MERANIE CHYBY PRENOSU

MEASUREMENT OF THE TRANSMISSION ERROR

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Abstract
The characteristics of angle transmission mechanisms exert a great influence on the servo performance in the robotic or mechatronic mechanism. Especially, the backlash of angle transmission mechanism is preferable the small amount. Recently, some new types of gear reducers with non-backlash have been developed for robots. However, the measurement and evaluation method of the backlash of gear trains has not been considered except old methods which can statically measure at only several meshing points of gears.

Key words
Measurement, Mechatronic system, Transmission error.

Introduction

The characteristics of angle transmission mechanisms, especially the transmission error and backlash exert a great influence on the servo performance in the mechatronic system. As a measurement system for mechatronic application, it should be available in various dynamic conditions both for measurement of transmission error including backlash and measurement of motion parameters in time domain simultaneously, which is important for analysis of dynamic behavior due to the transmission error. [1]

Measurement

To make difference between the values of different rotation directions, we use "+" for clockwise rotation and "-" for counterclockwise rotation. Then, the transmission errors in two rotation directions can be written as Eqs. (1) and (2).

$$\varepsilon^{+}(\theta_2)=\theta_2^{+}-\frac{1}{k}\theta_1^{+} \quad (1)$$

$$\varepsilon^{-}(\theta_2)=\theta_2^{-}-\frac{1}{k}\theta_1^{-} \quad (2)$$

where

θ_1: Measured angular position of input axis of angle transmission mechanism

θ_2: Measured angular position of output axis of angle transmission mechanism

k: Reduction ratio (=input angle/output angle) of angle transmission mechanism

By subtracting Eq. (3) from Eq. (2), Eq. (4) can be obtained.

$$\varepsilon^{+}(\theta_2)-\varepsilon^{-}(\theta_2)=\theta_2^{+}-\theta_2^{-}-\frac{1}{k}(\theta_1^{+}-\theta_1^{-}) \quad (3)$$

By measuring θ_2^{+}, θ_2^{-} at the condition of $\theta_1^{+}=\theta_1^{-}$ in measurement, following equation can be derived.

$$\varepsilon^{+}(\theta_2)-\varepsilon^{-}(\theta_2)=\theta_2^{+}-\theta_2^{-} \quad (4)$$

It is obvious that the right side of Eq. (4) represents the backlash of angle transmission mechanism.

Figure 1 shows the basic configuration of prototype of composite single flank meshing test system for gear reducers. [2]

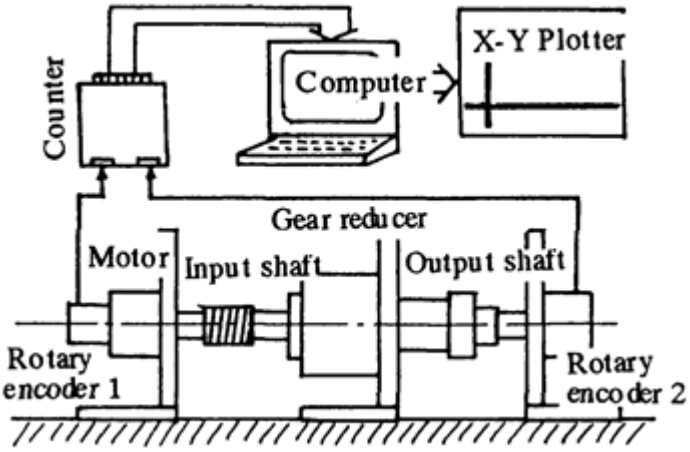


Fig. 1 Composite single flank gear meshing test system [2, edited and supplemented by author]

As shown in Fig. 1, two rotary encoders are attached on the input axis and output axis of gear reducer to measure the angular positions θ_1 and θ_2. The measured angular positions are inputted to computer, and transmission errors are calculated by Eqs. (1), (2) and (4). The input axis is driven by servo motor and its angular position is measured by an encoder (1 500 P/R) built in the motor. The angular position of output axis is measured by an encoder (5 000 P/R), and a resolution of 50 000 P/R (25.92"/P) is realized by using interpolating circuit of 10 times. Pulse from each encoder is counted by up/down counter so that the value of counter always shows the angular position from the starting point, independent of rotation direction. The transmission error is calculated and displayed on CRT by computer in real time. The rotation direction of input axis can be changed at arbitrary pre-assigned angular position. [2]

