Research on Automatic Programming Methods of CNC Machining Parameters of Gear

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Abstract—Analysis tool axis and workpiece axis motion relation principle of gear hobbing and synchronous control, interface input using the key parameter, the realization of programming automatically parameters of CNC system, the parameter programming method were discussed. Application is able to simplify the processing procedures, shortening the processing time of programming, improve processing efficiency on special occasions.

Keyword—gear; NC machining; parameter; automatic programming method

I. INTRODUCTION

Gear transmission is one of the main ways of the machine movement and power transmission, it is widely used in all kinds of mechanical equipment and instruments. But in gear machining, cutting method as the domestic and foreign application of hobbing most widely, is decided by its steady processing, good anti vibration characteristics. The number of moving coordinate axis hobbing machine, the linkage relation is very complex, the machining process and the gear is to keep dividing in the workpiece and tool case synchronously generating motion and complete, is a complex process. The NC system of gear hobbing machine, different motion axis of machine tool of numerical control, so that between the corresponding coordinates with linkage relationship.[2][6]

In actual processing, due to the movement of the complex relationship, hobbing is divided into a plurality of step to finish machining process, so the programming method of cutter locations often procedure based on the large amount of. But because of the different characteristics of simple processing gear, gear between the process is similar, can realize the parametric programming. That is, with a few parameters of gear machining feature representation, processing program for gear hobbing requirements so as to automatically build.[1][6][10]

II. THE ANALYSIS OF PARAMETERIZED PROGRAMMING GEAR NC MACHINING

The principle of gear hobbing is cutting by generating method of. Rotary motion hob with cutting groove and the spiral angle of the hypothetical form linear movement, the workpiece according to hob helix angle, the direction of rotation is in accordance with the provisions of the method for rotary movement. Therefore, gear hobbing machine hob and table in addition to rotating exhibition into motion, the general must also have the axial feed motion, radial feed motion and tangential feed movement. Among them, the rolling key tooth machine control is the synchronization between the workpiece and the spindle shaft: hob turned a turn, the workpiece is just turned a tooth. The typical five axes hobbing machine. The control shaft is respectively: X axial - radial feeding movement; Y axis - tangential feed movement; the Z shaft axial feed motion; B shaft hob rotary motion; the C axis rotary table a motion.- Y axis control gear circumferential surface of the axis of motion, is actually moving direction by generating motion is imaginary rack; the Z axis is the axis of motion control of tooth thickness; B axis is the hobrotating axis of motion control; C axis is the control shaft rotary motion worktable, is mainly used to control the angle of installation angle and bevel gear machining.[5]

Gear structure is complex, but its shape is generated by certain rules. As long as you know the general cylindrical gear modulus m, pressure angle, addendum coefficient ha*, radial clearance coefficient c* and tooth number Z, other parameters can be determined from table 1.[8]

<table>
<thead>
<tr>
<th>The name</th>
<th>Symbol</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>pitch diameter; standard pitch diameter</td>
<td>d</td>
<td>d = mz</td>
</tr>
<tr>
<td>base circle diameter (BCD); base diameter</td>
<td>d_b</td>
<td>d_b = d cosa</td>
</tr>
<tr>
<td>tip diameter</td>
<td>d_a</td>
<td>d_a = (Z+2ha*)m</td>
</tr>
<tr>
<td>root diameter</td>
<td>d_f</td>
<td>d_f = (Z-2ha*- c*)m</td>
</tr>
<tr>
<td>Tooth addendum; tooth head; addendum</td>
<td>h_a</td>
<td>h_a = ha*m</td>
</tr>
<tr>
<td></td>
<td>h_f</td>
<td>h_f = (ha* + c*)m</td>
</tr>
<tr>
<td>whole depth</td>
<td>h</td>
<td>h = h_a + h_f = (2ha* + c*)m</td>
</tr>
<tr>
<td>Tooth pitch</td>
<td>p</td>
<td>p = m (\pi)</td>
</tr>
<tr>
<td>space width</td>
<td>e</td>
<td>e = m (\pi) /2</td>
</tr>
<tr>
<td>Tooth thickness</td>
<td>s</td>
<td>s = m (\pi) /2</td>
</tr>
</tbody>
</table>

Because the gear processing characteristics, CNC system for hobbing machine programming and common milling CNC system is completely different. Gear machining is not convenient to directly describe the processing path, if the input gear hob parameters, tool parameters, special gear input data of gear, and the gear machining processing according to the input data, and then by the CNC system calculated and converted
to a coordinate axis movement of the program, which will
direct than on gear processing knife site programming
computer convenient and simple. This is the parameter automatic
programming. [3]

The specific parameters and the meaning of gear
parametric automatic programming required as shown in table
2 : [9]

