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Generalized Tool Path Planning Approach for Finish Machining For 3-Axis Vertical Milling

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ABSTRACT
The generalized tool path planning approach for finish machining has been presented in this paper. The aim of present work is development of generalized tool path planning for finish machining / pencil cutting for 3-axis vertical milling. The CAD modeller provides the information about the part geometry, which has been taken as STL file (Stereo Lithography). The STL data has been used as input to the tool path generation algorithm, which calculates the cutter location (CL) points for a pre-decided density of CL positions in X-Y plane. With the help of CL data as input for pencil cut tracing algorithm, the CL data pints for continuous contoured pencil cutting operation has been extracted.
The main features of the proposed approach are the extraction of pencil-cut points from the CL-surface, which has been scanned in X and Y directions by continuously comparing the Z level values of respective CL points. The relationship for estimation of the scallop height for ball end mill has been used to find the best CL data density for finding the appropriate pencil cutting positions. It is well known fact that the scallop height can be reduced with the help of reducing the side step value between two adjacent tool paths. The process of generating pencil-cut path is clear to understand, robust, and efficient, and the quality of the resulting path is high. The verification and testing of the accuracy of the pencil cutting algorithm has been done using a graphical simulator for 3-axis NC machining.

Introduction

Numerically controlled (NC) robotized machine tools, for example, milling shaper, drills and machines, that work from guidelines in a program. Original machines were hardwired to perform particular undertakings or customized in a low-level machine dialect. Today, they are controlled by microchips and are modified in abnormal state dialects, for example, APT and COMPACT II, which naturally create the tool path. Machining is utilized broadly in the aviation, car and numerous different businesses. NC has a noteworthy part in the everyday life. NC is fundamental to the activity of current modern robots.

Basic Components Of Cnc System

The CNC system consists of basic components. These basic components are discussed below in detail.

1. Program Of Instruction

The program of directions is the point by point well ordered guidelines to the machine tool to do. The most well-known strategy for the information is one broad punched tape. When alternate mediums likewise come in the presence like punched card, attractive tape, and even 35-mm movie film [36]. One can likewise include the guidelines straightforwardly into the control unit physically, this technique is called manual data input (MDI), which is utilized for exceptionally basic employments. Part programs are for the most part produced physically or with Computer Aided Manufacturing (CAM) programming bundles by utilizing the cutting parameters and the part's Computer Aided model information.

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2. NC Controller Unit Or Machine Control Unit (MCU)

The machine control unit is the heart of the CNC system. There are two sub units in the machine control unit; the Data Processing unit (DPU) and the Control loop unit (CLU).

(i) Data Processing Unit

DPU firstly interprets the part programme after receiving it and encodes the part programme for internal machine codes. The interpolator of the DPU then calculate the intermediate positions of the motion in terms of BLU (basic length unit) which is the smallest unit length that can be handled by the controller. This calculated data are passed to control lop unit for undue action.

(ii) Control Loop Unit

In CLU, to control the driving framework, the information from DPU are changed over in to electrical signs to perform the required movements. Different machine tool activity like machine shaft ON/OFF, Coolant ON/OFF and so forth are additionally controlled by the CLU according to machining interior codes feed by the software engineer.

3. Machine Tool

This can be any kind of machine tool or hardware. Keeping in mind the end goal to accomplish high exactness and repeatability, the plan and make of the machine slide and the driving lead screw of a CNC machine is of vital centrality.

A machine tool is a machine for molding or machining metal or other inflexible materials utilizing regular metal expulsion forms like cutting, exhausting, crushing, shearing or different forms of deformation like press working and utilizing non-customary machining forms like electric release machining or laser cutting. All machine tools have a few methods for compelling the work piece and give a guided development of the parts of the machine.

NC Machining Strategy

A machine tool is a machine for molding or machining metal or other inflexible materials utilizing common metal evacuation forms like cutting, exhausting, pounding, shearing or different forms of deformation like press working and utilizing non-regular machining forms like electric release machining or laser cutting. All machine tools have a few methods for compelling the work piece and give a guided development of the parts of the machine. In this way the relative development between the work piece and the cutting tool which is known as the tool path is controlled or compelled by the mechanical system of machine tool.

