Design and Research of Oil Film Compensation Control Based on Hydraulic AGC System

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Abstract

With the rapid development of a heavy plate production line, it is of great significance to control the precision of the finished plate thickness of the rolling mill. Oil film compensation is an important compensation amount of the hydraulic AGC system; this paper combines a heavy plate production line, introduces the calculation method of oil film compensation speed and load function and the control realization of compensation amount.

Keywords

Oil film compensation; hydraulic AGC; oil film bearing; rolling mill speed; rolling force.

1. Introduction

The Hydraulic AGC System (automatic gauge control system with hydraulic actuator) is an important part of the wide and heavy plate rolling project, which is a control system for the on-line adjusting the thickness accuracy of the rolling mill. The hydraulic AGC system has fast response speed, high control precision and other the advantages, which is widely used in steel rolling systems at home and abroad. In the process of realizing the automatic thickness control system of the equipment, the hydraulic AGC system uses many compensation measures to improve the control precision of plate thickness and the rolling yield of the product, one of the most important compensation amounts is the oil film compensation, therefore, the oil film compensation is of great significance to the design and development of heavy plate mills.

The upper and lower backup rolls of the heavy plate mill adopt oil film bearings, oil film bearings are also called as fluid lubrication bearings or liquid friction bearings.. Because there is lubricating oil between the shaft and the bearing, it has the incomparable advantages for the general sliding bearing and the rolling bearing, such as small friction factor, low loss, high rigidity, etc., it is widely used in the highly sophisticated equipment of steel, mine, metallurgy, electric power, aviation, aerospace and other systems. Moreover, the oil film bearing is an important factor that directly affects the oil film thickness, rolling mill speed and rolling force, because the rolling force causes the roll shaft journal to move, forces the center of the roll to be eccentric, and the working area forms a complete pressure oil film, causes the metal to come out of contact, results in friction of the pure liquid, and its effect is reflected in the change of the roll gap. The oil film thickness changes with the rolling force and the speed of the roller shaft, when the rolling force decreases or the speed of roll shaft increases, the oil film thickness becomes larger, so that the roll gap becomes smaller, and the thickness of the outlet side plate become thinner; on the contrary, when the speed of roll shaft reduces or the rolling force increases, the oil film thickness is reduced, the roll gap become larger, and the thickness of the outlet side plate is increased.

This will have a serious impact on the accuracy of the plate thickness control, due to the development of rolling theory, computer technology and other disciplines, the hydraulic AGC system has been further developed, therefore, therefore, the control links of the oil film compensation is added to the hydraulic AGC system. The oil film compensation is used to compensate the change of the oil film thickness separately, in order to eliminate the change of the oil film thickness, thereby eliminating the influence on the plate thickness. Oil film compensation can better meet the quality requirements of rolling steel products, and it is also a necessary supplement and improvement of the development of hydraulic AGC system.

The change in the oil film thickness is a change inside the bearing and cannot be directly measured by the detecting instrument; however, the change of rolling speed and rolling pressure in the rolling process directly affects the oil film thickness of oil film bearing of rolling mill, the speed of rolling mill can be obtained by the feedback speed of the main drive, and the pressure can be obtained by a pressure sensor installed on the rolling mill. Therefore, oil film compensation is to implement compensation control based on rolling mill speed and rolling force

2. Oil Film Compensation

There are many ways to calculate the oil film thickness, such as the Hamrock-Dowson formula and the Reynolds equation, etc. Hamrock-Dowson's minimum oil film calculation formula is derived from Hertz theory, contact of lateral transmission mechanism in transmission process is obtained by analysis of profile equation, it is the study of the lubrication state during the meshing process of the mechanism, and the determination of its various coefficients is slightly complicated. In this paper, the calculation method of obtaining oil film compensation amount is by load function and speed function, respectively, which provides theoretical basis for the precision of plate thickness control.

2.1 Parameters affecting the oil film thickness

Previous studies have shown that the load w, the roller radius R, and the mill speed have a significant effect on the oil film thickness. However, the increase of the load w will make the oil film thickness become smaller, moreover, it cause the temperature rise, so a reasonable limit is the key to achieve full-film lubrication, thereby achieving a precise influence on the plate thickness control. The roller radius should be increased as much as possible, so that the oil film bearing speed will be increased to achieve full film lubrication. However, this practice will also cause the temperature of the oil film to rise rapidly and the oil film bearing to be damaged.

