iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 8 **Issue:** III **Month of publication:** March 2020

DOI:

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 8 Issue III Mar 2020- Available at www.ijraset.com

Machining Simulation of the Three-axes CNC Lathe of the Drilling

Dr. N. Senthilvelan [1], T. N. Anbarasu[2], G. Rajamahendran[3]
[1] Professor , [2, 3]Assistant Professor, Department of Mechanical Engineering, Sembodai Rukmani Varatharajan Engineering College, Vedaranyam, Tamil Nadu, India

Abstract: The paper designs the algorithm of three-axes CNC Lathe processing program tool path on the basis of traditional CNC Lathe processing program and the machining simulation is made on the platform CAXA. The algorithm includes end face G01 drilling and radial G01 drilling.
Keywords: lathe, algorithm, simulation, drilling

I. INTRODUCTION

The machining simulation is one of the core technologies of CNC machining systems. Traditional methods of machining on the NC program is not only time consuming but costly. However, problems existing in the NC program can be found by simulation technology for CNC machining process simulation. Then the track can be modified and optimized[1~4]. For ordinary CNC lathe, the drilling is limited to the processing center hole. But the drilling of other positions' holes of parts' end face and radial needs the help of other machines[5]. The ordinary CNC lathe cannot guarantee complete machining in one clamping. Not only does it reduce efficiency, it is not conducive to guarantee the quality of parts. In contrast, the three-axes NC, with its spindle having indexing features, as well as the power holder, drilling location will no longer be restricted. When drilling holes of the end face are needed, we just need to transfer to the center of the hole to the horizontal position one by one, and then move longitudinally to determine the cut point, next drilling a horizontal direction. When drilling holes of the radial are needed, we just need to transfer to the center of the hole to the horizontal position one by one, and then move longitudinally to determine the cut point, next drilling a horizontal direction[6-8]. CAXA has powerful graphics capabilities and sophisticated external data interface of CAD software which is capable of drawing any complex graphics and is able to exchange data with other systems via DXF, IGES and other data interface[9~11].

II. THE ALGORITHM OF DRILLING

A. Algorithm of end face G01 Drilling Motion Simulation

1) *Concept of end face G01 drilling:* First, G01 end face drilling, is the process of complete the processing of parts anywhere in the end face of the borehole, using three-axis CNC lathe C-axis spindle indexing function as well as linear interpolation G01 instruction. When axis CNC lathe end faces, the tool involves three positions in the Z coordinate movement hole machining process, namely: the initial level height, R plane height and flat bottom of the hole, as shown in Figure 1.

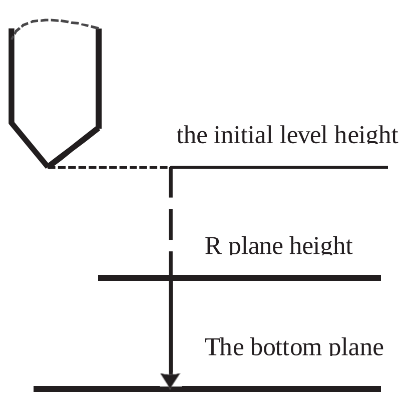


Fig. 1 The Z coordinate movement of drilling

2) *Design the algorithm for end face G01 drilling:* End face drilling can generate distinct section of the upper end face machining tool path at the same time. Therefore, before the tool path calculations, we need to determine the location of the point to be drilled on each section. Because there are a front view and a left view illustrating the parts, the drilling point is determined by the drilling points of cross section in the left view and gaze position of cross section in the front view. Drilling positions were picked up by the interaction, the process is as follows, and the algorithm architecture is shown in Figure 1.

a) Picked up the left-sectional view of the origin of coordinates, set sectional view of the origin of coordinates for the left as $O(x, y, z)$.

b) Pick up the drill point in the cross-sectional view of left, P_1 , P_2 ...P_n (n □ 1)

c) Note the picked curve chain, pick up the gaze position in the cross-sectional view of front.

d) Repeat process (2), (3) until finishing picking up drill points for all sections.

