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Pearson BTEC Level _ Higher Nationals in Engineering (RQF)

Unit 23: Computer Aided Design and Manufacture

Unit Workbook 1

in a series of 2 for this unit

Learning Outcome 1

Key Principles of CAD/CAM

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Contents

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INTRODUCTION

Describe the key principles of manufacturing using a CAD/CAM system.

- *Hardware:*
    - CAD workstation, printers, USB flash drives and network cables.
- *Software:*
    - Operating systems, hard disk requirements, processor, CAD software e.g. SolidWorks, Autodesk Inventor, CATIA; CAM software e.g. Edgecam, Delcam, GibbsCAM, SolidCAM.
- *Inputs:*
    - CAD model, material specifications, tooling data, spindle speeds and feed rate data calculations.
- *Outputs:*
    - Commodity and Engineering Thermoplastics.
    - CAM files, program code and coordinates, manufacturing sequences, tooling requirements, auxiliary data.
- *Programming Methods:*
    - CAD/CAM, manual programming, conversational programming.
- *Component Setup:*
    - Zero datum setting, tool set-up and offsets, axis of movements.
- *Work-Holding:*
    - Machine vice, chuck, fixtures, clamping, jigs.
- *Tooling:*
    - Milling cutters, lathe tools, drills, specialist tooling, tool holders, tool turrets and carousels.

Produce 3D solid models of a component suitable for transfer into a CAM system.

1. *Solid modelling:*
    - Extrude, cut, fillet, chamfer, holes, sweep, revolve, lines, arcs, insert planes, properties of solid models e.g. mass, centre of gravity, surface area.
2. *Geometry manipulation:*
    - Mirror, rotate, copy, array, offset.
3. *Component drawing:*
    - Set-up template, orthographic and multi-view drawings, sections, scale, dimensions, drawing.
    - Attributes e.g. material, reference points, tolerances, finish.

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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.

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1.1 Manufacturing Using CAD/CAM

1.1.1 Overview

Computer aided design and manufacture are extensively used across a magnitude of different engineering applications as well as in other industries. An enormously diverse range of companies utilise CAD/CAM in order to produce original, precision-made components, assemblies and products.
CAM is best described as the use of software to control machine tools in the manufacture of components whereas CAD is the use of computer systems to create, modify and optimise a design.

1.1.2 Hardware

In order to facilitate CAD and CAM, there must be input from a suitably qualified person or persons. These qualified persons must interface with design and manufacture software via the use of a high-performance computer, which is commonly referred to as a workstation. This workstation also usually includes the standard computer operating equipment (mouse, keyboard etc.) along with some extra paraphernalia such as 3D manipulators, printers, 3D printers, USB flash drives, network cables, scanners, power supplies and archiving/backup systems.

Commonly, once an engineer has a design, it will be reviewed by peers and/or managers and, in order for this to happen a printout is produced which is then easily shown amongst a group and notes can also be added quickly. This review process may also be carried out electronically, which eliminates the need for a physical printout of the design. A 3D printer is a very useful tool for presenting design ideas; It can be used to produce representations and even low-level prototypes of designs to be reviewed.

Flash drives are usually used to enable the transfer of data, in the form of large 3D files which exceed the file size of email attachments, they are oftentimes also considered to be a more reliable form of data transfer.

Other equipment is generally used to facilitate more efficient design or to allow for uninterrupted power supply and data transfer and/or backup.

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1.1.3 Software

The vast majority of CAD and CAM software packages are compatible with standard operating systems, such as Windows and Apple masOS. There are usually relatively high system requirements for operating advanced CAD or CAM software packages, however it may not always be required to install the full software package onto a workstation because only certain features are needed. Depending on the requisite software, system requirements will differ, however, generally the computer will require a high-specification processor and graphics card, a solid-state drive are also recommended, along with reasonable disk space and RAM.

Although there are a plethora of CAD/CAM software packages available, a select few are most commonly used due to their usability, compatibility and support available.

