Development of a Workpiece Location Determ ination System in Parallel Mechanism Type Machine Tools

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Abstract: This paper uses HexaM made by ToyodaMachine Works Co.as an analyticalmodel of parallel mechanism type machine tools. Much collision may be generated for its complicated structure and working space, when a workpiece is mach inedusing this machine. For example, those collisions are generated.between the moving components of the parallel mechanism ,between the moving components and a workpiece and between themoving components and the tool storage for autom atic changing.In th is paper,an algorithm for detecting and avoiding those collision swasproposed. The method for avoiding the collisions was conducted by readjusting the location of the workpiece without am ending the toolpath.It is confirmed through experim ent that the proposed algorithm is useful for detecting the collisions and determining the location of the workp ieceprior to the actual machining.

Keywords: parallel machine tools;ollision check; avoidance; toolpath; in stallation site

In recent years, the PMT development and application of the growing, but because of its structure and working space is very complicated, use it for processing the workpiece, it is very possible the machine components themselves interfere with the workpiece and the machine interference. Also, if like PMT HexaM [1], work on stage in the installation of automatic tool change devices and other peripheral equipment, the installation of the workpiece. It may limit the installation of the workpiece location, that is, peripheral equipment and workpiece interference that may arise when processing machines and peripheral equipment to interfere.

PMT on their way to check interference and machine work space has been much research [2 ~ 5]. Among them, This writer and other Japanese companies Toyota Machine Works of PMT HexaM [1] as a model. Discussion of PMTs their interference in the inspection, the work space approximate expression [5]. the other hand, 5-axis NC machining, cutting tool (knife, Chuck and Spindle) and the workpiece (workpiece and fixture) interference methods also have many. Among them, Takeuchi, etc. [6] tool system from the surface for a number of points as interference checking, and the workpiece surface are relatively simple function, when interference check point at the internal functions, be able to judge for the machine and workpiece occurred interference; The author, etc. [7] and the method proposed here just the opposite. that is, from the workpiece surface, system selection interference checking, whether the system access tool for interference checking. As CNC machine peripheral devices are not generally placed in the work tops , So, in these two methods, they did not consider processing machines and peripheral equipment to interfere in the issue.

These studies are discussed in detail PMT their interference in the machine tool and workpiece and the interference checking and evasive methods, However, the use of PMT ago, but there are several problems :

① working platform for peripheral devices such as a barrier Machine [1] should consider the machines and peripheral equipment possible interference;

② the inspection machine and the interference of the workpiece. Consideration should also be given spindle plywood, plywood hinge link with the workpiece and the possibility of interference, However, the existing CAM software does not include such interference detection;

③ machine when there is interference with the workpiece. General Tool always postural adjustments to avoid interference. In fact, PMT, in addition to postural adjustment tool, You can also adjust the location of the workpiece to avoid all interference. Moreover, This approach avoided the biggest advantage is not to change the existing CAM software.

Based on common CAM software tool path of the output-based, shorten the time to interfere in the inspection checkpoints document composition, By adjusting the location of the installation of the workpiece to avoid the possibility of all kinds of interference, of the workpiece can test for processing at the workpiece and machinability best installation location calculation.

1.Interference checking and avoid interference

Using the PMT HexaM, peripheral equipment (the knife) and the workpiece installation diagram shown in Figure 1. Therefore, For the machine, during processing and installation of the workpiece at the possibility of interference with his interference, machine tool and workpiece interference machines and the peripheral equipment, and interference with the surrounding devices workpiece interference.

If you are using a parallel machine table without peripheral devices or devices placed around the far more, will not affect the location of the workpiece machining process or there will not be machines and peripheral equipment interference, can be omitted from the workpiece and the machine and equipment around the interference checking.

