Controlling Parameters of Drilling and Fracking using Simulation Modeling

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Abstract

- Automation is a growing trend in many sectors, with the oil and gas industry being no exception. As operating costs rise, companies are seeking methods to maximize the production of wells in the most cost-effective manner. Automated drilling systems provide a way to control equipment performance and maintenance, then relay this information to a surface operator for adjustments. This intelligent communication can occur through an open architecture of sensors, actuators, and processors. Fracking is undergoing a similar shift to automation, as different processes like blender mixing and liquid storage are controlled remotely.

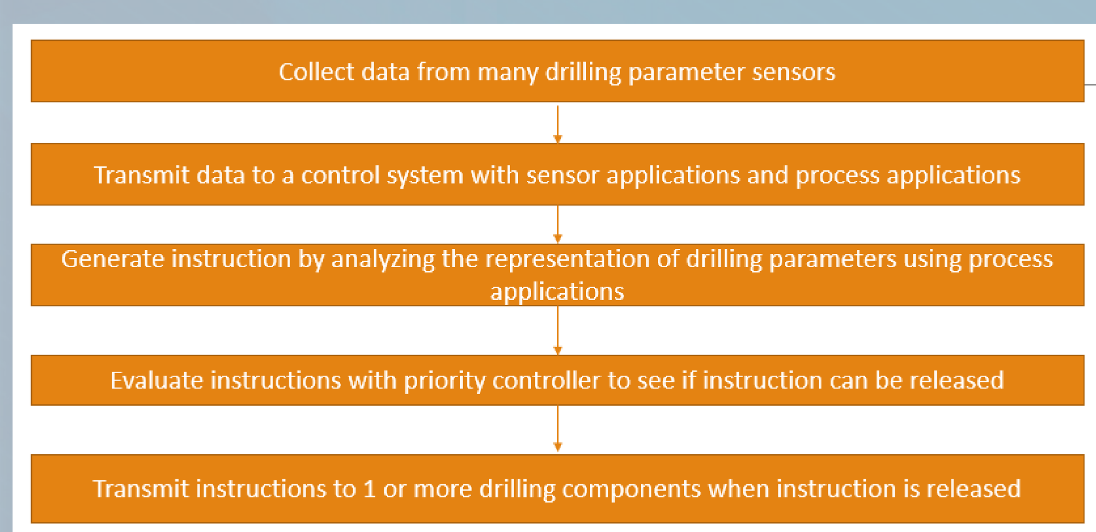


Figure 1: Sensor Data Collection to Operating Conditions

Objectives

- To understand the shift to automation in the petroleum and natural gas industry and what it can accomplish
- Research different components of a drilling or fracking job, and if they can be automated
- Learn how to control operational parameters using algorithms and functional relationships
- Implement a mathematical model that can simulate the controller of a drilling or fracking parameter

Methods

- Analyze patents and research articles for general block diagrams
- Draw out the structure for the parameter controller and write in functions for each block
- Equations used in Simulink consisted of transfer functions and differentials found in published research articles
- 3 different controller models were created in the Simulink software, each to control a unique parameter in a frac tank
- Parameters controlled were temperature, pressure, and volume
- Run simulations and generate graphs that show feedback and fluctuations during operations