Examples of professional CAD packages available include: Autodesk Inventor & AutoCAD, Solidworks, CATIA, Ansys and Rhino. There are also some more simple free packages available such as Google Sketchup, TinkerCAD and FreeCAD.

Some examples of CAM software include: EdgeCAM, DelCAM, GibbsCAM, Solidworks CAM, Autodesk Powermill & Fusion 360 and SolidCAM.

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1.1.4 Inputs

For a design to move from the design phase through the review, prototype and then the manufacturing phase, certain inputs must be provided (in terms of design and manufacturing requirements). Firstly, the design must either be imported from an existing source or a new one created. The file format of this 3D or 2D design is dependant on the software that was used to create it, usually a CAD model will be one of the following file formats: DXF, DWG, IGES, STL, STEP, X3D or Parasolid (there are many other less common file formats as well). This CAD file contains all the geometric information about the component that has been designed, a 2D drawing will likely also be produced alongside any 3D file which is important in providing manufacturing and assembly instructions.

Within a 3D CAD model, there are several attributes which can be assigned such as the material, surface finish, hole detail, finishing notes, bend radii, coating notes etc. These are usually requirements if the component is to be analysed using FEA or other structural analysis tools, they are also necessary pieces of information required for manufacture.

Consider the following part which is a simple block featuring a blind hole which is threaded. There are many different factors to consider before it can be manufactured. The design of this, and indeed any part, must be sympathetic to the manufacturing capabilities and limitations of the manufacturing department or supplier.

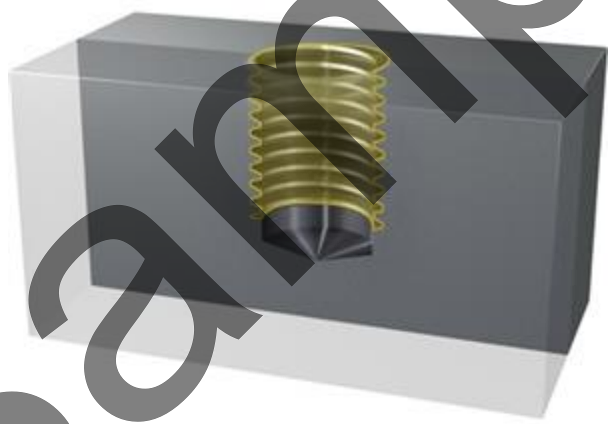

Figure 1.1: *Threaded Hole in a Block Part*

Often in industry, issues arise due to errors or miscommunications between design and manufacturing, just consider that the design department has specified a fully threaded blind hole in the above part. It is not actually physically possible to produce a fully threaded blind hole, there will always be a small area at the base of the hole that is not threaded. In this case the manufacturer of this block part will either delay the manufacture of this part, use a best guess or just potentially leave the hole un-threaded. Whatever choice they make in this case, there will be delays and/or quality issues arising.

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Once the manufacturing department or external supplier has all of the information that they require, and before they start machining a component, they must select the most appropriate machine(s) to be used as well as then set them up correctly. Certain inputs must be decided prior to machining, usually the spindle speed and cutting speed which lead onto feed rate calculations. These calculations must be carried out in order for the machine to run efficiently and safely, whilst maintaining the required surface finish. It is important to note that whilst the part is being machined it is referred to as a workpiece.

Cutting speed can be defined as the difference in speed between the cutting tool and the surface of the workpiece being machined. Feed rate is the relative velocity at which the cutting tool is advanced along the workpiece and is dependant on the motion of the tool and the workpiece. When the workpiece does not rotate (as in a milling application) the units of feed rate are usually in millimetres per minute. When the workpiece is rotating the units are millimetres per revolution. The spindle speed is essentially the rotational frequency of the spindle of the machine, usually measured in RPM.
It is important that the feed rate is considered, to put it simply if a car were travelling at 70 mph towards a 90-degree corner it would be highly advisable to slow down otherwise the car would likely crash. This is a metaphor for the feed rate, as the tool is travelling to turn a corner it must slow down otherwise it may cause damage to both itself and the work piece.

