Chapter 4 SELECTOR Quick Start

4.1 Introduction

This *Quick Start* provides a brief overview of the facilities of SELECTOR. It is not comprehensive in its coverage of the facilities in SELECTOR. It assumes that you are familiar with running programs under the Windows™ operating system. For detailed instructions on all aspects of the package, see the on-line Tutorials in the SELECTOR *Help* system.

Note that this *Quick Start* uses the CES UNIVERSE series database for its examples. This database is similar to EDUPACK Level 3, If you don't have one of these databases available, when you go through this guide, you may need to modify the actions slightly in some places.

This *Quick Start* has five main parts:

Section 4.2 – Getting Started	introduces the Help system.
Section 4.3 – Browse	presents some features of the database; shows you the Table trees and how to view records; explains about 'layouts' and 'subsets' and describes *links* between data tables.
Section 4.4 - Search	explains how to search the database for the occurrence of a word or group of words.
Section 4.5 – CES INDEPTH	shows you how to obtain information by browsing and searching the on-line book CES INDEPTH, and explains the on–line interactive case studies.
Section 4.6 – Select	shows you how to set the selection *settings*, and how to: perform 'limit' and 'tree' selection stages to select a process; view the selection results; plot a simple material property chart; and select a subset of materials from the chart. It also presents various graph formatting options.
Section 4.7 – Further Facilities	shows you how to: change units and currency; save your work in a Project file; perform more complex selections; and export data to other applications.

Before starting this *Quick Start*, you will need to install the program by following the instructions in Chapter 2 of this manual.

4.2 Getting Started

4.2.1 Starting CES

The installation process will make a Program Manager group called 'CES Selector 4.0, which will contain the icons for CES software components, as shown in figure 2.7.

Double-click on the CES SELECTOR icon to run the program:

You can also access the CES SELECTOR Start Menu Program group from the **Programs** option on the **Start** menu (usually at the bottom left of the Windows™ screen).

> **If you are using the educational database, select the 'Edu Level 3' option on the Change Configuration dialog.**
>
> **Alternatively, open the CES UNIVERSE Series database or the Edu Level 3 database using the File / Change Database menu.**

4.2.2 The Main Tool Bar

The main menu bar (figure 4.1) is always available at the top of the screen. Each button leads one of the main functions. To browse the database click once on **Browse**, to perform a selection, click once on **Select**, etc. The **Help**, button gives context sensitive help, as described in the next section.

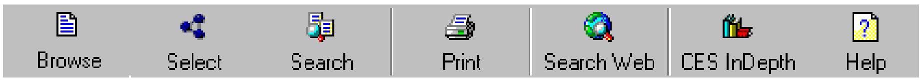


Fig. 4.1 The main tool bar.

4.2.3 Help!

Obtain *Help* as follows:

> **Click once on the *Context Help* button [?] on the main toolbar, then click somewhere on the Browse window on the left of the screen.**

Context help for the **Browse** window will appear (figure 4.2).

> **If the left hand splitter window pane is not visible, click on the *Show* button [Show] at the top left of the Help screen**

The Help system has a set of buttons along the top, and a splitter on the left: giving two separate window panes. The set of tabbed windows in the left hand pane can be toggled on and off using the **Hide** (**Show**) button on the Help toolbar. The **Locate** button synchronises the contents list in the left window pane with the topic currently in the main Help window on the right.

Open one of the on-line Tutorials as follows:

> **In the Help Contents window, open the <u>Tutorials</u> branch (click on the '+')**
>
> **Open <u>Part 3 Graphical Selection</u>**
>
> **Open <u>3.1 Selection Charts</u>**
>
> **Double-click on <u>3.1.1 Setting the Selection Table</u>**

You will see the *Help Tutorial* screen shown in figure 4.3. Along the top of the Tutorial screen is the 'Tutorial navigation line'. This line can be used to take you forwards and backwards through the current tutorial. Simply click on the 'stations' along the line to see that part of the Tutorial. Click on the 'menu' icon at the start of the navigation line to open go back to the menu options for this Tutorial. Click on the arrows at either end of the navigation line to go to the previous and next tutorials.

Another way into the Help system is to select the **Help/Contents** menu at the top of the screen. This option will lead you to the *Help Contents* window. This window can be used to search for help topics in several different ways, as shown in figure 4.4.

> **When you have finished, close the Help system by clicking on the [X] at the top right of the window.**

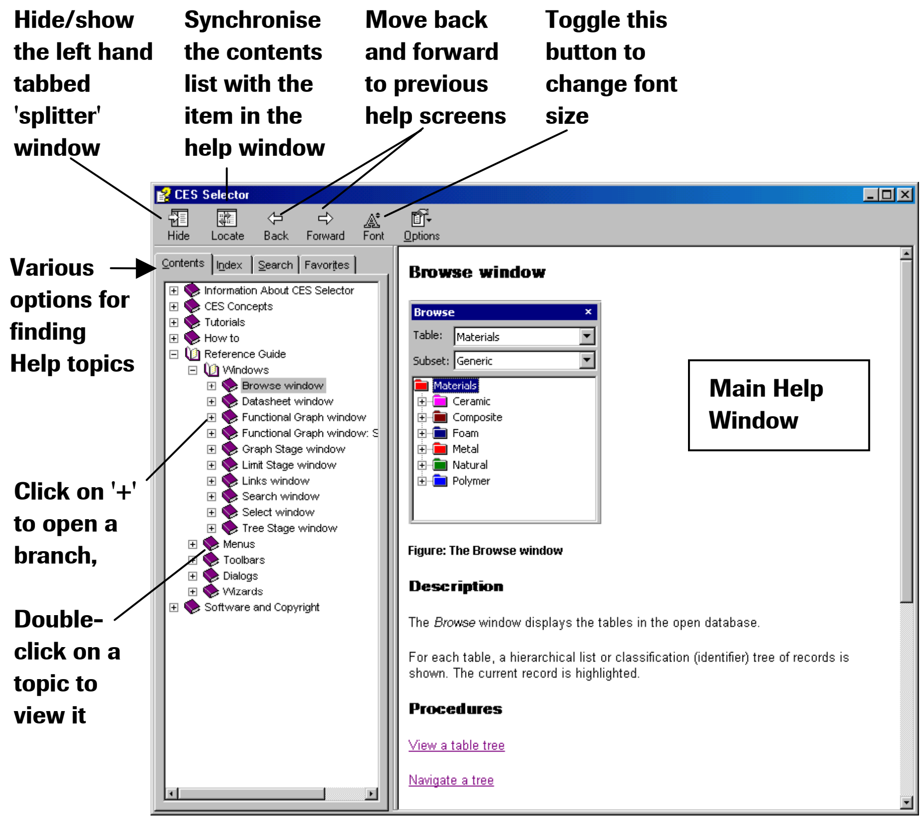


Fig. 4.2 Context Help for the *Browse* window.

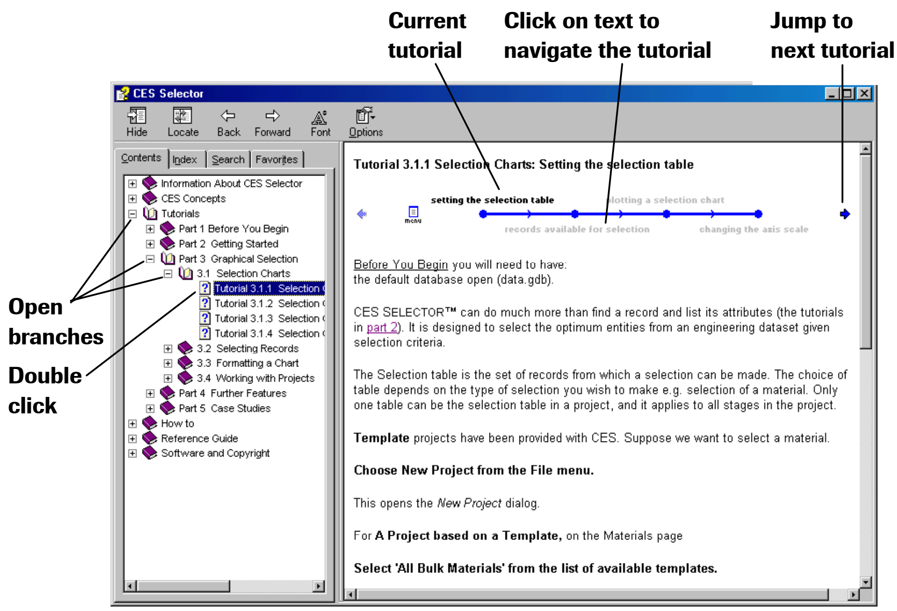


Fig. 4.3 Part of the *Help* system.

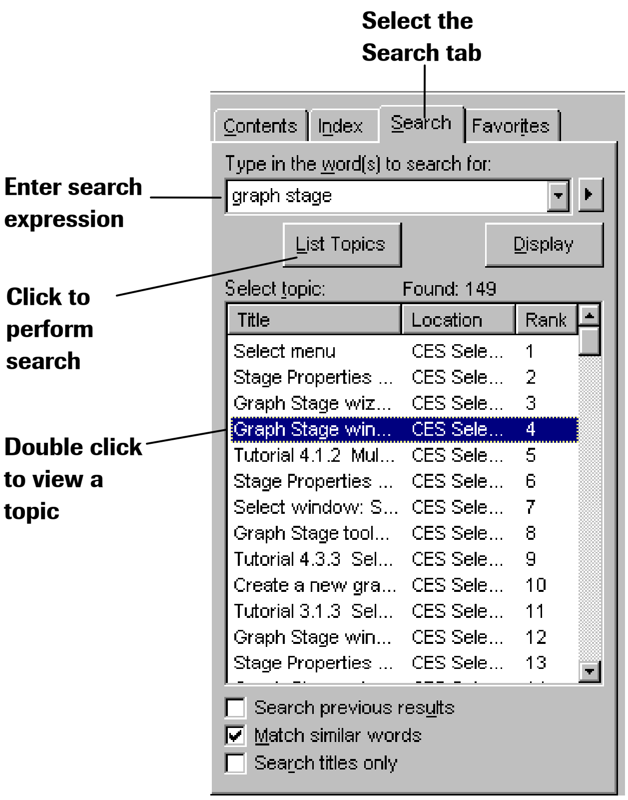


Fig. 4.4 Searching the *Help* system

4.3 Browse

This section shows you how to view the attributes of a record in the database. As an example, we will examine the material 'Wrought Aluminium Alloy 2014–T6', and view the processes by which it can be formed. If you do not have the MATERIALUNIVERSE database or the Edu Pack Level 3 database, follow the same procedure, but use one of the other data tables instead.

4.3.1 Table Trees and Subsets

One way to find the attributes of a record in the database is to use a table tree, which can be accessed from the *Browse* window (figure 4.5).

Click on the Browse button at the top of the screen, and select the MATERIALUNIVERSE table from the drop-down list of tables

Select the 'All Bulk Materials' subset from the second drop-down list.

The top level of the MATERIALUNIVERSE table tree will be displayed. A '+' on any branch of the tree indicates that there are more branches below it.

Open the 'Metals' branch by clicking once on the '+' to the left of 'Metals' with the left mouse button

Open 'Non-ferrous Alloys', then 'Aluminium'

'Wrought Aluminium Alloys' is a *generic* record, whose attributes span the range of attributes of a number of *specific* records below it in the tree (in this case, all wrought aluminium alloys) This fact is indicated by the generic record icon on its branch of the tree (see section 3.2.4). View the *specific* wrought aluminium alloys as follows (see figure 4.5):

Continue opening branches until you can see the 2014 series alloys

The Table tree should now look something like figure 4.5.

