Solidmodeling And 5-Axis Manufacturing Of 3d-Impeller Of Centrifugalcompressor

K.Sunitha * & Ch.Srinivas Rao**

*M.Tech (CAD/CAM) Student

**Associate Professor of Mechanical Engineering

Department of Mechanical Engineering

Sreenidhi Institute of Science and Technology

(An Autonomous Institution under JNTU)

Ghatkesar, Hyderabad-501301

ABSTRACT

Impeller is the most vital component in functioning of a centrifugal compressor which consists of curved vanes which are fitted symmetrically. The fluid enters the impeller axially at the eye of impeller and then flows radially out of impeller. The gas then goes through diffuser to the return channel and further goes into next impeller. The rotating impeller imparts kinetic energy to the flowing gas, which is then converted into pressure energy in the diffuser.

. Because of the twists and the narrow gap between the vanes, normal 3 axes CNC machining methods are not adequate. As the complexity of the component geometry is high, Computer Aided Part Programming techniques are essential for generating the required 5-axes CNC code. The commercially available CAD/CAM software's do not offer ready solutions in respect of the complexities involved in 3D-impellers.

Unigraphics is the software through which one can draw and create the part module and the manufacturing applications allow us to create NC machining programs, generate tool paths, visualize material removal, simulate the machine tool, and post process.

Previously they used to draw the module through AUTOCAD generate the program using C or manually for 2D for 3D they used to bring the program from R&D unit.

In this Paper, a model of 3D-impellers has been drawn through Unigraphics. Then machining has be done for the given vanes and remaining part. After that the program has been post process by 3-axis the post processor in built in Unigraphics. This post processor program then transferred to CNC 5-AXIS Machine through DNC. The above program has been checked through simulation mode followed by Optimization technique used for minimizing the undercuts and finally used to machine the component followed by inspection.

Key words: Modelling in Unigraphic , Generating CNC Part programming, Optimization Technique, Manufacturing of 3D-Impeller in 5-axis Machine.

ISSN: 2278-0181
Vol. 1 Issue 9, November- 2012

INTRODUCTION

Typically, in a 3D- Impeller the vane surfaces are twisted ruled surfaces. The twist in the ruled surface results in varied orientations of the normals at the extreme points of the same rulings. The difference in orientation of the normals on the same ruling will cause undercut while machining the vane by keeping the ball nose end mill cutter tangential at any one end of the rulings. To minimise the undercuts and keep the impeller within the geometrical tolerances, it is necessary to adopt new techniques while placing the cutter along the vane surface. The normal 3-axes CNC machining methods are not adequate, and hence 5-axes CNC codes are required to be generated. In order to exercise better control over the tool orientation, it is essential that specific user-developed modules are integrated with the CAD/CAM packages for successful generation of 5-axes CNC codes. This paper discusses the important aspects of 5-axes CNC programming for 3D-Impellers and an optimisation technique for minimising undercuts.

5-AXIS MACHINE

5-Axis machining refers to the ability of a CNC machine to move a part or tool on 5 different axes simultaneously. It allows the machine tool to access all sides of the component, subject to fixturing restrictions and can be used for basic positioning (sometimes referred to as 3+2) or full simultaneous 4- or 5-Axis machining where the linear and one or more rotary axes are used simultaneously. There are a number of areas to consider with 5-Axis machining:

- SWARF cutting is a popular technique in 5-Axis machining, where the side of tool is used to machine tilted walls and can provide large efficiency improvements over traditional 3-Axis methods.

UNIGRAPHICS

Unigraphics is sophisticated software used to create complex designs with great precision. The design intent of any 3– Dimensional model or an assembly is defined by its specifications and its use. One can use the powerful tool of design intent of any complex model by incorporating intelligence into the design.

Fig 1 shows the model of the 3D-impeller in Unigraphics and its Tool path simulation is given in Fig.2. After modelling of 3D-Impeller,

