

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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SAMPLE

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.

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.

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:

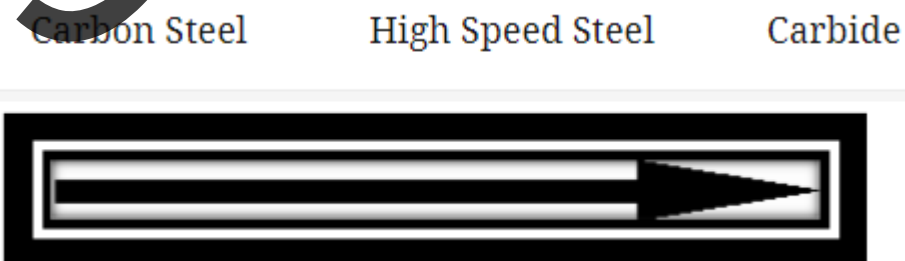


Figure 1.3: Cutting Speed Based on Cutting Tool Material Hardness

This kind of alpha-numeric code is incredibly powerful and efficient for defining motion and function (G##), defining position (X## Y## Z##), selecting values (F## or S##), selecting items (T##), switching items (such as coolant, bed height, spindles etc) on and off (M##).

An example of a section of G-code could be: 'G01 X1 Y1 F20 T01 M04 S500', this means that there is a linear feed movement (G01), to a specified position (X1 Y1), at a feed rate of 20 (F20), with spindle speed 500 (S500) and a miscellaneous function (M04) (likely to be a command to put the spindle on anticlockwise).

There are common examples of G-code which are used regularly by CNC machine operators, some everyday examples include: G81 (basic drilling cycle), G34 (variable pitch threading), G68 (rotate coordinate system) and G100 (tool length measurement).

