Design of a special tool for dismantling and fitting of the lead sleeve in marine fuel injection pump

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Abstract. The existing dismantling and fitting tool of the lead sleeve in fuel injection pump in the laboratory is taken as the research object, aiming at its shortcomings or problems like the limited scope of application, the laborious operation, the hidden danger of personnel injury and so on. Starting from the design requirements of the special tool for the dismantling and fitting of the lead sleeve in the marine fuel injection pump, a special tool for disassembling and assembling of the lead sleeve of the injection pump is designed by using the graphic design software AutoCAD2014, and the working principle and the main components of the tool are introduced. Finally, from the aspects of technique, operation, maintenance, economy and so on, the feasibility of the special tool for the dismantling and fitting of the lead sleeve in the fuel injection pump was taken analyzed.

Key words: Design; Marine fuel injection pump; Special tool for disassembling and assembling; Feasibility analysis.

1. Introduction
Fuel injection pump is the most important part of diesel engine, and is regarded as the heart of diesel engine[1]. It is not only the core component of the injection system of marine diesel engine, but also a kind of precision component, which plays the role of producing high injection pressure, controlling the timing and quantity of fuel supply, etc. Its performance largely determines the performance of diesel engine. The fuel injection pump will transmit the diesel to the injector at the fixed time with fixed quantity under constant pressure according to the different working conditions of the diesel engine, and then the diesel will be atomized and injected into the cylinder by the injector, working by combustion under high temperature and high pressure. If the fuel injection pump fails, the normal operation of the diesel engine will be affected. Therefore, after running for a period of time, the fuel injection pump needs to be dismantled and measured to check whether the fuel injection pump is in good condition. During this process, the dismantling and fitting of the lead sleeve is a vital part of the disassembling and assembling of the fuel injection pump[2].

When dismantling and fitting the lead sleeve, other devices, such as a radial drilling machine or special tools, are generally used. These devices have their own deficiencies or problems like being time-consuming and labour-some with high construction cost, large occupied space, limited scope of
application, and potential safety hazards of personnel injuries[3]. Thus, to design a dismantling and fitting device with simple operation, low cost, high efficiency and safety for the lead sleeve in marine fuel injection pump becomes is a realistic problem that requires consideration[4].

2. Dismantling and fitting device for the lead sleeve in fuel injection pump and its existing deficiencies or problems

2.1. Radial drilling machine

The radial drilling machine, also known as the radial drill, is a kind of hole processing equipment, generally used to complete drilling, reaming, fraising, tapping, end face repairing and scraping, and other forms of processing. According to the power of the radial drilling machine, it is divided mainly into two types, the hydraulic and the mechanical.

The steps of using radial drill in the dismantling and fitting of the lead sleeve in fuel injection pump are as follows: (1) place the injection pump on the upper surface of the worktable on the base of the radial drilling machine, and exert a small force to rotate the rocker arm until the vertical spindle of the drilling machine just touches the upper surface of the lead sleeve; (2) exert a large force to rotate the rocker arm slowly with the vertical spindle moving down continuously, and under the down force of the spindle, the lead sleeve moves down continuously with respect to the injection pump body until the clip spring groove is completely exposed; (3) squeeze the screwdriver into the clip spring groove and slightly pry the clip spring out; (4) rotate the rocker arm reversely until the vertical spindle is at a certain distance away from the lead sleeve of the fuel injection pump, then take out the clip spring, and remove the lead sleeve, the spring seat, the spring and the plunger, finishing the dismantling of the lead sleeve; (5) after the overhauling, put the plunger, spring, spring seat and lead sleeve into the pump, rotate the rocker arm to press down the lead sleeve, and squeeze the clip spring into the groove , completing the installation of the lead sleeve.

It’s very convenient to disassemble and assemble, and easy to operate this kind of device, but it needs to be equipped with a radial drilling machine, which requires high cost and a certain laboratory space. Besides, one person is needed to assist when dismantling and fitting the device.

2.2. Special tools

The structure and composition of the bench vice are shown in fig. 1. The steps of the dismantling and fitting of the lead sleeve in fuel injection pump are as follows: (1) turn the lead screw so that the distance between the fixed jaw and the movable jaw is sufficient to place the fuel injection pump; (2) put two pieces of wood or the soft pad into the fixed jaw and the movable jaw to avoid direct contact between the jaw and the lead sleeve, resulting in deformation and damage of the fuel injection pump[5]; (3) clamp the fuel injection pump by turning the lead screw in the opposite direction to avoid losing its working position when the fuel injection pump is dismantled, and at the same time taking care not to turn the lead screw excessively so as to avoid the stress deformation of the fuel injection pump; (4) put the hook
of the special tool in fig. 2 into the pin hole of the fuel injection pump, and find the central position on the lead sleeve as its working position; (5) gently press down the main rod, and then the lead sleeve will move down under the down force until the clip spring groove is fully exposed[6]; (6) squeeze the screwdriver into the clip spring groove and slightly pry the clip spring out. (7) loosen the main rod and take out the clip spring, then remove the lead sleeve, spring seat, spring and plunger, completing the dismantling of the lead sleeve,(8) after the overhauling, put the plunger, spring, spring seat and lead sleeve into the pump, press down the main rod so as to press down the lead sleeve, and squeeze the clip spring into the groove , completing the installation of the lead sleeve[7].

