Innovative CAD/CAM Curriculum for Industrial Technology Programs

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Abstract

The CAD/CAM process integrates the geometry, toolpath and the G-code program to create a part on a milling machine. Three different steps are taken for a CAD/CAM process. First the geometry for the part is created as a CAD file. The second step is to create a toolpath by assigning a cutting option to a section of the drawing. Each selected toolpath has its own parameters. The result, which is a visible toolpath, can be verified and checked for accuracy. Finally, the CNC program can be created using the selected postprocessor for the specific milling machine which will be used to cut the part.

The CAD/CAM process should be a step-by-step process done in a logical manner. Using the layer feature during the generation of the CAD drawing is a logical and innovative way of creating toolpath for a 3D model or part. This feature can be used to break down a 3D model into different sections, allowing for the creation of each section of a drawing on a specific layer according to its toolpath requirements. Combination of all toolpaths created for each level will produce the complex toolpath for the part. Creation of different layer for the purpose of toolpath generation is an effective method for making a part. This method allows the programmer to simplify the toolpath creation and combine individual toolpaths to create a part program.

Introduction

Computer Numerical Control (CNC) is a technology that controls machine tools by using coded command instructions commonly known as G-code program. These codes are then converted into motion and miscellaneous control signals that are used to control the position and the speed of the machine axis and spindle. One of the major contributions to the growing acceptance of Computer Numerical Control (CNC) has been the development of Computer Aided Manufacturing (CAM). The CAD/CAM program uses CAD drawings along with the cutting parameters to generate the CNC programs. A variety of PC-based CAD/CAM software is used in industry to create the G-code program for machine tools.

Using the layer feature during the generation of the CAD drawing is a new way of creating toolpath for a part. This feature can be used to break down a part into different sections, allowing for the creation of each section of a drawing on a specific layer according to its toolpath requirements. Combination of all toolpath created for each level will produce the complex toolpath for the part. Creation of different layers for the purpose of toolpath generation is an effective method for making a part. This method allows the programmer to simplify the toolpath creation and combine individual toolpath to create a part program.

CAD/CAM Process

Three different steps are taken during the CAD/CAM process. First, the part program is created and saved as a CAD file. Next, the milling operation is selected by assigning each operation to a section of a drawing. The drawing sections each have their own toolpath and parameters related to tool definitions and cutting parameters including: feed, speed, and plung rate, depth of cut and size of the cutter. For each section a visible toolpath can be verified and checked for accuracy and correctness. This is the CAM process, which the geometry is used to create a visible toolpath. Finally, the CNC program can be created using the appropriate postprocessor for milling machine controller.

There are five different toolpath options provided by CAD/CAM software to create a part program. They are face toolpath, contour toolpath, drill toolpath, pocket toolpath, and engrave toolpath. The five basic milling operations are used to create CNC program for most parts. The face toolpath removes materials across the top surface of the work piece. Contour toolpath, removes material to a certain depth along a specified CAD drawing. Drill toolpath; identify selected points on a drawing to drill holes to a specific depth. Pocket toolpath, removes all materials within the outline of an enclosed geometry. Pocket has the useful feature of island, which allows any shape within the enclosed geometry stay intact, and remains, as an island. The island feature of the pocket toolpath is used in many complex parts. Engrave toolpath, creates toolpath to engrave art and letters.

In creating drawing for CAD/CAM process layers are used to identify different parts of the same geometry on different levels. Each layer or combinations of layers can be selected to be visible or invisible. It is also possible to delete, move, or copy entities from layer to layer. This feature can be used to create part programs for complex parts by breaking down the geometry into different sections and creating each section of a drawing on a specific level according to its toolpath requirements. Each layer can be selected at a time for certain toolpath operation. Combination of all toolpaths for each layer produces the part.

Example

The following drawing was created as an example to represent the application of layers in a complex part. The drawing is divided to five different sections. Each section presents a layer and toolpath (Figure 1). The drawing will require three pocket operation, a face operation, a drill operation, and a pocket with island option operation at different Z depth to create the part. The combinations of all toolpaths result in the creation of CNC program for the part shown in Figure 2. It would be impossible to create this part using a single 2D drawing due to the overlapping of different sections of the drawing.