Feed rate and cutting speed are mostly determined by the material of the workpiece, deepness of 'cut' into the material and machine specification. As a general rule the cutting speed will probably increase as the work material hardness decreases:

Figure 1.2: *Cutting Speed Based on Work Material Hardness*

Additionally, the cutting tool material itself can also have an affect on the cutting speed; a harder tool material will mean that the cutting speed should be increased:

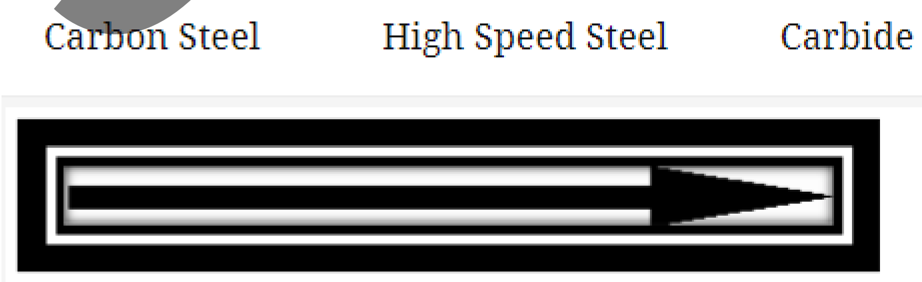

Figure 1.3: *Cutting Speed Based on Cutting Tool Material Hardness*

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Experienced fabricators will possess the knowledge needed in order to be able to setup and programme machines quickly and efficiently but there is an array of resources available which are used to inform CAM setup and programming.

Take this online tool guide and cutting speed calculator for example:

https://www.sandvik.coromant.com/en-gb/products/Pages/toolguide.aspx

1.1.5 Outputs

The outputs of a CAD/CAM process are generally in the forms of CAM files, program code and coordinates, manufacturing sequences, tooling requirements and other auxiliary data. For a solid model part or component to be processed and exported through a CAM application, there are several processes which occur, as follows:

1. Develop a manufacturing process plan for a fully featured part, suitable for manufacture using, as a minimum, a CNC (computer numerical control) machine.
2. Produce a full set of machining sequences for the manufacture of the part.
3. Use CADCAM software to simulate the manufacturing of the part and to estimate the machining time.

Using a suitable software application, the solid model part is defined and, if necessary, converted into a convenient file format. The manufacturing process plan can then begin, starting with carrying out the tool definition, there are many tooling catalogues and applications which can be called upon in order to inform this process.

The results of the manufacturing process plan will depend on several factors such as:

- is the component rotational (a) or non-rotational (prismatic) (b)?

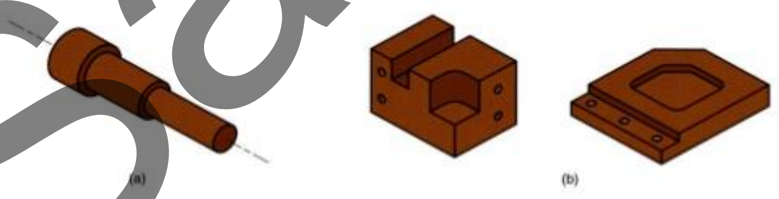

Figure 1.4: *Rotational and Non-Rotational Parts*

- what kind of machining is to be carried out (is it a hole, a pocket, slot, thread, planed surface etc.?
- what specific machining is to be carried out (is it a blind hole or through hole for example)?
- the material must be defined, is it to be manufactured from a low alloy steel, cast iron, aluminium based alloy etc.?
- then what kind of machine is to be used to actually manufacture the part, is it a universal high-performance machine or a generic large multitask type machine and what size chuck, if any, does it feature?

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