GF1 Control System: 2nd Interim Report

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Introduction

[intro]

Lagged Inputs

To realise the system practically, there are control valves controlled by servo-motors which have a small lag. We added first order lag to the product flowrate, steam pressure and cooling water flowrate inputs using an integrator and gain block with negative feedback with gain . Across the integrator, . Taking Laplace transforms, i.e. first order lag, as desired. Step inputs were put into the process with and without the lag to verify the response looked sensible.

Proportional Control

A screenshot of a computer

Description automatically generated with medium confidenceIt was now set out to control the separator level () using a proportional controller to set the product flowrate ). A negative gain is required since the process has a negative gain from F2 to L2. The first approach is heuristic. The gain was increased until the response to a step in the L2 set-point gave a second order response with desired damping factor – we found K = -27. The response to changes in L2 set point and F1 was investigated (Fig. 1). There is a steady state error after the step, but also before due to initial disturbance from initial conditions. Hayman worked on this part whilst I looked at the linearised design method.

Fig. 1 – L2 response to step increase in F1 from 1 to 1.1

Graphical user interface

Description automatically generatedThe process system was first linearised about the desired operating point, and the frequency response of the F2-L2 transfer function obtained (Fig. 2). The proportional gain desired is the one to give 45 phase margin. This gain can be calculated from the Bode plot; proportional control will scale the magnitude response, but have no effect on the frequency response. Hence the required controller gain is the gain at which open-loop system has frequency response .

Fig. 2 – Bode Plot of the process linearised about the operating point

In our case, this occurred at and required a gain of 23 dB (x14) to be achieved.

Clearly for the this method the phase margin of the controlled system is 45 by design. For the heuristically obtained gain, it can be calculated from the Bode Plot. Since ,  
, so we scale the B matrix by k and read the phase margin from the Bode Plot. For the case of , the phase margin is .

Integral Action

It was observed before that with step changes in F1, a steady state error is induced in L2. Even though the plant (the separator in particular) contains an integrator, it also has a zero at the origin, so there is a pole-zero cancellation.

To remedy this, an integrator can be included in the controller – PI control:

The proportional gain was kept as before, and the value of calculated for give a controller phase lag of at the crossover frequency of the plant, i.e. . With as before, .

Keeping old Kp, calculation of Ti for desired phase lag

Saturation

Investigate whether L2 controller still works well

What are the largest step disturbances on F1 and X1 which controller can cope with?

Conclusion

[words]