Machining process rules for connecting rod parts and special fixture design

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Abstract: for the current development of our country, the development of industry is going hand in hand with the economic development of our country, with the development of industry, the overall maturity of machinery manufacturing industry is gradually increasing. In the mechanical manufacturing industry, connecting rod parts are one of the important components of piston engine and compressor, so for these two kinds of machinery, the importance of connecting rod parts is self-evident. This paper will take the machining technology of connecting rod and the corresponding furniture design in the processing process as the starting point to analyze the problems that need attention in the design and processing process.

1. Introduction
Along with China's rapid economic development, the machinery manufacturing industry has witnessed remarkable advancement. In the machinery manufacturing industry, parts and products with specialized functions are manufactured as a result, which is also an important factor to boost the progress of the machinery manufacturing and constitutes as part of people’s necessities. It is obvious that the manufacturing industry has implications for people's life and national production. This paper studies the connecting rod parts in the manufacturing industry, offering analysis on its manufacturing technology, and special fixture design.

2. Machining process rules on connecting rod parts

2.1 Selection of manufacturing base surface
Before machining, the manufacturing base surface needs to be selected. The base surface is mainly to calculate the water level and the starting surface of the high-rise. The selection of base surface is one of the key tasks for the manufacturing process design and a key link for the machining design of parts. The base surface must be designed and selected in a scientific and reasonable way, so that the efficiency of the mechanical fabrication can be ensured. Accurately and scientifically selected base surface can greatly reduce the probability of failure and make up for the loopholes that may happen in the whole manufacturing process. In the selection of base surface, generally unprocessed plane on the upper end of the base surface is taken as the rough benchmark while the processed internal cord is used as a fine benchmark.

2.2 Identification of Processing Route
In the whole machining process, processing route is a series of steps that real fabrication undergoes, which is the result of the sequence arrangement between multiple processes. The fundamental purpose is to ensure that the parts can be fabricated in a phased manner to form a coherent operation process and reach target standards. As the processing route is predictable, it can help the
manufacturers stringently control the details of the operation in the manufacturing process. It is also an important means to exercise quota management on mechanical fabrication. The principle of machining process routes is to ensure product quality. The machining process of connecting rod parts can be designed as the following steps. Step 1, casting; step 2, aging treatment; step 3, milling the upper and lower end faces; step 4, milling the lower end faces and sides; step 5, drilling; step 6, boring; step 7, further drilling; step 9, making the groove; step 10, milling the wide groove; step 11, quality inspection; and the final step, warehousing. Processing route is not always the same for the fabrication of parts. The features of the parts and their future applications are key factors for consideration during routing design. Therefore, routing details shall be well integrated with its applications during design so that it can ensure work efficiency and manufacturing quality.

3. Design of connecting rod parts

3.1 Technical requirements

A connecting rod is one important part of a piston engine that connects the piston to the crankshaft. The connecting rod generates power by converting the reciprocating motion of the piston into the rotation of the crankshaft. Figure 1 is the part drawing of an automobile connecting rod. It made up of large and small head holes, and both ends face. The rod body connects the large head hole, small head hole, and both ends face. The material is 45 steel, precision forging. The main processing surface of the connecting rod is a large and small head hole, both end faces, a joint surface of the connecting rod cover and the connecting rod body, and a bolted positioning hole.

![Figure 1. Parts of an engine connecting rod](image)

Processing requirements for large and small holes: The axis of small head hole and large head hole are parallel to each other and parallel to the horizontal symmetry plane B of the rod body. The axis of the small head hole is perpendicular to the vertical symmetry plane G of the rod body. The spacing between the large and small holes is $(190 \pm 0.05)$ mm. The surface roughness of the small head hole is $Ra0.8 \mu M$. Processing requirements for both end faces of large and small head holes: The upper and lower end faces of the large head are symmetrical with the vertical symmetry plane G of the rod body and perpendicular to the axis of the large head hole; the upper and lower end faces of the small head are symmetrical with the vertical symmetry plane G of the rod body; the surface roughness of the end face is $Ra0.8 \mu M$. Processing requirements for the rod cap and the rod connecting bolt hole: Symmetry and positional degree are required between the axis of the two bolt holes and the horizontal symmetry plane B of the rod body.

