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Exploration into New Method for Measuring Gear Pump Clearance of Marine Auxiliary Engine

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Abstract: Belonging to the marine vocational and technical education system, the course "Marine Auxiliary Engine" is a core course in marine engine engineering technology major and also a compulsory subject required by STCW Convention. In the competency assessment of marine auxiliary engine, the measurement and adjustment of gear pump clearance is an important assessment item of marine engine major. Teachers usually have relatively mature methods for teaching of related content. This paper proposes two new methods for measuring gear pump clearance, and makes comparison with the old methods to demonstrate the operability, simplicity, practicability and innovation of the new method, which will provide certain reference and enlightenment for professionals engaged in teaching training and office work. Details are described as follows.

1. Introduction

Gear pump is taught in the course of “Marine Auxiliary Engine”. As a lubricating oil pump, gear pump is one of the most important pumps in marine engine room. Through the learning of the structure and working principle of the gear pump, the paper analyzes the internal leakage of the gear pump (that is, the oil leakage from the outlet to the suction port) from three clearance leakage (Figure 1, Figure 2): The first is the leakage from the end clearance between the gear face and the end cover; The second is the leakage from the gear tip clearance between the tooth tip and the inner surface of the pump case; The third is the leakage from the backlash at the gear engagement site [1]. Gear pump internal leakage causes hazards of flow, pressure drop, oil heating, efficient reduction. Hence, in the gear pump operation management and maintenance, special attention should be paid to the measurement and adjustment of the three clearances, so as to meet the specification requirements. According to years of teaching experience, professional peer knowledge and actual office work, the three clearances are often measured using conventional and mature method. Combining the teaching practice, the author believes that the measurement operation of the gear pump side clearance is often completed in relatively unified method. A simple and practical method is proposed for the measurement of the gear tip clearance and backlash. Comparative research method verifies that the new method is scientific and effective, which has practical guiding significance in helping students successfully pass the assessment and strengthening the job performance ability of enterprises.

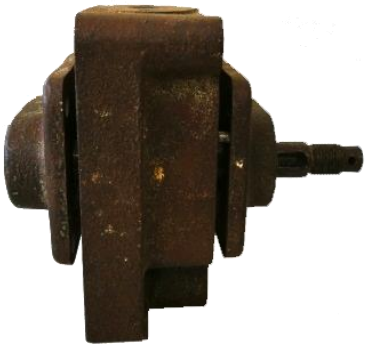

Figure 1: External structure of gear pump.

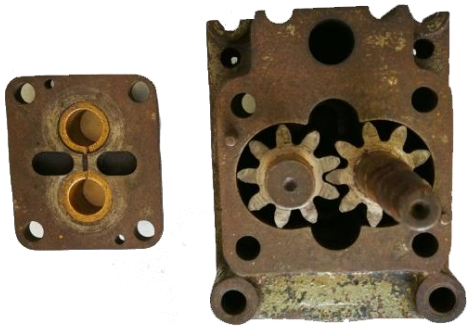

Figure 2: Internal structure of gear pump

2. Gear Tip Clearance Measurement

2.1. What is the Gear Tip Clearance

Gear tip clearance refers to the clearance between the top of the tooth tip and the inner surface of the pump case, with an annular clearance formed along the outer circumference of the gear.

2.2. Effect of Gear Tip Clearance on Gear Pump Operation

During gear pump operation, the gear rotates at a high speed relative to the pump case. Hence, in the process of design and assembly, appropriate gear tip clearance should be reserved. Nevertheless, gear tip clearance changes with the gear pump operation. As for the harm, when the gear tip clearance increases, due to the pressure difference between the left and right chamber (suction discharge) divided by tooth meshing, there is increased leakage of oil from the discharge chamber to the suction chamber along the gear tip clearance, resulting in reduced displacement of the gear pump and lower outlet pressure [2]. When the gear tip clearance gets smaller, friction occurs between the tooth tip and the pump case [3], which will increase abrasion, power consumption and noise of the gear pump, and even cause breakdown. Therefore, in operation management, it is necessary to measure and adjust the gear rip clearance.