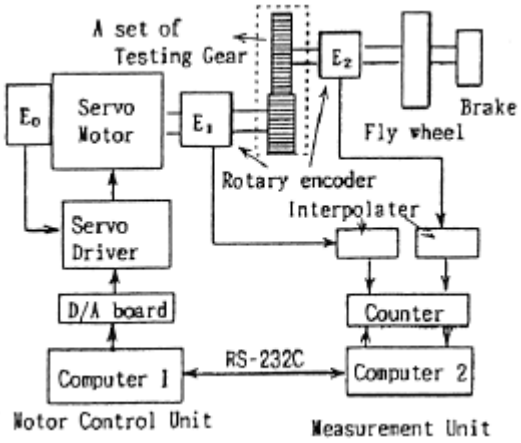


Fig. 2 Configuration of general measurement system [2, edited and supplemented by author]

The resolution of angular position measuring in both input axis and output axis is 360 000 P/R (=5.4"/P) by using a interpolator of ten times and quad mode of counter. Maximum speed of the system is 2 000 rpm and natural frequency of it is 200 Hz. In output unit, fly wheel and brake are mounted on the spindle to provide various types of loads to the system. Input unit and output unit can be moved along x-axis and y-axis, so that different

types of angle transmission mechanisms (gear, toothed belt, chain, etc.) can he measured by the system. [1]

3 Examples

As the preliminary experiment, one pair of spur gears with pre-set backlash is tested. The measured result is shown in Fig. 3. [3]

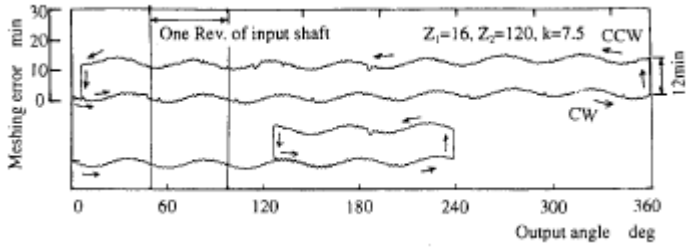
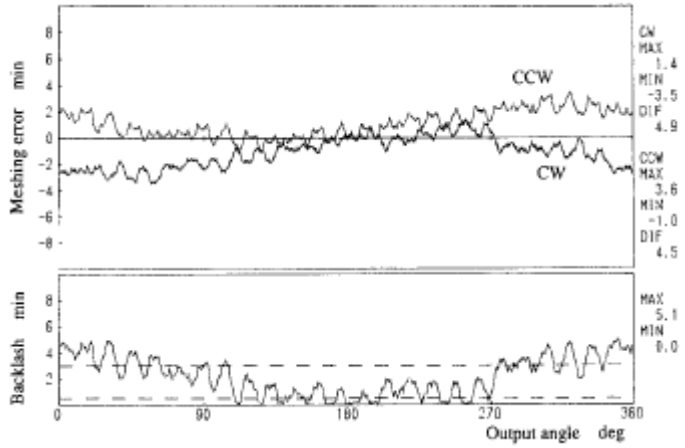
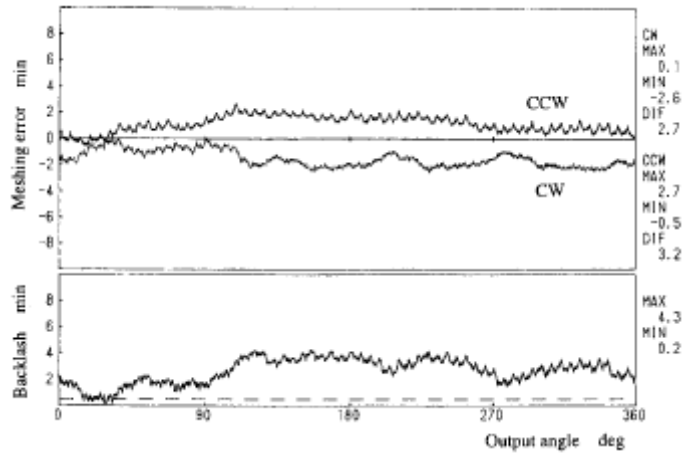


Fig. 3 Measured result on one pair of spur gears [3, edited and supplemented by author]

The reducer is developed for the usage in robot and has small backlash. The measured results with different pinion shafts are shown in Figs. 4 (a) and (b). [3]



a) In the case of opinion shaft with large offset



b) In the case of opinion shaft with small offset

Fig. 4 Measured results on the parallel axis gear reducer [3, edited and supplemented by author]

