VÔĽA V MECHATRONICKÝCH SYSTÉMOCH

BACKLASH IN THE MECHATRONICS SYSTEMS

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Abstract
The overall performance testing method of angle transmission mechanisms for the mechatronic systems can measure the angle transmission error both clockwise and counterclockwise. In addition the backlash can be continuously measured in all meshing positions automatically. This system has been applied to the testing process in the production line of gear reducers for robots, and it has been effective for reducing the backlash of the gear trains.

Key words
Gear, Mechatronics system, Backlash

Introduction

Accuracy of angle transmission is one of the important characteristics of angle transmission mechanism. In the case of gear reducers, this accuracy is evaluated by single flank gear meshing error. The meshing error will be also called as transmission error. Several types of single flank gear meshing test systems have been developed for measuring the error. By these systems, only meshing error of the rotation in one direction can be measured. On the other hand, angle transmission mechanisms used in mechatronic systems such as robot usually rotate in both directions (clockwise and counterclockwise) and accelerate/decelerate frequently. [1]

Systems including backlash

Consider a simple model of angle transmission mechanism shown in Fig. 1. If the angular positions of both input axis and output axis of angle transmission mechanism at the starting moment of measurement are set to zero, transmission error of angle transmission mechanism can be defined by Eq. (1).

$$\mathcal{E}(\theta 2)=\theta 2-\frac{1}{k}\theta 1 \qquad (1)$$

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 [2]

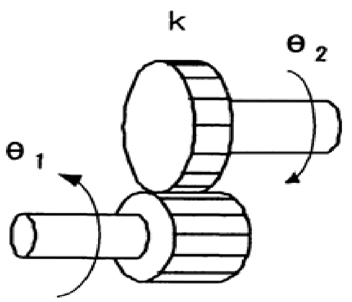

Fig. 1 A model of angle transmission mechanism [2, edited and supplemented by author]

Figure 2 shows the detailed construction of the system being used for inspecting gear reducers in production line. The reducer is supported by two vertical centers. A prony brake or a fly wheel can be attached to the output axis of reducer to provide loads to the system. The motion of servo motor, that is, the motion of input axis, can be controlled to realize an arbitrary velocity pattern by computer. For this reason, it is also possible to measure the dynamic behavior of reducers by the system. [2]

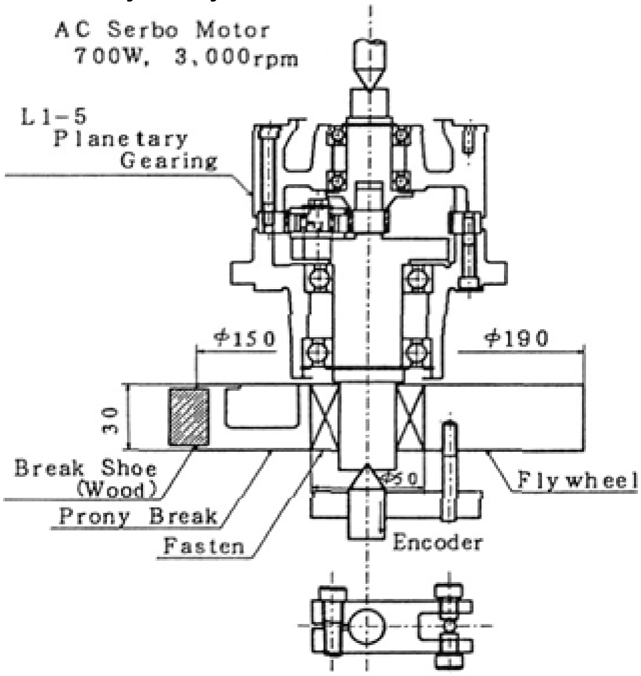

Fig. 2 Detailed construction near the setup of reducer [2, edited and supplemented by author]

