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Improvement of friction testing machine and study on friction test

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In order to improve microcomputer control multi-functional friction testing machine MMS-2A, put forward with PLC control stepper motor method, and the stepper motor drives the spring compression friction pair , this method replace the original method, which operated by manual. Studied the effect of load on friction coefficient on the improved machine show that, the improved machine is more convenient to use, and the accuracy is greatly improved; In a certain range, the friction coefficient decreases with the increase of the load; At the same speed, with the increase of the load, scratches of the pin surface is increased, the main type of wear forms are abrasive wear and adhesive wear.

Abstract: *In order to improve microcomputer control multi-functional friction testing machine MMS-2A, put forward with PLC control stepper motor method, and the stepper motor drives the spring compression friction pair, this method replace the original method, which operated by manual. Studied the effect of load on friction coefficient on the improved machine show that, the improved machine is more convenient to use, and the accuracy is greatly improved; In a certain range, the friction coefficient decreased with the increase of the load; At the same speed, with the increase of the load, scratches of the pin surface is increased, the main type of wear forms are abrasive wear and adhesive wear.*

Keywords: *Friction testing machine, Machine improvement, Innovation, Friction factor, Test analysis*

I. INTRODUCTION

Tribology is the cross discipline, which study the friction, lubrication and wear between the relative movement of contact surfaces, the theory and application of the relationship in both are included too[1,2]. It is very common in people's production practice and life.

There are many factors that affect the friction and wear properties of materials. Such as temperature, speed, friction mode, surface state, etc. Therefore, it is not only beneficial to improve the quality and prolong the service life of mechanical equipment, but also save energy and raw materials when mastered the law of friction and wear properties[3-4]. Some industrial developed countries have made it clear that the tribology design is required in mechanical design[5].

In order to study the effect of friction pair's load and speed on the friction coefficient, a large number of experiments are done on the MMS-2A microcomputer controlled multi-functional friction machine. But a significant drawback of this testing machine is the change of load on friction pair must need by manual operation. This leads to two problems, first is the load can not be changed continuously in the test, and the second is force can not be controlled by experimentor. In order to solve this problem, we carried out the electrical transformation of the test machine. This paper mainly discusses the method of electrical transformation, and discusses the influence of the load and speed on the friction coefficient of the friction pair used by 45 steel pin plate in test machine.

II. MECHANICAL AND ELECTRICAL MODIFICATION OF TEST MACHINE

2.1 Introduce the background

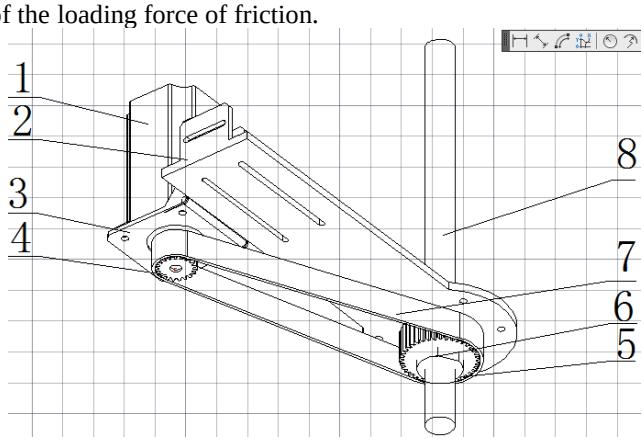
MMS-2A a multi-functional friction and wear testing machine, which can do the metal and non metal materials (nylon, plastic, etc.) wear resistance test in the statement of sliding friction, rolling friction, rolling-sliding friction, and also can do the friction test in the condition of wet friction, dry friction and abrasive wear conditions[6].At the same time, the friction coefficient of the material can be measured.

Fig.1 Test machine before improvement

Testing machine loading device is manually operated, that is, move the body up and down and compressing the spring by using a wrench to unscrew the nut from the screw, so as to achieve the purpose of loading or unloading force. In the process of testing the existing test machine, the test force is adjusted to the setting value by manual, and then carried out the next process. So during the whole movement, the test force is a constant value, it is difficult to research the wear question of friction pairs under variable load conditions.

2.2 Mechanical part

The key of this project is design a reasonable automatic device to replace the nut which moved up and down in the screw rod. What we considered in this paper are as follows: PLC control stepper motor 1 drives the screw sleeve 6 to rotate, the threaded sleeve 6 moved up and down on screw rod 8 through screw pair, so as to achieve accurate control of the loading force of friction.



1.Step motor 2.System frame 3.Motor bracket 4.Small gear 5.Big gear 6.Thread sleeve 7.Synchronous belt 8.helicoid screw

Fig2. Added mechanism

2.3 Electrical control

On the motion way of electrical control, the method of combining manual control and automatic control is adopted. Manual control is to press the corresponding direction button to load the force. Automatic control mode is separated into single cycle mode and cyclic mode. The single cycle model is load and unload linear force just once on friction pair automatically by step motor. The cyclic mode is load and unload linear force in cyclic. The following Fig3 and Fig4 are the state transfer diagram of PLC control in automatic and electrical system diagram respectively.

