RAL

DESIGN & DISCOVERY

Open Days July 1990

RUTHERFORD APPLETON LABORATORY

SCIENCE AND ENGINEERING RESEARCH COUNCIL

COMPUTER AIDED ENGINEERING (CAE)

Introduction

In order to support the wide range of scientific research that is carried out on site, the Laboratory has invested in several state-of-the-art CAE technologies. These technologies have been electronically linked so as to complement each other, thus enabling the Laboratory to undertake the design, analysis and manufacture of advanced and novel experimental equipment.

Computer Aided Design (CAD)

Computer Aided Design provides the use of a large advanced integrated modular system, capable of producing accurate two dimensional (2D) drawings and generating three dimensional (3D) mathematical models of components and assemblies.

The 2D system provides comprehensive facilities to allow the designer to create engineering drawings of all types. Geometric information can be input through a wide range of commands to create lines and text and then to move, rotate, scale, copy, delete and generally manipulate either single elements or groups of elements on the drawing. Facilities such as dimensioning, cross-hatching, parts-listing, symbol libraries, macros and the production of high quality prints are also available.

The 3D system has powerful facilities to interpret a specially annotated drawing and produce from it a 3D representation of an object. There are a number of programs to analyse the model directly, including those to calculate volume, mass, surface area, centre of gravity and moments of inertia. Also programs are available to produce other views of the object including isometrics, sections, perspective and realistic shaded views. The information about the object can be transferred from the 2D system to the 3D one or vice versa.

Finite Element Analysis (FEA)

Finite Element Analysis is a general purpose tool for performing engineering calculations on structures. The structure is split up into simple elements- bricks, plates and bars- which are analysed separately. The results of these calculations are combined to show the performance of the whole structure.

Almost any structure can be analysed in this way and several types of analysis can be done. The stresses and deflections resulting from gravitational or other loads can be evaluated and graphically displayed. Thermal stresses and heat flows can be found, and the effects of complex vibrational forces can be explored.

One of the most time-consuming parts of the analysis is the splitting up of the structure into the many small elements. In the past, each element together with its position and properties was laboriously typed into the computer. Today automatic mesh generation programmes are available which allow the elements to be specified much more easily. As a further enhancement, it is possible to transfer the shape of an object from the CAD system to the FEA programme, thus avoiding the need to enter the same data twice.

Computer Aided Manufacture (CAM)

Computer Aided Manufacture is the tool for the pre-programming of the various moves the machine tools will subsequently carry out in order to make the required part. The system consists of three steps: geometry creation, geometry manipulation and machining sequence definition.

Geometry creation can be achieved by two different routes. Firstly the programmer can create the geometry needed for machining by line, point and circle definition commands. Alternatively the geometry created by the designer can in whole or part be transferred from the CAD system.

The geometry can be manipulated ie copied, translated, rotated, mirrored and scaled etc until all the geometry is ready for machining.

The machining sequence can then be added by commands that relate to the geometry already created. Predefined tool and macro libraries may be called upon to aid the process. The machine tool environment is simulated on the screen, the machining sequence verified and modifications made where necessary.

Computer Numerically Controlled (CNC) machine tools

Computer Numerically Controlled machine tools are the equipment that actually cut the material to the required shapes. The finished CAM machining sequence can be converted into a form that the CNC machine tool can use and the file generated transferred directly to the machine. The CNC machine tool controller will then drive the cutting tools under computer control as specified by the programmer's machining sequence so producing the shapes originally prescribed by the designer.

Conclusions

The systems being used allow the Laboratory to exploit the potentials of modern computer technology in design, analysis and manufacture in the most economical way. Electronic communication with other research centres and outside companies can be utilised to transfer exact geometry between sites. Savings in time for job creation, reduced chance of errors and the production of more complicated shapes are all tangible benefits of the CAE system described.

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