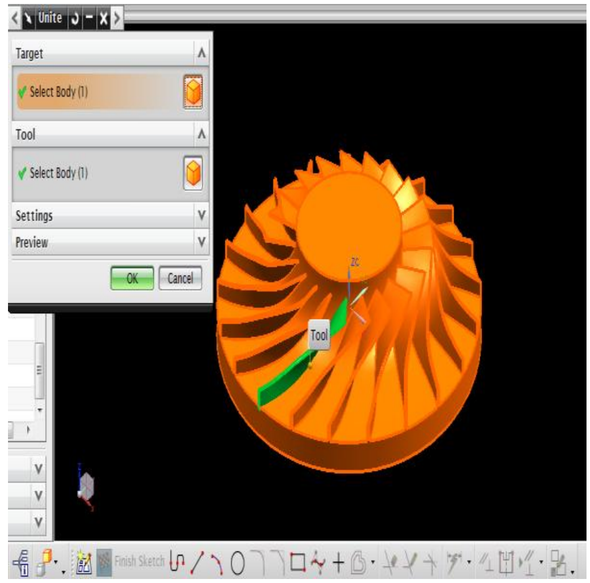

Fig 1 : Geometrical model of 3D-Impeller

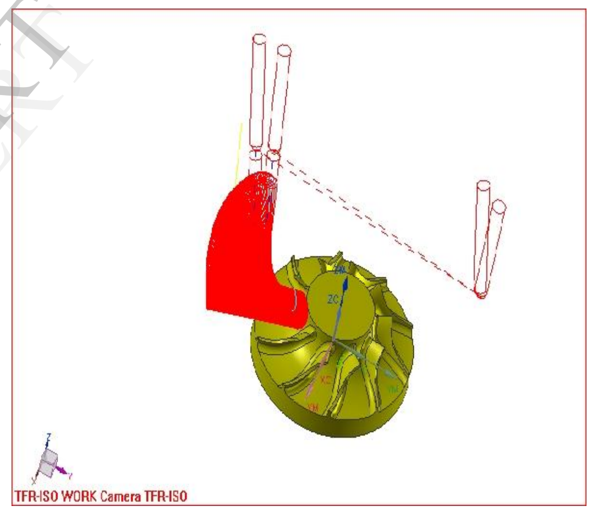

Fig 2: Tool path simulation

OPTIMIZATION TECHNIQUE

FLANK MILLING (Swarf Machining)

In this method, the tool is placed parallel to the rulings of the vane surface and the side of the cutter machines the vane surface. By this method, the surface finish on the vane surface is excellent, but considerable amount of undercut is formed on the vane surface.

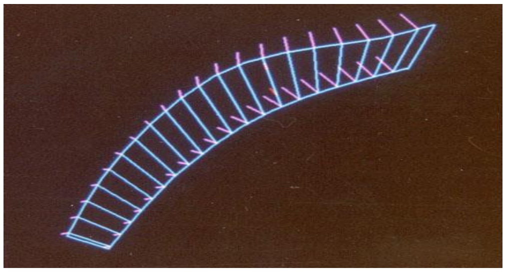

Fig 3 Surface normals of vane

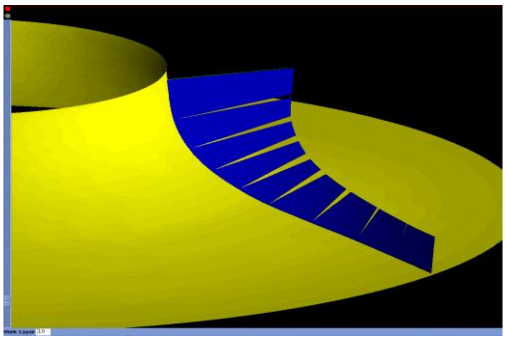

Fig 4 Undercut on vane surface

EXTENT OF UNDERCUT IN FLANK MILLING

The extent of undercut (d) formed in the Flank Milling method, basically depends on the difference in the slopes of the two parameter lines of the vane surface. This is nothing but the deviation in the angles (A) of the normals. The other parameter which influences the undercut is the cutter radius (R). The undercut is the function of the cutter radius and the variation in normals, as given , $d = R \{1-\cos(A/2)\}$.... (1)

This feature can be appreciated by studying the concept of machining a cylinder with the side of the cutter whose axis is skewed. Since the normals of the two end points on the cylinder surface are at different orientations, the undercut will be formed. This will be the maximum in the middle of the cylinder and will decrease gradually to the two ends. This amount of undercut will depend on the angle made by the two axes and the cutter radius. Though the cutter radius is one of the criteria, the selection of cutter radius is constrained because of two main considerations:

a) the fillet radius between the vane and the hub;

b) the slenderness of the cutter. Hence, the programmer is left with an option of optimising the tool orientations for achieving the dimensional tolerances.

MATHEMATICAL SOLUTION FOR MINIMISING UNDERCUT

In the normal practice, the placement of the tool will be with respect to the hub and shroud parameter lines of the vane, i.e. the 0 and 100 percent of vane surface, which results in undercuts at the middle of the vane surface. An iterative procedure is adopted to distribute the undercut throughout the vane, to achieve the required dimensional tolerances.