Double-click with the left mouse button on the material 2014–T6 to view its attributes.

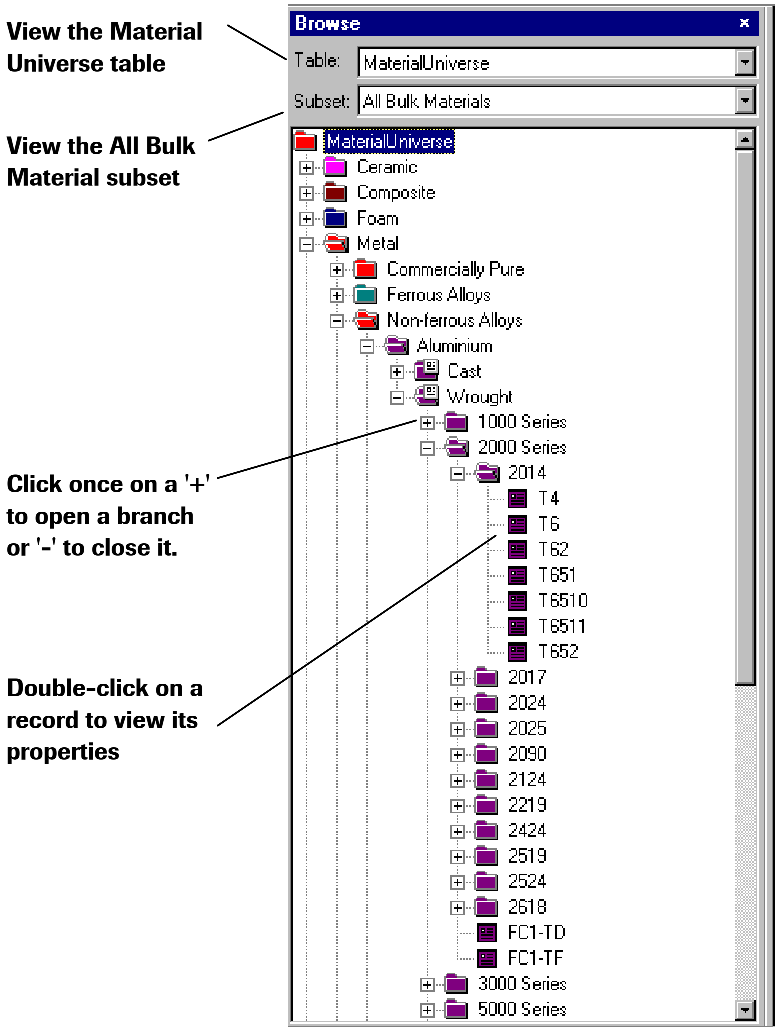


Fig. 4.5 The MATERIALUNIVERSE table tree in the *Browse* window.

The default *subset* for the MATERIALUNIVERSE table is called 'All Bulk Materials' (See section 3.2.6). This subset displays about 3200 materials - from each of the main classes. It does not display about 400 material records in the database which are not normally used in bulk form in engineering applications. Examples of these are fibres and particulates which are used in composites, but not normally on their own. However, these records can be accessed readily whenever they are needed using the <All Records> subset, which lists all 3620 or so materials in the database. The subset can be changed in the list box at the top of the **Browse** window (figure 3.6).

4.3.2 The Datasheet Window

The *Datasheet* window will now display information about 2014–T6, as shown in figure 4.6. There are several 'pages' of information in the listing, and you can use the scroll bars to view these.

Each attribute can take a range of values, for example the elastic limit (yield strength) of this material lies in the range 324 to 440 MPa. Some properties, for which data is not available, are estimated, and indicated by a '*' – see section 3.6. (Note that all material properties in the database are defined in CES INDEPTH.)

The contents of the *Datasheet* window can be printed using the **Print** command on the **File** menu at the top left of the screen (**File/Print**). Alternatively, the contents can be copied using **Edit/Copy,** and then pasted into another Windows™ program, eg a word-processor or spread sheet.

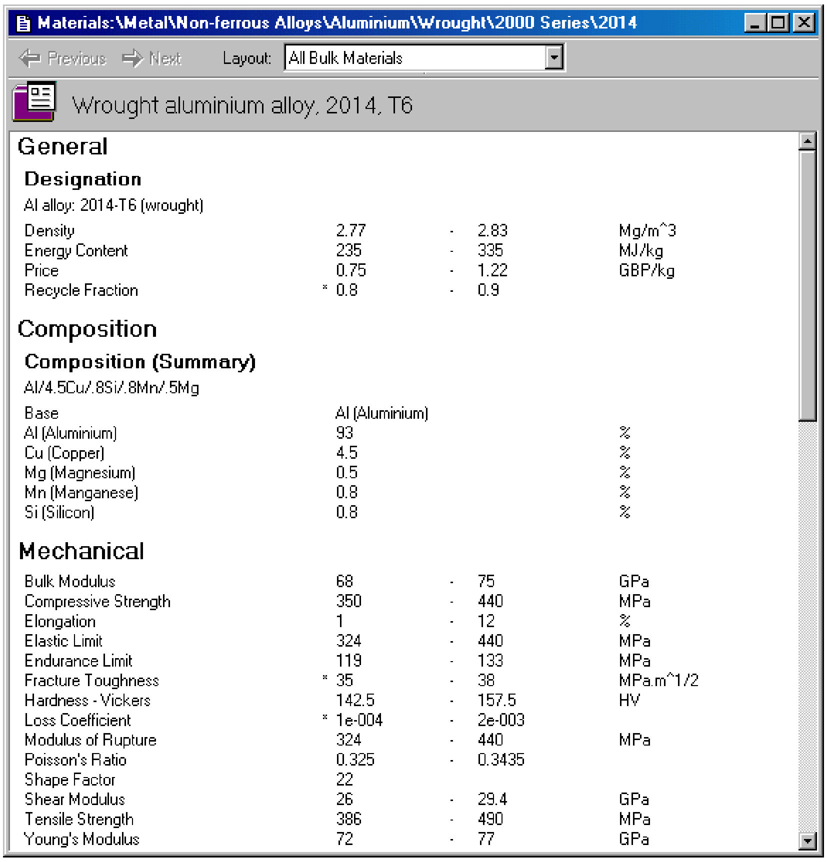


Fig. 4.6 The *Datasheet Window*, showing the first page of properties of wrought aluminium 2014–T6 .

4.3.3 Layouts

A Layout is a template that specifies the attributes that are visible and their format, in the *Datasheet Window*. In figure 4.6, the Layout used is the default layout called 'All Bulk Materials', which displays attributes that are applicable to all classes of materials. Other layouts display the properties that are relevant to particular classes of materials (e.g. polymers), or some other subset of properties. The 'Metal' layout shows additional information which is specific to metals.

Set the Subset to 'Metal'

Examine the first page of attributes for Aluminium 2014-T6 again.

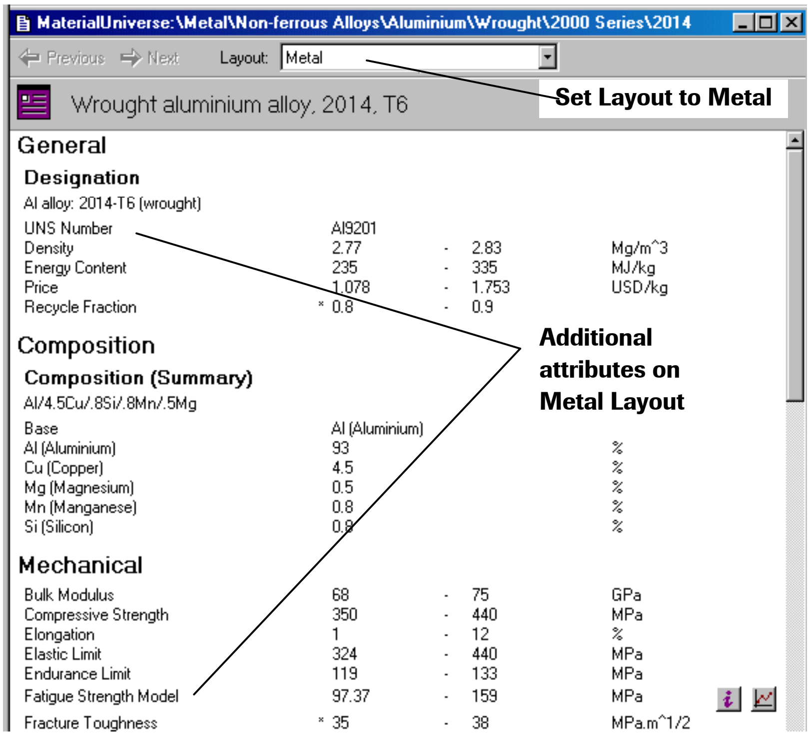


Fig. 4.7 The *Datasheet Window*, showing the properties of wrought aluminium 2014–T6 with the 'Composition' Layout set. (Compare with figure 4.6.)

Notice that there are two new properties visible in the *Datasheet Window* (figure 4.7), compared to those available in the 'All Bulk Materials' layout (figure 4.6). They are the 'UNS Number' (A92014) and the 'Fatigue Strength Model', in the Mechanical Properties. Note that the Fatigue Strength Model attribute has two buttons next to it: and . The presence of these two buttons indicates that 'Fatigue Strength Model' is a 'functional' property (see section 3.3.1). (Further down the *Datasheet Window*, are other properties that are only relevant for metals, and hence are not available on the 'All Bulk Materials' layout - eg 'Similar Standards'.)

It is often (but not always) desirable to set the Layout (*Datasheet* Window) and Subset (*Browse* Window) to have the same name. For example if you wish to view detailed data for polymers, it desirable to set both the Subset and Layout to 'Polymer'. The Subset will then limit the materials available (for viewing and selection) to polymers, and the *Datasheet* Window will show just the properties relevant to polymers, as specified in the Polymer Layout.

Note that if you set the *subset* to Polymer in the **Browse** window CES will automatically set the *layout* to Polymer in the **Datasheet** window. The reverse is not true however… setting the *layout* in the **Datasheet** window does not change the subset in the **Browse** window. Try it…

Set the Subset in the Browse window to Polymer

Double-click on a polymer in the Browse window and view its properties.

Note that some of the specific properties of polymers (not shown in the 'All Bulk Materials' form), are: Oxygen Index, Water Absorption, % Filler, Filler type, Polymer type, Hardness - Rockwell M, Hardness Rockwell R, Izod Toughness, Heat Deflection Temperature, and so on.

4.3.4 Viewing Functional Data

All metals in the MATERIALUNIVERSE table have a fatigue strength model or 'S-N' curve (applied stress vs no of cycles to failure). The fatigue strength depends on two parameters: the stress ratio, '*R*' (ratio of minimum applied stress to maximum applied stress), and the number of cycles to failure '*N*'[1]. These parameters have default values of R=-1 and $N = 10^7$, respectively.

Change the Subset and Layout back to Metal, and open the record for 2014-T6

Click on to see the parameters used to evaluate the Fatigue Strength Model.

Click on to see a graph of the function.

The graph on the right of figure 4.8 will appear. It shows the fatigue strength calculated by the model as a function of *N*, with *R* set to -1. (These are Project Defaults.)

At a value of $N = 10^7$ (1E7) cycles (the Project Default), the function ranges between values of 97.3 MPa and 159 MPa. These are the values displayed for the fatigue strength on the Datasheet (figure 4.7).