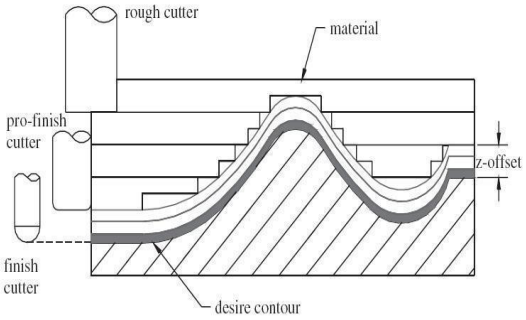

Figure 1- Different Machining Process

Strategies Used For Pencil Cutting

Amid the last 5– 6 years, a developing pattern has been creating in Computer-Graphics, and in addition in the CAD people group, towards surface models in view of discrete components like polygons, triangles and, as of late, focuses. With respect to and triangles, these have long been the standard essential component in realistic expanding in CAD/CAE/CAM.

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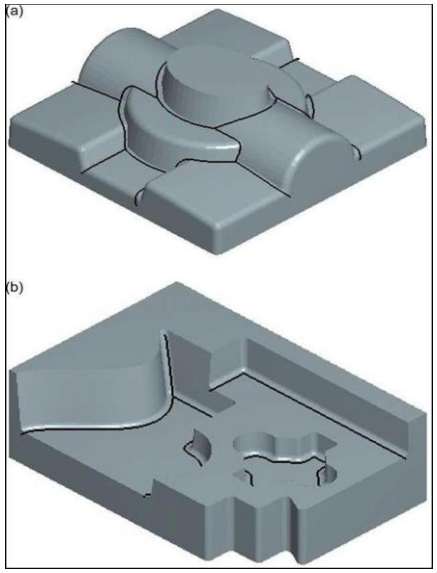

Figure 2-Pencil cutting regions in the contoured part geometry

Tool Path Planning Methods For NC Machining

Yau [11] and Lee [23] have presented tool path planning method, which have two types of tool paths, first one parametric and other non-parametric tool paths. The tool path is defined by two or three parameters which represents the complete surface. The computer representation of the designed surface is usually of parametric form. These parametric form are Bezier, B-helical, and Non-uniform rational B-helical (NURB) surfaces.

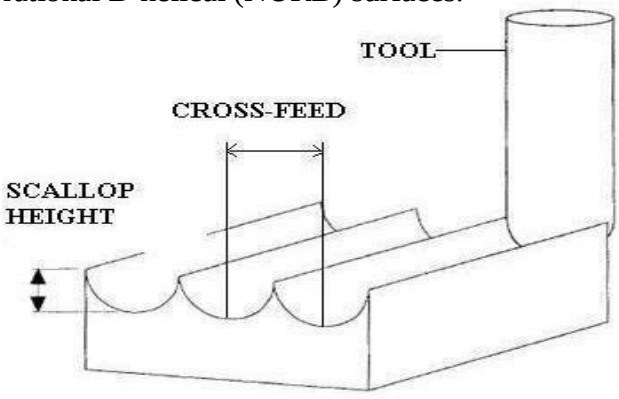

Figure 3- Cross Feed and Scallop Height Definition

Pencil-Cut Machining

Lee et proposed another Material-Side-Tracing strategy and a pencil-cut bend change system are anticipated for 3-axis pencil-cut path age. Pencil-slice machining has been utilized to dispose of staying material at very corners or bended areas after the finishing procedure.

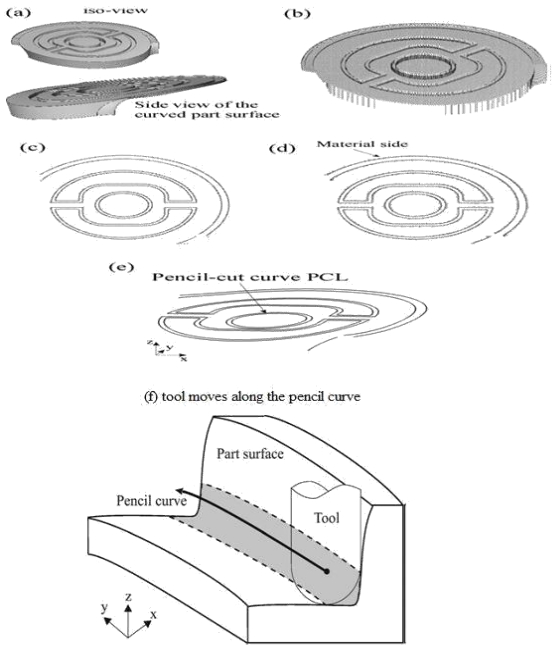

Figure 4- Pencil Cut Curve

Mathematical Modelling For Pencil Cutting Tool Path Planning

According to the pencil curve generation surface, the techniques of computing pencil curves can be classified into two categories:
1.Cutter-contact (CC) surface approach and
2.Cutter location (CL) surface approach.

