Design and Manufacture of Spindle Bores for Processing Large Diesel Engine Bodies

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Abstract: The machining of the main shaft holes of large diesel engine bodies generally faces problems such as long boring tool lengths and poor stability when working with spindle-driven boring tools. In order to improve the efficiency of the main bore processing while ensuring the precision of the processing, the research has designed a spindle bore installation suitable for processing large diesel engine bodies. By positioning the support components, the body is positioned precisely and steadily, and the guide setting reduces the need for boring tool length, allows the roughing of the main shaft hole and the processing of the thrust surface to be completed in one go, reduces the processing cycle of the main shaft hole, and increases the productivity of the enterprise.

Keywords: Large Diesel Engine; Spindle Bore; Boring Tool; Thrust Tool

1. Introduction

As a key part of the diesel engine body, the precision of its dimensions, shape and position directly affect the overall performance of the diesel engine [1], and the processing quality directly influences the safe operation of the diesel engine [2]. If the spindle bore is processed with dimensional deviations, poor shape, or surface roughness that is not in accordance with the requirements, it may cause excessive or small mating clearance between the spindle and the body, which may lead to vibration, noise, and wear, etc. Reduce the life of the diesel engine [3].

The main equipment for the main spindle hole currently being processed consists mainly of the base, support bracket and spindle, where the base places the machine body to be processed, the support bracket supports the axial end of the boring tool, and the main spindle is used to grasp the opposite end of the boring tool in an axial direction and to drive the boring tool around the axis and along its axial straight line. The block is placed between the support bracket and the main shaft for processing operations, and the boring tool runs axially across the opposite ends of the body along the crankshaft bore, which requires the boring tool to be longer than the body in a single molding operation.

When processing large diesel engine bodies, the stability of the spindle gripping boring tool needs to be significantly increased, the length of the boring tool needs to be significantly increased, the longer the boring tool length, the more difficult the spindle can be to maintain stability when driving the boring tool. Therefore, for the crankshaft bores machine of large diesel engine bodies, the precision is always low, and it needs to be processed repeatedly, and a machine tool is urgently needed. To solve the technical problems you are facing today.

2. Overall Design of the Main Bore Unit of the Machine Body

2.1 Design Purpose

In order to speed up the processing of the main shaft holes of large diesel engine bodies and ensure the precision of the processing, the design of the new body spindle hole processing unit should meet the following key requirements: Optimize the tool configuration, the boring tool length is moderate, and the boring tool length must no longer be satisfied with the length of the boring tool being larger than the body length. Reduce vibrations and errors that can occur due to excessive tool length, while ensuring the stability and reliability of the spindle when gripping and driving the boring tool, avoiding scrap resulting from excessive hole clearance after processing, and the need for frequent rework due to tight hole clearance. In addition, additional tools for thrust surfaces on both ends of the main spindle should be added to the boring tool, reducing the number and frequency of tool changes, so as to improve the efficiency of the main spindle bore and maintain the continuity and stability of the processing process.

2.2 Design Content

2.2.1 Positioning System

To ensure the precision of the main bores in the processing of large diesel engine bodies, it is particularly important that the body is accurately and securely positioned to the predetermined processing position, and the precision of the body positioning directly affects the precision of the machined surfaces of each spindle bore. To improve the accuracy of the positioning of the body, the body positioning device system has been designed, with the specific structure of the equipment shown in Figures 1 and 2. The unit consists mainly of the base, positioning support components, and guide, which not only supports the weight of the entire body, but also has a swivel table to enable 180° conversion of the machine face function; the guide design reduces the length of the boring tools required. The vibration and error that can be caused by the tool being too long is reduced, which greatly improves the stability of the processing process.

The concept of the new processing spindle bores is as follows: The body is lifted via a lifting device into the processing equipment base area, the body is fully positioned by positioning the round and diamond pins in the support assembly, restricting its six degrees of freedom, and an optical sensor is placed in the positioning surface of the custom support assembly. The function is to warn the operator if the body does not fit with the positioning surface or if there are chips, and the operator can reposition the body according to the actual situation.

