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experiment 22: Pressure Control (Short Report)

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**Contents**

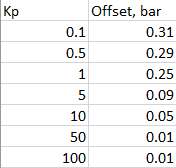
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**Results**

Experiment 1, Comparison of a First Order and a Second Order System

Experiment 2, Comparison of a Proportional-Only and a Proportional-Integral Controller

The Effect of the Value of the Proportional Gain on the Response of a Control System to a Step Change in the Setpoint



**Discussion of Results**

The aim of this experiment was to gain experience with system dynamics and control engineering, specifically, pressure control. We investigated the effect of changing the controller parameters in a Gunt RT 532 Pressure Control Trainer (G.U.N.T. Gerätebau GmbH, 2018) and investigated the different responses that can be expected from first and second order systems. (Heriot-Watt University School of Engineering & Physical Sciences, 2018)

The aim of the first part of the experiment was to compare the response of a first order and a second order system using a proportional integral controller. When only one tank is used, the system can be modelled by a linear first order differential equation:

When two tanks are used, the system can be modelled by a linear second order differential equation:

The proportional-integral controller function can be represented by:

The system when using the proportional-integral controller constantly uses feedback from the pressure sensor in the system to adjust valve position based on the controller output, the error and the chosen Kc and τI parameters specified in the RT650.50 software. (G.U.N.T. Gerätebau GmbH, 2018) (Heriot-Watt University School of Engineering & Physical Sciences, 2018)

As expected, the first order system initially shows a rise above the setpoint value, then a decline slightly past the intended value before adjusting to the setpoint. In comparison, the second order system shows oscillatory behaviour, rising above and falling below the setpoint by nearly the same value each time and never converging on the setpoint. This is likely because it is much more difficult for the valve to equalise the pressure throughout a second order system in comparison to a first order system due to the added complexity of the second tank.

For the second part of the experiment, the aim was to explore the effects of the values of the controller parameters on the response of a first order system using a proportional-only controller. The proportional only-controller function can be represented by:

The system when using the proportional-integral controller constantly uses feedback from the pressure sensor in the system to adjust valve position based on the controller output, the error and the chosen Kc parameter specified in the RT650.50 software. Upon comparison of the proportional-integral controller and proportional-only controller graphs at Kc = 1, it can be seen that the proportional-integral controller adjusts the pressure to the exact setpoint (4 bar), whereas the proportional-only controller adjusts to a value (4.25 bar) with a slight offset above the setpoint. This is because without the integral controller, the system does not fully adjust to the error value, hence causing a pressure offset to occur.

The third aim of the experiment was to investigate the value of the proportional gain on the response of a control system to a step change in the setpoint. This experiment was conducted by varying the Kc parameter for a first order system and measuring the offset. As can be seen in the table of results and the corresponding graph, there is a clear positive correlation between the Kc and the offset – when the Kc value increases, the offset decreases according to a logarithmic correlation.

As shown by the correlation of the final part of the experiment, and the collected results following the expected patterns in the other parts of the experiment, we can assume that the collected results were very accurate. There were very few sources of error identified in the experiment, and all are related to human mistakes in control. Some of the valves were quite difficult to control, as it was not clear from the instructions as to how far they should be open as it was not marked on the valve, possibly causing a systematic error. The experiments also required the setting of the different parameters to be done very quickly, which could have caused a slight error when it was not done quickly enough.

In conclusion, it was found that using a proportional-integral controller was more effective at reaching a more accurate setpoint than the proportional-only controller. It was also found that it was more difficult to control the pressure of a second order system than a first order system. Finally, it was found that there is a clear positive correlation between the Kc and the offset – when the Kc value increases, the offset decreases according to a logarithmic correlation.

# **References**

G.U.N.T. Gerätebau GmbH, 2018. *RT 532 Pressure control trainer.* [Online]   
Available at: https://www.gunt.de/en/products/mechatronics/automation-and-process-control-engineering/simple-process-engineering-control-systems/pressure-control-trainer/080.53200/rt532/glct-1:pa-148:ca-83:pr-1187  
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