Cutter contact (CC) and cutter location (CL) have been shown in figure 3.1. The radius of the concave-edge region is smaller than the radius of the ball-end mill.

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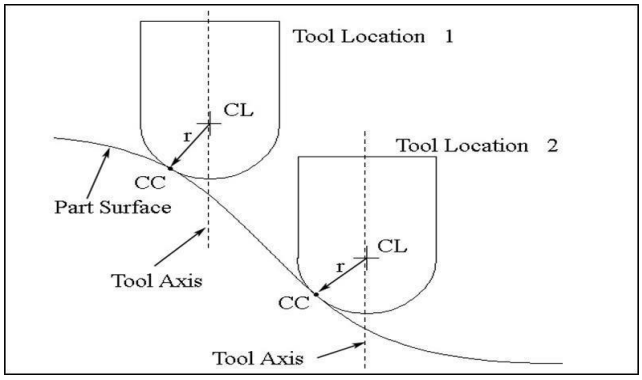

Figure 5- Cutter Contact CC and Cutter Location CL Points

Specification Of 3-Axis NC Milling Machine

The tool planning is improved the situation 3 Axis NC Raster Milling machine is having each of the three translational movements, tool infiltrate the work piece along Z axis, the tool cross along Y axis till it compasses to most extreme position of it with forward feed and after that bounce back to X axis with some client characterized side feed till the finish of part.

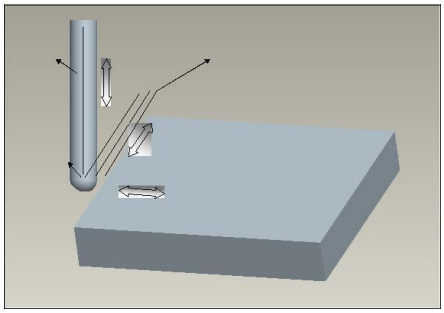

Figure 6-axis NC raster milling

Inputs Required For NC Tool Path Planning

The various inputs which are used for the machining to be done are:

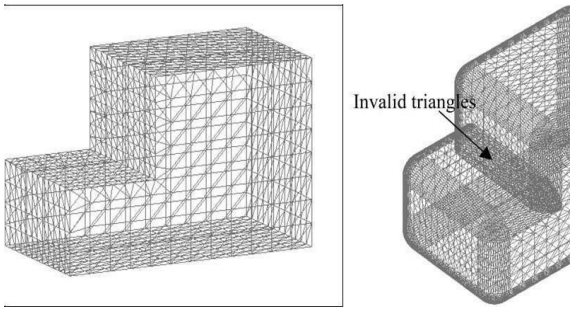

Figure 7- Triangular Mesh

STL Data For CAD Model

The STL record [5][19] is utilized as first contribution to the tool path age calculation for finish machining. This STL(Stereo-lithography) can be made on any of the each CAD demonstrate has capacity to store the CAD display as .The info CAD modals are triangulated surface modals .STL format. For now the SOLIDWORK has been utilized to make the .STL document.

solid*name*

facet normal *n1 n2 n3*

outer loop

vertex*v11 v12 v13*

vertex*v21 v22 v23*

vertex*v31 v32 v33*

endloop

endfacet

endsolid*name*

Figure 8- STL File Format

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CL-Surface And The CL-Net Data

A CL-net is utilized to store the CL information of a given best perspective of work piece. To make a CL-net, a progression of CL (bends cut from CL-surface by parallel guide planes) are first made along both the X and Y headings with an interim d, separately.