Figure 3 shows the configuration of the system. It consists of input unit, output unit, and angle transmission mechanism or test between the two units. In input unit, the spindle is driven by AC servo motor and can be controlled to implement an arbitrary motion by computer. Two rotary encoders (6 000 P/R) are used for measuring the angular positions of input axis and output axis of angle transmission mechanism. [1]

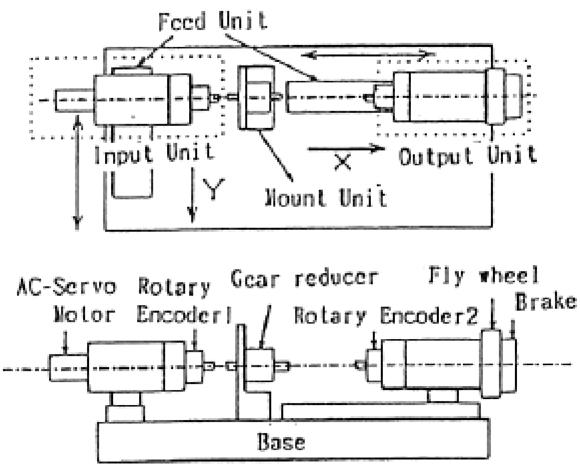

Fig. 3 Construction of mechanism [1, edited and supplemented by author]

3 Experiments

Parallel axis gear reducer with two pairs of spur gears shown in Fig. 4, is tested. [3]

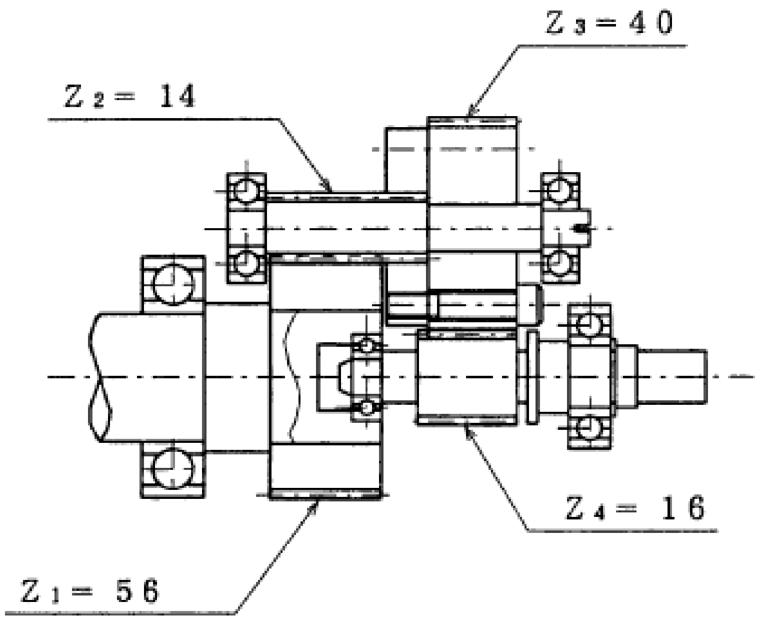

Fig. 4 Structure of a parallel axis gear reducer [3, edited and supplemented by author]

Figure 5 shows the measured results in three different speeds. In Fig. 6, input axis first rotates in clockwise direction (ab=acceleration period, bc=period of constant speed, cd=deceleration period) and then rotate in counterclockwise direction immediately (dc=acceleration period, bc=period of constant speed, cd=dece1eration period). [3]