The parameters plotted on the graph can be changed:

Double-click somewhere on the frame of the graph.

The *Functional Graph Properties* dialog will appear (left of figure 4.8). This dialog box enables you to set various options for the display of the function.

Try plotting the fatigue strength as a function of stress ratio *R*, by changing the x-axis parameter in the *Functional Graph Properties* dialog

Note that if the 'Project Defaults' check box at the bottom of the dialog is ticked, the graph will be plotted using the *project default* parameters. If it is not ticked, then the graph will be plotted using whatever parameter values you enter when you click on *Edit*. (See Section 3.3.9 for further details about *default parameters*.)

Click on OK to plot the graph.

[1] The fatigue model is based on the Basquin and Coffin-Manson approximations for high and low cycle fatigue. It uses Goodman's rule to model the dependence on stress ratio. See Section 2.2.2 of CES INDEPTH.

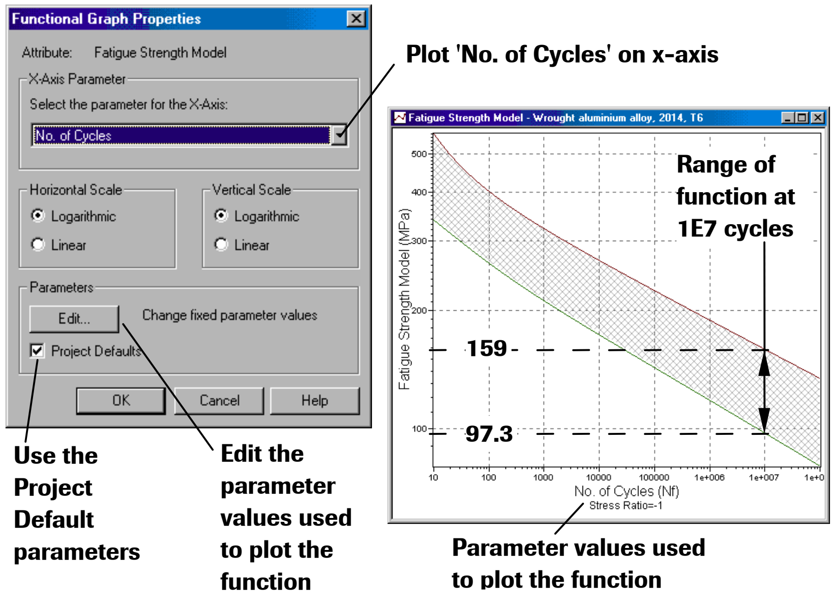


Fig. 4.8 Fatigue Strength Model for 2014-T6: An example of functional data.

It is possible to edit the parameters used to plot the graph, using the *Edit* button at the bottom of the dialog. If the check box is ticked when you click on *Edit* you will edit the Project Default parameters. If the check box is not ticked, you will just edit the parameters used to plot the graph, but the project defaults will not be changed.

Set the Subset and Layout back to 'All Bulk Materials' when you have finished.

4.3.5 Viewing Links

At the bottom of every page of attributes, is a set of *Links* buttons. These buttons are used to view records in other tables that are linked to this record. These might be *processes* that can be used to form this material, or companies who *supply* it, or the *shapes* to which it can be formed, etc.

Scroll down to the bottom of the *Datasheet Window* for 2014-T6 (figure 4.9)

Click once on the ProcessUniverse Link button

The links window will appear (figure 4.10), showing all the processes that can be used to shape 2014–T6. (These links can be used in for selection purposes, as explained later.)

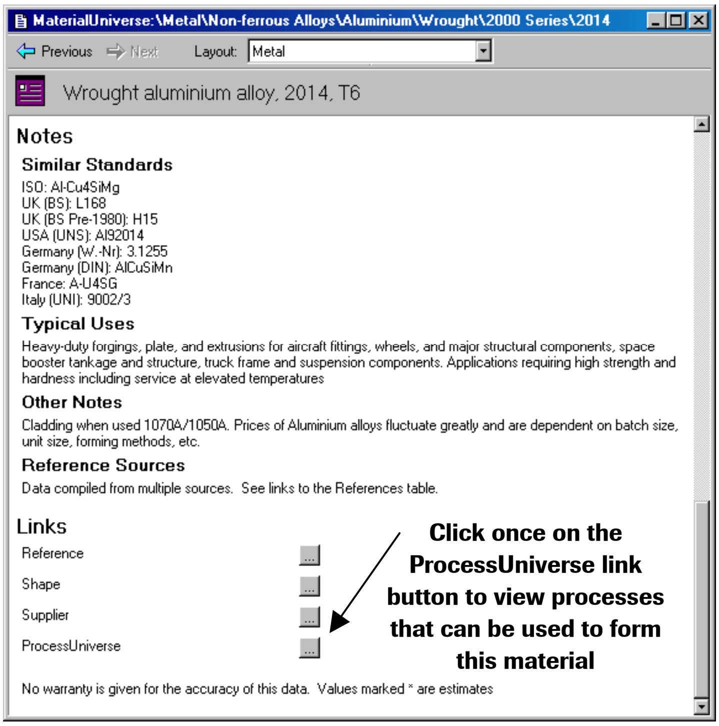


Fig. 4.9 *Datasheet Window* for 2014-T6 showing the **Links** buttons.

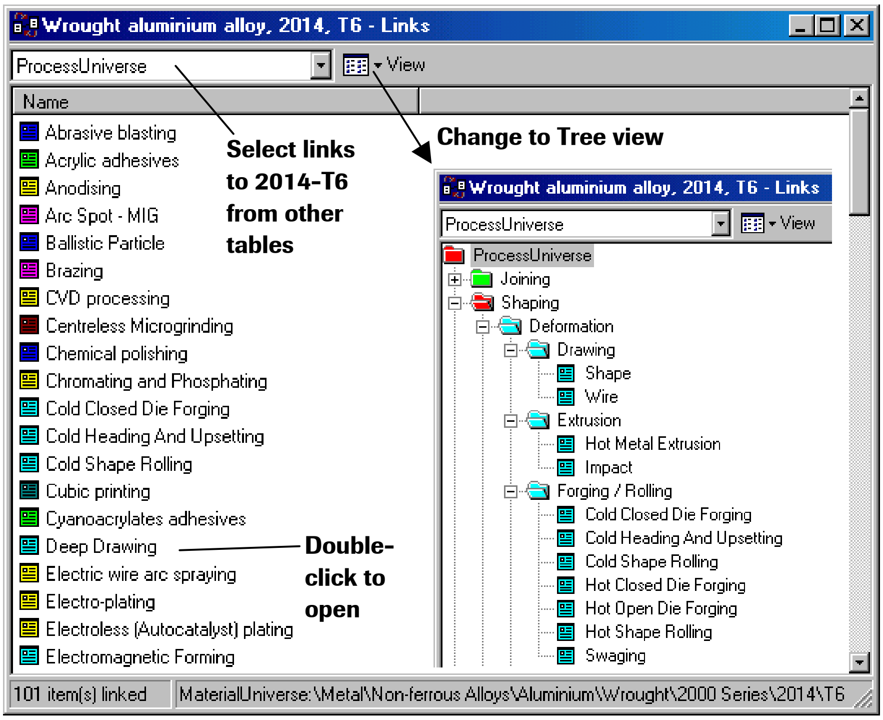


Fig. 4.10 Process Links for aluminium 2014–T6.

Click on the View button View at the top of the *Links* window to see the links arranged in a tree structure.

To view links to 2014–T6 *from other tables*, eg Suppliers, or References, select the table name of interest from the list box at the top left of the *Links* window. Alternatively, return to the *Datasheet Window* and click on one of the other links buttons.

To view the attributes of an item in the *Links* window, simply double-click on it...

Double–click on 'Deep Drawing'

Details of the process will appear in a new *Datasheet Window* (figure 4.11). Scroll down the record to see more information about the process. At the bottom you will find **Links** buttons, including one for the MATERIALUNIVERSE database. Clicking on this button will generate a list of all the materials that can be formed by deep drawing. Among them, of course, will be 2014–T6.

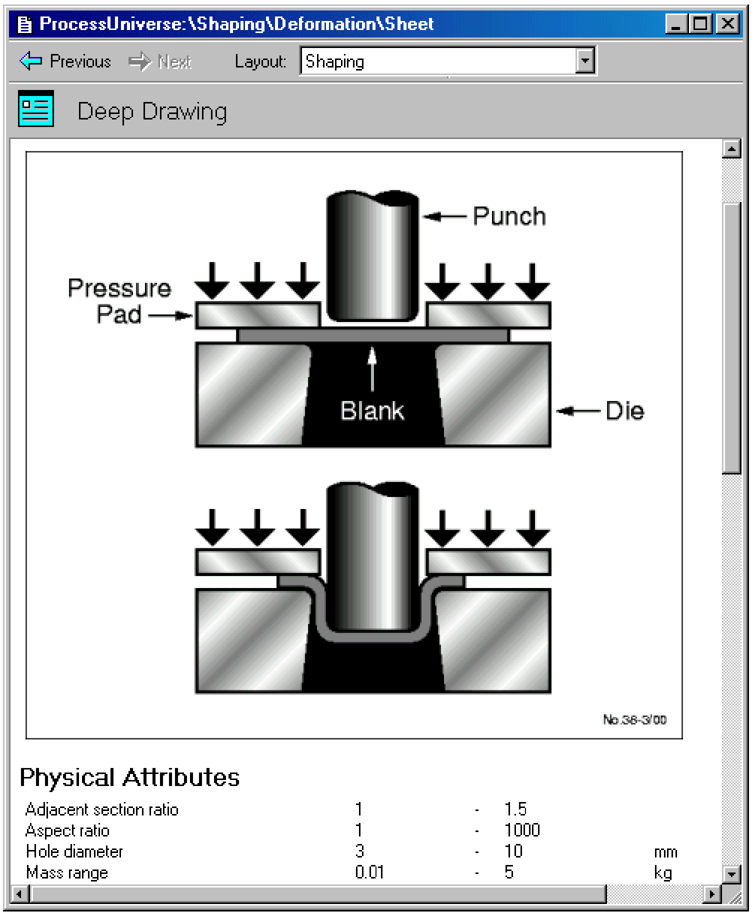


Fig. 4.11 *Datasheet Window*, showing the first screen of information for the process 'Deep Drawing'.

4.4 Search

This section explains how to search the database for entities containing a simple text string. This function can be used for tasks such as finding materials with particular designations or trade names, or finding typical uses.

Open the search window by clicking on the Search button 

, main toolbar

Enter the trade name of a polymer '<u>Diakon</u>' into the input field in the search dialog and click on the *Find Now* button (figure 4.12)

Double-click on 'PMMA Heat Resistant' (in the bottom half of the Search window) to view the record

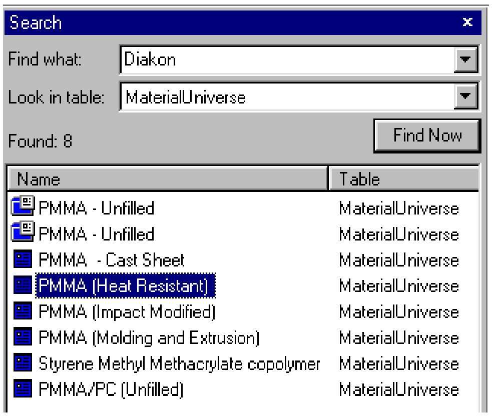


Fig 4.12 Search results for 'Diakon' in the MATERIALUNIVERSE table

The tradenames field in the *Datasheet* window contains various manufacturer's names for this material…among them are the common names 'Perspex' (UK) and 'Plexiglass' (USA)

> *Acrive, Acrylite, Acryrex, Altuglas, Cyrolite,* ***Diakon****, Glasflex, Goldrex, Lucite, Lucryl, Optix, Oroglas, Perspex, Plexiglas, Plexit, Sumiplex*

4.5 CES INDEPTH

CES INDEPTH is an on–line documentation system, that provides a wide variety of information about CES to support users. It has a similar user interface to the Help system (Section 4.2.3). CES INDEPTH includes background on the selection process; information about the CES databases; solutions to many standard engineering problems; 50 interactive case studies on material, process and shape selection; and more. It is worth taking a little time to explore the contents.