2.3. Traditional Methods for Measuring Gear Tip Clearance

2.3.1. Thickness Gauge (Referred to as Feeler Gauge) Method

The steps are described as follows:

(1) The end cover on one side of the gear pump is removed;

(2) A thickness gauge is prepared, one of the pieces is selected according to the tip clearance standard specification. The selected thickness gauge is preferably thick, which should be inserted repeatedly in the gear tip clearance in turn (clockwise or counterclockwise). Three situations will happen here. First, if the insertion is easy, the next gear tip clearance should be measured. Second, when insertion is impossible, thickness gauge of a smaller size should be used instead. Third, if the thickness gauge is inserted freely, with a certain frictional resistance normal in the measurement, the next gear tip clearance should be measured until the last gear tip clearance is measured since smaller gear tip clearance is possible. By determining the thickness of the thickness gauge as the gear tip clearance value of the gear pump, we can find the minimum gear tip clearance at this time;

(3) The gear is rotated to change the working position of the gear. Another minimum value of the gear tip clearance should be measured in the same way as step (2);

(4) The minimum value of the gear tip clearance is measured at several different positions. Comparison is made to select a minimum value as the gear tip clearance, and then it is compared with the standard specification to determine the adjustment method.

(5) The end cover is reinstalled and the gear tip clearance measurement is thus completed.

2.3.2. Shortcomings of Traditional Methods

(1) Seen from the above 5 measurement steps, there are many steps involved, which increases the operation error rate. In particular, step 2 requires the operator to make repeated comparisons, which increases the operation complexity [4].

(2) In the process of gear tip clearance measurement, the end cover should be removed, which increases the operation step. Meanwhile, after the end cover is removed, it is impossible for the gear shaft to support the bearing hole on the side of the end cover, and only bearing hole on the other side will be supported, with one side suspended in the air. The measured gear tip clearance at this time is inaccurate.

2.4. New method for Measuring Gear Tip Clearance

2.4.1. Pressing Lead Wire Method

Steps are described as follows:

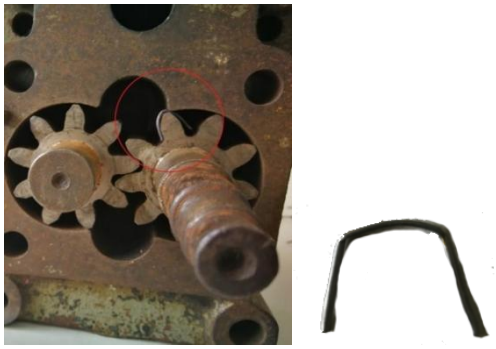

Figure 3: A new method for measuring gear tip clearance

(1) According to the standard specification of gear tip clearance, lead wire with diameter of

appropriate size is selected and cut into three sections. The length of each section of the lead wire is appropriate if it wraps a tooth surface, as shown in Figure 3;

(2) From the suction port (except small gear pump suction port with the outlet in none-radial arrangement), the three sections of lead wire are evenly wrapped on the tooth surface with grease along the tooth width direction;

(3) The gear is rotated clockwise. The lead wire will be flattened when passing through the gear tip clearance. The lead wire is drawn out from another outlet to measure the thickness of the three flattened sections of the lead wire using vernier caliper, so that three measured values are available. The three values are averaged to calculate gear tip clearance value;

(4) Different gear teeth is randomly selected and the above steps are repeated to calculate different gear tip clearance values. One of the minimum values is taken as the measured value of gear tip clearance [5].

2.4.2. Strength of Gear Tip Clearance Measurement Using the Pressing Lead Wire Method

(1) By comparing the steps of thickness gauge method and pressing lead wire method, it can be seen that the new method does not require removal of the end cover, and there is no need for repeated comparisons, insertions as in the thickness gauge method, so that the operation is simple and effective.

(2) Seen from the accuracy of measurement data, the new method is to measure data through measuring tools, which avoids excessive artificial judgment, and different positions are randomly selected for measurement, so the measurement is scientific and rigorous, demonstrating strong logic, high accuracy of measurement data.

3. Measurement of Gear Backlash

3.1. What is the Gear Backlash

The gear backlash refers to the clearance generated by the meshing between the driving gear and the driven gear teeth of gear pump [6].

3.2. Effect of Gear Backlash on Gear Pump Operation

In gear pump operation, in order to reduce abrasion, appropriate clearance is required at the meshing between the driving gear and driven gear tooth. However, under the pressure difference of suction and discharge chambers divided by tooth meshing, the discharged oil will unavoidably leak back to the suction side from the backlash [7]. In gear pump operation, gear backlash increases due to abrasion of the action surface. As for the harm, the interior leakage flow of drain will increase, resulting in reduced gear pump flow, discharge pressure, increased oil heat, lower efficiency. When the situation develops to a certain extent, the gear pump cannot operate normally. Hence, in the process of operation management, it is necessary to measure and adjust the backlash of gear pump [8].