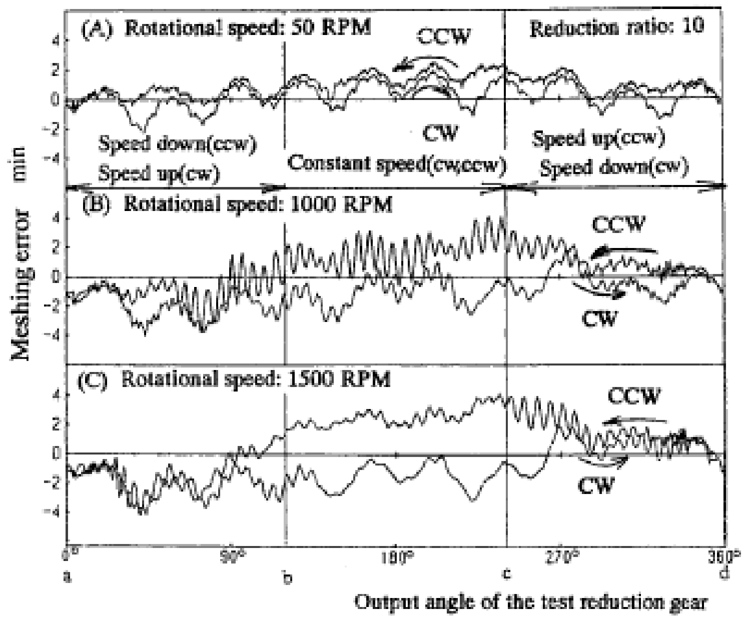

Fig. 5 Influence of speed and backlash on transmission errors – In the case of small backlash [3, edited and supplemented by author]

Ten waves related with the reduction ratio, and fifty-six waves related with the number of teeth of final gear in one revolution of output axis can be observed on all curves of transmission errors.

Figure 6 shows the measured results of the reducer with same construction but different parameters (k=15, backlash=25'). In both figures, the transmission error increases and larger vibrations occur with the increase of speed. [3]

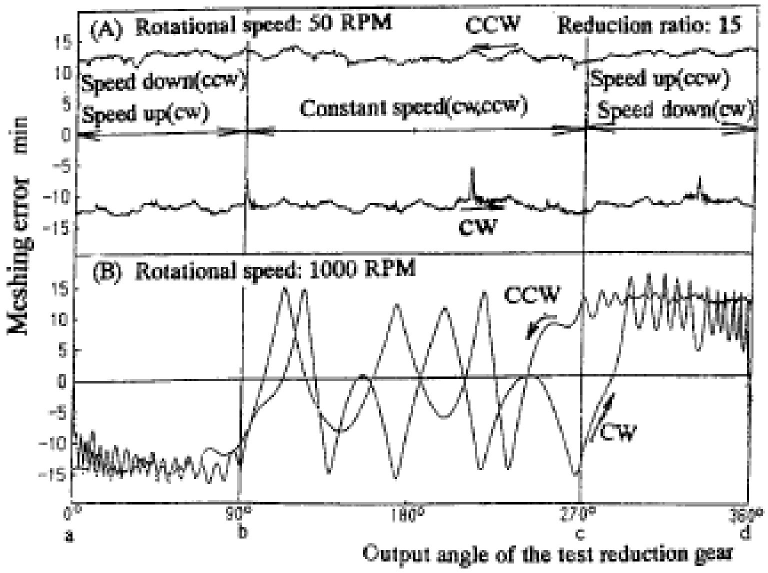

Fig. 6 Influence of speed and backlash on transmission errors – In the case of large backlash [3, edited and supplemented by author]

By comparing Fig. 5 with Fig. 6, we can know that the rotational vibrations in the deceleration period due to the collision into opposite face of teeth occurs obviously in the case of large backlash. Especially in Fig. 6, the characteristics of transmission error in the speed of 1 000 rpm is quite different from that of 50 rpm. The dynamic behavior of transmission error becomes very complicated in the case of high speed rotation. [3]

Conclusion

Following results are obtained from experimental measurements:

(1) The value of backlash varies with the meshing point in gear reducer. It is difficult to evaluating true value of backlash by measuring only at several meshing points in one revolution according to old measuring method.

(2) Dynamic transmission error is influenced greatly by the value of backlash and test conditions. Complicated behavior including contact, noncontact and collision due to backlash is observed.

Key words
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Literature

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[3] Materials provided by company

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