Because the change of the oil film thickness is the change inside the bearing and cannot be directly measured by the detecting instrument, the oil film thickness of the oil film bearing can be calculated by the rolling speed (rmp) and the rolling pressure (Ton). Under the condition that the bearing is working normally, through the rolling speed and rolling pressure, the damage of oil film bearing can be avoided by rapid temperature increase. The mill speed can be obtained from the feedback speed of the main drive and the pressure can be obtained by the pressure sensor installed on the mill. Therefore, the oil film compensation is to implement the compensation amount control based on the rolling mill speed and rolling force.

2.2 Calculation formula of the speed function:

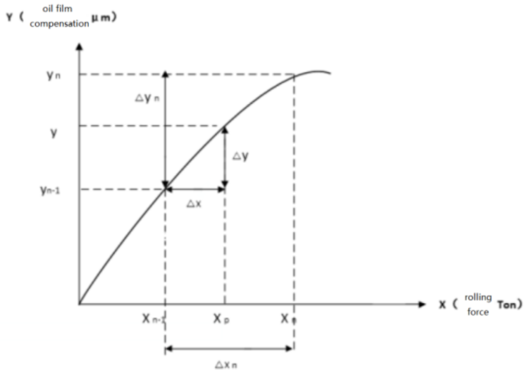

Figure.1 relationship between rolling force and oil film compensation

2.3 Calculation formula of the load function:

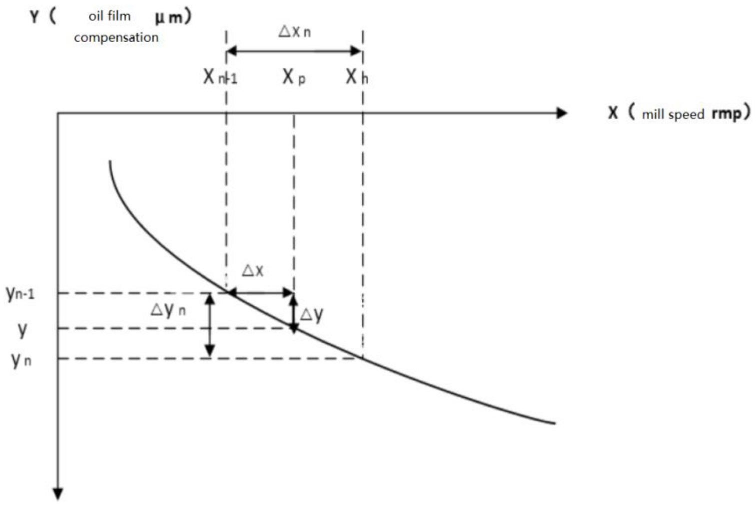

Figure.2 relationship between mill speed and oil film compensation

It is known from Fig.1 and Fig.2 that the rolling force and the rolling mill speed are important factors affecting the oil film compensation, and the variation of the rolling force, the rolling mill speed and the oil film compensation are calculated.

$$x_n - x_{n-2} = \Delta x_n \tag{1}$$

$$y_n - y_{n-2} = \Delta y_n \tag{2}$$

In order to ensure the accuracy of the plate thickness of the finished rolling mill, it is necessary to improve the accuracy of the calculation.

$$\Delta y_n^t = \Delta y_n \times 1000 \tag{3}$$

The corresponding functional relationship can be obtained by the formulas (1) and (3).

$$A_n = \Delta y_n^t + \Delta x_n \tag{4}$$

The current rolling mill speed or the changes of rolling force are obtained by means of Fig.1 and Fig.2. The oil film compensation corresponding to the rolling mill speed and the rolling force are also obtained by the formulas (4) and (5).

$$x_p - x_{n-2} = \Delta x \tag{5}$$

$$\Delta y = \Delta x \times A_n \tag{6}$$

Restore the original value before increasing accuracy.

$$\Delta y^t = \Delta y + 1000 \tag{7}$$

Finally, the oil film compensation is calculated.

$$y = \Delta y^t + y_{n-2} \tag{8}$$

2.4 Compensation on acceleration and deceleration

After the upper and lower support rolls of the heavy plate mill used the oil film bearing rotate, the oil film compensation varies with the rolling force and the rolling speed, so the oil film compensation is a function of the rolling force and the rolling speed. Especially when the rolling mill accelerates or decelerates, the rolling force and the rolling speed change greatly, and the oil film thickness also changes.