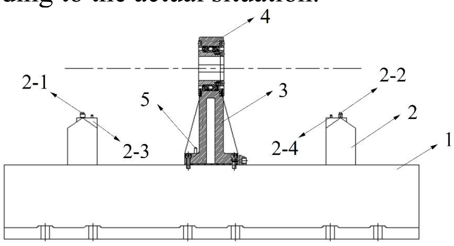

Figure 1. Front View of Processing Equipment

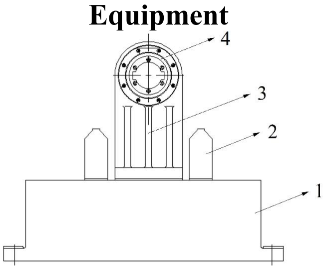

Figure 2. Processing Unit Side View

Where 1, base; 2, positioning support assembly; 2-1, round pin; 2-2, diamond pin; 2-3, Positioning surface; 2-4, optical sensor; 3, support base; 4, guide sleeve; 5, signal sensor.

2.2.2 Design for rough machining of spindle bore

In the process of processing large body spindle holes, to ensure the precision of the bore path meets the design requirements, the spindle holes of the processed body need to be roughing before further fine processing. The main spindle hole roughing is designed to be a boring tool, a roughing tool and a finishing tool in three parts, and the processing position is illustrated in Figure 3.

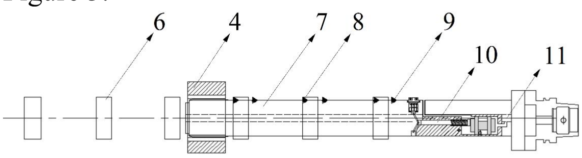

Figure 3. Illustration of the Processing Position

Of which 4, guide sleeve; 6, spindle hole; 7, boring knife; 8, roughing cutter; 9, Finishing tools; 10, thrust tool modules; 11, tool internal cold holes.

The main spindle rough machining unit is conceived as follows: The processing center spindle is programd to put the boring tool down into the crankshaft bore of the body, stop and move up at the right-hand side of the third spindle hole, and when the boring tool bar reaches the specified position, the drive assembly clamping boring tool rotates around the axis. The roughing tool on the cutterbar cuts the main shaft holes, and the tool moves gradually as the processing takes place, while the three main shaft holes are also roughing. After roughing the spindle holes, the boring tool bar continues to move forward around the axis, the finishing tool further fine cuts the spindle holes, and completes the finishing of the three spindle holes.

2.2.3 Design for thrust surface machining

In order to improve the processing efficiency and process integration of the main spindle holes of the machine to be processed, tools for machining thrust surfaces on both ends of the spindle holes have been added to the traditional boring tools. As the boring tool feeds, the tool bar moves forward in the guide sleeve, and when finishing the boring tool bar just goes through the left-hand side of the guide sleeve, the signal sensor senses and passes the control signal to the cutting fluid control switch. The cutting fluid flows out of the tool's internal cool hole in the middle of the boring tool, and the thrust tool module pushes out of the shank plane with water pressure, processing the right-hand thrust surface of the first spindle hole as the boring tool rotates. When the right-hand thrust surface is finished, the cutting fluid stops, the thrust tool module is restored, and the boring tool continues to move forward until the programd distance stops, when the thrust tool module is just to the left of the first spindle hole. The cutting fluid control switch opens and flows, and the thrust tool module again pushes out of the cutterbar plane, and the program controls the feed of the boring tool rotation backwards, enabling the processing of the thrust surface to the left of the first spindle hole. When the left-hand thrust surface is finished, the cutting fluid stops flowing, the thrust tool module is restored, and the program controls the boring tool exits the spindle bore, which completes the main bore on the side of the body.

2.2.4 Design for machining on the other side of the main spindle bore of the body

When the spindle holes on one side of the machine are finished, the swivel table on the base rotates 180° against the fixed table, enabling the front and rear ends of the machine to be swapped, repeating the roughing of the spindle holes and the thrust surface processing process, and completing the processing of the spindle holes on the other side of the machine.