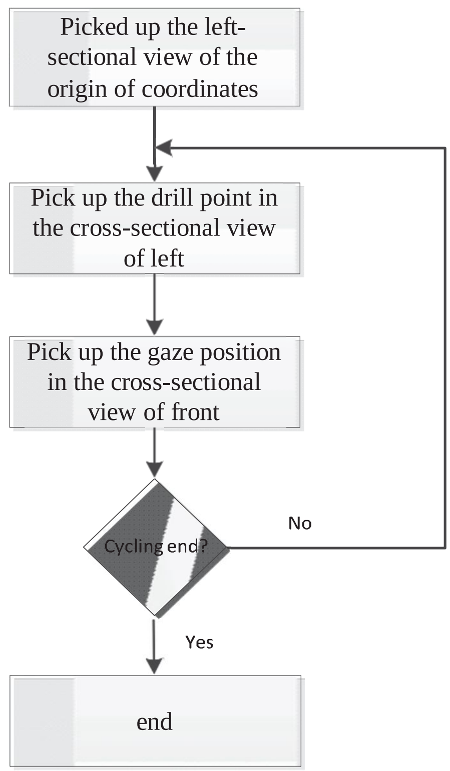


Fig. 2 Algorithm architecture

When the number of the picked-up section is n, comparing the values of horizontal coordinate in all sections and security height, we can ensure that safety plane is above the machining plane.

Calculate the number of cut and the cut depth for each hole.

Respectively, variables *num* and *depth* express them. Variable *deep* represents the drill depth, *step* represents the number of cut, *step _ dis* represent step length of cut.

depth □ *deep* / *step* (1)

num □ *step* (2)

In the algorithm of end face drilling, the drilling points for each section and the corresponding position of the axis tool path points are stored in the chain. Using the traversal of the chain of tool path, we can get a cross-section of all drilling points and axis position, then get drilling tool path.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 8 Issue III Mar 2020- Available at www.ijraset.com

Get all vectors of drilling points' tool axis. Assuming the drill point coordinates of a cross-section as $P_i\,(x, y, z)$, the corresponding point of the axis position as $AP_i\,(x, y, z)$, the tool axis vector representation of the point as $V_i\,(x, y, z)$, variable d_i represents the distance from the center to the drilling point. There,

$$d_i = \sqrt{(Pi_y - center\_pt_y)^2 + (Pi_y - center\_pt_y)^2 + (Pi_z - center\_pt_z)^2} \quad (3)$$

$$V_i = \left(0, (P_i - center\_pt_y)/d, (P_i - center\_pt_z)/d\right) \quad (4)$$

When drilling, the tool firstly moves to the location of the security planes, and then quickly move to the position of the R plane, after entering the R plane, the tool will start cutting. R plane is a tool which is the interface of fast-forward and normal-forward. To sum up, in order to get the tool path, you need to obtain safety plane of drill points and the position of R plane. With variable $safe\_pt\,(x, y, z)$ indicating the position of the safety plane, there,

$$safe\_pt_x = safe\_height \quad (5)$$

$$safe\_pt_y = Pi_y \quad (6)$$

$$safe\_pt_z = Pi_x - center\_pt_x \quad (7)$$

Where $safe\_height$ represent safety height.

Variable $ref\_pt(x, y, z)$ represents the position of R plane, there

$$ref\_pt_x = APi_x + dis \quad (8)$$

$$ref\_pt_y = safe\_pt_y \quad (9)$$

$$ref\_pt_z = safe\_pt_z \quad (10)$$

Where dis represents safety gap which means the distance from end face to cut point.

For the hole whose drilling point is $Pi\,(x, y, z)$, it starts drilling when tool path enters R plane. Then we need to calculate each cut's final point. Assuming the final point $cur\_pt(x, y, z)$ of the $i - th$ $(1 \le i \le num)$ cut. There is,

$$cur\_pt_y = ref\_pt_y \quad (11)$$

$$cur\_pt_z = ref\_pt_z \quad (12)$$

If $i \ne num$, namely, it is not the last cut, there will be:

$$cur\_pt_x = APi_x - i \cdot depth \quad (13)$$

If $i = num$, namely, it is the last cut, there will be:

$$cur\_pt_x = APi_x - i \cdot deep \quad (14)$$

Assuming the safety gap point of the $i - th$ $(1 \le i \le num)$ cut as $RP(x, y, z)$ in accordance, we can get:

$$RP_x = cur\_pt_x + dis \quad (15)$$

$$RP_y = ref\_pt_y \quad (16)$$

$$RP_z = ref\_pt_z \quad (17)$$

After calculating the tool position data, connect the straight line of the safety plane and the R plane as a fast feed trajectory drilling, connect safety plane and the straight line with the lower cut machining end point as the cutting tool path during drilling. If the processing is non-final cut, the rear end of the cutting tool will come back to the safety clearance point, which means that we need to connect the process under the cut straight starting with R plane as a retraction trajectory; if the processing is the final cut, after the end of the cutting tool will come back to the safety of the plane, which is to connect the final cut straight and machining plane as the starting point and finishing safe retraction trajectory. After the completion of the processing, move from the safety position of a hole to a secure location of the next hole Generates auxiliary tool path, which is to generate a corresponding trajectory of drilling in the sectional view of left. We can conclude that the track is composed of a series of circular components. Assuming to process the j □ th hole of the i □ th section, the position of the holes is $Pij(x, y, z)$.

