A Robust PID Autotuning Method for Steam/Water Loop in Large Scale Ships

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1 Introduction

During the voyage of the ship, disturbance from the sea is changeable and frequent, and the ship operation mode is also changeable. So it is needed to have good controlle for steam/water loop in large scale ships [1]. Due to the strong interaction and complexity existing in the steam/water loop in large scale ships, there is few study about the control for whole system, and most study is about the control for single sub-loop in this system. In this paper, a robust proportional-integral-derivative (PID) autotuning method [2] is presented and applied to the system. Based on single sine tests for every sub-loop in the steam/water loop, the controller is obtained during which the user-defined robustness margins guaranteed. Its performance is compared against to other PID autotuners, and results show its superiority.

2 System Description and Methodology

The steam/water loop works as follows. Firstly, the feed water is supplied into the boiler after heated in the economizer. Secondly, due to the higher density of the feed water, it will flow into the mud drum. Then, after heated in risers under the burning of the fuel, the feed water turn into saturated mixture of water and steam. Thirdly, the steam is separated from the mixture and used in steam turbine. Finally, the used steam will be condensed, deoxygenated and pumped to the boiler once again [3]. The main control problems existing in this system include the following aspects, i) drum water level control; ii) condensate and deaerator water level control loop; iii) deaerator and exhaust pipe pressure control.

The purpose of KC autotuner is to move a point B on the Nyquist curve of process $P(j\omega)$ to another point A on the Nyquist curve of the loop $L(j\omega))=P(j\omega))C(j\omega))$ through the PID controller indicated by $C(j\omega))$. Hence, the system can have a good dynamic characteristic. The tuning procedure is summarized as follows. i) Select a frequency ϖ; ii) Perform sine tests at frequency on the steam/water sub-loops; iii) Define a forbidden region for robustness in the Nyquist plane according to the loop modulus margin; iv) For each point on the region border, calculate PID controller; v) Find the point where the loop $L(j\omega)$ is tangent to the forbidden region; vi) The PID controller from step v) are final.

3 Results and Conclusions

In order to validate the performance of the proposed method, other PID autotuners such as Åström-Hägglund (AH), Phase Margin (PM) and Kaiser-Rajka (KR) are designed. According to the results shown in Figure 1, the steam/water loop obtained an ideal performance in tracking of system commands, and the proposed autotuning method obtains better results in all sub-loops.

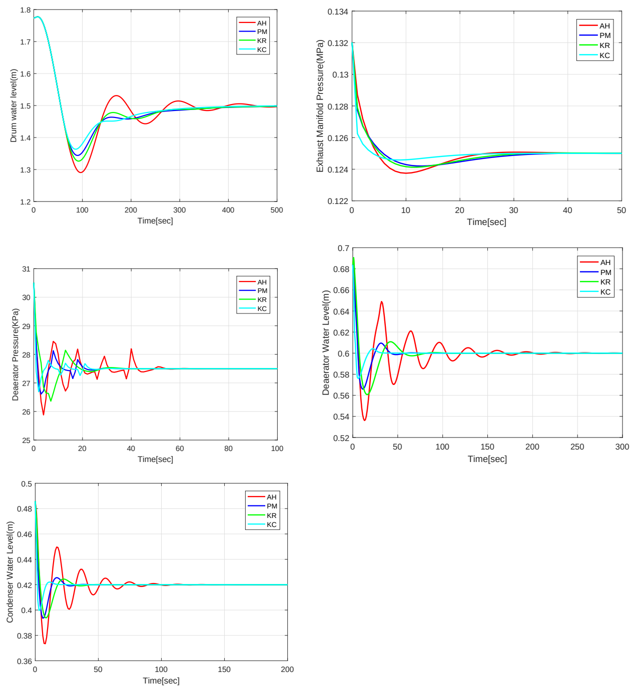

Figure 1: System outputs with different PID controllers

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