3. Thrust Tool Module Design

In the new type of machining large body main shaft hole unit, the thrust tool added is the core part, and its stability and reliability have a vital impact on the processing of the main shaft hole. Since the thrust surface of the main spindle hole of the body needs to be precision machined on both ends of the inner and outer sides, the initial length of the thrust tool is smaller than the diameter of the main spindle hole in order to ensure a smooth boring tool through the main spindle hole. To solve this problem, the study uses a retractable structure in the design of thrust tools to meet the actual processing needs, increasing the flexibility and adaptability of the processing process.

3.1 Cutting Preparation Process

The starting position of the thrust tool is shown in Figure 4. When the main spindle bore is finished, the cutting fluid flows from the cold bore of the tool and some water flows through the piping to the thrust tool module. Under water pressure, the moving valve compresses the spring through the stop pin stop, pushing the push rod forward to squeeze the telescopic assembly, which moves the cam body up, and the teeth on the top of the cam body make contact with the support bar of the rotating body during movement. Simultaneously moves the swivel body upward, with the thrust tool pushing out of the boring tool bar. The control switch reduces the cutting fluid flow rate, the water pressure is less than the spring force on the active valve, and the push rod moves the telescopic assembly back into position, when the support rod of the rotating body contacts the serrated on the top of the fixed housing during lowering and moves along the serrated tilt angle until the tooth bottom stops. The thrust tool is secured with a rotating body over the fixed housing and begins cutting the thrust surface, where the thrust tool is positioned as shown in Figure 5.

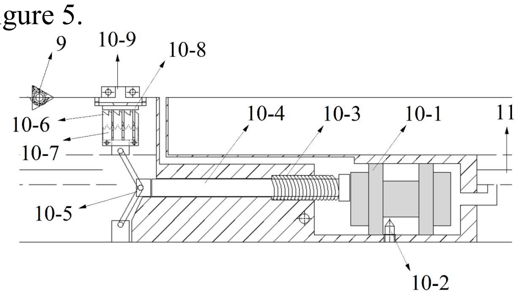

Figure 4. Schematic Illustration of the Thrust Tool Starting Position

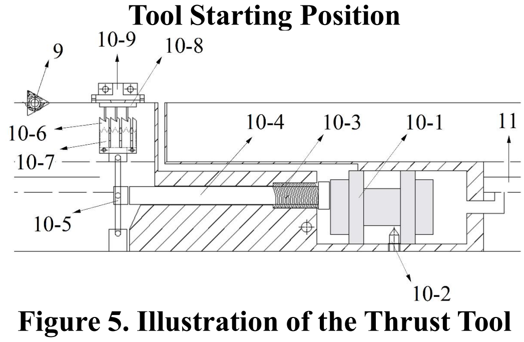

Figure 5. Illustration of the Thrust Tool Working Position

Of which 9, finishing tools; 10, thrust tool module; 10-1, moving valve; 10-2, blocking pin; 10-3, Spring; 10-4, push rod; 10-5, telescopic assembly; 10-6, fixed housing; 10-7, cam body; 10-8, Rotating body; 10-9, thrust tool; 11, tool internal cold bore.

3.2 Cutting End Process

After thrust surface processing, the control switch increases the cutting fluid flow rate, compresses the spring, pushes the push rod forward to compress the telescopic assembly, and the telescopic assembly moves the cam body up. The cam tip serrated contacts the support bar of the swivel body during movement, which leaves the fixed housing as the cam body moves. The control switch then reduces the cutting fluid flow rate, the telescopic assembly moves the cam body downwards, the rotating body drops back into place along the hollow area of the fixed housing, the thrust tool resets, and the cutting fluid stops.

4. Conclusion

(1) In order to improve the stability of the spindle while grasping the boring tool and to reduce the length of the boring tool appropriately, a spindle bore device for large diesel engine bodies has been designed, which precisely locates the body by positioning the support components, which not only enables the rough machining of the spindle bore. The thrust surface can be processed without changing the tool, greatly improving the efficiency of the large main bores.

(2) As the core part of the new processing unit, the thrust tool is designed in a retractable structure, which controls the lifting and lowering of the thrust tool through the water pressure of the cutting fluid, which is simple, efficient, Stability and other characteristics to meet the actual processing needs.

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