With the drill holes' coordinates and the diameter of the circle, we can define parameters of the coordinate system of the position, namely:

$$
\begin{aligned}
&Pc = Pij \\
&r = tool\_radius \\
&\alpha = 2\pi \\
&Px_x = Pc_x + 1 \\
&Px_y = Pc_y \\
&Px_z = Pc_z \\
&Py_x = Pc_x \\
&Py_y = Pc_y + 1 \\
&Pz_z = Pc_z
\end{aligned}
\tag{18}
$$

B. Algorithm of radial G01 drilling

1) *Concept of radial G01 drilling:* Radial G01 drilling, with the function of three-axis CNC Lathe C-axis indexing, using linear interpolation G01 instruction, is the process of radial drilling.
2) *Design the algorithm for radial G01 drilling* : Radial drilling parts diagram shows the view from the front view and left. The front view shows the position of a radial axis of the bore, and the left side view shows a cross- sectional where the radial bore is located, including the information of a radial hole's machining start point and machining end point. Assuming the origin of the coordinates in the left- sectional view as Ot □ x, y, z □ , the drilling cut point as St □ x, y, z □ , the final point for drilling as Et □ x, y, z □ , the axis location of the section line of drilling as At □ x, y, z □ . For the location of the axis of the section line, because only X is valid, the ordinate values of the cross-sectional center Y is equal to the Y coordinate, i.e. At_y □ Ot_y . And the starting point of the cut and the cut termination points are transformed into three-dimensional shape of the original location, and we can find the unit vector from the final cut point to the starting cut point, which is the tool axis vector V □ x, y, z □ .

According to coordinates of drilling starting point and final point, we will find the depth (deep) of the drilling, namely:

$$deep = \sqrt{(St_x - Et_x)^2 + (St_y - Et_y)^2 + (St_z - Et_z)^2} \tag{19}$$

Respectively, variables *num* and *depth* express cut times and cut depth. Variable *deep* represents the drill depth, *step* represents the number of cut, *step _ dis* represents step length of cut. There:

$$depth = deep / step \tag{20}$$

$$num = step \tag{21}$$

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 8 Issue III Mar 2020- Available at www.ijraset.com

According to the axis location's coordinate of the section line of drilling, tool axis vector and safe altitude, we can get the point of safe altitude $safe\_pt$ □x, y, z□:

$$safe\_pt_x = Ot_x + V_x \cdot h \tag{22}$$

$$safe\_pt_y = Ot_y + V_y \cdot h \tag{23}$$

$$safe\_pt_z = Ot_z + V_z \cdot h \tag{24}$$

Where h is safe altitude

According to drilling point, the tool axis vector and security clearance it can be obtained that is the security clearance point val_pt □x, y, z□:

$$val\_pt_x = St_x + V_x \cdot val\_dis \tag{25}$$

$$val\_pt_y = St_y + V_y \cdot val\_dis \tag{26}$$

$$val\_pt_z = St_z + V_z \cdot val\_dis \tag{27}$$

Where val_dis is security clearance

Assuming the final point as of the cut. There is,

If i □ num , namely, it is not the last cut, there will be:

$$cut\_pt_x = St_x - V_x \cdot i \cdot deep \tag{28}$$

$$cut\_pt_y = St_y - V_y \cdot i \cdot deep \tag{29}$$

$$cut\_pt_z = St_z - V_z \cdot i \cdot deep \tag{30}$$

If i □ num , namely, it is the last cut, there will be:

$$cut\_pt_x = Et_x \tag{31}$$

$$cut\_pt_y = Et_y \tag{32}$$

$$cut\_pt_z = Et_z \tag{33}$$

Assuming the safety gap point of the i-th (1□p pi □p num) cut as val2_ pt(x, y, z), in accordance, we can get:

$$val2\_pt_x = cur\_pt_x + V_x \cdot val\_dis \tag{34}$$

$$val2\_pt_y = cur\_pt_y + V_y \cdot val\_dis \tag{35}$$

$$val2\_pt_z = cur\_pt_z + V_z \cdot val\_dis \tag{36}$$

Connect secure altitude point and security clearance point as the linear tool path, which passes from a safe height point to point security clearance. Connect drilling starting and ending point and the straight line of the cut as a tool path, connect the starting point and the cut to the security clearance process as retraction trajectory track, and so forth, until all the cut once completed, Finally, connect the point of security clearance and linear safe altitude as the final point of the tool path.