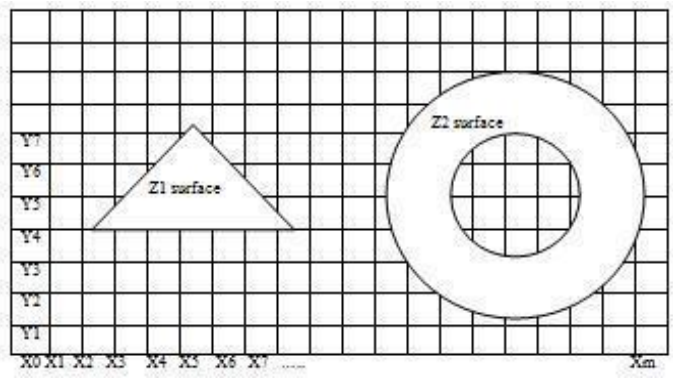

Figure 9-2D Graph with Top View

Detecting Pencil-Points

CL information net has x, y and z arranges for all focuses in top view. In this paper, filtering of CL information net has been two composes first in x direction and second in y direction. In the technique, discover the focuses, have bigger change in z arrange and get the estimations of least z. In x direction, information net has examined x least to x most extreme and in y direction, y least to y
greatest.

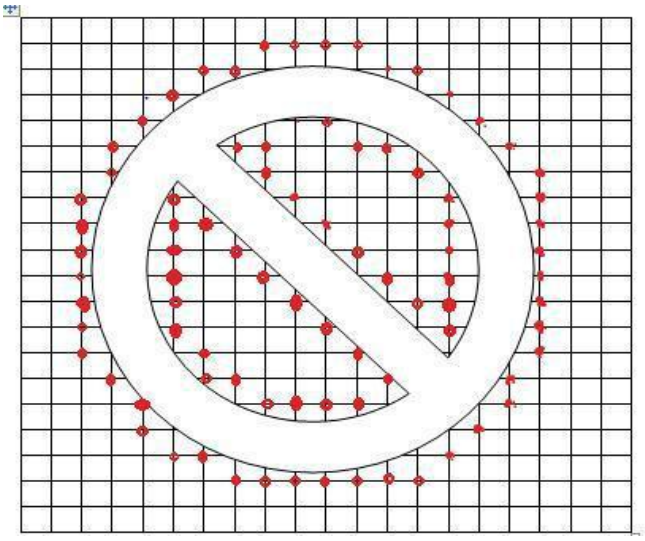

Figure10- Tool Path Points for Pencil Cutting

Solution Procedure For Pencil Cutting Tool Path Planning For3-Axis Vertical Milling

Based on methodology explained in earlier sections a computer program has been developed in JAVA. The flow chart of an iterative scheme is shown with full step taken in figure.