The drawing in Figure 1 is divided into five layers representing each section of the drawing. Layer one shown in Figure 3, contains the boarder and the shape profile of the part. The first toolpath is a pocket with the profile of the part as an island. The depth of cut is set at -1.5”, it will cut the boarder at the intervals of -.5”each time to the final depth of -1.5”. A ¼” flat end-mill cutter is used to cut this section of the part. The toolpath verification and the resulted part shape after the first operation are shown in Figure 3.

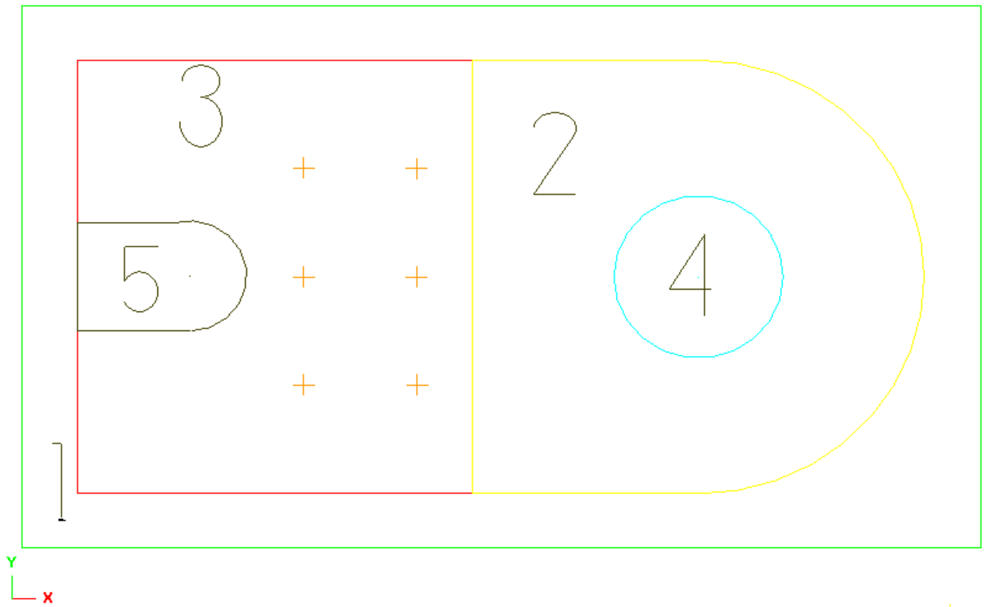

Figure 1: Drawing with five different layers saved as CAD drawing.

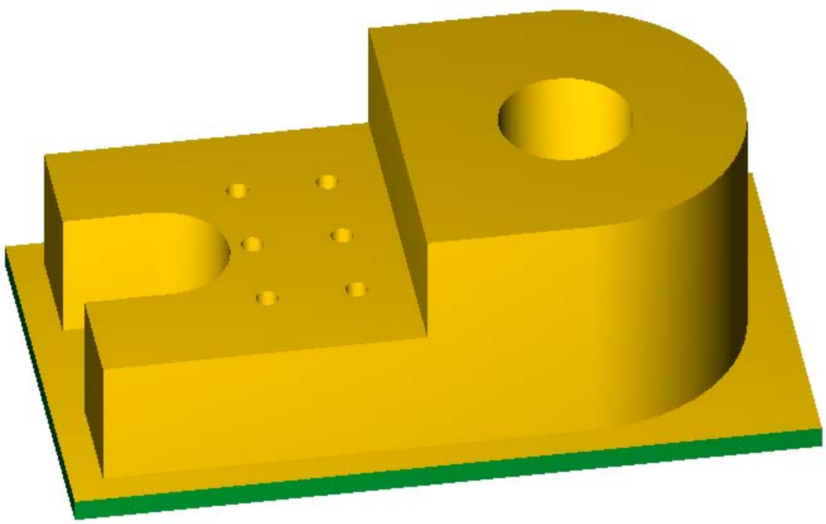

Figure 2: Finished machined part combining all five layers.