Methods Continued

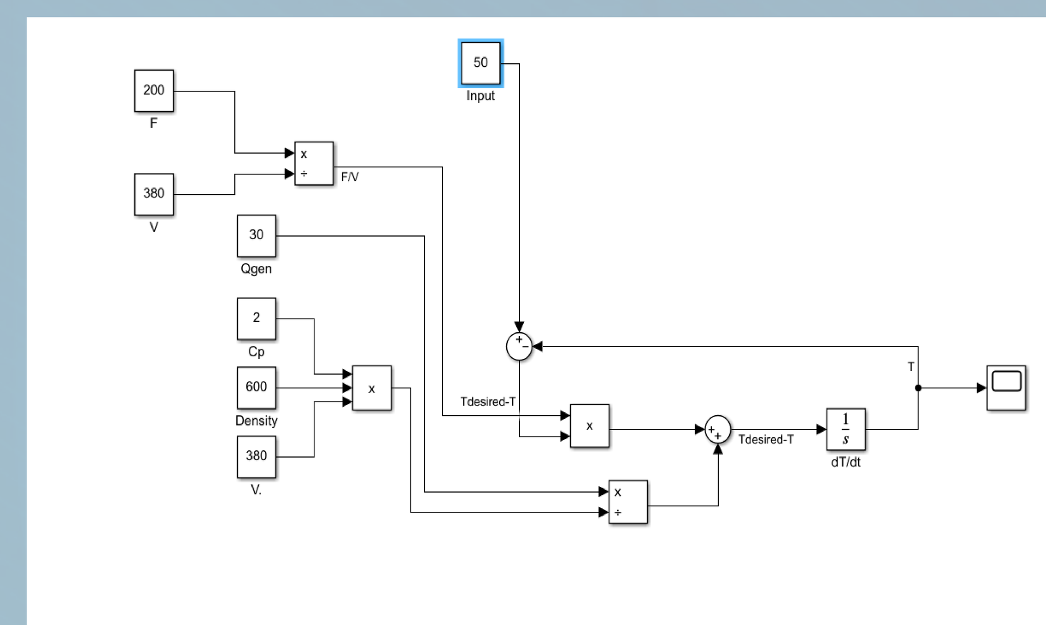


Figure 2: Temperature Controller

- For this model, the input is a temperature quantity, and the input is 50 degrees
- The actual temperature is calculated using the constant values and product blocks, which are structured after the equation
  - $\frac{dT}{dt} = \frac{F}{V}(T_{Desired} - \mathrm{T}) + \frac{Q}{\rho c_p V}$
- The difference in desired temperature minus actual temperature is the error signal
- Once the error is identified, the controller adjusts the temperature to what the quantity should be, or the input

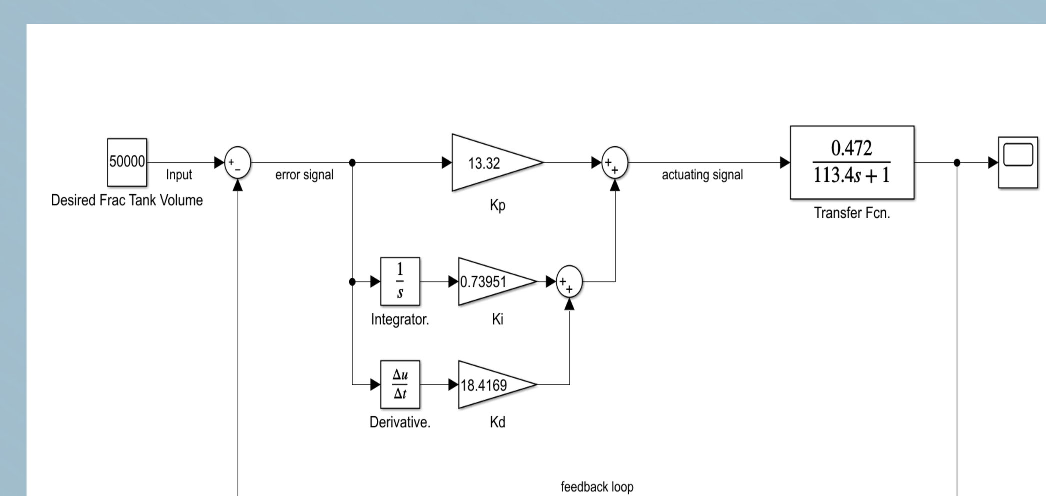


Figure 3: Single Tank Volume Controller

- This controller has the capacity to maintain an inputted volume in a rectangular frac tank
- To maintain the set volume, the model uses proportional-integral-derivative controls
- Derivative and Integrator blocks reduce error in measurements
- Transfer functions and gain coefficients used in this model were obtained from research studies

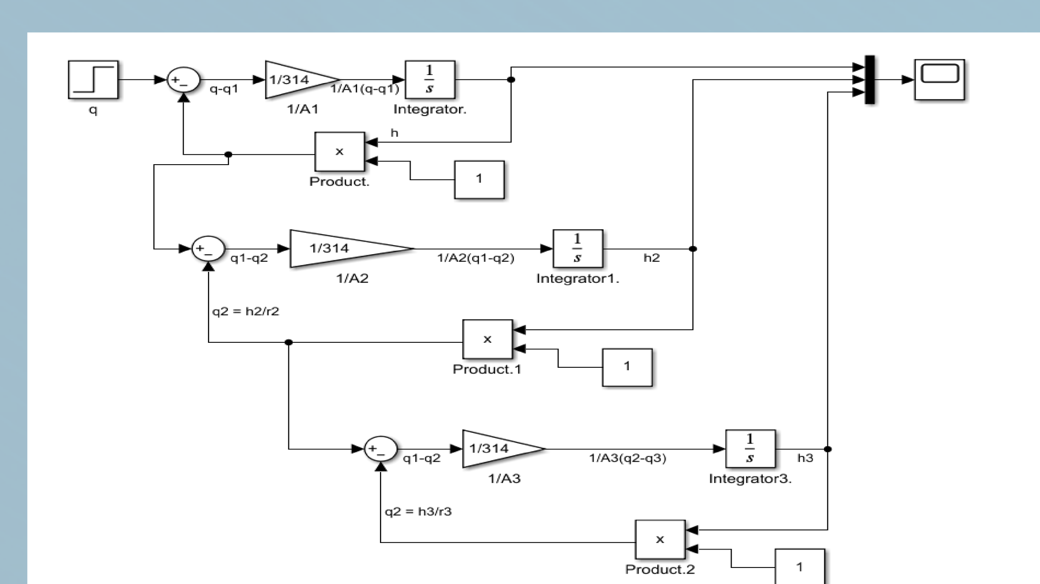
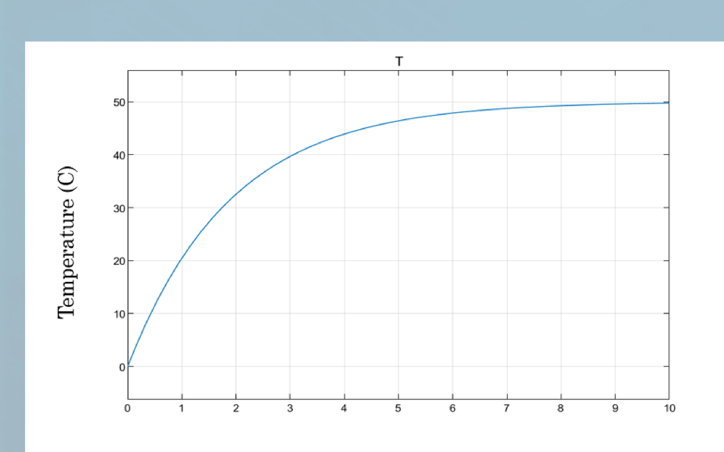