4.5.1 Browsing CES INDEPTH

Open CES INDEPTH by clicking once on the CES INDEPTH button on the main toolbar 

Open the branches of the contents tree down to 'Material Attribute Groups' as shown in figure 4.13

Click once on 'All Bulk Materials', then select 'Elastic Limit' from the list in the right hand pane.

The *right hand* window pane will now show the definition of the material attribute ‘Elastic Limit’ that is used in CES (figure 4.13).

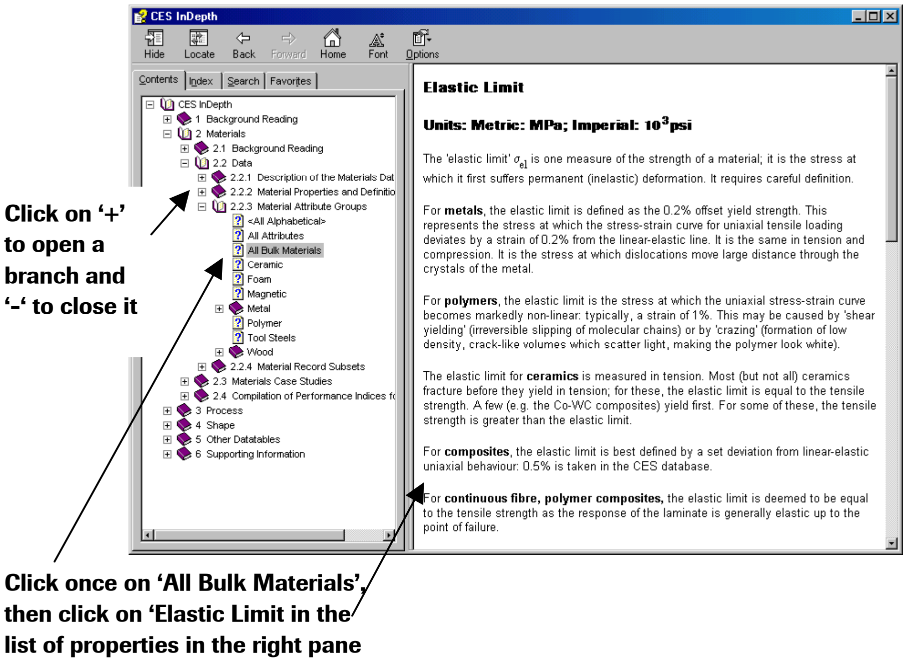


Fig. 4.13 The CES INDEPTH, contents and a page of information with the definition of the material attribute ‘Elastic Limit’

4.5.2 Searching CES INDEPTH

CES INDEPTH can be searched in a variety of ways. The simplest is a text search , which can be performed as follows (figure 4.14):

Click once on the Search tab of CES INDEPTH

Type the search string: <u>process near “case study”</u> in the input field

Click on the *List Topics* button to perform the search.

This will search through the books for any instances of ‘process’ *near* the string “case study”.

The search results will appear in the *Search Results* window, figure 4.14. There are fourteen instances in CES INDEPTH which satisfy the search criteria. We will examine the case study on process selection for a Spark Plug Insulator.

Double–click on ‘3.3.10 Spark Plug Insulator’ (figure 4.14)

The *Books* window will reappear, showing information about the case study. Scroll down to see more (figure 4.15).

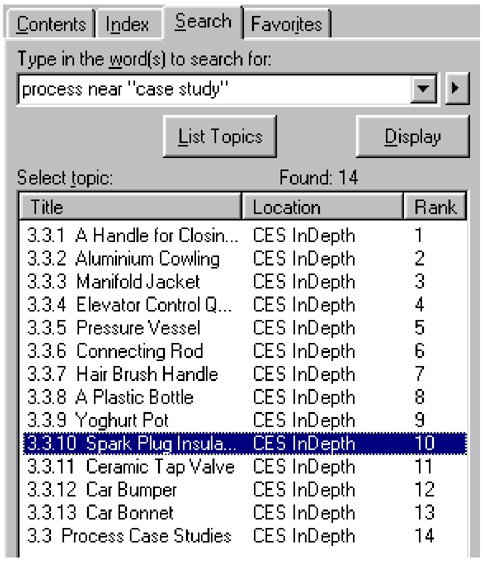


Fig. 4.14 Searching *CES INDEPTH*

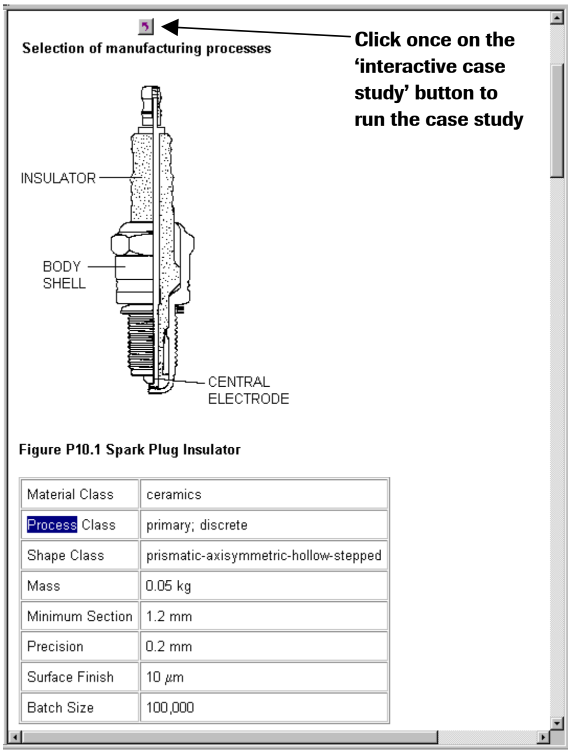
4.5.3 On–Line Case Studies

The on–line case studies can also be found simply by opening the *Books* contents page to the relevant sections, (as per figure 4.13). Materials selection case studies are in section 2.3 of CES INDEPTH, Process selection case studies are in section 3.3, and structural sections selection case studies are in section 5.3.3.

Each case study has a description of the problem and a list of design requirements, followed by a worked solution containing all of the relevant CES output.

It is also possible to get CES to *run the case study automatically*, by clicking on the 'interactive case study' button, shown in figure 4.16. This button (or a link to it) can be found somewhere in each case study - often near the end. Using it gives you the opportunity to examine the details of the case study in the worked example, edit the selection stages, add more stages of your own and explore the selection results in detail. We suggest that you read the worked example before running the interactive version of the case study.

Note that the Interactive case studies use the CES MATERIALSUNIVERSE table and PROCESSUNIVERSE table or the EDUPACK 'Level 3' database.



Material Class	ceramics
Process Class	primary; discrete
Shape Class	prismatic-axisymmetric-hollow-stepped
Mass	0.05 kg
Minimum Section	1.2 mm
Precision	0.2 mm
Surface Finish	10 µm
Batch Size	100,000

Fig. 4.15 Part of the Spark Plug Insulation case study, in CES INDEPTH.

4.6 Select

This section shows you how to setup a selection project, how to perform a simple 'Limit' selection, how to plot materials selection charts, how to select a subset of materials from the chart, how to view the selection results and some graph formatting options.

4.6.1 Selection Settings

The first example in this section will be selection of a manufacturing process for a spark plug insulator. (You will only be able to do this if you purchased a database containing the PROCESS UNIVERSE Table, or the Level 3 EDUPACK database).

Click on the Select button Select

The *New Project* dialog will appear (figure 4.16). This dialog displays a set of project *templates*, each of which contains pre-set selection *settings*. (The settings include the table to be used for selection, as well as the subsets and the layouts used for the selection table and for other related tables.)

We wish to select a shaping process to form a ceramic material into the insulator for a spark plug.

Click on the 'Process Universe' tab in the New Project dialog

Select the 'Shaping Processes' template, then click on OK

The *Select* window will appear, with *Settings* as shown in the right half in figure 4.16. The *Selection Criteria* panel is blank because no selection criteria have been set yet, and consequently the *Results* panel shows that all shaping processes (112 of them) have passed the selection.

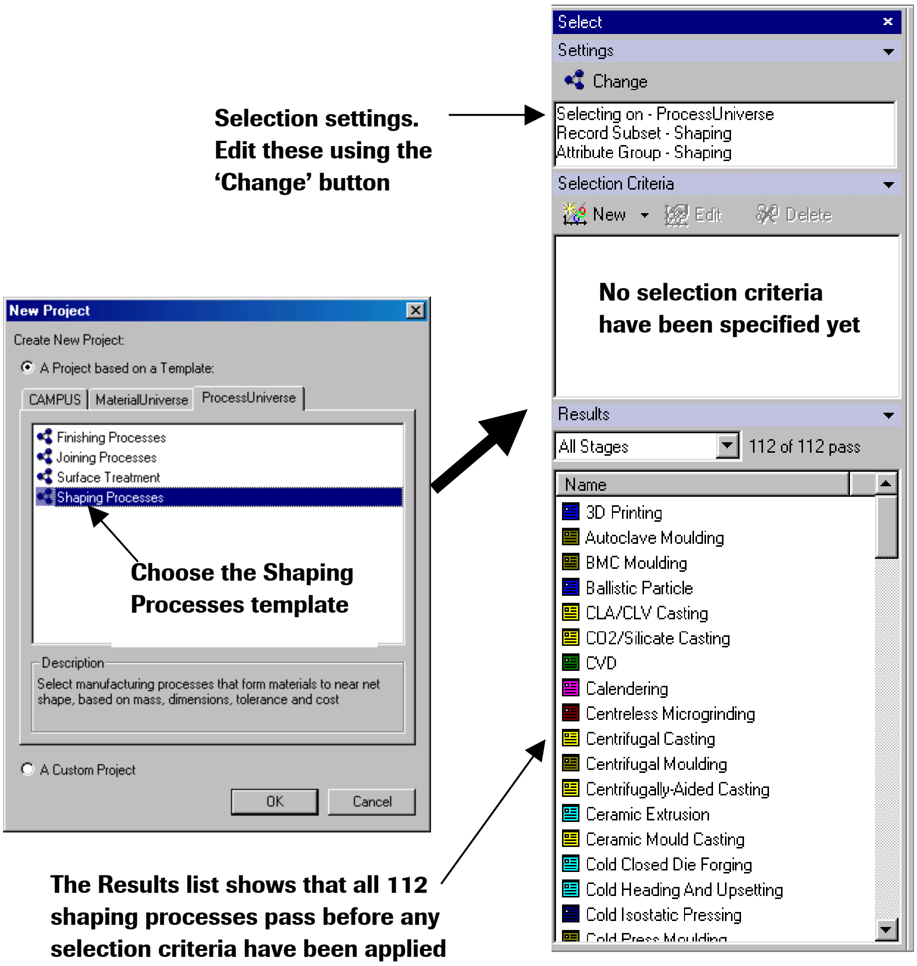


Fig. 4.16 Creating a new selection project

4.6.2 Performing Limit Selections

The design requirements for the spark plug insulator can be seen in figure 4.15. It must be made from a ceramic (Alumina, Al_2O_3), using a Discrete, Primary process (one which can make individual components from a raw material). The mass of the component will be approximately 50 grams, its minimum section will be 1.2 mm, the surface finish must have an RMS roughness less than 10 μm, the batch size will be at least 100,000, and so on. Most of these requirements can simply be entered as upper and/or lower limits in the *Limit Selection* form.