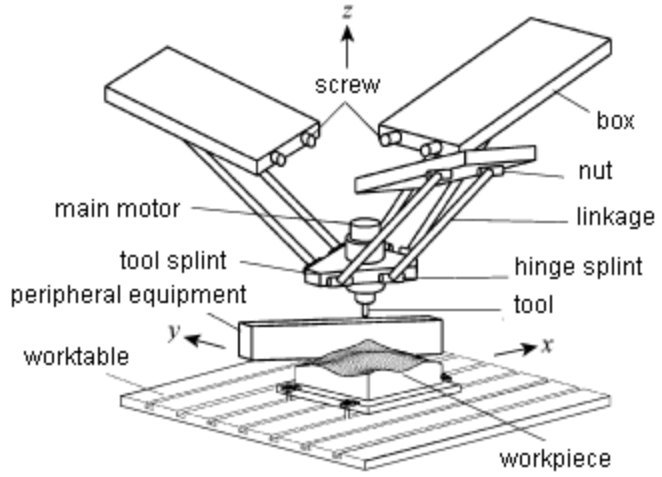


Fig. 1 Schematic of the parallelmechanism HexaM

1.1 Their interference

1.1.1 The composition checkpoints During processing, All tools can be applied to position literature [5] described method to check whether their intervention will happen. if there is interference, can be used in the adjustment of the workpiece location to avoid interference. Parts of the installation location changes, Processing Tool position will naturally be changed. Therefore, the need to conduct another inspection, not occur until the date their interference. As an installation at each location to location of all the tools for inspection

computing time will be very long. To shorten the time of calculation, this is not the right tool for all locations and to extract only a small number of knives location (hereinafter referred to as check points) interference checking. Therefore, point out checks must be done : at checkpoints if no interference in its own. in the other cutter location would not interfere in their occurrence. setting up check-points advantage of a significant reduction in the frequency of inspections.

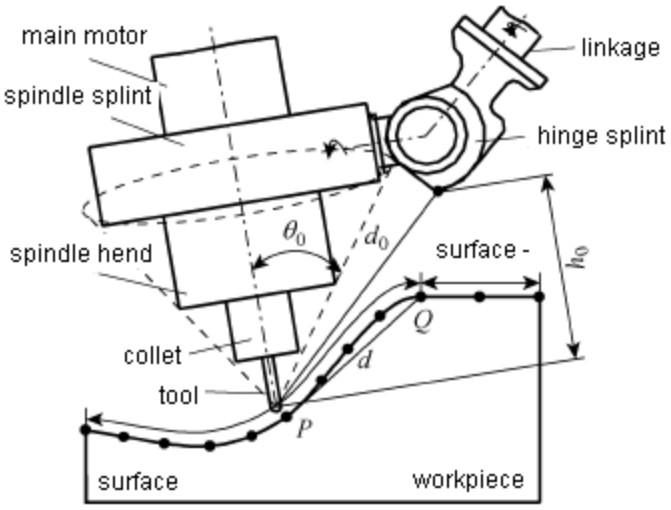
From the z-axis cutter farther, the higher the position, the greater the degree of tilt, the more prone they interfere in [5]. Therefore, wait for the processing of the workpiece, the tool path from the outside to share the measurement point, the higher the cutter location, tool tilt angle larger point as to determine whether they interfere in the check points.

1.1.2 Interfere with the inspection methods Tool position and posture straight at the moon and the space rotary disk space, it would be interference in its own [5]. Therefore, they interfere with the inspection methods : ① read all checkpoints, obtained a checkpoint each corresponding to the straight and rotating space Yuan Yuan space [5]. ② cutter position and posture in response The straight round space and space Rotary Circle, convicted of the checkpoint will not interfere in their occurrence; In all the check points are not interfered, were judged to be installed in the position not to interfere in their occurrence. ③ If a check point in the location or position of the straight excess space Yuan Yuan, or rotating space, can be used in the literature [5] mentioned in the inspection methods to interfere in the review. As space than the average round of inspections interference [5] calculation to be much smaller, so this kind of method can shorten each inspection, the computation time.