<table>
<thead>
<tr>
<th>tool parameter</th>
<th>gear parameters</th>
<th>The tooth profile parameters</th>
<th>Process data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modulus</td>
<td>lead angle</td>
<td>Bone shaped inner diameter</td>
<td>Finish machining allowance</td>
</tr>
<tr>
<td>pressure angle</td>
<td>tooth width</td>
<td>Addendum angle</td>
<td>Cutting times</td>
</tr>
<tr>
<td>Cutter diameter</td>
<td>Outside diameter of gear blank</td>
<td>Root angle</td>
<td>Rough machining speed</td>
</tr>
<tr>
<td>The number of cutter head</td>
<td>number of teeth</td>
<td>...</td>
<td>Machining speed</td>
</tr>
<tr>
<td>...</td>
<td>whole depth</td>
<td>...</td>
<td>Radial feed speed</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
<td>Installation Base Surface</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

Thus, as long as the determination of parameters of basic,
other related dimensions can be calculated according to
the formula of processing, so the parametric processing is feasible
gear. As long as the parameters of the interface input
processing required parameters, can be calculated by the
numerical control system and the automatic generation of
machining program. Therefore, the parameters of NC
programming is of universal significance to analyze and
conclude the promotion, as long as the product machining and
programming ideas, to establish its model, so as to realize the
parametric programming. It is suitable for special parts
processing. [4] [7]

III. ANALYSIS OF CONTROL CNC GEAR HOBBING MOVEMENT

Hobbing is by a pair of gears of the same modulus and
pressure angle are engaged with each other, according to
the principle of conjugate tooth profile of gear cutting developing
each other to. Hobbing hob and gear blank, pure rolling in the
day round place, the envelope can be the profile hob is
involuted tooth profile of gear machining. Can also be hob
rotary motion is equivalent to the rack moves through the rack
and the gear blank, meshing motion realization of gear hobbing.
By a coordinate transformation that in coordinate system O
-xY Z hob, if moving a distance L, in the O -x Y Z gear
blankgear coordinate rotation angle. Because of the hob
and gear blank pure rolling do on the pitch circle, then there is
a relation between the =L/r. When different L values, can
rotate with different angles. Thus, when used as a hob rack to
move forward, leaving a series of specific location in the path,
thus formed the tooth profile lines enveloping graph is the gear
blank. As shown in figure 1.

FIGURE I. HOBBING TOOTH PROFILE ENVELOPE.

IV. THE RELATIONSHIP BETWEEN THE ROLLING MOTION
GEAR MACHINING IS DERIVED

Because the traditional hobbing machine for machining
error response time lag, there are large, the current
model hobbing system, using double driven synchronous control
method to realize synchronous motion control of axis, it adopts
phase locked servo high precision synchronous precision
control, high precision, fast response speed. How to put the
relationship between tooth movement into movement
relationship of equivalent track gear machining, is the key to
the movement of NC machining. Hob speed (r/min) to n
rotation, equivalent tooth rack at a speed of V (mm/min)
mobile. A hob rotates one circle time used for T, there are:

\[ n = \frac{L}{r} \]  \hspace{2cm} (1)

At this time, the equivalent of the rack to move forward
pitch P:

\[ P = v t \]  \hspace{2cm} (2)

According to the pitch of the size definition:

\[ P = m \pi \]  \hspace{2cm} (3)

From the above relations, can launch hob speed (r/min) and
V (mm/min rack rate) relationship:

\[ V = m / 2 \cdot n \]  \hspace{2cm} (4)

By (1) to (4) may be introduced in hobbing movement, the
relationship between hob shift knife every forward stepand
gear blank rotation angle as required:

\[ \theta_{\text{work}} = \frac{n_{\text{total}} \cdot 180}{z_{\text{work}} \cdot \pi} = \frac{2 \pi \cdot p \cdot \left( 1 - \frac{180}{360} \cdot m \cdot \pi \right)}{\text{Step}_{\text{knife}} \cdot z_{\text{work}}} \]

In the roll cutting, radial feed is ensured by means of two
times the amount of feed. The first rough cut out most of the
tooth height, can according to the gear size to the processing
of the determined. Second finishing is based on the first
processing, according to the measure for the first time after
rough machining of gear common normal length 1W, to
determine the second times the amount of feed h:

\[ \Delta h = \frac{W - W}{2 \sin \alpha} \]

Compute the motion relationship between the radial and
axial direction of the hob and gear blanks, position change can
be programmed to calculate each moment. The motion state is
V. CONCLUSION

Gear tooth surface NC processing must be carried out by computer aided, according to the tooth surface of the digital data, the automatic generation of NC code corresponding to the tool parameters and installation parameters. We analyzed the roll key movement in gear processing, generating motion and its decomposition into the relationship between the two synchronous shaft. So as long as the given conjugate generating motion corresponding to get another generating motion of the generating NC code.

To realize the parameterized hobbing programming, depends on the compiler can complete the programming function, namely according to the workpiece, the tool data, process data and related parameters of cutting machine to automatically generate G code function. Automatic programming to the operator for processing through the processing parameters of gear control panel input, NC machining program of gear machining CNC system can identify and automatically, to simplify the process of the operator's operation.

REFERENCE

[8] FANUC Series 21i-MB; FANUC Series 21Oi-MB