Click once on the New Selection button New on the *Selection* window (Fig. 4.17)

Choose Limit Stage from the drop-down list

Open categories in the limit selection window by clicking on the headings, or on the arrows

Enter the design requirements as shown in figure 4.18.....

Attribute	***Minimum***	***Maximum***	***Units***
Mass range (normal)	**0.04**	**0.06**	**kg**
Roughness (normal)		**10**	**µm**
Section (normal)	**1.2**		**mm**
Tolerance (normal)		**0.2**	**mm**
Economic batch size (units)	**100000**		
Primary	**√**		
Discrete	**√**		

Click once on the Apply button at the top of the window to perform the selection.

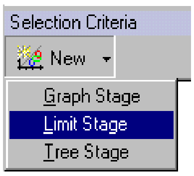


Fig. 4.17 Starting a new Limit selection

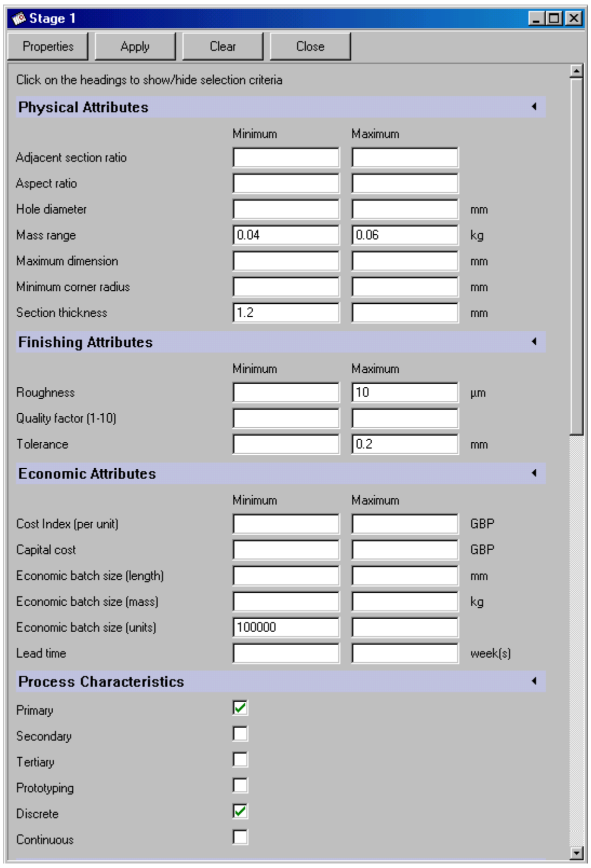


Fig. 4.18 Selecting processes for a spark plug insulator, using the *Limit Selection* window.

4.6.3 Selection Results

The selection results will appear in the Results section at the bottom of the *Select* window pane automatically (figure 4.19).

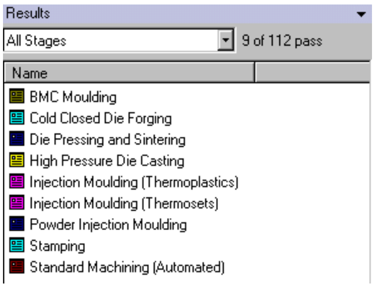


Fig. 4.19 Results of the process selection *Limit* stage.

Nine processes satisfy all of the selection criteria. However, not all of these processes are suitable for manufacturing the spark plug insulator, because some cannot form ceramics.

The default format for selection results is entities passing 'All stages', as shown in figure 4.19. Since only one selection stage has been performed, the processes currently shown in the list are the ones that passed the *Limit* stage. If you had performed more than one selection stage, the list would show only the processes that had passed them all. The selection results can be set to various other formats by changing the drop–down list box at the top of the Results section. You can examine the attributes of one of the processes on the list by double-clicking on it. This will display the attributes of your selected process in the *Datasheet* window.

4.6.4 Tree Selection Stages

It is possible to perform selections based on the categories of entities in the selection table (the PROCESS UNIVERSE table in the current example). For example, you could specify that only Deformation processes and Machining processes (say) should pass the selection.

It is also possible to select entities based on their *links* to entities in related tables. In the current example, it is desirable to select processes that are linked to particular material classes in the MATERIALUNIVERSE table - ie to select processes that can form particular types of materials.

Both of these types of selection can be performed with a 'Tree' stage.

Perform a second selection stage to select only those processes that can form technical ceramics and glasses. This requires the use of the **Tree Stage** tool (figure 4.20).

Click once on the New Selection button 

on the *Selection* window and choose *Tree Stage* from the drop-down list (figure 4.20)

Set the table in the list in the middle of the dialog to MaterialUniverse

Open the Ceramics branch of the MaterialUniverse tree

Click once on the 'Technical' branch, then click on 'Insert'

Do the same for the 'Glass' branch

This should generate the following entries in the edit box near the top of the dialog:

[MaterialUniverse:\Ceramic\Technical]

[MaterialUniverse:\Ceramic\Glass]

Optionally, enter a stage title (eg <u>Material class</u>) at the top of the dialog

Click on OK to exit the dialog and perform the selection.

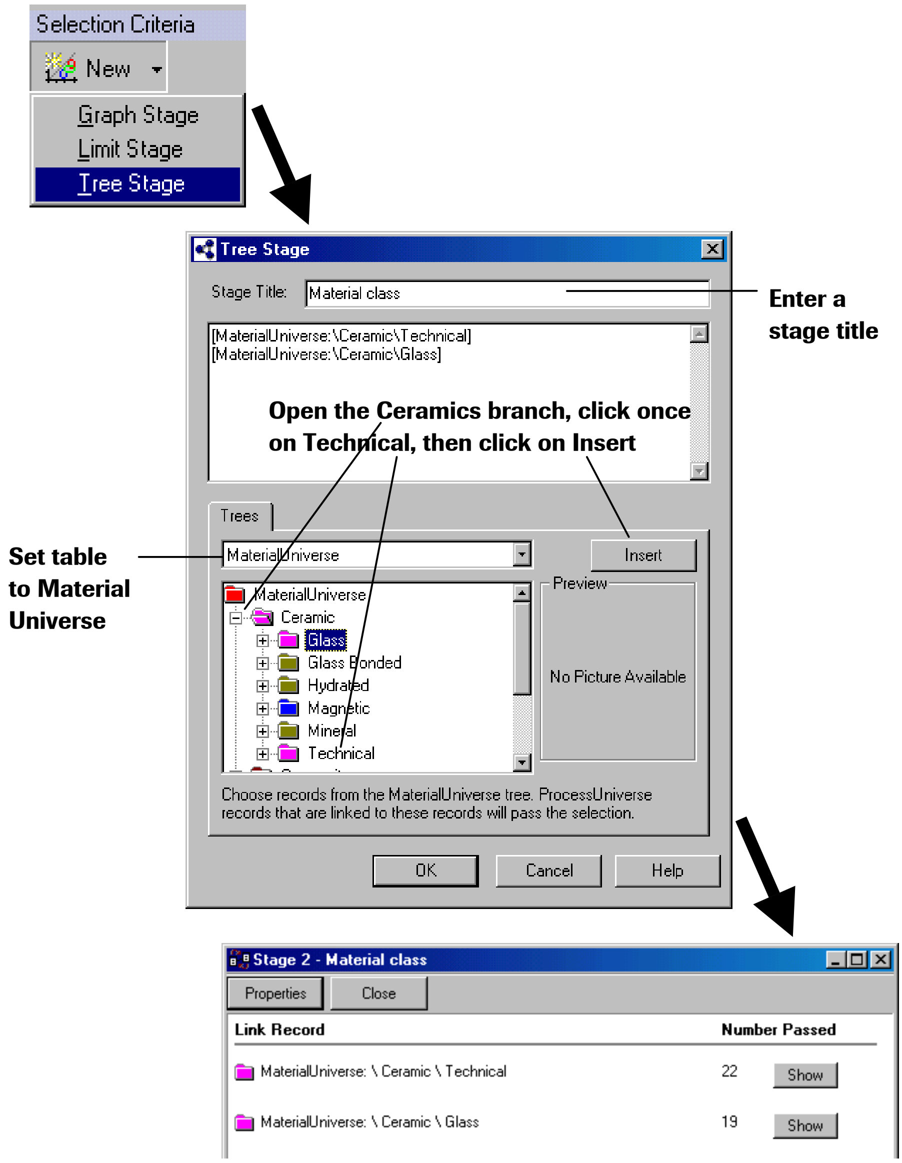


Fig. 4.20 Use of the 'Tree' Selection tool to select processes which can form Technical Ceramics and Glasses.

The *Tree Stage* window will appear (see bottom of figure 4.20). It shows that 22 processes can be used to form Technical Ceramics, and 19 processes can be used to form Glasses.

The selection results now show that three processes passed both selection stages. They are 'Die Pressing and Sintering', 'Powder Injection Moulding' and 'Standard Machining (Automated)'. Note that only the first two of these processes are suitable for shaping Alumina (which is what the insulator is really made of). Standard Machining can be used to shape some machineable glasses. We allowed these into the selection in Stage 2. Had glasses not been included in Stage 2, only the first two processes would have passed the selection.

Click on the first two processes in the results list, and scroll down their datasheets to see their Typical uses.

4.6.5 Plotting a Material Property Chart

The next example will investigate selection of materials from the MATERIALUNIVERSE table. The first step is to change the selection settings to use a different template. (Follow the instructions in section 4.6.1)

Click on the Change button in the Settings section at the top of the Select Window pane (see figure 4.16)

Change the Selection Template to 'All Bulk Materials' on the MaterialUniverse tab.

This template includes essentially all of the main types of engineering materials, and the properties that are common to all classes. It is a good template to use for general materials selection problems when you wish to consider all possible materials.

Suppose you wish to find materials with relatively low densities and high strengths. The best way to use CES for this is to plot a selection chart of *Elastic Limit* against *Density*, and then select all materials in the area of interest.

Note: The *Elastic Limit* is one measure of the strength of a material; it is the stress at which it first suffers permanent (inelastic) deformation. For metals, the elastic limit is the yield strength; for polymers it is the stress at which the uniaxial stress strain curve becomes markedly non-linear, typically at 1% strain. There are other definitions for other classes of materials. See CES INDEPTH for definitions of material attributes. (See also figure 4.13).

Plot a selection chart as follows:

Click once on the New Selection button [New] on the *Selection* window (Fig. 4.21)

Choose Graph Stage from the drop-down list

The *Graph Stage Wizard* dialog box will appear (figure 4.21). Plot a chart of Elastic Limit vs Density as follows:

Click once on the *X-Axis* tab (top left of the dialog box).

Select 'General' properties from the Category list box as shown

Select 'Density' from the Attributes list box

Repeat the process to select 'Elastic Limit' (a Mechanical property) for the Y-Axis of the chart

Finally click once on *OK* to exit the *Graph Stage Wizard* and plot the chart.