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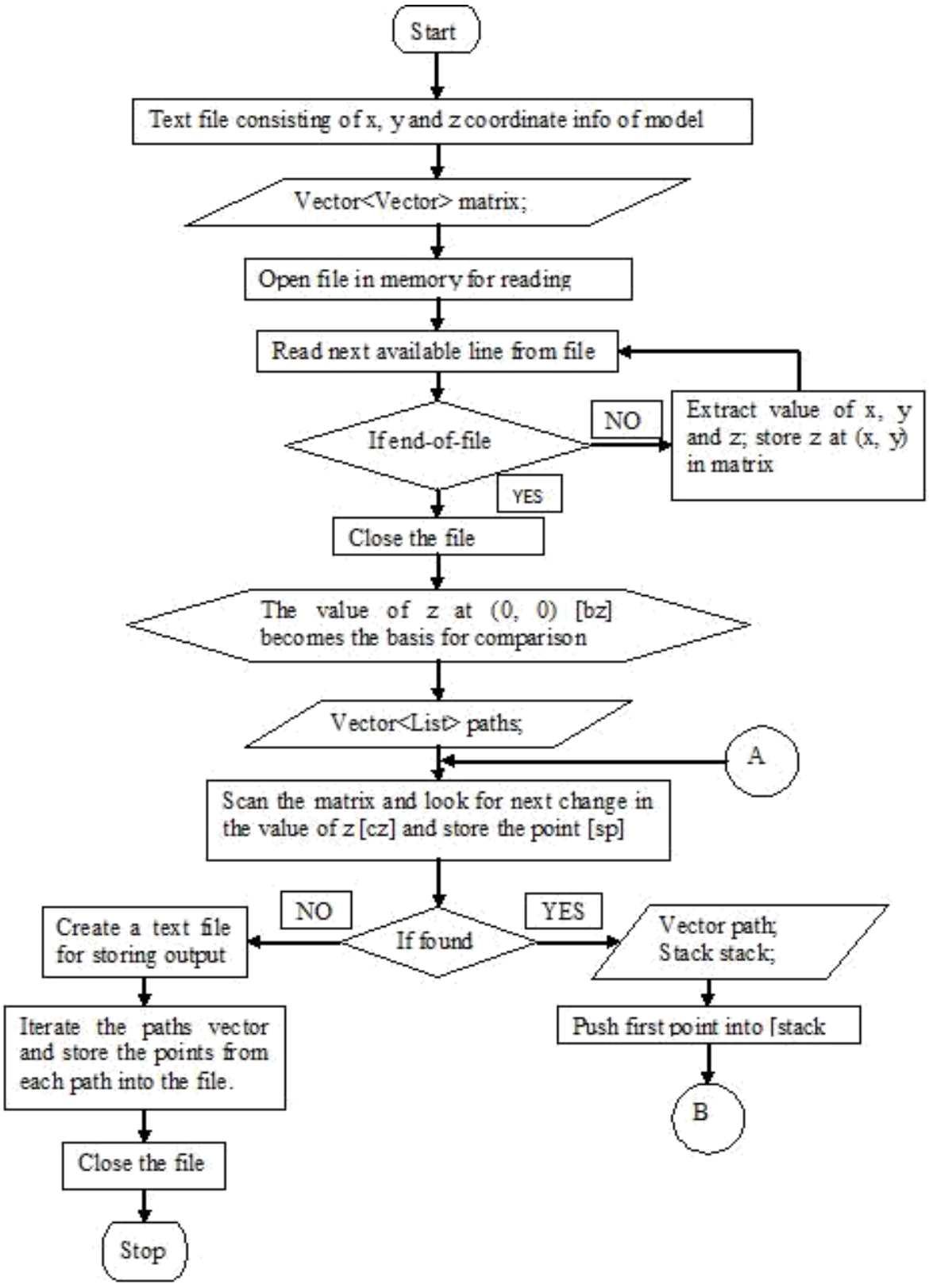

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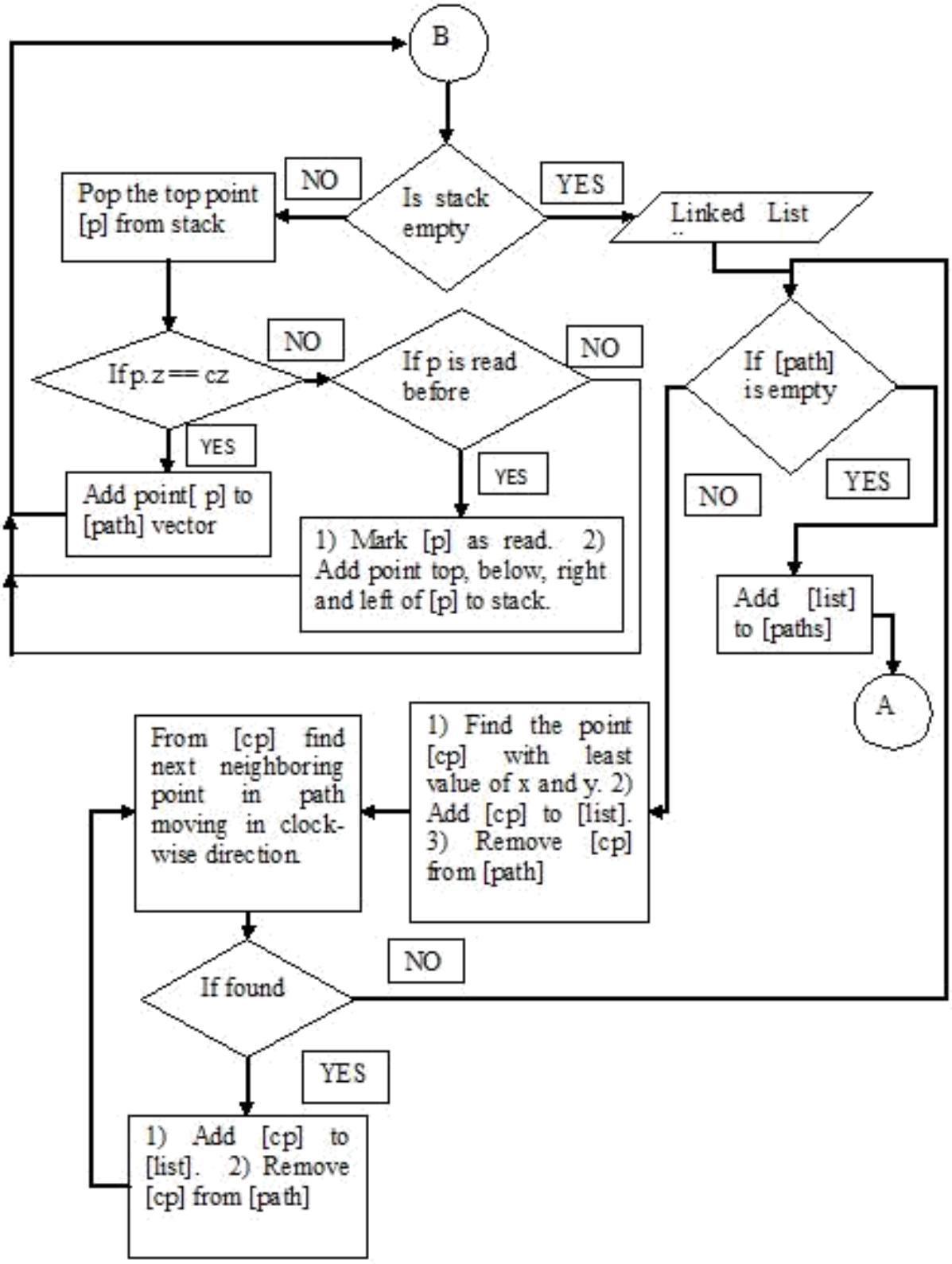

