

to another unit. If the process fluid is not at the desired output temperature, the performance of the unit (reactor, etc.) may not be as good as desired, and therefore not as profitable.

1.1 The control block diagram for the process furnace is shown below in Figure 1. Where the the signals are



Figure 1-1: Control block diagram of process furnace follows:

- T_{set} : Temperature setpoint
- p_{in} : Valve top pressure
- F_{in} : Fuel gas flowrate
- F_p : Process fluid flowrate
- T_p : Process fluid inlet temperature
- T : Temperature of process fluid outlet
- T_m : Measured temperature

1.4

The problem statement tells us that the gasoline is worth \$200,000 a day. A 2% increase in value is:

$$\frac{\$200,000}{\text{day}} \times 0.02 = \frac{\$40,000}{\text{day}}$$

We are also given that the savings will cost \$2,000,000. We can now calculate the time required to payback the control system investment:

$$\frac{\$2,000,000}{\frac{\$40,000}{\text{day}}} = 200\text{days}$$

Therefore, we know it will take 200 days to pay off the investment.

1.7

$$2\text{yrs} = 4.4 \text{ million } \$/\text{yr} \times 0.25 = \$1,100,000$$

1.8

We know from the problem statement that the inlet (F_{in}) and outlet (F_{out}) flowrates can be represented with the following equations:

$$F_{in} = 50 + 10 \sin(0.1t)$$

$$F_{out} = 50$$

The change in volume as a function of time is

$$\frac{dV}{dt} = F_{in} - F_{out}$$

substituting what we know:

$$\frac{dV}{dt} = 50 + 10 \sin(0.1t) - 50$$

Simplifying:

$$\frac{dV}{dt} = 10 \sin(0.1t)$$

Rearranging the equation:

$$dV = 10 \sin(0.1t) dt$$

Taking the integral of both sides:

$$\int dV = \int 10 \sin(0.1t) dt$$

Using basic calculus to solve:

$$V - V_0 = \frac{-10}{0.1} \cos(0.1t) \Big|_{t=0}^t$$

We know the initial tank volume is 500 liters:

$$V - 500 = -100 \cos(0.1t) - 100 \cos(0)$$

$$V - 500 = -100 \cos(0.1t) + 100$$

$$V(t) = 600 - 100 \cos(0.1t)$$

The equation above tells us how the volume of the tank will vary with time. This can also be seen visually in Figure 2 below.

1.9

a.

The objective is to maintain a desired blood glucose concentration by insulin injection. Insulin is the manipulated input and blood glucose is the measured output. As performed by injections, the input is really discrete and not continuous. Also, glucose is not continuously measured, as the measured output is discrete. Disturbances include meal consumption and exercise. Feedforward action is used when a diabetic administers an injection to compensate for a

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