1.1.3 Avoid interference method As in the same horizontal plane, the cutter in the z-axis location at the least prone to his interference. Therefore, If a checkpoint in a self-interference then we check points and the z-axis direction connectivity as evasive. Then, Parts of the installation location along the direction of movement of evading 10 mm. If two consecutive evade direction of the angle is greater than 150 °. that could have been avoided reversed direction in the horizontal plane does not exist in the location to install, so The workpiece can be installed to enhance upward position. In this paper, each increase by 10 mm. If they interfere with the main motor is a rotary screw lower interference Note workpiece is too high or the location of the workpiece too high, not with the machine tool.

1.2 Machine interfere with the workpiece

1.2.1 The composition checkpoints As shown in figure 2, machine and workpiece possible interference between parts of a knife, chuck, spindle head, spindle splint, Hinges and plywood link. workpiece can be seen from the surface and surface composition. Among them, Surface processing from the point with machine might happen to the non-interference by non-machined surface processing point is, here, processing and point and non-point processing collectively referred inquiries to the point.



F ig. 2 Check method of the collision betw een the parallelmechanism and wo rkp iece

Inquiries point with knives, and Chuck, The first spindle axis and the splint interference known as a category interference. Such interference only with knives, the posture, and workpiece position unrelated to the installation. Therefore, if the screening of such interference, and only postural adjustment tool for evasive, This requires changes CAM software, beyond the scope of this discussion.

Inquiries point splint hinge connecting rod or interfere in the resolution as interference in two categories. Such interference can be adjusted through the installation of the workpiece - Purchase avoided. Below these two types of intervention on the check points formed.

With a cone, its center point for the tool, cone angle of H0 included knives, and Chuck, The first spindle axis and the minimum angle of plywood; Tool center hinge splint to the minimum distance of d002; Tool axis in the direction of the minimum distance of h0, H0, d002 and h0 machine parts according to the size and structure of plywood hinge back corner of the largest such parameters obtained.

For the processing of a point P, P calculated with all inquiries Q-point connectivity PQ and the tool axis angle H, d line segment and the length of the segment PQ tool axis direction on the length of the projection h. Therefore, satisfy conditions H "H 0 inquiries point as a kind of interference in check; satisfy conditions d "h and d 0" h0 inquiries points as Class 2 interfere in the check points. As with all the processing points have obtained two checkpoints, and deposited checkpoints document.

1.1.2 Interfere with the inspection methods Checking whether there was interference in Category 1, the first knife, Chuck, The first spindle axis and splint (referred to as Tool System), and a type of intervention checkpoints x z plane to the projection, then, Tool checks into the projection system checks whether the point system and tool interference [7]. As the No. 1 category interfere with the workpiece unrelated to the installation location, in the calculation of the workpiece location, only for a meeting of this kind of checking calculations.

Due to the location of the installation of the workpiece, which will definitely lead to splint hinge and link the position and posture change. Therefore, Parts of each installation location adjustments, we must check whether there will be interference in the first two categories. Therefore, How to reduce interference in the first two categories of the inspection is to shorten the clearance time of the key. In this paper, judgment Category 2 interference check point is to satisfy the conditions d "h and d 0" h0, This small workpiece or relatively flat workpiece can be significantly reduced check points.

1.2.3 Avoid interference method When interference, and its method of avoiding interference in its own when there are evading the same method.

1.3 Machine and equipment around the interference

1.3.1 The composition checkpoints Figure 3 for PMT HexaM of peripheral equipment, workpiece machining and tool path when the vertical view. From Figure 3, we can see that peripheral equipment installed in the workstations to a quadrant, so Tool path to the center of a quadrant of the outer (.), as interference in the check points.

