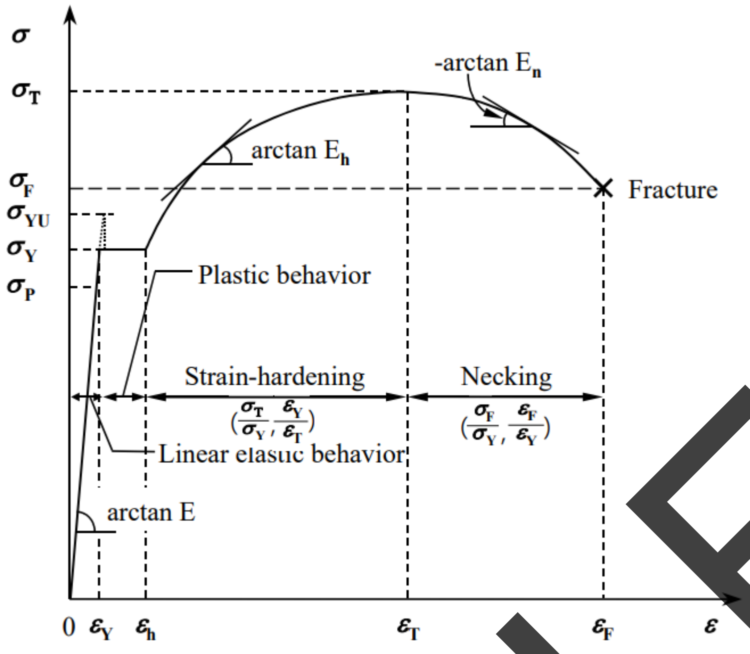

Figure 1.5: *Stress-Strain Relationship*

The test was carried out on two different grades of mild Steel, at three different temperatures of 20, -20 and -60 degrees centigrade, there were three tests carried out on each grade at each different temperature in order to find a mean value, accounting for any anomalies. The results of the tensile testing can be seen below:

Temp. (°C)	Grade A				
	E (GPa)	σ_Y (MPa)	σ_T (MPa)	ε_F	ν
20	199.6	299.3	464.9	0.423	0.3
	196.1	298.9	464.6	0.427	0.3
	186.3	300.8	462.4	0.426	0.3
Mean	194.0	299.6	463.9	0.425	0.3
-20	212.2	310.7	485.5	0.425	0.3
	208.6	323.8	512.6	0.439	0.3
	206.5	326.3	506.4	0.410	0.3
Mean	209.1	320.3	501.5	0.424	0.3
-60	181.2	345.0	512.5	0.458	0.3
	173.8	349.6	514.2	0.436	0.3
	189.8	345.4	509.2	0.448	0.3
Mean	181.6	346.7	512.0	0.447	0.3

Figure 1.6: *Mechanical Properties of Grade A Steel*