Figure 11- Flow Chart for overall process

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Results And Discussion

The tool path age and planning which has been done in section 3 has been approved and genuine finishing for level surface part on 3 Axis vertical milling. The tool path age and planning for finishing for raster milling is approved on test system.

Tooling Used

The tool utilized as a part of the calculation is ball nose end process shaper. The span of the tool is 1.5875 mm utilized, however their range can be altered and the calculation works for any tool sweep. In the calculation, the tool is moving in direct and nonlinear way.

CL information focuses have been computed for the ball end factory of 1.5875 mm range. At that point utilizing the JAVA calculation pencil cutting tool path is extricated from CL information net to check the reasonableness of the above created calculation. Three section models have been picks as portrayed in the approval and exchange some portion of this part.

Relation Between Side Step Values And Scallop Height

Relation between side step and scallops height has been discussed below with the help of figure.

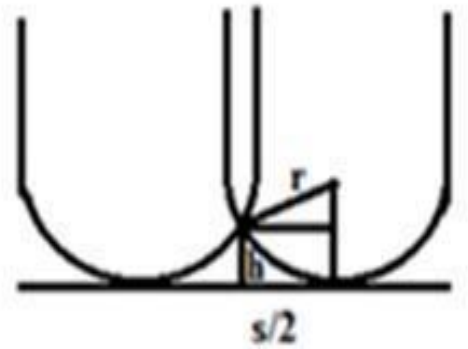

Figure 12-Scallop Height (h) And Side Step (s)

The scallop height is density proportional to side step value for ball end mill. The mathematical relationship between scallop height (h) and side step value(s) is as written below :

Scallop height formula:

$$h = r - \sqrt{(r^2 - s^2/4)}$$

Where h= scallops height
r = radius of tool
s= side step

Pencil tool radius (r) in Mm	Side step (s)in mm	scallops height (h) in mm
1.5875	0.5	0.019808624
1.5875	0.4	0.012648816
1.5875	0.3	0.007102502
1.5875	0.2	0.003152736
1.5875	0.1	0.000787596

For validation of results from the pencil cutting algorithm the side step values of 0.5, 0.4, 0.3, 0.2 and 0.1mm has been chosen. The maximum scallop height that will be generated in finish milling machining these scallop height has been calculated and shown in table.

Validation And Results Of Pencil Cutting Algorithm

Stomach muscle modular without pencil cutting has been appeared in figure.