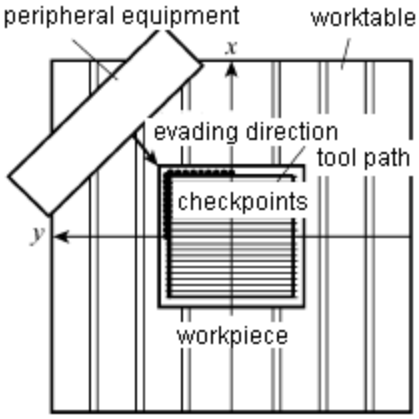


Fig. 3 Check po ints and avo idance vecto r of the co llisionbetw een the parallelmechanism and magazine

1.3.2 Interfere with the inspection methods And peripheral equipment may interfere with the parts of a machine tool, chuck, spindle head, plywood hinge connecting rod and spindle splint, Their shape of a cylinder and the plane circles constitute the polyhedron, and peripheral equipment for the many facets of the shape. Therefore, peripheral equipment and machine parts will be used between "bounded plane and cylinder" and "bounded plane and bounded plane" interference method [5]. That is, in all the checkpoints, causing peripheral equipment bounded plane and the cylindrical machine parts sector plane or whether there is an intersection between. If Nodal, Information on interference; If no intersection, a statement that no interference. As noted above, workpiece location of the installation will bring different machine parts location and posture change, so each set new workpiece location, must re-examine whether there has been peripheral equipment and machine interference.

1.3.3 Avoid interference method If the machine occurred with the surrounding equipment interference, peripheral equipment will surface before the normal direction as to evade direction, and the occurrence of evading their own methods of avoiding interference in the same way.

1.4 Workpiece and the interference of neighboring devices

In order to be able to quickly detect when installing the workpiece and the existence of peripheral equipment interference, the first of the workpiece to the xy plane projection, and bounded by polygons workpiece envelope projection. Then, use "bounded plane and bounded plane" [5] to check the workpiece and the interference of neighboring devices. each installation location given workpiece after, the need for such interference checking.

If the workpiece and interfere with the surrounding equipment, peripheral equipment will surface before the normal direction as to evade direction, and the occurrence of evading their own methods of avoiding interference in the same way.

1.5 Interpolation of check points

From the above content aware that apart from the workpiece and the interference of neighboring equipment checks, other checks are interfering in the inspection point in terms of interference. Therefore, if the check points between the distance is too large, There were at checkpoints without interference, while at checkpoints will happen between interference, But such interference has not been found possible. in actual processing time is absolutely impermissible.

To solve checkpoints may exist between the interference problem, there are two major ways : First, a simple function with polyhedron intersection method [8]; two is to check the distance between the point narrowing. No. 1 methods for screening machine and the interference of the workpiece particularly effective, But they can not be used to solve interference; 2 methods for the various types of interference in the inspection applies to all, But if the checkpoints between the distance is too small, check points, a huge amount, Inspection interfere in the calculation will be very long. Therefore, we set a safe distance, Under this safe distance from the check point to shorten the distance between, in order to achieve the results we are reliable, also short time inspection purposes. specific methods are as follows.

Conducting two objects judgment interference, One of the first objects to expand 5 mm. If the expanded intersection of two objects. was convicted of two objects there is interference. If the intersection from the surface of objects within 5 mm. In fact, this is still no interference. If convicted of two objects there is no interference, then the distance between the two objects in more than 5 mm. Here, this 5 mm called safe distance.

CAM system for output from the reference point and tool path, If adjacent to the inquiry or the distance tool path is greater than the distance between a safe distance Inquiries points in the tool path between or among some interpolation points. that is, after inquiries after the interpolation between the points and tool path is the distance between less safe distance. So, when the two checkpoints there are no interference. in between them would not have happened interference. Thus, a safe distance from the need to determine whether the interpolation, can prevent missed interference, without excessive increase in computing time.

2. Workpiece location of the installation method of calculation

2.1 Parts of the best installation location

In this paper, "Pad of the minimum height; from the shortest distance from the center stage "as a measure of the workpiece best installation location standards. Specifically, First to the workpiece is placed in the bottom table (At this point, the height of the pan 0) Tool tracks in the xy plane projection center and the center coincides workstations (distance from the center of the worktable 0) Workpiece as the best installation location. If there is interference in the location to be installed, in order to guarantee the minimum height Pad, will be the workpiece within the same level from the inside outward movement Find no interference in the installation location. If not found in the same horizontal plane does not interfere with the installation location, workpiece will be gradually upwards (increase Pad height) Mobile and then in the same horizontal plane to find, until they found the location of the installation or come in the machine can not be processed conclusion has been reached.