3.2 Analysis of the manufacturing process

The conventional manufacturing process requires manufacturers to adopt a dispersed process or multiple steps to manufacture large and small head holes as per the technical specifications on fabrication of connecting rod parts. However, the dispersed process involves fabrication and clamping of multiple sets. It undoubtedly brings about an increasing production costs and lowered production precision due to the tolerance of multiple clamping. In contrast, a centralized fabrication process may
not only reduces costs in the fabrication of fixtures but may complete the fabrication of multiple surfaces at a one-time clamping, ensuring the precise position of the fabrication surface. However, it is hard to realize the centralized fabrication process due to restrictions of conventional fabrication equipment. The machining process for standard parts witnesses substantial changes due to the successful application of CNC technology in metal cutting machine tools. New forms of manufacturing process keep emerging. The design of automatic fixtures is featured by utilizing the four-shaft processing center to complete the semi-finishing of large and small head holes and both end faces of the connecting rod. Its manufacturing process: Step 1, milling one end face of large and small heads with the end-milling cutter. Step 2, drilling small end holes with twist drills and enlarge the holes with end-milling cutter. Step 3, milling the other end faces of large and small heads with end mills. The large and small head holes as well as their end faces of the connecting rod are fabricated in a one-time clamping. It can not only ensure the dimensional accuracy between large and small head holes but also ensure the mutual position accuracy of the axis and end face of two holes. So it has implications for increased machining accuracy of connecting rod parts.

3.3 Small head hole drilling fixture
Due to the stringent requirements on the materials for connecting rod, steel is used to ensure the strength of a connecting rod for production on a batch basis. A set of small head hole drilling fixture is designed as per the tutor's requirements. The fixture with high precision is designed to improve efficiency and ensure the rational specifications and dimensions of a connecting rod. Issues needed to be pointed out: The fixture is for large head holes with specification Φ42. However, it has certain precision requirements on its axis line. So, we design the small hole first. Then, we drill and enlarge aperture for improved efficiency. Design of fixture: (1) Selection of positioning datum. From the design drawing, it can be spotted that the end face of the connecting rod has been completed before the fabrication of a small head hole. It requires high surface roughness on the overall. The rotation of Z-shaft does not hinder the positioning of the small hole center. The process featured by quick replacement of drill dies is adopted to accelerate the entire fabrication process and cope with the huge production load of connecting rods. It can help reduce the time required by the manufacture process. (2) Clamping plan. Due to a downward force to the small hole during the drilling process, double bolts are used to clamp the large end hole. The V-block will also play a certain limiting role in the clamping process. (3) Calculation of cutting force and clamping force. It aims to expand the small head hole. The following parameters need to be calculated.

3.4 Working Principle
The work piece clamp leaps forward and grips the cylinder piston transversely to contract. The clamp opens. When the industrial robot places the workpiece on the floating support seat No.5, the transverse clamping cylinder No.1 starts up. Pushed by the piston No.3 transversely, clamping block No.4 moves along the dovetail groove on the longitudinal clamping block No.13 to realize the lateral positioning and clamping of the connecting rod blank. Then, the longitudinal clamping cylinder No.15 starts up. Driven by the piston No.17, the longitudinal clamping block No.13 moves along the dovetail groove on the fixture base No.7, pushing the connecting rod blank to move towards the V-shaped positioning block. In turn, the longitudinal positioning and clamping of the connecting rod work piece is realized. When the horizontal and longitudinal clamping cylinders locate and grip the blank, the forging difference of the workpiece may cause the connecting rod body to press down the floating support seat No.5 and avoid over-clamping. The floating support seat only plays an auxiliary supporting role. When the workpiece is well clamped, the large and small head hole and one of the end faces can be fabricated.

4. Conclusion
To sum up, this paper focuses on an overall analysis of the connecting rod to offer inspiration to readers. In the machining process of connecting rod parts, as the well-fledged development of
machinery manufacturing industry and manufacturing technology, the manufacturing process and fixtures used in the fabrication process need to be scientifically and reasonably designed to ensure high efficiency of connecting rods and fit for different applications.

Author's brief introduction
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