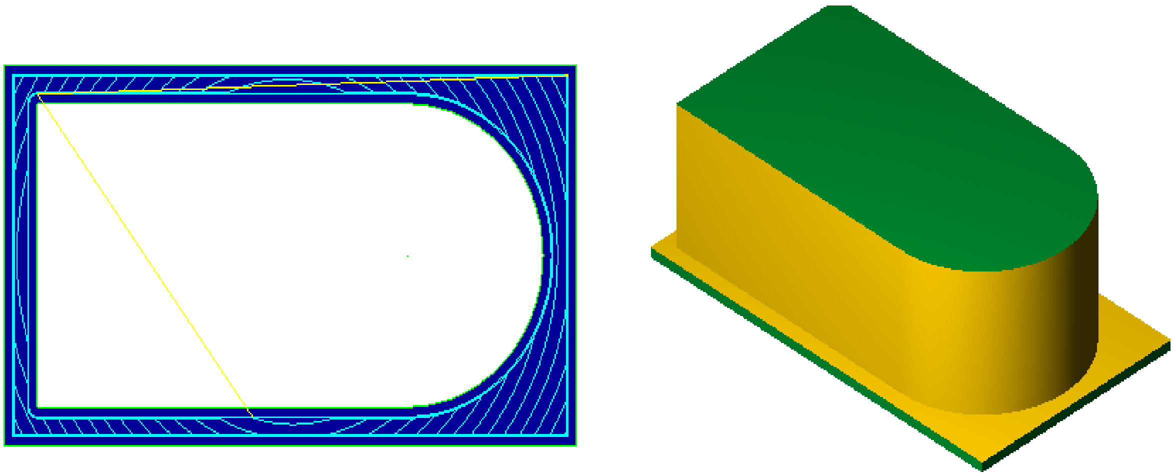

Figure 3: Toolpath verification and resulted part for layer 1.

Toolpath for layer 2 is a face operation which produces a flat surface. A face operation produces an oversized flat surface on top of a part. The depth of cut for facing operation is set at -.25. The cutter used to machine this section is a ½” flat end-mill. The spindle speed is set at a high speed to produce a smooth finished cut. Figure 4 shows the toolpath verification and the resulted part shape for the second operation.

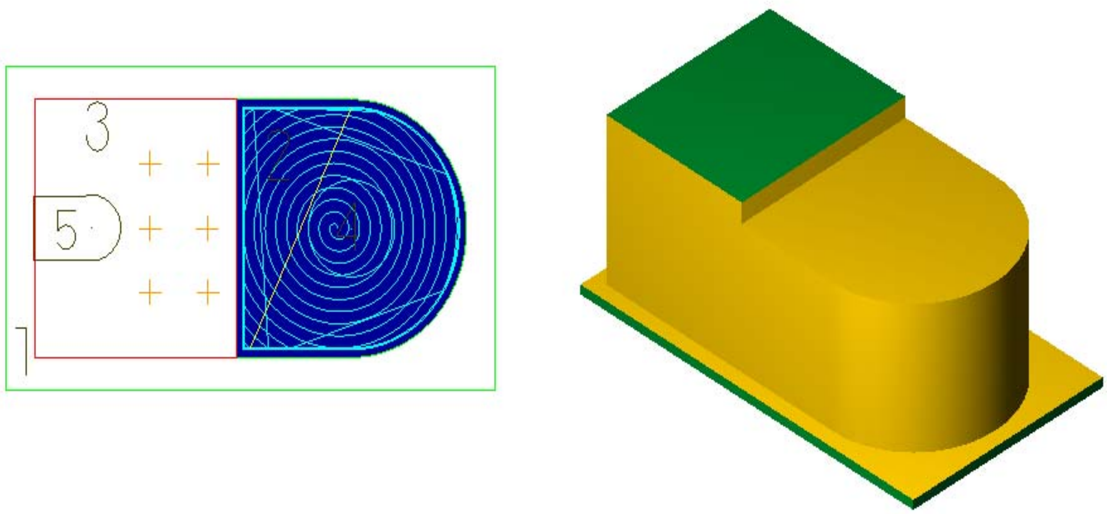

Figure 4: Toolpath verification and resulted part for layer 2.

