Abstract—The precision of machining of a CNC machine tool depends largely on the precision of temperature control of its cooling system. The nonlinearity, uncertainty, delay and large thermal load fluctuations make the design of the temperature controller difficult. This project aims at the designing of a high-precision self-tuning temperature controller suitable for various industrial cooling machines. The proposed controller features automatic detection and tuning of its parameters according to the dynamics of the cooling system, thereby better adapting to different cooling systems and achieving higher temperature precision. This project focuses on the development of three key techniques for high-precision temperature control: self tuning, nonlinearity compensation, dynamic thermal load compensation. The controller will be implemented and verified on a 2kW hot-gas-bypass machine cooler, and the temperature error is hopefully no more than plus minus 0.1°C.

Relay Feedback System Identification

AUTO-tuning of the temperature control has been done with the aid of the relay feedback system identification, as shown in Fig. 2. To perform system identification, an on-off relay is to replace the controller in the feedback loop, causing the oscillation of the system. According to the oscillation waveform of the output temperature, parameters of the first-order delayed plant model are estimated using the proposed algorithm.

Auto-Tuning Controller

ONCE the plant’s parameters have been estimated, a double-integrator controller in Fig. 3 will be synthesized using the direct synthesis method. The figure below shows the output temperature of the cooling system under the proposed auto-tuning control. The output temperature is regulated at a constant level, with very small temperature perturbation (less than 0.2°C) even under a sudden 5kW thermal load change.

Features

The designed auto-tuning control board for the temperature control of an industrial cooling machine as displayed in Fig. 1 has the following features.

- Relay-feedback system identification
- Auto-tuning control with nonlinear compensation
- Rejection of dynamic thermal disturbance