Compared with the radial drilling machine, the special tool for dismantling and fitting of the lead sleeve has the advantages of simple structure, convenient, labor-saving and quick operation, low construction cost, and no need to occupy extra laboratory space. There is no way to adjust the length of the hook and the distance between the hook and the force bearing rod, therefore, the special tool is only suitable for the dismantling and fitting of a certain type of fuel injection pump. At the same time, the force bearing rod and the lead sleeve are in contact with a metal surface, and are easy to slip when operating, thus, there exist potential safety hazards of personnel injuries[8].

3. Design of a special tool for the dismantling and fitting of the lead sleeve in fuel injection pump

3.1. Analysis of the Design requirements for the special tool for the dismantling and fitting of the lead sleeve in fuel injection pump

The special tool for dismantling and fitting of the lead sleeve of the fuel injection pump in the laboratory is taken as the reference object, considering the structure, technology, operation, cost and maintenance, etc. Its design requirements mainly include the following aspects:

1) It should have a generally simple structure of mechanical connection with reasonable composition and quite few components and parts;
2) The dismantling and fitting technology of the lead sleeve should be advanced or practical;
3) It should have quite few operation steps of dismantling and fitting with simple and labor-saving operation and efficient dismantling and fitting. Meanwhile, the maintenance workload of the special tool needs to be low;
4) The initial investment cost or the modification cost should be low;
5) It should have a relatively wide scope of application, being used for the dismantling and fitting of different types of lead sleeves in fuel injection pumps.

3.2. Operating principle of the special tool for the dismantling and fitting of the lead sleeve in fuel injection pump

The structure of the special tool for dismantling and fitting of the lead sleeve in fuel injection pump is shown in fig. 3.
3.2.1. Dismantling of the lead sleeve. Put the fuel injection pump into the bench vice, and put a board or a soft pad on the movable jaw and the fixed jaw respectively, then turn the lead screw and clamp the injection pump, ensuring that the lead sleeve 11 in fuel injection pump can not slide when dismantling and fitting, and maintain its upper end face horizontal. When rotating the lead screw, do not exert too much force to avoid deformation of the fuel injection pump;

Place the hook 9 in the second pin hole 13 of the fuel injection pump base 12, and move the slidable frame 3 on the main rod 1 so that the force bearing rod 14 is approximately at the center of the lead sleeve 11, then turn the lock nut 2, making it fixed on the main rod 1. Turn the inner thread steel pipe 4 and the force bearing nut 7 so that the main rod 1 is basically in a horizontal position. The spring gasket 8 belongs to the consumable article, whose hardness is slightly lower than that of the force bearing nut 7 and the main rod 1, avoiding damaging them. And when the spring gasket 8 is damaged, it must be promptly replaced.

Exert a downward force at the left end of the main rod 1, and according to the lever principle, the force bearing rod 14 will produce a downward force, so that the lead sleeve 11 will move downwards, exposing the clip spring in the groove of the fuel injection pump housing 10. Then the clip spring can be taken out with a screwdriver, followed by the lead sleeve, the spring seat, the spring and the plunger, thus completing the dismantling of the lead sleeve.

3.2.2. Fitting of the lead sleeve. Exert a downward force at the left end of the main rod 1, and according to the lever principle, the force bearing rod 14 will produce a downward force, so that the lead sleeve 11 will move downwards[9], exposing the clip spring groove in the fuel injection pump housing 10. Then press the clip spring in by nipper pliers, completing the fitting of the lead sleeve 11.

When the type and size of the dismantled fuel injection pump are changed, the distance \(L\) between the center line of the lead sleeve 11 in fuel injection pump and that of the second pin hole 13 of the injection pump base 12, and the height \(H\) between the upper end of the lead sleeve 11 in injection pump and the bottom end face of the pin on the injection pump base 12 may differ. If the distance \(L\) between the center line of the lead sleeve 11 in fuel injection pump and that of the second pin hole 13 of the injection pump base 12 changes, the position of the slidable frame 3 on the main rod 1 can be adjusted. If the height \(H\) between the upper end face of the lead sleeve 11 in fuel injection pump and the bottom end face of the pin on the injection pump base changes, the inner thread steel pipe 4 and the force bearing nut 7 can be rotated so that the main rod can still remain in a horizontal position.