Calculating unit vector V'(x, y, z) of the original starting point in a left side view and the end point of the two- dimensional processing. Set an intermediately conversed point $trans\_pt$ □x, y, z□, and based on the central coordinates of the screen in a left view, the unit vector and safe height, it can be obtained:

$$trans\_pt_x = Ot_x + V'_x \cdot h \quad (37)$$

$$trans\_pt_y = Ot_y + V'_y \cdot h \quad (38)$$

$$trans\_pt_z = Ot_z + V'_z \cdot h \quad (39)$$

Transform sectional center point to the cross-sectional axis position. A transformation matrix $M_{4\times4}$ is obtained [12], provided the corresponding safety height point coordinates of the cross-sectional in a left side view as $safe2\_pt(x, y, z)$, then:

$$safe2\_pt = trans\_pt \times M_{4\times4} \quad (40)$$

We can get height increment dh.

If $St \le 0$, $dh = h$;

If $St \ge 0$, $dh = (safe2\_pt - Ot_y)/V'_y$;

Then:

$$safe2\_pt_x = Ot_x + V'_x \cdot dh \quad (41)$$

$$safe2\_pt_z = Ot_z + V'_z \cdot dh \quad (42)$$

Connect a straight line of the final cut point and safe altitude point, which is the auxiliary tool path in the left-sectional view.

III. MOTION SIMULATION

A. Motion Simulation Module Platform's Generation

By CAXA, a certain number of toolbars containing a series of interactive commands will be grouped in a different workbench. This will help to find and use tools. In the new motion simulation workbench it needs to show the resulting series of toolbars, menus, etc. To establish future operating workbench requires the following steps:

1) Create an interface for the workbench;
2) Create a workbench;
3) Create a workbench describing the class;
4) Create the title of a response command;
5) Create a workbench and arrange icon button of response;
6) To provide pictures and other resources, and then insert the new workbench into start menu;
7) Create a display interface of the workbench.

B. Machining Simulation of the Drilling

Taking a typical part as an example to validate the technology of this paper, we need to confirm the processing route, generate correspondent tool path and simulate the machining process to explain the application process of three- axis CNC lathe system. The graph of the work blank is as shown in the figure 3.

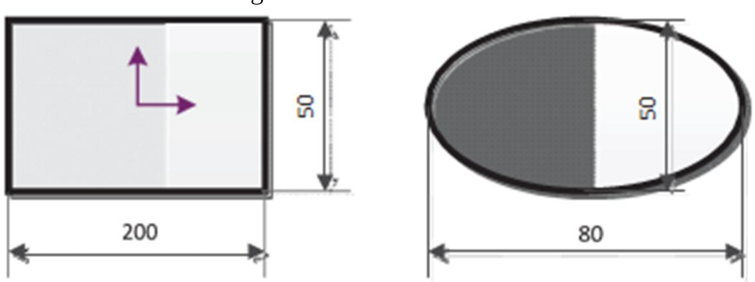


Fig. 3 The work blank

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 8 Issue III Mar 2020- Available at www.ijraset.com

By the indexing function of axis C, we can make it done once upon a time to finish drilling of any part of axis parts' end face in the lathe. It improves efficiency and processing quality largely. When drilling 3 central hole of the right end face of the part shown in figure 3, the depth of drilling is 10mm, cut twice, adopt the drill bit whose diameter is 3mm and angle is 120. The generated tool path is shown in the figure 4.

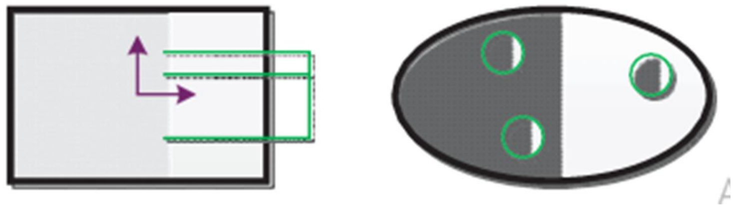


Fig. 4 The tool path of end face drilling.