A selection chart will appear on the screen (figure 4.22). The colours of the material bubbles indicate their main classes as indicated on the MATERIALUNIVERSE table tree in the *Browse* window. Note that the axes are logarithmic by default, since the properties span such a wide range of values. This can be changed by selecting linear scales in the *Graph Stage Wizard* dialog box, or using the **Stage Properties** button on the *Graph Stage* toolbar.

Click *once* on any material 'bubble' on the chart to see a label showing its identity. If desired, you can change the format of the label using a right mouse click.

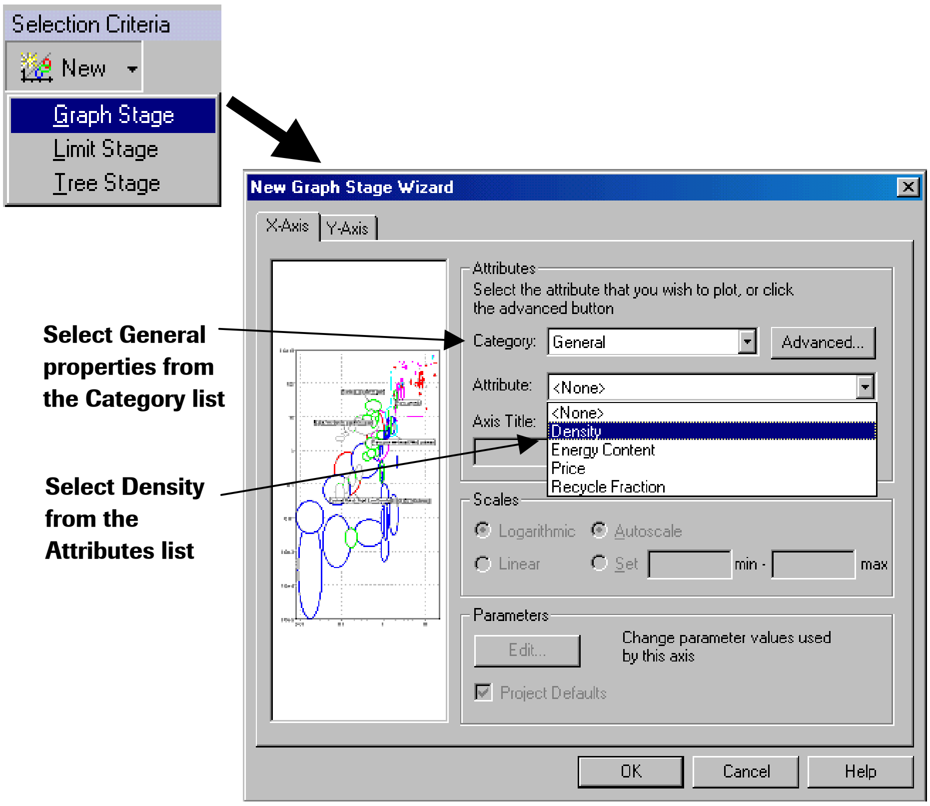


Fig. 4.21 Choosing properties for the X-axis of a selection chart.

4.6.6 Selecting Materials within a Property Range

Now select all materials in the database with Density and Elastic Limit in the range: 1 Mg/m^3 < Density < 10 Mg/m^3, and 100 MPa < Elastic Limit < 3000 MPa, as shown in figure 4.22.

Click once on the *Box Selection* button on the *Graph Stage* toolbar

Click once on point (x, y) = (1.0, 100) on the chart, and hold the mouse button down (The coordinates of the cursor are shown at the bottom left of the screen.)

Drag the cursor to a point near (10.0, 3000) on the chart, then release the mouse button. (3000 = 3.0E3).

Materials within the box, and all materials that *cross* the boundary of the box are now plotted in colour. This indicates that they have been included in the current subset of materials – they 'passed' the selection stage. Materials that are not included in the subset have been plotted in grey because they 'failed' the selection stage.

Optionally, click the *Hide Failed Records* button to hide the grey bubbles

You can change your selection at any time by re–sizing the selection box. Click once on the side of the box to reveal square 'handles'. Click on a handle and, while holding the mouse button down, move it to a new position.

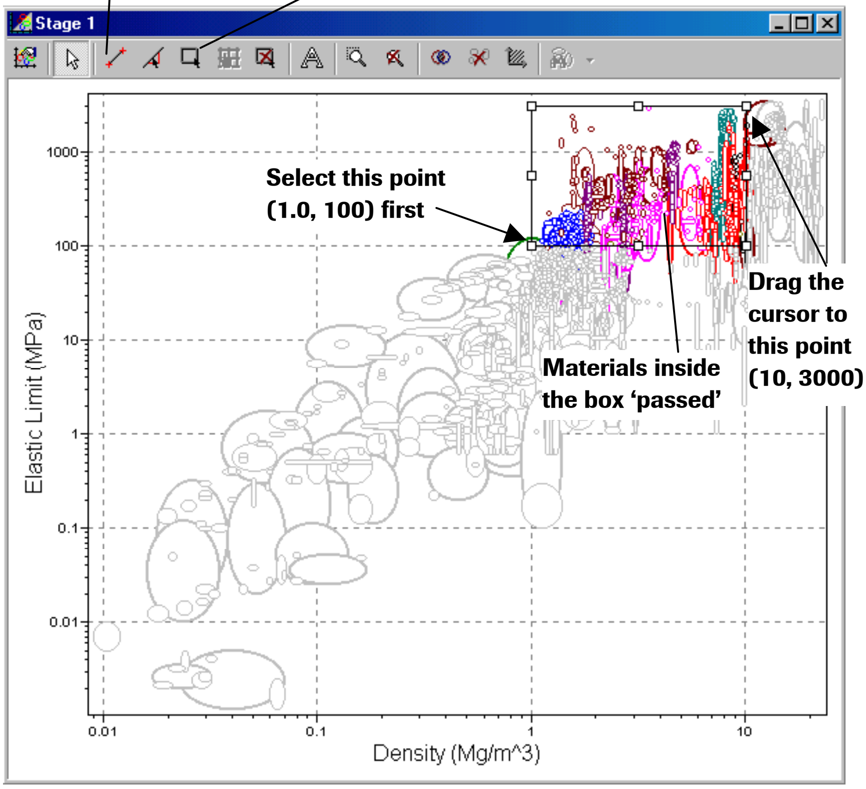


Fig. 4.22 Materials selection chart of Elastic Limit vs. Density. Selecting materials within a 'box'

4.6.7 Maximising a Performance Index

In many cases it is desirable to select materials so as to maximise a combination of material properties, a 'performance index'. One such combination is the 'specific strength' or strength/density ratio:

$$M = \sigma_{el}/\rho,$$

where σ_{el} is the elastic limit and ρ is the density.

Taking logarithms of both sides of this equation, gives

$$\log_{10} \sigma_{el} = \log_{10} \rho + \log_{10} M.$$

This equation can be plotted on a selection chart with logarithmic axes, as a line of slope 1.0 with an intercept of $\log_{10} M$ (at $\rho = 1.0$). All materials that lie along such a line have the same value of M. Materials above the line have a higher value of M and will perform better if high strength and low weight is needed. A list of performance indices for standard design cases can be found in CES INDEPTH.

To select a subset of materials with a high value of M, do the following:

Click once on  **(point-slope selection button) on the** ***Graph Stage*** **toolbar**

The program will now present you with the *Line Selection* dialog box. The default slope is 1.0, which is what you want for M, so:

Click once on OK to accept the slope of 1, then

Click once on a point near (1.0, 200) on the chart. Hold down the mouse button and drag the line to (1.0, 200) and release it. (See the coordinates at the bottom left of the window.)

A diagonal selection line will appear on the chart (figure 4.23)

Click once on a point *above the line* with the hand cursor, to indicate that you want to select materials in that area (those with high σ_{el}/ρ)

All materials above the line and all materials that cross the line 'passed' the selection stage and are now plotted in colour. All other materials 'failed' and they are plotted in grey. You can move the selection line to change the subset of materials that pass the selection in two different ways:

Move the cursor over the line until it changes to 'four–way arrows', then 'drag and drop' the line to a new position

Click on the Graph Stage Properties button , and choose the 'Selection tab', then set the position of the point to X: 1, Y: 200 and click on 'OK'.

Note that this line selection superseded the previous 'box' selection because only one selection is possible on each stage.

4.6.8 Graph Format Options

Next zoom–in on part of the chart, and add some extra formatting information, to make it look like figure 4.23:

Click once on the *Magnify* button on the *Graph Stage* toolbar

Click once on point (1.0, 10) on the chart, hold the mouse button down, then drag the cursor to a point near (10.0, 4000) on the chart.

Now add some material name labels:

Click once on a material bubble, to generate a label.

Change the format of the label by clicking with the right mouse on the label and selecting the *Format Label* option from the context menu. (You can change the text in the label by selecting other options from the context menu.)

Select the type size, font and text format, using the 'Font' button then click on *OK* to exit.

The label that appears on the selection chart can be moved by 'dragging and dropping' it with the mouse.

Repeat these steps to label other materials. (Note that you can set the *default* format for labels from the ***Tools/Options/Labels*** menu.)

You can also add text to the chart using the **Text** button on the **Graph Stage** toolbar, and you can draw a set of parallel lines of any desired slope across the chart using the **Guidelines** button. Your chart should end up looking something like figure 4.23.

The selection chart can be printed using **File/Print**. You can also use the **Edit/Copy** to send a copy of the chart to your Windows™ clipboard. The contents of the clipboard can then be pasted into another Windows™ program (eg, word processor).

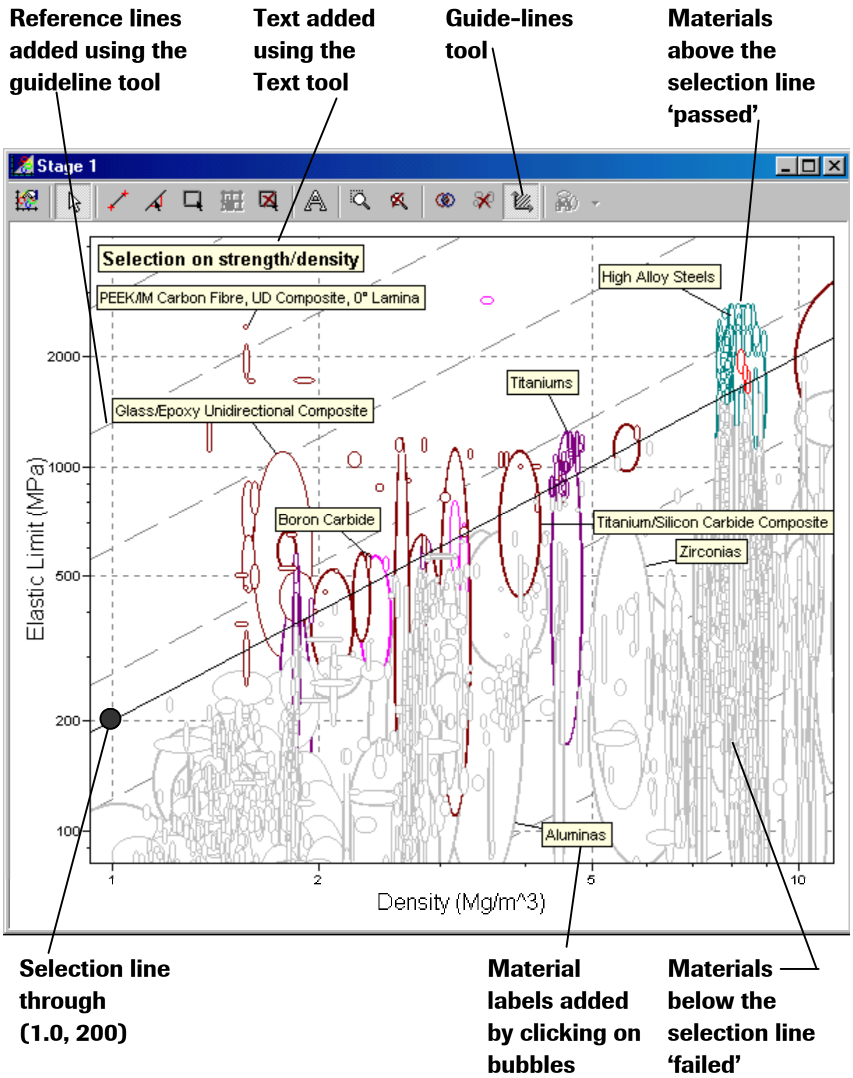


Fig. 4.23 Selecting a subset of materials with $\sigma_{el}/\rho > 200$ MPa.m^3/Mg
Other formatting information added using buttons on the *Graph Stage* toolbar.

