Research on the Cam Processing in the TH5680 Machining Center

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Abstract: In the market, stamping machine tools are required to have high productivity and good processing quality. The J72-45D punch is a 45-ton automatic punch. The sliding Table of the punch has a width of 1 meter. It is driven by a coaxial double main cam mechanism in working condition. It can realize synchronous processing of twelve jobs. Therefore, the design and processing of the main cam is particularly important. The original technology employed in the processing of the main cam is to process a single cam by a coordinate grinder. It has been difficult to eliminate the phase error of the two cams when they are assembled on the mandrel after the grinding. In the following experiment, by changing the processing technology, the two cams are assembled on the mandrel with complete processing, so as to correct the error and deliver better performance.

1. Design and Analysis of Main Cam of J72-45D Punch Press

In the design and processing of J72-45D punch, the main cam is an important part of the machine, which mainly functions as the driving part of sliding Table with variable impulse falling and rising [1-2]. The main cam is composed of two sinusoidal acceleration curve cams with the same shape and phase on a mandrel string which is 1.4 meters in length (the maximum eccentricity of the cam is 192.5 mm, the diameter of the middle hole 105 mm, and the material 9CrWMn). Its structure is shown in the Figure 1 below. The traditional processing technology of main cam is to process a single cam by a coordinate grinder [3]. After the grinding, the cam assembly is assembled on the mandrel. The biggest problem of this installation method is that it is difficult to eliminate the errors in the phase of two cams, which results in the assembly of cam components on both sides failing to work synchronously on the sliding platform of the automatic punch [4-5]. If the main cam is assembled before the grinding, the processing cost is very high. Therefore, it is urgent to improve the processing technology of the main cam.

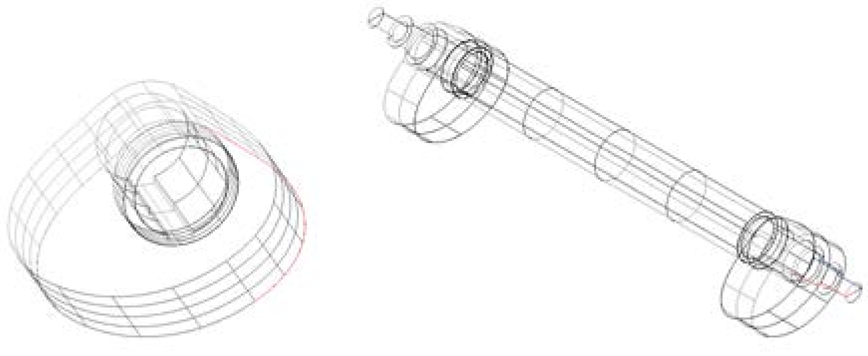

Figure 1 Assembly of Main Cam

2. Improvement of Machining Technology of Main Cam

After repeated research and demonstration, a new processing technology of main cam is put forward. The specific process is as follows [6-7]:

(1) First, the cam blank is forged.

(2) After roughing the rough surface of the cam, the cam shape, inner hole and keyway are cut into shape by a wire cutting machine.

(3) Heat treatment, quenching and tempering HB217-255, surface hardness quenching HR60-64.

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(4) The two cams are assembled on the fully machined mandrel by drying and shrinking (with emphasis on ensuring the profile accuracy of the keyway matched with the cam on the mandrel).

(5) Refitting the machining center TH5680 to have the function of five-axis triple motion (five axes are X-axis, Y-axis, Z-axis, turnTable B-axis, grinding spindle). The Z axis of the machining center is the lift of sinusoidal acceleration curve caused by the change of angle. The angle drives the turnTable in a micro-incremental way and drives the spindle of the main cam to rotate. Tool grinding wheels are installed at the end of the spindle of the machining center [8]. The normal grinding of sinusoidal accelerated cam is realized by two-axis linkage. After grinding one cam, the X-axis moves to grind another cam.

3. Problems to be Solved in the New Production Process of Main Cam

The problems surfacing when new technology is adopted in the processing of the main cam and their corresponding solutions are as follows:

(1) Modification of Machine Tools

Remove the servo axis of the tool magazine on the TH5680 machining center and connect it with the NC turnTable produced by Yantai Machine Tool Parts Factory. Change the parameters of the NC system of machine tool and manufacture a special hanging wheel, the number of whose teeth renders the rotary circle between servo motor and turnTable coordinated perfectly. Longitudinally place a lathe tailstock and a turnTable on the X axis of the lathe to form a linkable NC turnTable [9-10]. Dismantle the spindle end wedge of the machining center and fix an electric grinding shaft support frame on the screw hole of the front end of the spindle box. Cover the cutter hole of the spindle to prevent dust pollution of the grinding wheel, and install the electric grinding spindle along the X-axis direction. After modification of the machine tool, install a workpiece for trial cutting, which can realize the anticipated processing idea. The workpiece processing layout structure is shown in the Figure 2.