3.3. Traditional Methods for Measuring Gear Backlash

3.3.1. Pressing Lead Wire Method

Steps are described as follows:

(1) The end cover on one side of the gear pump is removed;

(2) According to the standard specification of gear backlash, lead wire of appropriate size is

selected and cut into three sections. The length of each section of the lead wire is appropriate if it wraps a tooth surface;

(3) The driven gear is removed, grease is used to evenly wrap three sections of lead wire around a tooth surface along the tooth width direction. The lead wire should be installed at the discharge chamber. Then, the end cover is reinstalled. The shaft end can be properly marked in order to clearly show the lead wire position;

(4) The gear is rotated, the lead wire is meshed from the discharge chamber to the suction chamber, and the rotation angle is controlled through the mark on the shaft end. The lead wire is flattened amid tooth meshing;

(5) The end cover is removed and the lead wire is taken off. The top of each section of the lead wire is symmetrically flattened where it is bent. The thickness of two flattened site is measured to obtain two measured values. The two values are added to calculate gear backlash on a section of the lead wire. There are three gear backlashes on three sections of the lead wire [9]. The three gear backlashes are averaged to determine the gear backlash value of the gear pump, which is then compared with the standard specification to determine the repair method.

3.3.2. Shortcomings of Traditional Methods

(1) When using this method to measure the gear backlash, the end cover is removed. In the measurement project, the end cover is disassembled and assembled twice, which increases the measurement duration and complexity;

(2) The end cover side is reinstalled and the lead wire is removed. In order to grasp the position of the lead wire in measurement, the shaft end is properly marked, and the shaft angle rotation is controlled, which increases the operation difficulty.

3.4. New Method for Measuring Gear Backlash

3.4.1. The Improved Pressing Lead Wire Method

Its steps are described as follows:

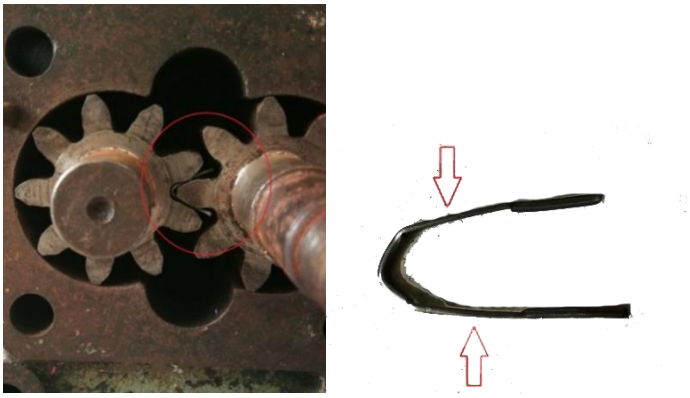

Figure 4: New method for measuring gear backlash

(1) According to the standard specification of gear backlash, lead wire of appropriate size is selected and cut into three sections. The length of each section of the lead wire is appropriate if it wraps a tooth surface, as shown in Figure 4;

(2) Lead wire is installed from the suction port (except small gear pump suction port with the outlet in none-radial arrangement). The three sections of lead wire are evenly wrapped on the tooth surface with grease along the tooth width direction. The gear is rotated so that the lead wire meshes from the discharge chamber to the suction chamber, and then three sections of lead wire are taken

out from the suction port;

(3) The top of each section of the lead wire is symmetrically flattened where it is bent. The thickness of two flattened site is measured to obtain two measured values. The two values are added to calculate gear backlash on a section of the lead wire. There are three gear backlashes on the three sections of lead wire. The three gear backlashes are averaged to determine the gear backlash value of the gear pump.

3.4.2. Strength of the New Method

(1) Seen from the comparison of old and new measurement steps, the traditional method involves five steps, but the new method only has three steps, so the operation steps are simplified;

(2) The new method does not require removal of the end cover, with the installation and removal of the lead wire performed from the gear pump outlet and suction port respectively, which greatly simplifies the installation and removal of the lead wire, demonstrating strong operability in the actual operation.

4. Conclusion

The method is described above for measuring the gear tip clearance and gear backlash of marine auxiliary engine. This paper emphasizes the popularization and application of the new method, since it has simple and intuitive operation with great enlightenment. Through the in-depth exploration and constant innovation of new methods and technologies in teaching, marine engineering technology major students can successfully pass the competency assessment, which will effectively increase our school students' passing rate in competency assessment, and lay a good foundation for students to find employment smoothly. Meanwhile, it has a certain guiding significance for the overhaul of the gear pump in the marine engine room.

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