4.7 Further Facilities

This section shows you how to change units and currencies, save your work in a Project file, how to select materials using more complex selection charts, and how to export files containing property lists or selection results.

4.7.1 Units and Currency

The default units and currency used by CES are obtained automatically from your computer's Regional Settings which are defined by Windows™. (See the *Regional Settings* Control Panel in Windows™.) These regional settings are denoted <Automatic> in the *Tools/Options* dialog shown in figure 4.24.

Open the *Tools / Options* dialog

To change the currency (eg to US$), or the units (eg to 'US Imperial'), simply select different settings in the list boxes. All attribute data in property lists or selection charts, etc will change automatically.

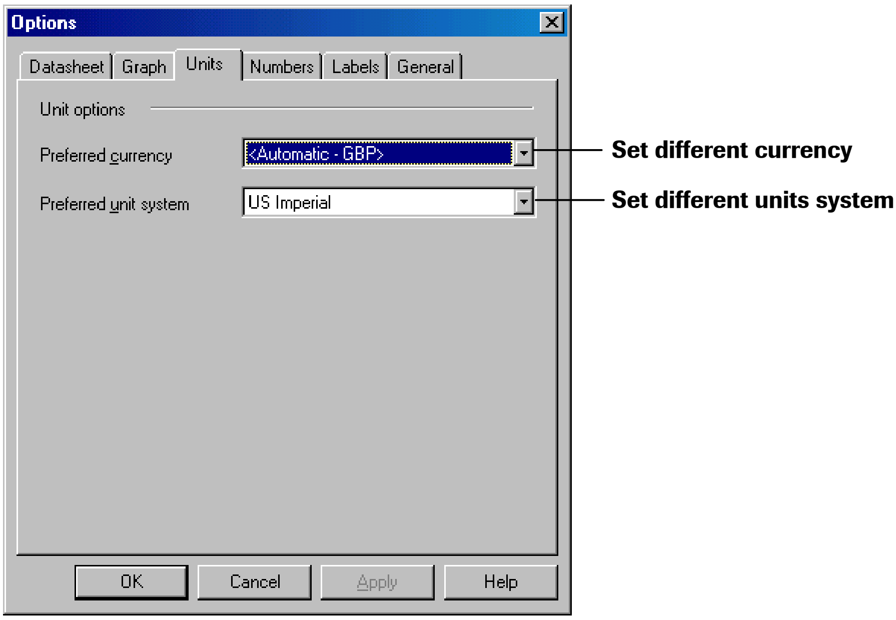


Fig. 4.24 *Options* dialog

4.7.2 Project Files

To save your work in a project file, do the following:

Open the Project/Settings dialog. Then select the *Summary* tab.

Enter the title of the project, the author and a description, then exit the dialog.

Select *File/Save Project As.* The *Save As* dialog box will open.

Set the File Type in the drop–down list box (bottom of the dialog box) to 'CES Projects (*.ces)'

Enter the file name 'sample' in the input field

Set the file directory using the directory tree options at the top of the window

Click once on *Save* to save the file and exit the dialog box.

Your current CES session can be saved again at any time by selecting **File/Save Project** (Ctrl+S). If you wish to open an old project file, use **File/Open Project** – but beware, this will overwrite the current state of the program – so you will lose any selections currently on the screen. If you think you might need them again, save your selections before opening another project file.

4.7.3 Some Other Chart Options

The following illustrates the second type of materials selection chart: a bar chart. We will plot a graph of a 'user–defined' numerical property as a function of the type of material – ie its position on the material table tree.

Start by clearing all previous selections, and then set–up the X-axis to contain the five main material classes as follows:

> **Select *File/New Project***
>
> **Start a new graphical selection stage using the 'All Bulk Materials' template on the MATERIALUNIVERSE table**
>
> **Select the X-Axis tab and then the *Advanced* button in the *Graph Stage* Wizard. This will display the *Set Axis* dialog, shown in figure 4.25.**
>
> **Click once on 'Trees' tab at the top of the lower window pane, and select the 'MaterialUniverse' table from the drop-down list. This will display a copy of the MATERIALUNIVERSE table tree in the lower window pane.**
>
> **Click once on each of the material folders in the lower pane, then click on *Insert* to send it to the expression field: Ceramic, Composite, Foam, Metal, etc.**
>
> **Click on OK to exit the dialog box.**
>
> **Enter the title 'Material Class' for the X-axis title in the *Graph Stage* Wizard**

Note that it is also possible to perform 'cross-tabular' tree selections – based on the links between tables – using the same procedure. For example, you could select all materials that can be formed by (are linked to) a particular process by selecting the PROCESSUNIVERSE table from the drop-down list (figure 4.25). The Process table tree will then appear in the lower window pane. Simply select the processes or process classes of interest from the tree (eg Injection Moulding).

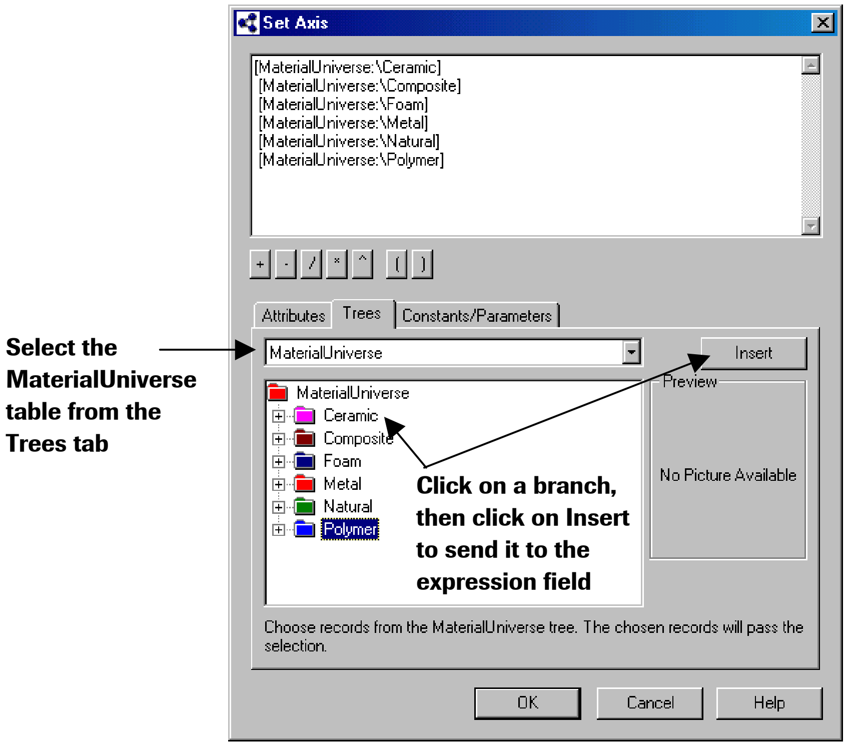


Fig. 4.25 *Set Axis* dialog, showing the selection of material classes for a graph axis.

Now generate a 'user defined' property representing the performance index $M = \sigma_{el}/\rho$ for the Y–axis of the chart as follows:

Select the Y-Axis tab and then the *Advanced* button in the *Graph Stage* Wizard.

Select the 'Attributes' tab (figure 4.26)

Select Mechanical properties from the drop down list

Double–click on 'Elastic Limit' in the lower pane to send it to the expression

Click once on the divide button / in the middle of the window (or type "/")

Select General properties from the drop down list

Then double-click on 'Density' to generate the expression shown in figure 4.26.

Click on OK to exit the *Set Axis* Dialog

Enter the name of the new property: '<u>Strength/Density MPa/(Mg/m^3)</u>' in the Title field in the *Graph Stage* Wizard

Click on OK to exit the Wizard.

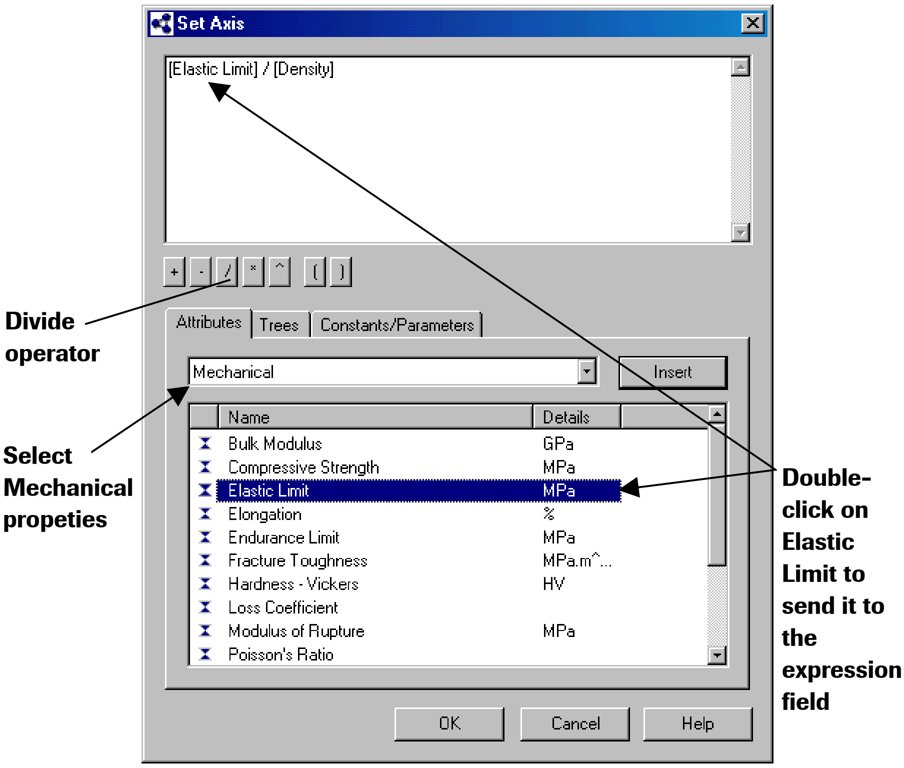


Fig. 4.26 Generating the 'user–defined' property σ_{el}/ρ for Y-Axis.

The selection chart will look like figure 4.27. The columns represent the various classes of materials (metals, polymers, etc), and each coloured bar represents the range of values of the property 'Strength/Density' = σ_{el}/ρ for one material.