2.2 Best installation location method of calculation

Based on the best parts of the installation location concept, this paper presents a workpiece machining installation location calculation steps are as follows :

1) Read the basic data. Include : knives, and Chuck extend the radius and length; Inquiries; Tool path;

peripheral equipment and the location of the xy plane with the other projector.

(2) to determine whether the machine processing. According to the workpiece Inquiries point and the tool path, Calculation workpiece xy z direction in the shape and size of the cutter Mobile distance. When the workpiece size or shape of the movement distance Tool too large, given the workpiece on the machine can process of warnings. the end of the operation.

(3) various types of interference generated inspection checkpoints document. Among them : checking their interference, The machine tool and workpiece Class 1 and Class 2 interference, Machine interfere with peripheral equipment check-point document.

(4) to check whether there are machine the workpiece with a type interference. If depositors in, due to the interference by not moving the workpiece to avoid the installation location, so given the "unavoidable existence of a category of interference" warning, the end of the system.

(5) to set the tool path Center C (x, y, z) of the initial position. To meet the workpiece best installation location definition, C (x, y, z) of the initial set of home : x = 0; y = 0; z = s. Among them, 's center for the tool path to the bottom of the workpiece distance.

(6) Calculation tool path C center position. According to interfere in the inspection Methods and evasive methods, and keep track of mobile tool center installation location, until they found no interference or location of the installation is not in the workpiece on the machine processing warning to date.

(7) loser workpiece location of the installation. (6) If there will not seek to interfere in the tool path of the center position, based on the value of the structure and size of the workpiece, calculated and output workpiece installation location.

3. Analysis of the experimental results

For the map shown in the four dimensions of 350 mm × 150 mm × 350mm workpiece, When using vertical machining, The use of a common software CAMAND CAM generated at the processing location Tool and Tool Posture (with the normal processing point is the same). maps, tool path of the location points to 123 201 points. Tool for ball milling, diameter 10 mm, Collet, which stretches out from the length of 50 mm and 60 mm in diameter chuck, which extend from the main shaft 45 mm.

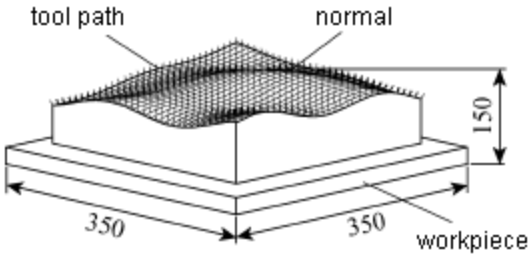


Fig. 4 The workpiece and tool path

Based on the above algorithm, This paper developed PMT workpiece machining time calculation system installation location. calculated as shown in Figure 4 processing workpieces installation location, computing time (computer CPU : 850MHz AMD THLON A), about 15 min.

3.1 Inspection Points

CAMAND software in the tool path generation, because there is no tool path than the adjacent safe distance, so no interpolation point of support. Also, as shown in Figure 4 on the workpiece, in addition to processing face, The remaining surface and the machine is unlikely to happen interference, therefore, All

inquiries from point to point tool path. Inquiries from the point out of their interference check points to 2382 points. Machine interfere with peripheral equipment for the inspection of 248 points; Machine parts and the first one species, 2 kinds of interference in the inspection points are 0:00 a.m.. Workpiece peripheral equipment and interference checking has become two quadrilateral asked for the intersection issue.

3.2 Installation location analysis, the experimental results

Workpiece location of the installation process of change as shown in Figure 5. Know from the calculation process, When the workpiece is low installation location near the center stage, prone machines and peripheral equipment interference; If the workpiece location distant from the center, the machine itself prone to interference. Finally, When the workpiece installation height of 70 mm, only to find no interference by the installation location.