Toolpath for layer 3 is a pocket operation it removes the material from an enclosed boundary. The depth of cut is set at -.5 and a ¼” flat end-mill is used to perform this operation. The cutting pattern to do this operation is set as a true-spiral path for a better finish. The toolpath verification and the resulted part are presented in Figure 5.

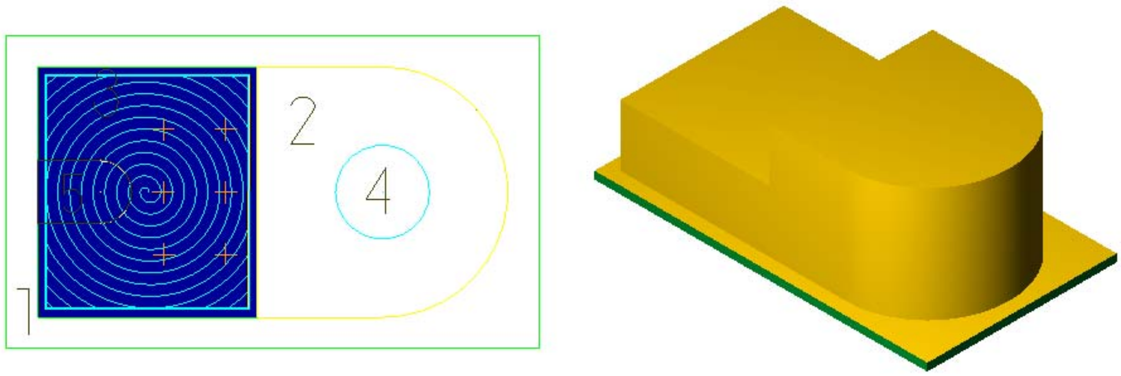

Figure 5: Toolpath verification for layer 3.

The pocket option is used to cut layer 4 which is a 1' diameter hole. It is pocketed at the depth of -1.5 inches in intervals of -.5 inch cuts. A 1/8" diameter cutter is used to make the round hole as true as possible. The toolpath verification and the resulted part shape are shown in Figure 6.

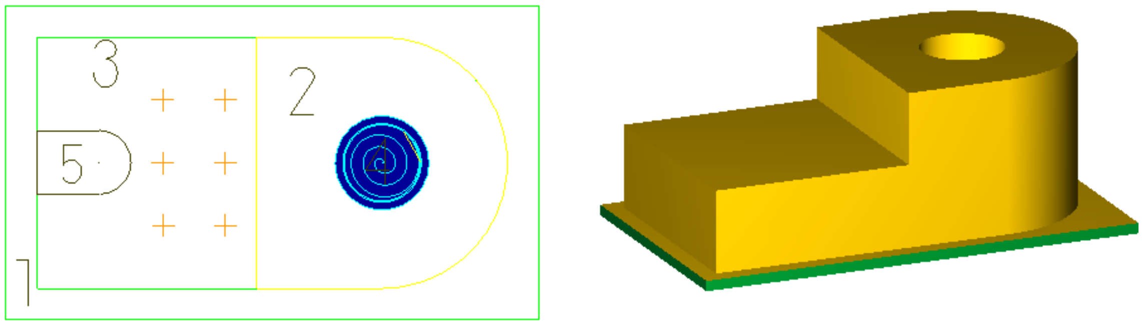

Figure 6: Toolpath verification and resulted part for layer 4.

The pocket option is also used for layer 5 which is a short keyway. The depth of cut is set at -1.5 inches and is cut in intervals of -.5 inch. The toolpath verification and the resulted part are shown in Figure 7.