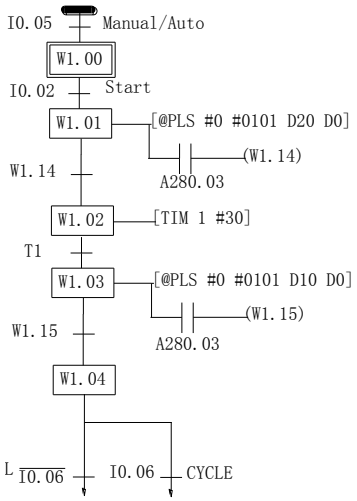


Fig3. The state transfer diagram of PLC control in automatic

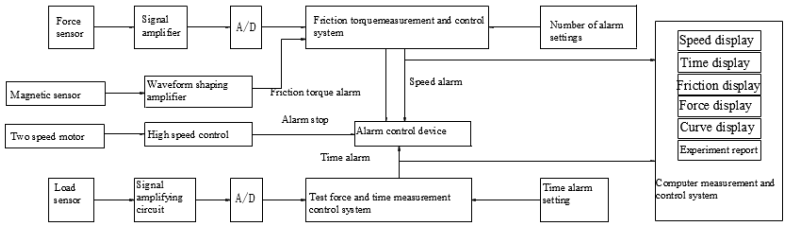


Fig4.Electrical system diagram

III. FRICTION TEST WITH IMPROVED FRICTION TEST MACHINE

3.1 Experiment design

The main purpose of the experiment is to investigate the advantages and disadvantages of the improved testing machine. Because of the improvement of the machine is the way of load force, so in this paper, use control variable method, study on the influence of load variation on the friction coefficient in condition of maintain the speed of the friction pair.

Pin and plate specimen are used for 45 steel, the dimensions are $\phi 4.8\times 12.7$mm and $\phi 38\text{mm}\times\phi 54\text{mm}\times 10$mm respectively. Test force 0~100N continuous change, wear time is 3min.

Secondly, record the test data in each group. As the experimental data is collected once per 10s, the test data is needed to make the chart, and the corresponding analysis is carried out according to the chart.

The friction coefficient u is measured by the balance of torque. The calculation formula is as follows:

$$f = uP \quad (1)$$

$$T = fr \quad (2)$$

$$u = \frac{T}{P\cdot r} \quad (3)$$

Where, f -Friction, u -Friction coefficient, P-Axial force test, r -Track radius of disc specimen and pin contact point.

3.2 Test results and analysis

According to the test record, friction coefficient data under different force is sorted and analyzed as below:

Tab.1 Relationship between load friction coefficient

Force	Friction coefficient	Force	Friction coefficient
0	1	160	0.1
20	0.8	180	0.1
40	0.6	200	0.1
60	0.5	220	0.0
80	0.4	240	0.0
100	0.3	260	0.0
120	0.2	280	0.0
140	0.2	300	0.0

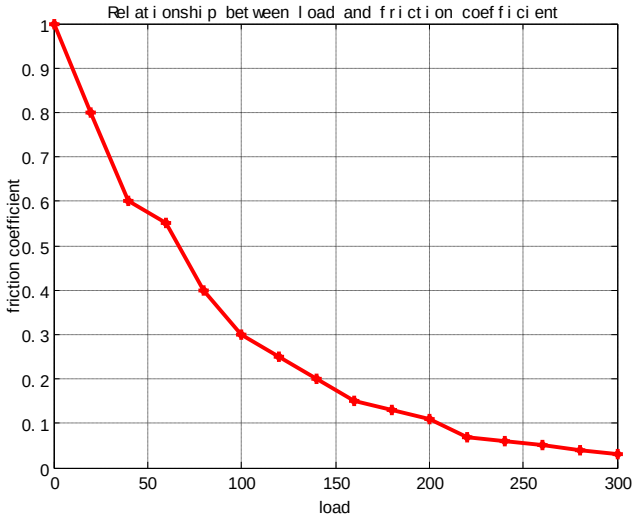


Fig.5 Relationship between load friction coefficient

From the above picture, we can come to conclusion that the pressure of the contact surface is increased with the increase of the test force, but the friction coefficient of the friction pair is gradually reduced. Further analysis shows that at the start of the trial in the initial stage, due to the formation of granular debris in the process of friction , it is more likely in higher friction coefficient by the improvement of mesh force in friction pair[7,8].

With the increase of wear and the numbers of particles, the force on contact surface is increased[9], the surface micro-hardness of friction pair is improved and the friction coefficient is decreased.

At low speed and load, the relative sliding between pin and disc pair is equivalent to abrasive wear. The forces acting on the surface of the friction can be divided into normal force and tangential force[10]. The effect of normal force is press the abrasive into the surface, and the tangential force make the abrasive grains move along the tangential direction. The formation of furrow, which caused by comprehensive effect above, resulting in abrasive wear and debris.

IV. CONCLUSION

To ensure a high-quality product, diagrams and lettering MUST be either computer-drafted or drawn using India ink. Figure captions appear below the figure, are flush left, and are in lower case letters. When referring to a figure in the body of the text, the abbreviation "Fig." is used. Figures should be numbered in the order they appear in the text.

Table captions appear centered above the table in upper and lower case letters. When referring to a table in the text, no abbreviation is used and "Table" is capitalized.

By using the improved friction testing machine, the friction coefficient of pin plate with the change of load is obtained by using the model of pin plate wear test. Research can draw the following conclusions:

(1)The improved test machine is more convenient to use, and the accuracy is greatly improved.

(2) In a certain range, the friction coefficient decreases with the increase of the load.

(3) At the same speed, with the increase of the load, scratches of the pin surface is increased, the main performance of wear forms are abrasive wear and adhesive wear.

V. ACKNOWLEDGEMENTS

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