Figure 4: Triple Tank Volume Controller

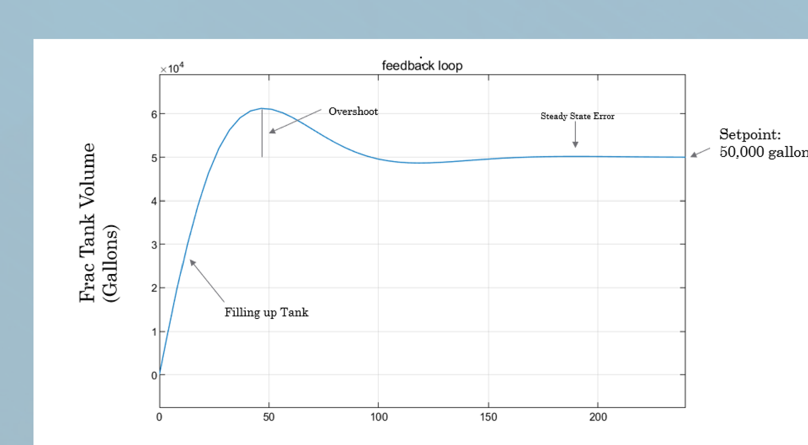
- Like the previous model, this controller maintains volume, but of 3 tanks simultaneously rather than 1
- Used differential relationships to model a control structure
- Each tank reaches inputted volumes at different times
- The flow inside any of tanks at an instant could be represented as
  - $q_i - q_o = A\frac{dh}{dt}$ *(A being an equivalent surface area for all containers)*

Results



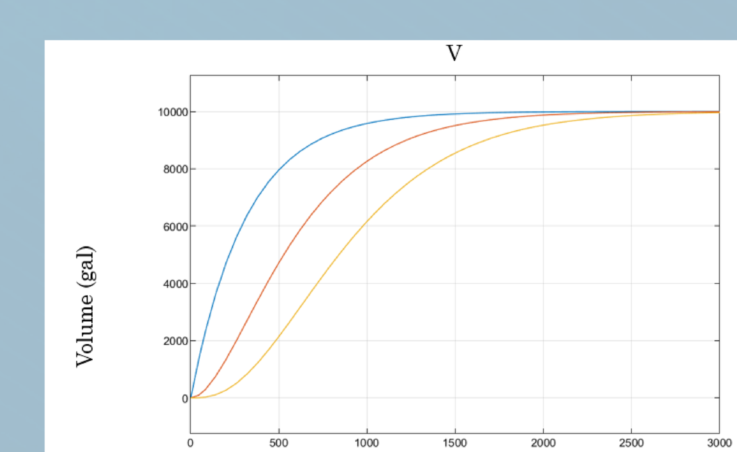
Graph for Figure 2

Input: 50 degrees



Graph for Figure 3

Input: 50000 gallons



Graph for Figure 4

Input: 10000 gallons

Conclusions

- Automation has the capability to increase production through minimizing costs, intelligent equipment performance, and parameter controls.
- Simulation Modeling allows operators to run scenarios without using the resources required, thus optimizing the process
- Control Systems allow for a near-perfect measurement of a parameter quantity, reducing overshoots and excessive costs
- With an automated process, there exists a complex infrastructure of sensors, processors, actuators, and other equipment that communicates constantly about operating conditions
- Automated drilling and fracking processes create a safer operation, as dangerous tasks can be done remotely

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