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Figure 13- AB Modal without Pencil Cutting

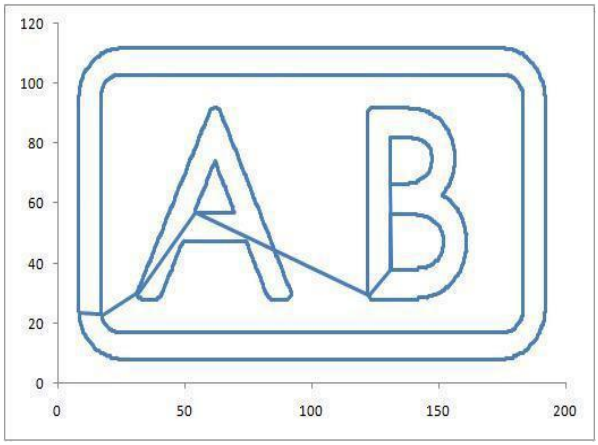

Figure 14- Pencil Cutting Tool Path for 0.5 Side Step

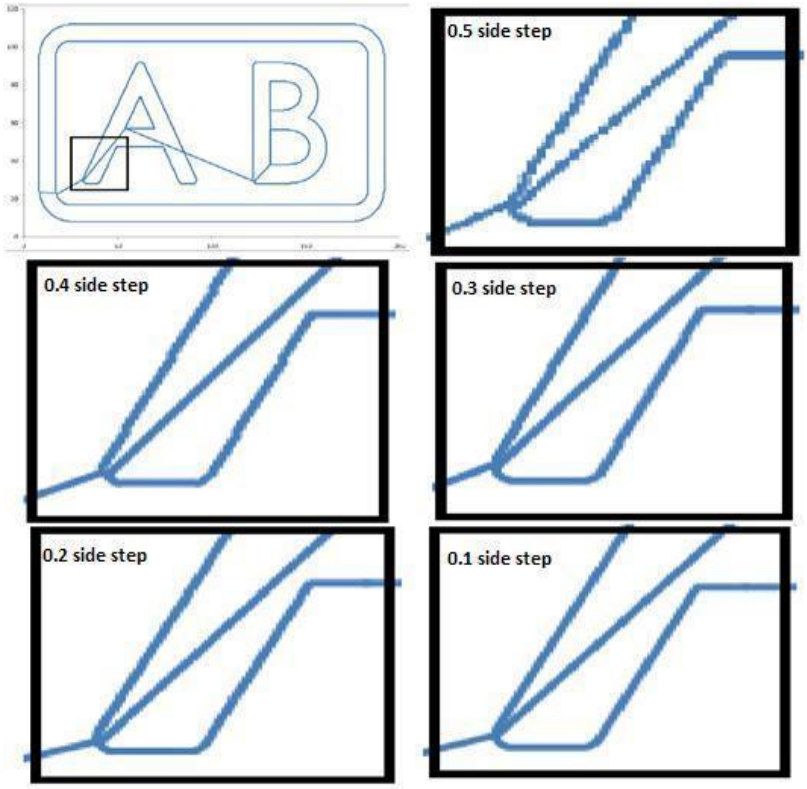

Figure -15 Pencil Cutting Tool Path for all five Side Step

To analyze the precision of pencil cut tool paths, the pencil cut tool paths were additionally produced for 0.4mm, 0.3mm, 0.2mm and 0.1mm evade esteems and the gives of pencil cut tool path in X-Y plane for littler segment as featured in figure15 has been appeared for every one of the five avoid esteems. One can look at that the 0.1mm avoid tool path is the most exact out of aggregate time pencil path. The figure 15 demonstrates the finish cutting activities for AB modular without pencil cut tool. The CL information for AB demonstrate for finish machining is produced for raster machining.

Conclusions

The results and validation for working of the pencil cutting algorithm developed in the present paper.

(i) It takes a lot of computational time for calculation of CL data net for finish machining at finer side step values, but one can suitably choose comparatively larger side step value for finish machining and one can take finer side step values for CL data generation for extraction of pencil cutting tool paths. The pencil cut tool path acquired for finer side steps will be far shorter than the corresponding total CL data net.

(ii) The actual machining time for pencil cutting operation is going to be far smaller than finishing operation time even at very fin side step values for finishing.

(iii) The present algorithm is free from additional computations required for offsetting the actual STL surface and other hazels of eliminating the excessive offset data for finding the suitable CL data net for finish and pencil cut operations.

(iv) The present approach gives the best results compared t other pencil cutting approaches reported in text so far in terms of computational simplicity and accuracy of pencil cutting tool path data as the pencil cut data extracted from CL data net is gouge free.

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