Practical 2P10
Materials Selection

What you should learn from this practical

Science
In this practical you will attempt to link the choice of material, processing routes and forming methods to the demands made by the function and environment of real engineering components.

Practical Skills
You will learn how to take a motorcycle engine to bits... though, unfortunately, you won’t learn how to put one back together.

Overview of practical
You will choose 4 or 5 components from the engine (depending on their complexity), and examine them metallographically and in any other ways that seem appropriate. You will attempt to determine the material used, and any likely processing routes and forming and joining methods used to make the component. You will then consider why that particular material, etc., was used for the component.

Experimental details

Engines
You are not going to make very much of this practical unless you have at least some idea of how an internal combustion engine works. You can ask a demonstrator for help but you may have to do some reading around. Whilst you are materials scientists rather than engineers, it is important for you to be aware of the uses to which alloys are put, and the
constraints the real world can place on material selection. This is one of the purposes of this practical.

**Choice of component**

One of the objects of the exercise is to look at a wide variety of components and materials. Choose five components with this in mind. Try to choose ferrous and non-ferrous materials, components of both complex and simple shapes, subject to high stresses and low stresses, high temperatures, corrosive environments, etc. You might, for example, look at:

- Various parts of the carburettor - why are so many different materials and forming routes used?
- The piston / connecting rod / crankshaft system - including the bearings
- The cylinder / piston system - including the piston rings
- The gearbox assembly
- The engine housings and how they are connected together
- The various types of bearings used throughout - why are different types used in different parts of the engine?
- The cylinder head, camshaft, valve and guide assembly

This list is not meant to be exclusive.

Before you make your final choice, think about what each component is meant to do, and what “attacks” it will be subjected to (stresses, chemicals, heat, wear, etc.), and therefore what you might choose to make it from and how. Write this down for each of your final choices.
Method of examination
Don’t rush into cutting up the component. First of all look at it as a whole; does the surface appear to have been machined, cast or what? General colour and appearance? Is it magnetic? How dense is it?

Now think before you reach for the hacksaw. Is the surface likely to be treated? Is it likely to vary in any other way from place to place or with direction of section? Choose the cutting direction to examine this.

Now cut and, if necessary, mount the section in cold mounting compound or Bakelite. Grind and polish. Try some etchants. The ones that don’t work might help with identification, as well as any etch that does reveal the microstructure. Examine at low magnifications first e.g. by eye or hand-lens, to see what large scale variations in microstructure there might be. Draw what you see (not what you expect to see!) or take a digital image. Choose the magnification(s) used to best show what is going on.

Safety note: Make sure you wear a laboratory coat, suitable gloves and eye-protection when etching your samples.

Be prepared for the fine microstructural scale of many real alloys (especially steels), compared to the “model” microstructures you have mostly looked at till now.

Would a hardness test help? You might use the materials handbooks, or the CMS database, to see what hardness values various alloys have. These are often also useful in that they give information about the usual applications of real alloys.
Making sense of it
Now go back to the ideas you wrote down before you did the examination. Is the material / heat treatment / forming route what you expected? If not, why not? If it is, what alternatives might have been used, and why weren’t they in this case?

Timetable
Day 1: Choice of components.
   Sectioning and etching.

Days 2 & 3: Etching and metallography.
   Writing-up.

What should be in the report
Structure of report
Your report should include a brief description of the aims of the experiment, including reasons for your choice of components, and the experimental methods used. The main part of the report should be the description of each component’s purpose, material, microstructure, heat treatment, forming route, etc., discussion of the observations and the explanation of the choice of material.

Length of report
Include necessary sketches or images of the components and microstructures, at the most appropriate scale.

Questions you should try to answer
I. What does the component do?
II. What are the principal “loads” on it (stresses, chemicals, temperature, wear, etc.)?

III. What other design constraints are there (shape, possible forming / joining methods, cost...)?

IV. What type of material would you expect?

V. What did your examination of the component tell you about:
   A. What material was used?
   B. What heat treatment it had?
   C. How the surface was treated?
   D. How the component was made?

VI. What alternatives might have been used? Why weren’t they?

VII. How might the component fail?

VIII. How could it be improved?

**Marking considerations**

A good report will contain:

- The reasons for choosing the components.
- A very brief description of what was done generally.
- A well laid-out, complete, and concise description of what was observed in each case, including necessary sketches and micrographs.
- A good discussion of the expected and observed results (see “questions” above).
- A brief and comprehensive summing up.

**Not wanted in the report**

More than brief details of the experimental procedure.
Useful reference texts

“How Things Work” or similar.

“Engineering Materials Handbook” (copies in Teaching Lab.)

“Cambridge Materials Selector” database (on one of the Teaching lab computers)