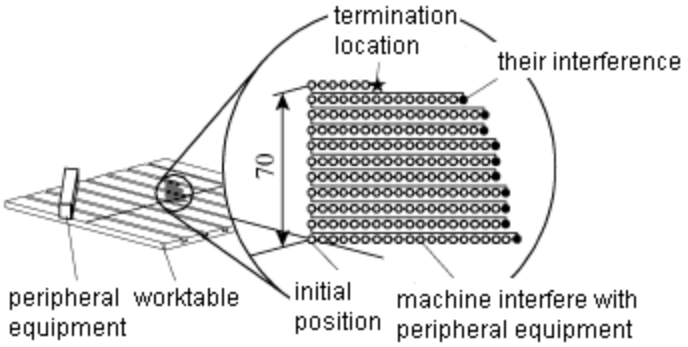


Fig. 5 Change of p rocess of the locat ion of workpiece

Figure 6 workpiece to be installed in Figure 5 ★ location of the installation diagram. From Figure 6 shows, Workpiece bottom center is not the center of the table, but from the center, from workstations (-42. 05. -42. 05, 70) mm. This is because, to avoid the machine and placed in a quadrant of the first stage of the peripheral equipment interference, it must workpiece to the first three workstations Quadrant Mobile, and also upward movement installation of the workpiece to be placed under 70 mm high Pad.

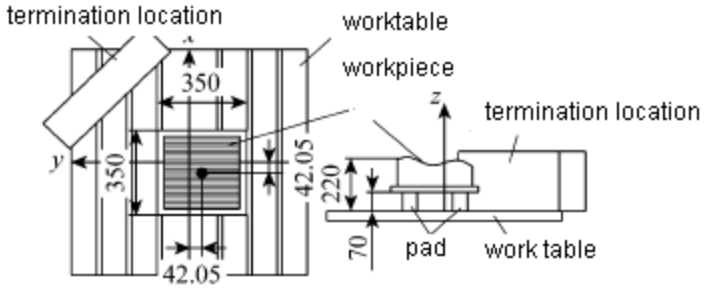


Fig. 6 The final locat ion of workpiece

To check the installation shown in Figure 6 position and to make appropriate location for the entire whether there will be interference, Using machine HexaM experiments, installation location and experimental results, as shown in table 1. Among them, the smallest gap is the method of visual observation.

Tab 1 Calculation and experimental result of the location

NO.	installation location/mm			does interference		minimum distance
	x	y	z	analysis	experiment	/mm
1	- 42.05	- 42.05	70	○	○	7
2	- 40	- 40	70	○	○	6
3	- 35	- 35	70	×	○	3
4	- 20	- 20	80	○	○	7
5	0	0	90	○	○	13

注: ○ said no onterference × said interference

Table 1, except for the line 3 position (x =-35, y =-35, z = 70) mm installed outside the workpiece, Analytical and experimental results the same, ie no interference. and the third line position shown in the installation of the workpiece, by the experimental knowledge, Machine and equipment surrounding the smallest gap is 3 mm, as compared with the analytic system created a safe distance from the small 5 mm. Analysis of the natural judged to be interfering in there. Although the analytical and experimental results, But they can still view the results of analysis are reasonable and correct. Therefore, It can be said that this proposed method of calculation and the development of the workpiece location calculation system is effective. the actual processing is available.

4. Conclusion

In this paper, Japanese companies Toyota Machine Works of PMT HexaM model, we investigated the use of parallel processing machine. Machine own interference, machine tools and parts, machines and peripheral equipment and peripheral equipment with the workpiece interference in the inspection, By adjusting the workpiece and the installation location to avoid interference method. Finally, Through a series of analytical and experimental results contrast, This study proved that the calculation made by the installation position of the workpiece algorithm and the development of the software is correct. From the above exposition process can be concluded as follows :

(1) the development of the system can automatically calculate the machine is possible to track the processing to the processing of the workpiece.

(2) In the judgment can be processed under the circumstances, can be calculated not to interfere with the installation of the workpiece location.

This paper presents the methods and interference checking evasive method is effective and can solve practical problems.