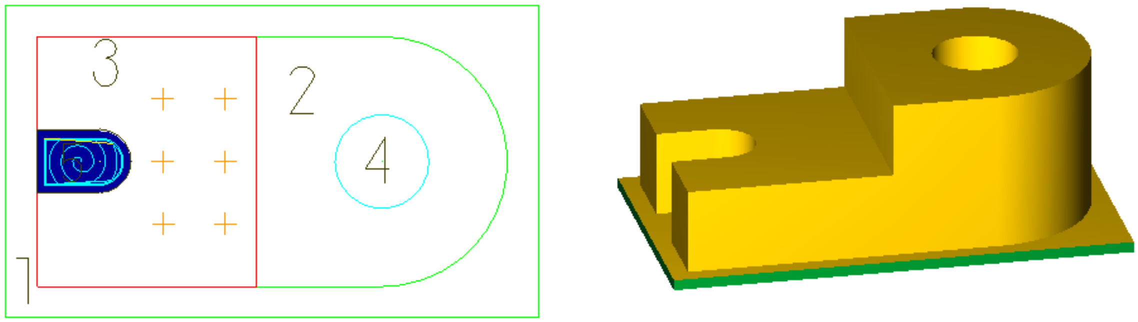

Figure 7: Toolpath verification and resulted part for layer 5.

The last operation to finish the part is a drilling operation. It will select all existing points within a window as the drill center locations. There are six point and they will be drilled to the depth of 1.5”. This operation completes the part and is shown in Figure 8.
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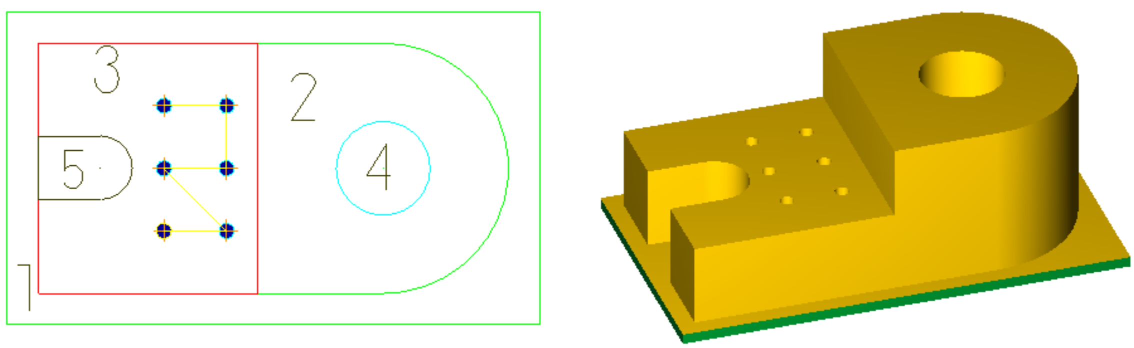

Figure 8: Toolpath verification for the finished part.

Summary and Conclusion

Creation of a part program using CAD/CAM process is a common practice in industry. The CAD/CAM process integrates the geometry, toolpath, and G-code program to create machine parts. The CAD/CAM procedure should be a step-by-step process done in a logical manner. The following steps are involved in the CAD/CAM process:

1. Creation of a CAD drawing
2. Assigning toolpath and cutting parameters to the drawing.
3. Producing needed toolpath for the shape.
4. Combining all the toolpaths to machine the part.
5. Creation of a final G-code program for the part.

Construction of different layers for a drawing is an innovative technique to simplify the process of generating a toolpath for a part. Understanding this method and implementing it in the instruction of the CAD/CAM process will enhance the learning ability of the industrial technology student. This method is an effective and innovative way for creating a challenging part and allows the programmer to simplify the toolpath creation process by combining individual toolpaths to create a part program.

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Dr. Heidari currently serves as an Associate Professor of Industrial Technology at Texas A&M University—Kingsville. Dr. Heidari has twenty years of teaching experience in CAD/CAM courses. He has numerous publications related to this topic. He is currently serving as the Graduate Coordinator for the Industrial Management Program.