By comparing the value of the speed with the previous speed, it can be judged that the current rolling mill is accelerating or decelerating, and the corresponding compensation is further increased by the rolling mill state. The oil film thickness is mainly determined by the rolling mill speed and the rolling force, the change of oil film thickness will change the displacement of the hydraulic cylinder, which will change the roll gap and affect the accuracy of plate thickness, therefore, the oil film compensation is conducted in the rolling mill.

The AGC system does not affect the thickness of the rolling plate due to the acceleration or deceleration of the rolling mill. If the acceleration of rolling mill is judged by comparison, the oil film is thickened by acceleration, so that the oil film compensation is given a corresponding negative value, the displacement of the hydraulic cylinder is reduced, and the roll gap is increased; if the rolling mill is decelerating, the oil film compensation is given corresponding positive value, the height of the hydraulic cylinder oil column is increased, make the roll gap smaller, and compensate for the roll gap change caused by the decrease of the oil film thickness.

3. Control of Oil Film Compensation

The control of the oil film compensation of the plate thickness of the rolling mill plays an important role in the whole production process, the hydraulic AGC control system with small inertia, high precision, high speed and strong anti-interference is adopted, in order to make the plate thickness of the rolling mill achieve better control, the quality of the system control directly affects the quality of the finished rolling mill. The change of rolling speed and rolling pressure in rolling process directly affects the oil film thickness of the oil film bearing of the rolling mill; therefore, the rolling speed and rolling force become the necessary basis for oil film compensation.

The purpose of the whole hydraulic AGC system control is to eliminate the plate thickness deviation, thus ensuring the accuracy of the mill plate thickness. First, the analog signals of the rolling mill speed and rolling force are collected in real time in the hardware unit, and then they are transmitted into the oil film compensation control system, and the rolling mill speed and the rolling force are A/D converted, they are converted into digital value can be processed, the digital value is substituted into the rolling force function and the rolling speed function, thus obtaining the corresponding oil film compensation X, and then the calculated oil film compensation X is D/A converted, finally, it is transferred to the Constant Position Control (CPC) unit via the hardware unit. There is also a monitoring system in the hardware unit, and the monitoring system conducts real-time monitoring through the feedback signal to ensure the accuracy of the oil film compensation X.

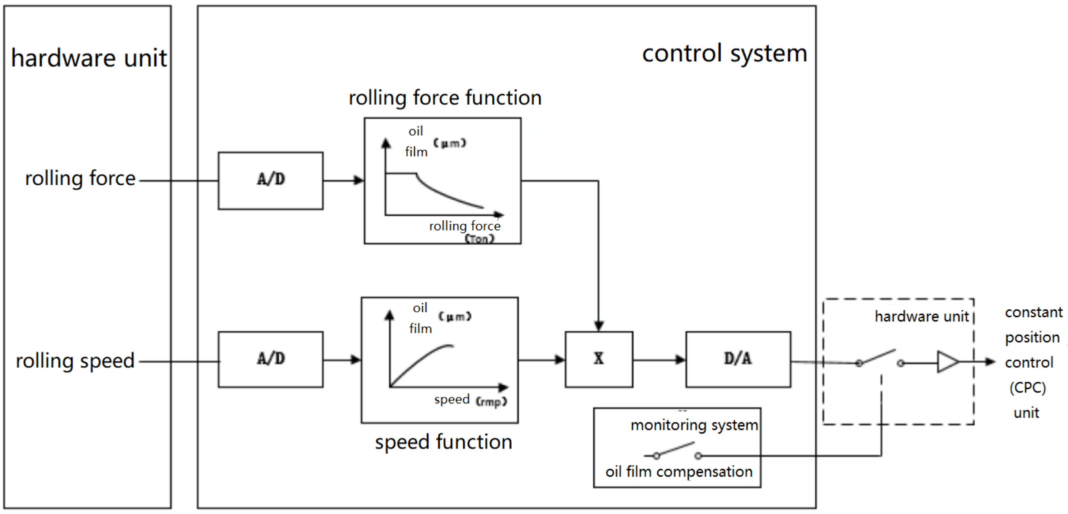

Figure.3 schematic diagram of oil film compensation control

The function transformation and the calculation of the compensation are the center of the whole oil film compensation link.

4. Conclusion

In this paper, the load function and the speed function are obtained by rolling force and rolling speed and the oil film compensation is calculated, the hydraulic AGC system is used to control and eliminate the plate thickness, and it is convenient for the implementation of the oil film compensation control, thus ensuring the accuracy of the plate thickness.

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