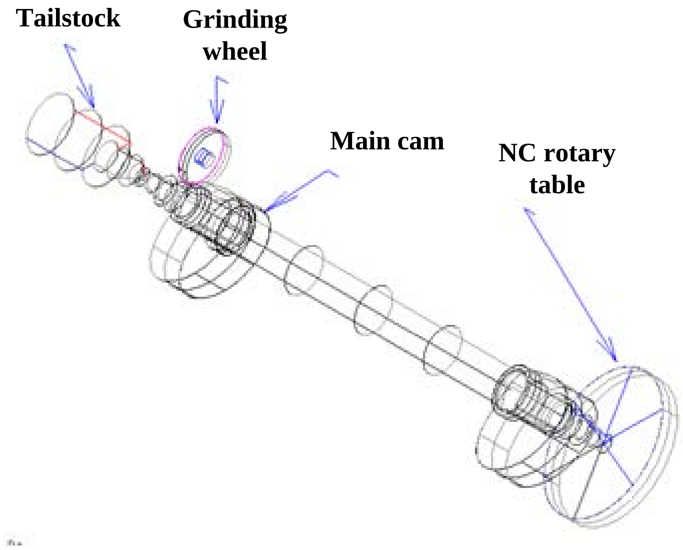

Figure 2 Layout of Workpiece Processing

(2) Selection of grinding spindle

When a spindle with a smaller power is used, grinding is found to be working improperly. Performance turns out to be better when the grinding spindle with a power of 0.75 kW is put to use.

(3) Selection of grinding wheel

Due to the high surface hardness of the workpiece, the grinding method is used (the driven wheel with the main cam is 100 mm in diameter). In the choice of materials, the iron chips in the ordinary diamond grinding wheel can easily block the capillary holes of the grinding wheel, in which case the grinding wheel quickly loses the function of cutting [11]. The surface of the grinding wheel is dryly rubbed against the surface of the workpiece to burn the surface of the workpiece. Cracks can also occur due to local overheating. After repeated trials, it is found that the brown corundum grinding wheel has a large chip hole, and after a strong cutting fluid squirting, no sign of a grinding surface burn occurs, and an ideal level of cutting effect can be produced.

(4) Quality control of workpiece shape

In order for the main cam to meet the requirements of an ideal curve, points on the curve should be calculated by the NC system with a smaller rotation angle to have higher density, and in that way the quality of the grinded cam curve can be closer to the ideal level. Based on the concept of the number of Z-axis displacement points in each degree, the processing error is analyzed. Two problems are found to hinder the increase in the number of points. First, the transmission rate of RS232 transmission line is 9600 words per second, one byte per 8 words, and 20 bytes per point, so the transmission rate of RS232 transmission line is 60 bits per second, which is the transmission limit set by machine tools. Secondly, the minimum displacement of Z-axis servo motor and transmission pair of screw rod is two wire, making extra points redundant. Through repeated experiments and theoretical analysis, some conclusions on the quality control of cam profile are drawn.

1) Choose different points according to the different curvature sections of the curve. The part with the biggest change of curvature uses 25-30 points, and the rest uses more than 10 points to meet the quality requirements of the shape.

2) Arc interpolation is used between points to make the shape of real cam closer to that of the ideal one.

3) The diameter of the grinding wheel after each trimming should be recalculated in the calculation formula of the curve point to obtain the correct position of the point (see Annex 3 for details);

4) Because the machine tool is large, the heat balance needs a long time to stabilize. Every finishing process must be done in one go. It can't be paused for too long in the process. Otherwise the processing will have unforeseeable errors.

5) Because of the long primary grinding process, the micro-wear of grinding wheel must be adjusted by the wear compensation in tool compensation.

6) Eccentricity of workpiece must be cancelled out by proper counterweight to eliminate the influence of clearance of screw rod on turnTable.

The error of the main cam can be obviously eliminated by the improvement of the above processes.

4. Conclusions

The modification of the machining center enables it to have the function of CNC grinding machine, and ensures that the main cam components can be successfully processed on the machine tool, expanding the function potential of the machining center. When the machine tool is not used to grind the main cam, it can be used as a NC milling machine as long as the grinding spindle is removed. The main cam components processed by the modified machine tool have high precision, good versatility, short production cycle and low manufacturing cost. The main difficulties have been overcome successfully for the development of a new type of multi-position punch. At the same time, this process provides a new idea for the transformation of NC machine tools and accumulates rich experience. Remarkable economic and social benefits have been achieved.

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