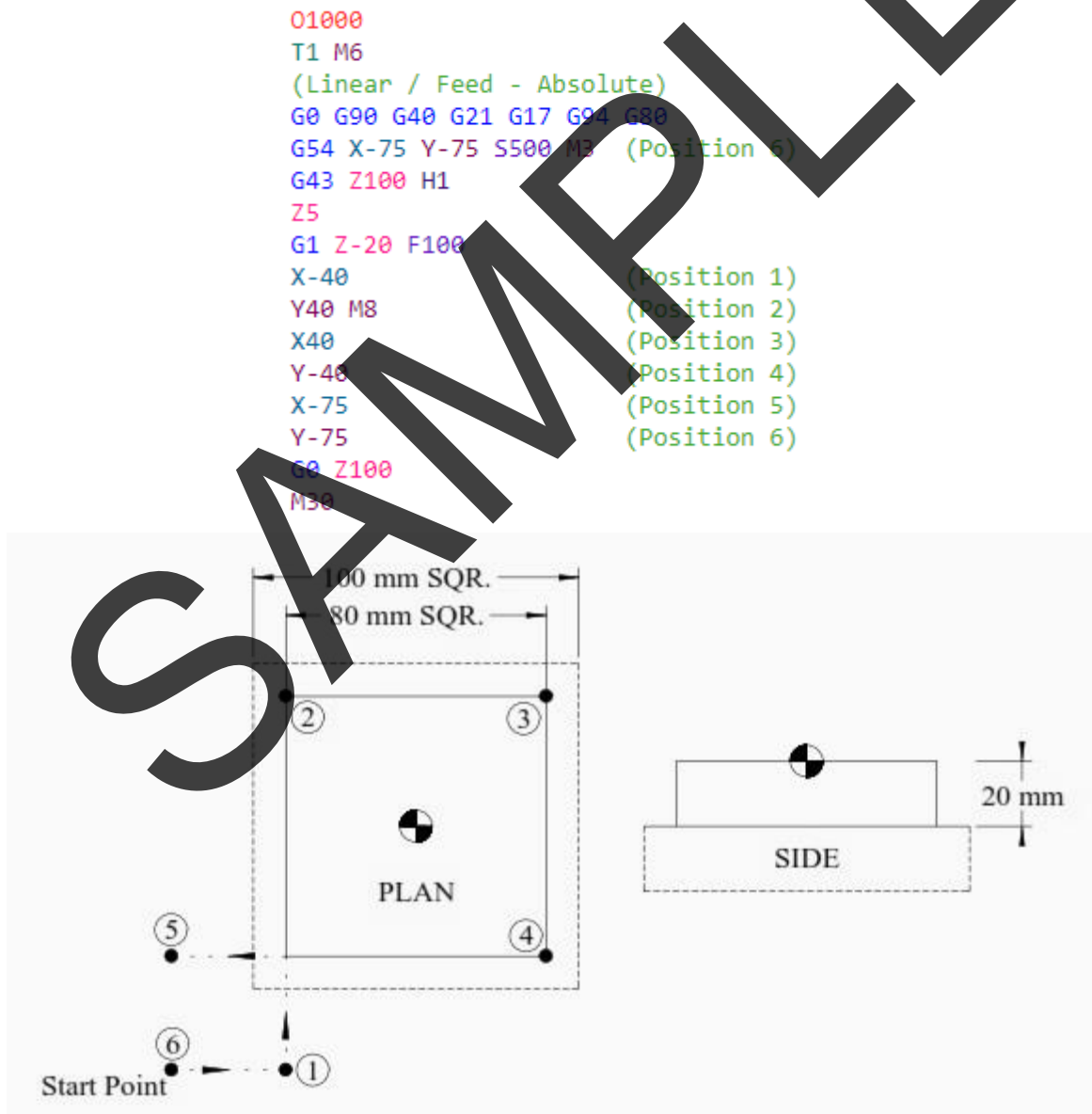


Figure 1.6: Simple G-Code Example

Usually, machining starts from a large billet or block of the base material and so therefore it is more practical to define the datum as a point in empty space rather than a corner of the to-be-finished part. That is to say, the edge of the original billet or block will not end up being the edge of the actual finished part. This workpiece datum is then defined in three dimensions.

There are several different ways to give the CNC machine the information about the tool length, either manual or automatic tool measurement techniques are both perfectly valid.

Touching-Off: This is the simplest way to measure tool length. It involves gradually lowering the tool and attempting to slide a gauge block of known dimensions underneath this tool until it can no longer be slid underneath. In doing so, the tool length is determined relative to some standard.

Paper Touch-Off is a very similar a method which is not sometimes used as a rough method. It involves slowly lowering a running tool down onto a touch off point which has a piece of paper lightly stuck to it's top, until the paper begins to move.

Tool Setter is the use of measuring tools or devices other than a gauge block. The tool is lowered down onto an active device which indicates the point at which it just touches.

Probe-Style Tool Setters are based on probe or sensor technology and are integrated into the machine's controller. The operator simply presses a button to instruct the machine to automatically probe the tool length and diameter.

When different machining actions are required on the same workpiece, a different tool is either manually or automatically loaded into the machine. Within the CNC machine programming, there is an 'offset file' which stores all the dimensional information about each tool, this information is very important because, if any of it is wrong, it will almost certainly result in damage to the workpiece and machine itself.

Any CNC machine has a certain number of axes of movement, often 2, 3, 4, 5, 6, 7, 11 or even 11. It is useful to familiarise oneself with the 6 axes (or degrees of freedom) that are commonly applied in areas of engineering and physics.

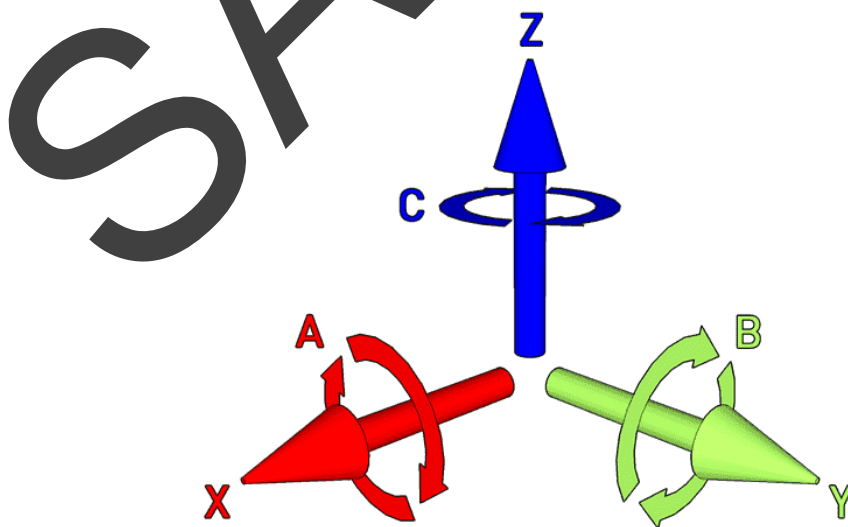


Figure 1.8: 6 Degrees

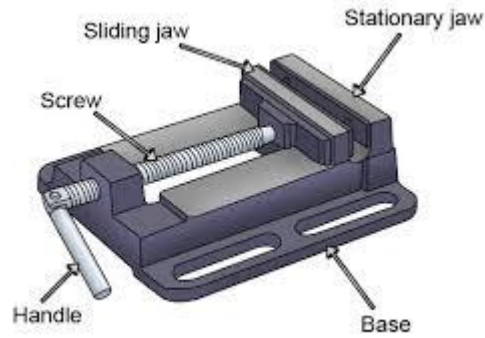


Figure 2.1: Machine Vice Key Features

Whichever device is used to hold the workpiece, the CNC machine must be given information on its dimensions and location relative to itself. This will enable machining to take place accurately as well as avoid any collisions. There are multiple variations of this basic vice design, but the essentials are the same and it is usually held to the bed of the machine via T-slots or equivalent.



Figure 2.2: Modern Self-Centering Vice

Step clamps are another common method of holding a workpiece in place via T-slots, an example of their application can be seen below:



Figure 2.3: Step Clamps in Action