Figure 5 shows the variation of measured transmission error and backlash while reducing the backlash by adjusting the screw which is used to determine the value of backlash in the parallel axis gear reducer. A backlash near zero is achieved in Fig. 5 (c). [3]

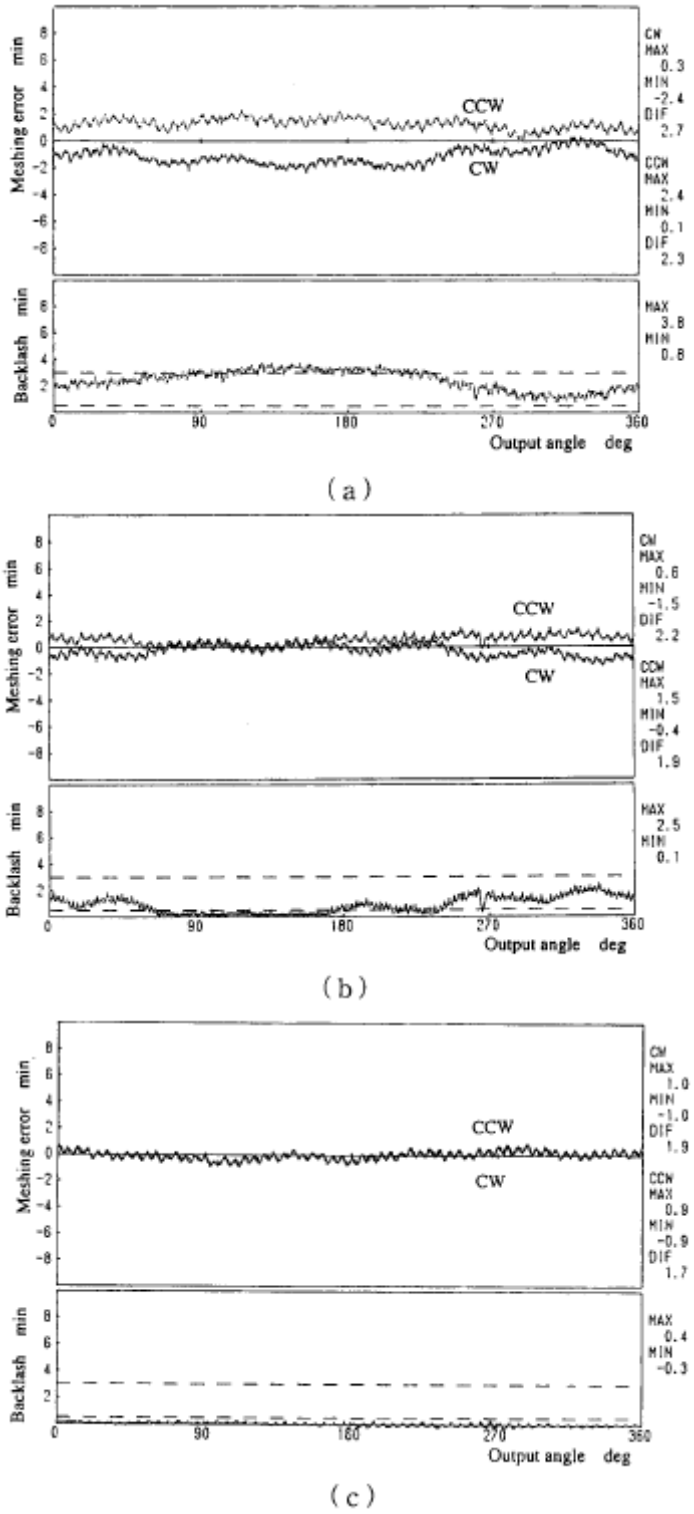


Fig. 5 Variation of measured transmission error and backlash with backlash adjusting mechanism [3, edited and supplemented by author]

Conclusion

A new measurement system of transmission error of angle transmission mechanism for mechatronic systems has been developed and its availability is shown by experimental measurements and industrial use. By this system, the measurement of transmission error and backlash at all meshing positions becomes possible. Besides, it is useful for inspecting and evaluating the dynamic characteristics of angle transmission mechanism.

Key words

Measurement, Mechatronic system, Transmission error.

Literature

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[2] Kurokawa, S., Aiura, Y. and Tachikake, K., Gear Transmission Errors of Cyclindrical Gears, 2004, pp. 407-412. ISSN 1340-8763,

[3] Materials provided by company.

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