Practical No. 6

Objective: The purpose of this experiment is to teach the process of calculating the coordinate points for a zig-zag milling pattern on a CNC machine. This pattern is commonly used in machining for operations like roughing out materials. By the end of this experiment, you will be able to:

1. Understand the basic concepts of coordinate systems in milling.
2. Calculate the required coordinates for a zig-zag milling operation.
3. Use these coordinates to generate tool paths for CNC machining.

Materials & Equipment:

1. CNC milling machine
2. Computer with CAM (Computer-Aided Manufacturing) software
3. G-code programming software (e.g., Fusion 360, SolidWorks CAM)
4. Measuring tools (callipers, micrometres)
5. Material block (aluminium, steel, etc.)
6. End mill cutter (appropriate size for operation)
7. Work holding device (vise, clamp, etc.)

Terminology:

Coordinate system: A system that defines positions in space, commonly used in machining. The two primary axes are X (horizontal) and Y (vertical), with Z representing depth.

G-code: The language used to control CNC machines, defining movements, speeds, and other operations.

Tool path: The planned route the cutting tool will follow, based on the coordinates and operation parameters.

Zig-zag milling: A milling pattern where the cutter moves back and forth across the material, typically used for rough cuts.

Procedure:

Step 1: Define the Workpiece and Setup: -

1.Material Selection: Choose a rectangular or square material block. A typical size for this experiment could be a 100mm x 100mm x 20mm piece of aluminium.

2.Workpiece Zero Point: Establish the zero point (origin) for the CNC machine. This is usually at the corner of the workpiece or the centre, depending on the job.

Option 1: Corner-based origin (X0, Y0 is at the corner).

Option 2: Centre-based origin (X0, Y0 is the centre of the workpiece).

3.Coordinate System Setup: If using a CNC machine, confirm that the machine's coordinate system matches the chosen origin and that it’s set to the correct units (usually millimetres or inches).

Step 2: Define the Zig-Zag Milling Pattern

A zig-zag pattern is used for operations where the cutting tool moves back and forth across the material. The tool starts from one edge, moves along the X or Y-axis, and then returns along the opposite direction.

1.Depth of Cut: For simplicity, assume each pass will cut to a depth of 2mm (or any desired depth based on material and cutter). The number of passes will depend on the thickness of the material and the depth of cut.

2.Cutting Width: This is the width of each pass. Typically, the cutter width should be around 80% of the cutter's diameter to ensure efficient material removal without excessive load.

3.Zig-Zag Path: The cutter will first cut along one direction (e.g., along the X-axis), then reverse and cut along the opposite direction (e.g., the opposite X-axis). The cutter will step down incrementally by the chosen depth of cut until the final depth is reached.

Step 3: Calculate the Coordinates

To calculate the coordinates for the zig-zag milling path, you will need to determine the following:

1. X and Y Axes Movements:

- For each pass, the cutter moves along the X or Y axis.

- Alternate between moving in the positive and negative directions along the X or Y axis to create the zig-zag pattern.

2. Step Increment: The step size depends on the cutter diameter and the desired width of each pass.

- If the cutter is 6mm in diameter and you choose an 80% step-over (width of cut), the step-over will be 4.8mm.

3. Depth of Cut: Start at the surface (Z0) and progressively decrease the Z-value by the depth of cut (e.g., 2mm) after each pass.

Example Calculation:

- Material Dimensions: 100mm x 100mm (length x width)

- Cutter Diameter: 6mm

- Step Over: 80% of cutter diameter (4.8mm)

- Depth of Cut: 2mm per pass

- Origin: Lower-left corner of the workpiece (X0, Y0 at the corner)

Pass 1 (First Zig):

- Start at (X0, Y0, Z0)

- Move along the X-axis to X = 4.8mm (first step-over).

- Move along the Y-axis to Y = 100mm (full width of workpiece).

- Step down to Z = -2mm for the next pass.

Pass 2 (First Zag):

- Move to X = 9.6mm (second step-over).

- Move along the Y-axis to Y = 0mm (start from the opposite side).

- Step down to Z = -4mm.

Continue:

- Repeat this process, alternating between the positive and negative X or Y-axis until the material is fully milled to the desired depth.

Step 4: G-Code Generation

Once the coordinates are calculated, you can input them into your CAM software or manually write the corresponding G-code. The basic G-code commands to control the CNC machine would include:

- G0: Rapid movement (non-cutting motion).

- G1: Linear cutting movement.

- Z: Depth control (e.g., Z-2.0 for 2mm depth).

- X, Y: Position control (e.g., X4.8, Y100).

Step 5: Testing the Tool Path

Before running the CNC machine on the actual material:

1. Use the "simulation" mode in your CAM software to verify the tool path.

2. Check for any collisions or errors in the path.

3. Conduct a dry run (without material) on the machine to ensure everything is functioning as expected.

Conclusion:

By following these steps, you have successfully calculated the coordinate points for a zig-zag milling job. This method is critical for generating accurate tool paths for rough milling operations, ensuring optimal cutting efficiency and material removal.