Three-axis CNC lathe adopts dynamic turret and we can make it done once upon a time to finish drilling of any part of axis parts' hole in the radial direction in the lathe. It improves efficiency and processing quality largely. When drilling hole in the radial direction of the part shown in figure 3, the depth of the hole is 8mm, cut twice, adopt the drill bit whose diameter is 5mm and angle is 120. The generated tool path is shown in the figure 5.

Fig. 5 The tool path of radial drilling.

Picked up the left-sectional view of the origin of coordinates, then the drill point in the cross-sectional view of left, then pick up the gaze position in the cross-sectional view of front. Repeat this process until finishing picking up drill points for all sections. The simulation of machining process can be acquired as figure 6 and figure 7.

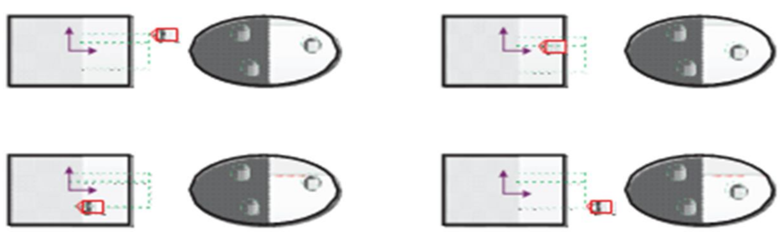


Fig. 6 The simulation of end face drilling.

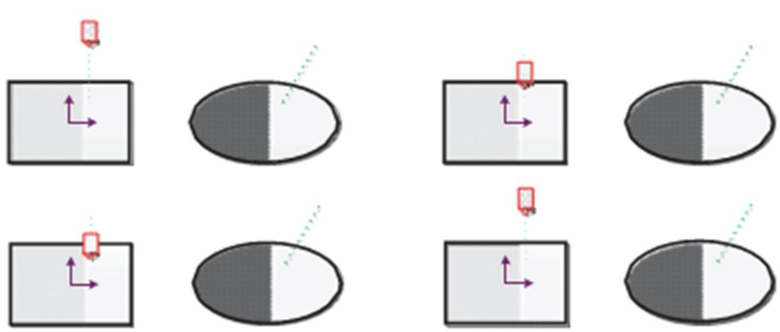


Fig. 7 The simulation of radial drilling.

IV. COCLUTION

The algorithm of end face drilling and radial drilling is designed base on the three-axes CNC lathe.

Application Visual C++ has completed the secondary development of CAXA interface and finished showing Tool path of the drilling of three-axes CNC Lathe and simulation of process motion based on CAXA.

CAXA has powerful graphics capabilities and sophisticated external data interface of CAD software, and is capable of accomplishing the simulation of lathing process. The bug in the process can be found easily and redesigned in time. It is simple, practical and functionally good to use.

REFERENCES

[1] A.Y.C. Nee, S.Q. Liu, S.K. Ong, Y.P. Chen. Real-time, dynamic level- of-detail management for three-axis NC milling simulation. Computer Aided Design, 2006, 38, pp. 378-391.

[2] W. B Lee, C. F Cheung, J.G Li, Applications of virtual manufacturing in materials processing, Journal of materials processing technology, 2001(113), pp. 416-423.

[3] P. V. S. Suresh, P. Venkateswara Rao, S. G. Deshmukh, A genetic algorithmic approach for optimization of surface roughness prediction model, International Journal of Machine Tools and Manufacture, 2002, 42(6), pp. 675-680.

[4] Uddin, M. S., Ibaraki, S., Matsubara, A., Prediction and Compensation of Machining Geometric Errors of Five-Axis Machining Centers with Kinematic Errors, Precision Engineering, 2009, 33(2), pp. 194-201.

[5] Lee, C. M., Ryu, S. P., Hwang, Y. S., Chung, W. J., Jung, J. Y., and Ko. T. J., a study on the evaluative method of workability for high speed machining, Proc. Of the KSME Autumn conference, 2003, pp. 1858-1863.