The only selection option that works for bar charts is the 'box' selection. Select materials with $\sigma_{el}/\rho > 200$ MPa/(Mg/m^3) as follows:

Click once on the *Box selection* button on the *Graph Stage* toolbar

Select materials with Strength/Density > 200 by drawing a box around the area shown in figure 4.27.

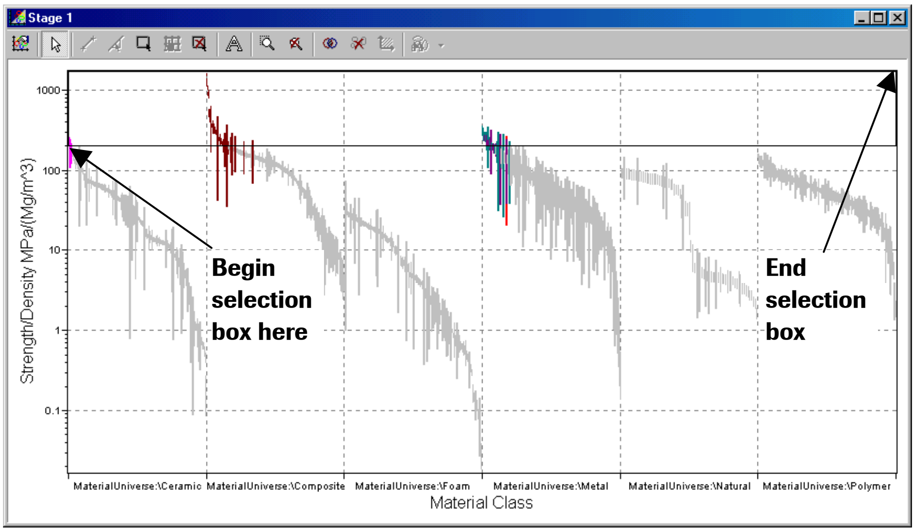


Fig. 4.27 Bar chart of σ_{el}/ρ vs. material category.

4.7.4 Selections using Functional Attributes

Selections can be performed using functional attributes in almost the same way as for other numerical attributes. The only difference is that it is necessary to specify the parameters to be used when interpolating the function. For example, if you wish to select a material based on its fatigue strength, it is necessary to specify the number of loading cycles (eg $N = 10^7$) and the stress ratio (eg $R = -1$)... (See Section 4.3.4 for more information about the Fatigue Strength Model.) To perform a graphical selection, proceed as follows.

Start a new project using the 'Metals' Template in the MATERIALUNIVERSE table

Begin a new graphical selection stage

Select Density for the X-Axis of the chart

Select 'Fatigue Strength Model' for the Y-Axis of the chart

Click on the 'Edit' parameters button in the *Graph Stage* Wizard (figure 4.28)

You can either use the 'global' project default parameters for evaluating the functional attribute (Fatigue Strength Model), or you can define a set of parameters for use on this stage only (see Section 3.3.9). If you use the project defaults, then if these are updated at any time in the current project, this selection chart will automatically be updated.

If the 'Project Defaults' check box is checked, then:

(i) the project default parameters will be used for evaluating the function for this axis of this selection stage (you can use different parameters for each axis if you wish);

(ii) when you *Edit* the parameters (as shown on the right of Fig. 4.28), the project default parameters will be updated.

If the ‘Project Defaults’ check box is *not* checked, then the parameters will be used for evaluating the function for *this selection stage only*, and the default values of the parameters will not be affected.

Change the parameter values if you wish

Click on OK to exit the *Axis Parameters* dialog, and OK to plot the chart

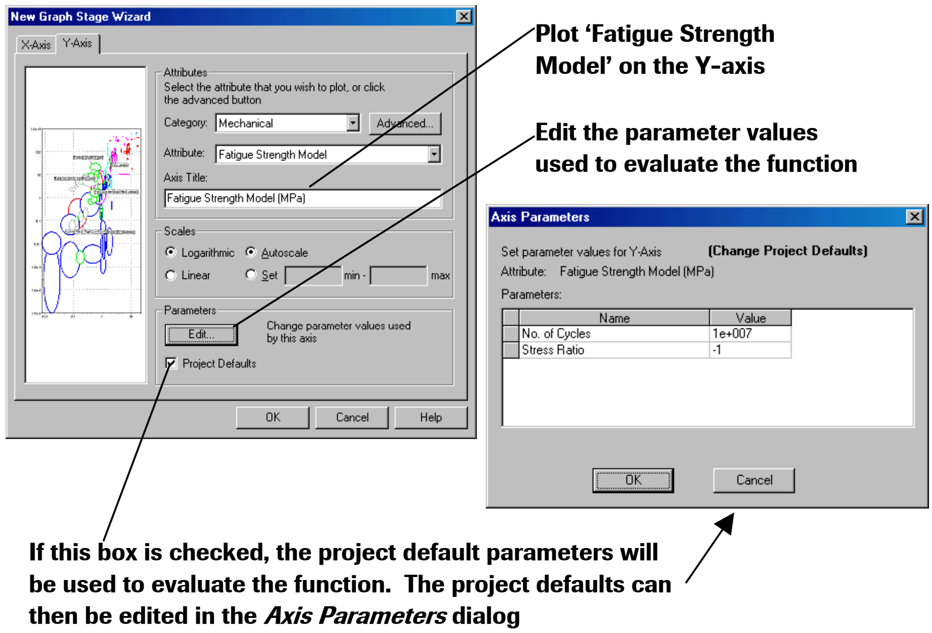


Fig. 4.28 Setting the parameters for plotting a chart with functional data.

A chart like that in figure 4.29 will appear. It shows the fatigue strength of most of the Metals, Metal Matrix Composites and Metal Foams (the contents of the *Metals subset*) in the database, evaluated at $N = 10^7$ cycles and a stress ratio of $R = -1$. Material labels have been added and the zoom function used to improve the appearance.

Note on Limit Selection Stages:

If you wish to perform a limit selection stage (see Section 4.6.2) using functional data, the values of the parameters used in the selection can be edited using the **Properties** button at the top of the *Limit Stage* window (eg figure 4.18).

4.7.5 Saving Material Properties and Results

You can transfer the contents of the *Attributes* or *Results* windows to an external file as follows:

Make the *Datasheet Window* or the *Select* window active by clicking on it

Select *Edit/Copy* to copy the contents to the clipboard

Open another Windows™ application - such as a spread–sheet or word processor.

Select *Edit/Paste* in the external program to import the contents of the clipboard. The format of the exported data will depend on the capabilities of the external program.

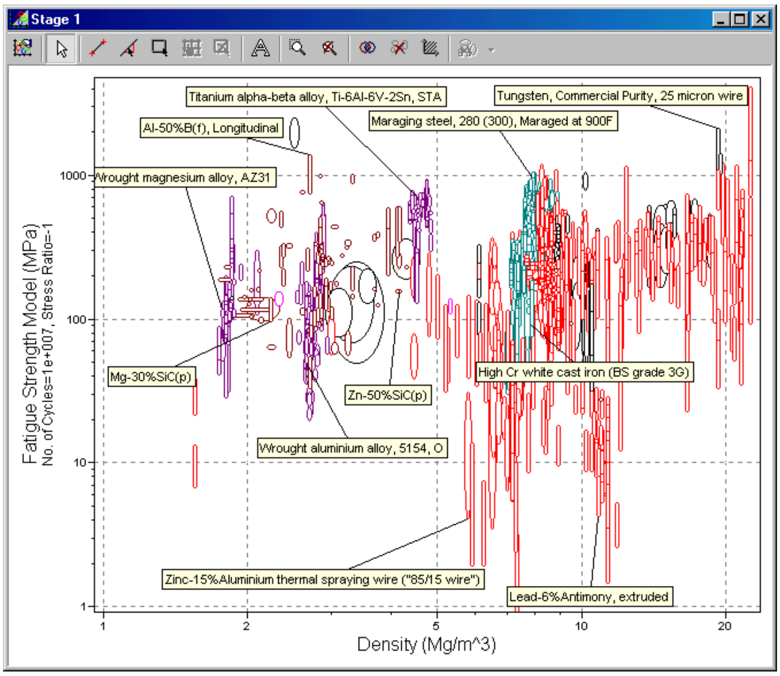


Fig. 4.29 Graph of Fatigue Strength (evaluated at N=10^7 cycles and R=-1) vs Density.

4.7.6 *Exporting data to Finite Element or CAD programs*

To export material property data to a Finite Element program:

Locate the material of interest: by clicking on a bubble on a chart, or by locating it on the Materials table tree in the *Browse* window

Select *File / Export Record*

Select the format for export in the *Export Record* dialog (figure 4.30)

Click on the *Settings* button to set the Export Settings., and choose either to output to Clipboard or to File. For export to file, specify the file name

Click on OK to exit the *Export Settings* dialog, then OK in the *Export Record* dialog to perform the export.

Notes:

(i) Only one record can be exported at a time

(ii) For the CES *4* release, the available output file formats are for: ABAQUS, ANSYS, NASTRAN, PATRAN and PRO/Engineer. Other formats may be available on request. Email: support@grantadesign.com for more details.

(iii) In most cases, the material data is assumed to be a linear and temperature-independent. Some of the file formats allow for the plastic or anisotropic material behaviour to be modelled. In these cases, this information is exported.

(iv) Unless the file format requires a particular set of units, the data is exported in the preferred database unit system, using the current number of significant figures. It is recommended that a 'consistent' unit system is used.

(v) See further details in the on-line Help.

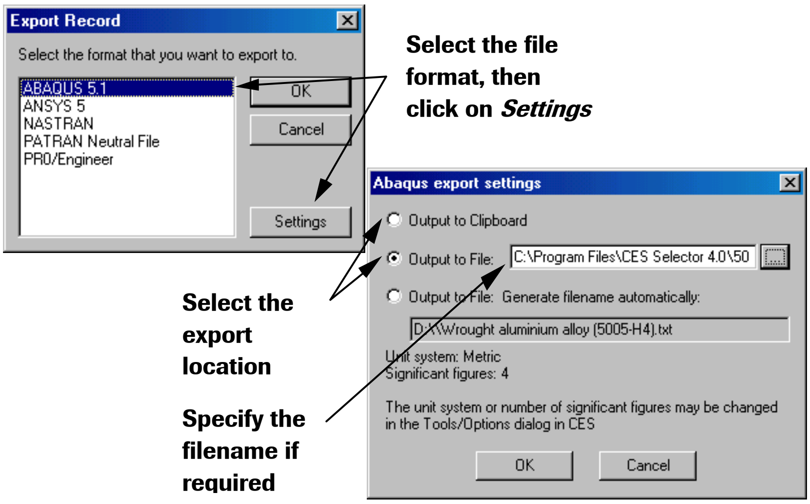


Fig. 4.30 Exporting material property data to a Finite Element program.

4.8 Concluding Remarks

This *Quick Start* has guided you through some of the more important functions of SELECTOR, in a rather condensed fashion. There are many more features that have not been discussed. You can learn more about the program by going through the Tutorials in the on-line Help system (see section 4.2.3) or by reading the User's Reference, in the Help system, which discusses all of the commands, buttons, windows and dialog boxes in detail.

We recommend that you also read about the selection methodology underlying SELECTOR in the Background Reading section of CES INDEPTH. But first, you might like to explore the system a little, to become familiar with the features that have been introduced here, and explore others. We hope that you will find the remaining features intuitive and easy to discover and use.