Basic Study on the Gear Reducer with Self-Compensating Control

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1. Introduction

In robotics and industrial machines, several kinds of gear reducers have been proposed. A gear reducer is essential for a mechanical system to minimize its power size and total machine size, with a higher revolution speed in the motor. The direct drive motor (DD-motor) has been developed in recent years. While the direct drive motor has the advantage that a reducer is not needed, it is limited to specific applications in which a large volume and installation space are possible. In the case of installation in mechanical systems, gear reducers are used selectively, depending on the characteristics of each particular gear system; factors affecting the selection are price, weight, size, construction, reduction ratio, and dynamic behavioral characteristics. However, even when a gear reducer is selected in accordance with these specifications, in reality the performance of the machine system is sometimes unsatisfactory after the reducer is installed, due to excitation for the driven machine system by the speed and/or torque ripple generated by the gear reducer itself. Thus, a gear reducer with dynamic characteristics including lower velocity and torque ripple is desirable, and an optimized technique for installing the gear reducer in mechanical systems is required.

In general, speed and torque ripple in gear reducers may be caused by the following:

(1)construction of the gear reducer
(2)element error of each component
(3)alignment error(incl. construction and installation)
(4)nonlinear characteristics of dynamic behavior accom-panied with backlash
(5)internal excitation depending on the meshing

It is difficult to eliminate the speed and torque ripple caused by item (1) to (3) above, because it costs too much to improve and maintain the accuracy. In addition, the level of possible improvements in accuracy is limited. With regard to item (4), further research is necessary (2). With respect to item (5), the self-excited vibration inside the gear reducer caused by profile errors of the teeth and gear meshing produces velocity and torque variations inside the geared system. Classifying the vibration phenomena caused by (1) to (5) in the frequency domain, it can be said that (1) to (3) are vibration phenomena in the range of relatively lower frequencies, while (4) and (5) are vibration phenomena in the higher frequency range. In order to achieve the desired performance level of industrial robots and industrial machines, the first factor that needs to be eliminated is the influence of forced vibration in

the lower-frequency range generated in the control frequency range(band-width) of a semi-closed loop control on the real machine system.

This paper mainly discusses the results of a basic study on using servo technology to reduce forced vibration in the lower-frequency range, caused by items (1) to (3).