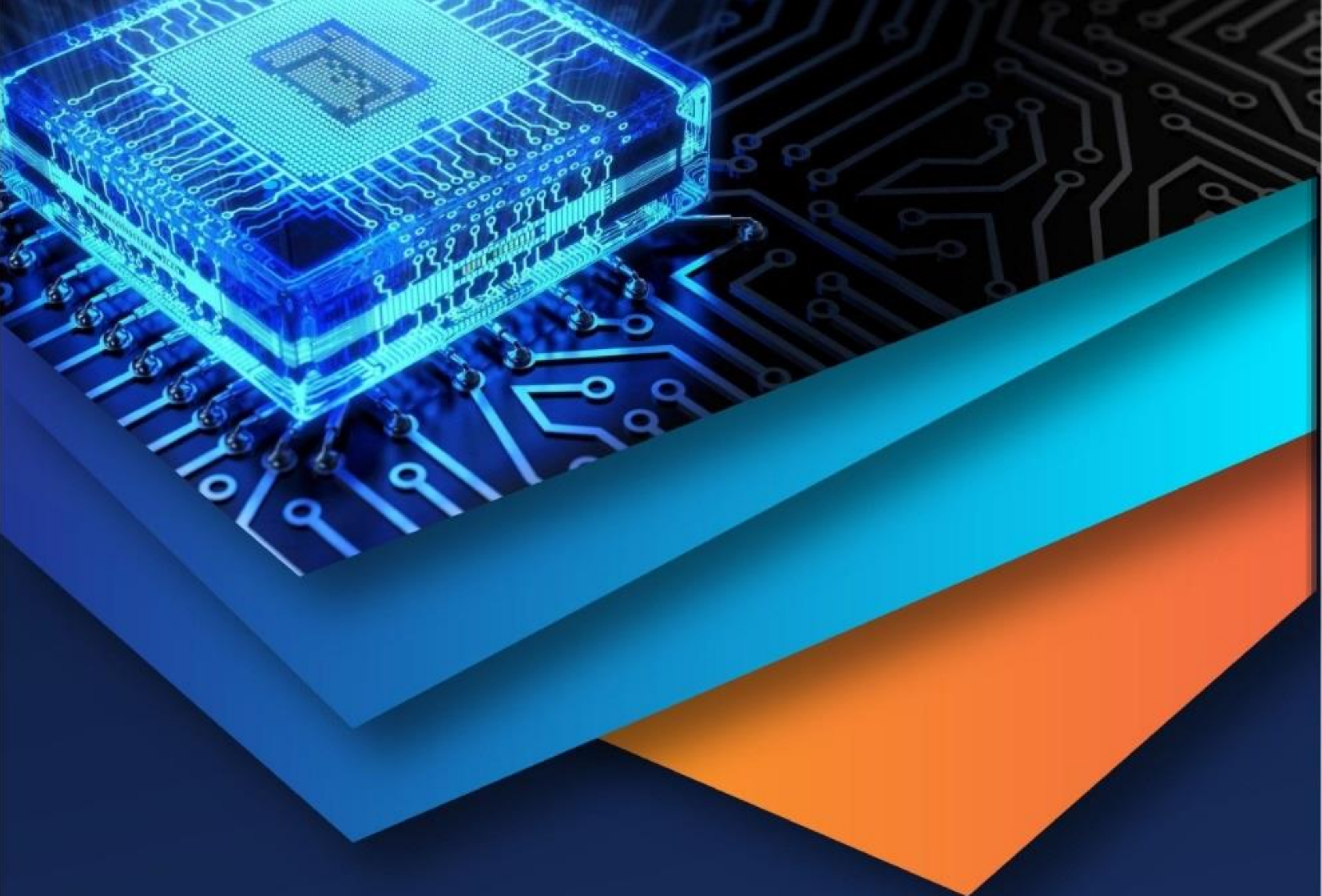
[6] S. Doruk Merdol, Yusuf Altintas, Virtual cutting and optimization of three-axis milling processes, International Journal of Machine Tools and Manufacture, 2008, 48(10), pp. 1063-1071.

[7] Zinan Lu, Takeshi Yoneyama, Micro cutting in the micro lathe turning system, International Journal of Machine Tools and Manufacture, 1999, 39(7), pp. 1171-1183

[8] Li Shijie, FANG Jing, Studying on the adaptive strategies for cutter- feeding in machining surface, Machinery Design & Manufacture, 2001, 38(1), pp. 62-64.

[9] K. S. Tsui, K. W. Chan, An efficient NC tool path planning approach, Computational Intelligence and Multimedia Applications, The 6th International Conference on Computational Intelligence and Multimedia Applications, 2005, pp. 132-137.

[10] Liu Tingting, Qu Jianhua, Hou Shulin, The CAD/CAM software of domestic and international, Mechanical Research & Application, 2005, 18(5), pp. 1-3.



doi crossref

10.22214/IJRASET

INDEX COPERNICUS

45.98

ISRA JIF

IMPACT FACTOR: 7.129

TOGETHER WE REACH THE GOAL

IMPACT FACTOR: 7.429