PARAMETER LINES FOR MINIMISING UNDERCUT

In this technique, the parameter lines of the vane surface at various levels, such as PL0, PL25, PL75 and PL100, are used as rails for guiding the. In the normal Flank Milling method, 0 and 100 percent parameter lines, designated as PL0 and PL100, are used for placing the tool tangential to the surface. In this optimisation technique, the angle between the two normals is optimised by selecting two parameter lines (e.g., PL25 and PL75) for distributing the undercut over the vane surface. The software sub-modules are to be developed for choosing the parameter lines on the vane surface in an iterative manner, to minimise the extent of undercut.

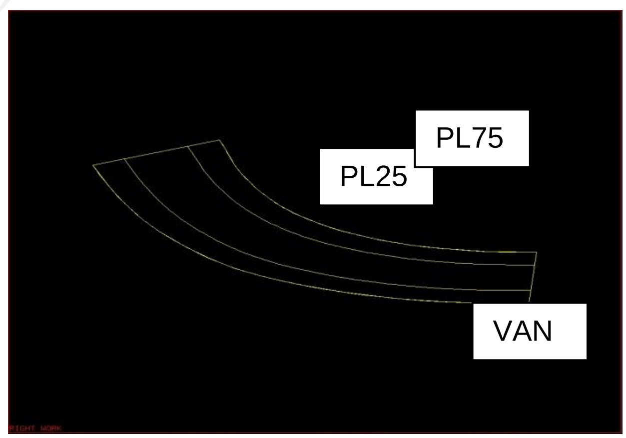

Fig 5 Parameter lines on the vane surface

The iterations are carried out to identify those parameter lines of the vane surface which will have the 25% and 75% of the included angle values with the base parameter line PL0. Since the twist of the vane is not uniform, the vane surfaces are divided into a number of patches, for which the optimal parameter lines to form the rails, for placing the tool, are identified. Subsequently, the complete tool path is evaluated and the Cutter Location data is generated.

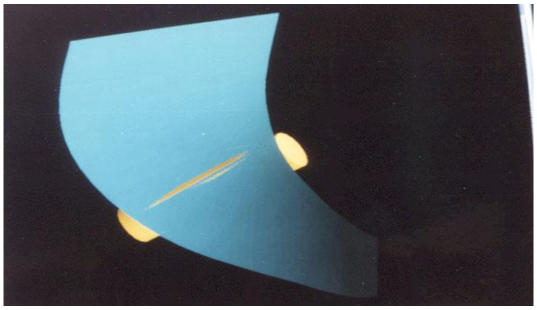

Fig 6 Undercut reduced significantly using optimization technique

RESULTS

In this paper, a model of 3D impeller was drawn through Unigraphics. Then machining has been done for the given vanes and remaining part. After that the program has been post process by 3 -axis the post processor in built in Unigraphics. This post processor program then transferred to CNC 5-AXIS Machine through DNC. The above program has been checked through simulation mode, performed optimization and finally machining has been done for the component followed by inspection.

A reduction of 50% in the undercut is observed using the parameter line optimisation technique, against the normal Flank Milling method. This technique for minimising undercut is found to be very fast and accurate, without necessitating any manual intervention or trial-and-error procedure.

A 3-D Impeller of 600 mm diameter, vane width varying from 20 mm to 70 mm from the outlet to inlet, with 10 vanes, was machined. The machining was carried out using 16 mm diameter ball nose cutter. An undercut of 0.20 mm was observed on the vane when the normal Flank Milling option was used. The undercut reduced to 0.10 mm when the above optimisation technique was used.

REFERENCES:

[1]. Erik L.J. Bohez, S.D. Ranjith Senadhera, Ketan Pole has described geometrical modeling and manufacturing of centrifugal impeller by 5-Axis machine

[2]. C.H. Chu, W.N. Huang, Y.Y. Hsu developed a new adjustment in improving machining accuracy of tool path in five-axes milling of flank ruled surfaces..

[3]. D Roth, S. Bedi, F. Ismail, S. Mann have presented a method of determining the shape of the surface swept by tool that follows a 5-Axis tool path for machining curved surfaces

[4]. C. G. Jensen, W.E. Red, J. Pi developed an automatic cutting tool selection methodology for five-axis finish surface machining based on techniques of curvature matched machining.