3.3. Main components of the special tool for dismantling and fitting of the lead sleeve in fuel injection pump

1. Vacuum sucker
   The vacuum sucker 5 has a combination structure, whose upper part has an external threaded steel structure, and has threaded connection with the inner thread steel pipe 4, ensuring that it has good interchangeability and disassemblability. The lower part of the vacuum sucker has a structure of rubber leather cup. When pressing downwards, the air in the leather cup will be extruded to realize vacuum suction on the upper surface of the lead sleeve 11, and the working position of the force bearing rod 14 of the special tool will be guaranteed to remain unchanged.

   When the rubber cup under the vacuum sucker has leakage due to deformation or being damaged, the rubber cup should be replaced in time to avoid skidding when loose pull-in occurs during the dismantling, causing injury to the personnel, etc.

2. Hook
   The hook 9 has an external thread structure at the end of the hook, which is threaded with the internal thread of the lock nut 16. Take off the lock nut 16 when dismantling and fitting, and put the hook 9 into
the second pin hole 13 of the fuel injection pump base 12, then fit the lock nut 16, making the hook 9 is locked and fixed on the fuel injection pump base 12, so that the hook 9 can be effectively prevented from falling off from the second pin hole 13.

When the special tool for dismantling and fitting of the lead sleeve in fuel injection pump is used for many times, the tail of the hook 9 may tilt. At that time, it should be corrected in time to make hook tail in the vertical position. If it can not be corrected, it should be replaced, so that the hook can fit well into the second pin hole 13 of the fuel injection pump.

4. Device feasibility analysis

4.1. Technical feasibility analysis

This dismantling and fitting tool mainly has a mechanical connection structure. The dismantling and fitting technology of the lead sleeve adopts the lever principle, which is simple, labor-saving and efficient with strong technical practicability[10].

Through clockwise or counterclockwise rotation of the force bearing nut 7 on the hook 9 and moving the slidable frame 3 on the main rod 1 left and right, it can be used for the dismantling and fitting of different types of lead sleeves in fuel injection pumps, having good technical applicability.

4.2. Structural feasibility analysis

This special tool has quite few components among which the slidable frame 3 and the lock nut 2, the inner threaded steel pipe 4 and the external threaded rubber cup, the force bearing nut 7 and the hook 9 poling, the lock nut 16 and the hook 9 tail all have threaded connection structures, and the components thereof belong to the standard parts, whose utility is quite good.

The main forms of damage of the dismantling device of the lead sleeve in fuel injection pump in production and daily life are the easy deformation, fracture, distortion of the force bearing rod hook and the crushing of the threads, etc. The strength and hardness of the dismantling device can be improved by relevant heat treatment so as to better avoid all kinds of damage[11].

Therefore, this special tool has great structural feasibility.

4.3. Operational feasibility analysis

This special tool has quite few components, such as slidable frame, lock bolt, vacuum sucker and so on. The main steps for dismantling and fitting are the screwing and tightening of the lock nut 16, the position adjustment of the force bearing nut 7 and the slidable frame 3, etc. And these can be completed by one person, thus, the operation is rather simple.
This device is simple, as the majority of its parts used are standard parts, so it has high reliability as well as quite less maintenance workload, and the damage can be easily repaired or renewed, therefore, its maintainability is good [12]. Hence, this special tool has great operational feasibility.

4.4. Economic feasibility analysis
This special tool is made mainly of plain carbon steel and rubber, which are relatively cheap and readily available on the market. Most of its components are standard components, whose price can be controlled and within the acceptable range. Therefore, the initial investment or modification cost of this special tool is relatively low.

In the meantime, this special tool has strong applicability. After mass production, this special tool will have a broad application prospect with considerable economic benefit. Therefore, this special tool has good economic feasibility.

5. Conclusion
① The shortcomings or problems of the existing dismantling and fitting device for the lead sleeve in marine fuel injection pump are summarized, such as being time-consuming and labour-some with high construction cost, large occupied space, limited scope of application, and potential safety hazards of personnel injuries and so on;
② The design requirements of a new type of special tool for dismantling and fitting of the lead sleeve in marine fuel injection pump are summarized from the aspects of technology, operation, maintenance and economy, etc;
③ Using AutoCAD2014 software platform, a special tool for dismantling and fitting of the lead sleeve in marine fuel injection pump is designed, which consists of slidable frame, lock bolt and vacuum sucker, etc. And the working principle of the tool as well as the structure of the two main components, vacuum sucker and hook, are introduced;
④ At last, the feasibility of the special tool is demonstrated from the aspects of technology, operation, maintenance and economy, etc, showing that the special tool has great feasibility.
⑤ The research of this paper belongs to the previous theoretical research, whether it can be applied to the dismantling and fitting of the lead sleeve in fuel injection pump in the real ship or laboratory needs to be further explored. In the future process of project development, it can be supported and improved from the aspects of numerical simulation, model test and so on.

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