

# Cornucopia of delights for materials teaching

The latest version of CES4 EduPACK was reviewed briefly in the September issue of *Materials World*. Here, Peter Goodhew puts it through its paces as a teaching aid.

The Cambridge Engineering Selector 4 (CES4) EduPACK is the latest development of the original Cambridge Materials Selector, and the title has been changed to reflect the increased breadth of this new version. The software is the result of 20 years of work by Professor Mike Ashby and his colleagues in the Engineering Department at Cambridge University, UK. Its scope is very ambitious, but Ashby and his colleagues have thought carefully about the use of this version of CES as an educational tool.

At the heart of CES4 is information about 2,940 materials and 203 processes for shaping, joining and finishing them. The user can access the data at three levels in three straightforward ways. At level 1, simple data is presented about 66 materials, chosen from the full database to represent ceramics, composites, foams, metals, natural materials and polymers. At the second CES level (EDU2) additional data is presented for each of the 66 'typical' materials. This level is appropriate for students who have completed their first 'materials' module. At the third level the data becomes very serious – not only are there many more materials, but each one is much more precisely defined. This level is aimed at final year students and is in fact the same data used in professional versions of CES.

In addition to the browse mode, the software also offers two other modes of use. The search mode offers just that – you can type in any term and retrieve only those records that contain that term, whether just as a peripheral mention or as a substantial part of the record. This is a powerful facility and is useful for the lateral thoughts provoked by serendipitous hits. The third mode of use is the one for which Ashby's approach is rightly famous. In CES4 it is simply called 'select', but behind this bland button lies a cornucopia of delights.

Using a sophisticated data tool such as CES, structured data can be plotted and compared. The select mode allows the user to set criteria for the display of materials from the database, and to produce 2D plots (Ashby diagrams) that show the relationship between almost any two sets of structured data. Figure 1 shows an example based on the 66 materials that make up levels 1 and 2. The figure shows the relationship between fracture toughness and elastic limit for opaque materials. Transparent and translucent materials have been filtered out. This plot took about 20 seconds to produce. Labels can be automatically added to show each material, which take a couple of seconds to add.

There is much more available to the advanced user of the software, such as processing data, material shape information, and automatic links between processes and materials. The software contains a huge amount of data and is capable of illustrating hundreds of relationships between and among materials and processes. That makes it almost endlessly fascinating for experienced materials scientists like me, and to satisfy those with more time, there is CES Constructor. This enables the user to add their own data records in CES format to complement the 2,940 materials or 203 processes supplied with the software.

But is it useful for teaching students? I believe that the answer is a qualified yes, particularly if you are prepared to give the guidance and background that a student will need in order to take away the most important lessons from their session with CES4. This means setting the right tasks, using the appropriate case studies and using different materials each year so that the students actually have to do their own thinking. The software can be used throughout an undergraduate programme – indeed it might be possible, given a bit of effort, to devise a complete undergraduate programme in materials science based on problem-based-learning (PBL) supported by CES4. CES can be used to introduce the materials aspects of many engineering programmes (mechanical, civil, aerospace, manufacturing, etc). This implies its use in the early years of a degree programme, at levels 1 and 2. However, it is even more powerful at level 3 for third and fourth year projects in materials engineering as well as other engineering disciplines.

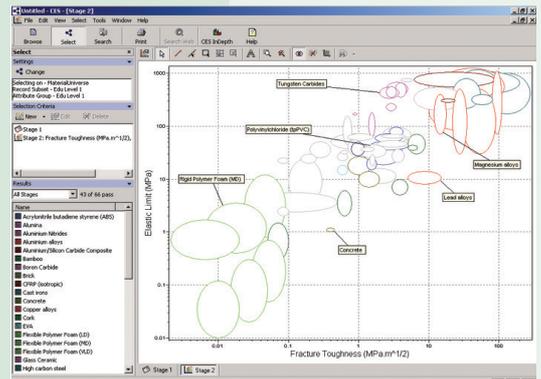


Figure 1 – Screen shot from CES4 EduPACK showing a typical property plot using only the materials at levels 1 and 2.

Unfortunately, there has never been a perfect piece of software. Occasionally I did not understand why I had to double-click rather than single click when selecting a browsed record to look at, for example. The links between processes and materials could be improved – for instance I was looking at an I-beam section in 6082 T6 aluminium, but clicking on the 'materials' link did not take me to the data for 6082. Searching would be greatly improved by highlighting the search terms when they are found. A built-in glossary would be very welcome, although there is one on the website. However, there are so many aspects of CES4 that are both intuitive and delightful.

CES4 is a very powerful piece of educational software. Within minutes a moderately mouse-literate user can make the Selector produce interesting data about a number of engineering materials. However, the full power of CES, and its proper educational usefulness, will not be revealed without devoting serious study (and serious time) to this rich and fascinating tool.

*Peter Goodhew*

## Further information

The EduPACK software comes with useful resources for university teaching, including Ashby's text 'Materials Selection in Mechanical Design', a book of 30 case studies in materials selection, and downloadable from the website, a complete lecture course with instructors notes in a PowerPoint format, plus suggested projects for students.

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