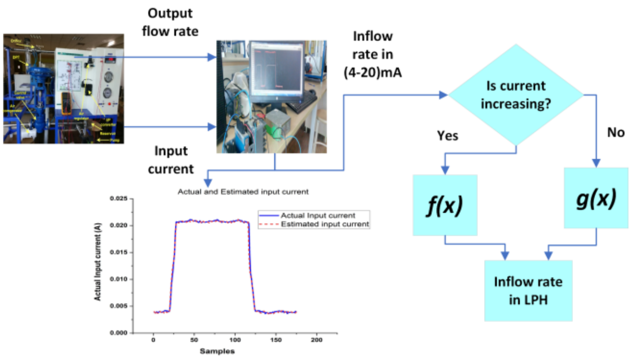
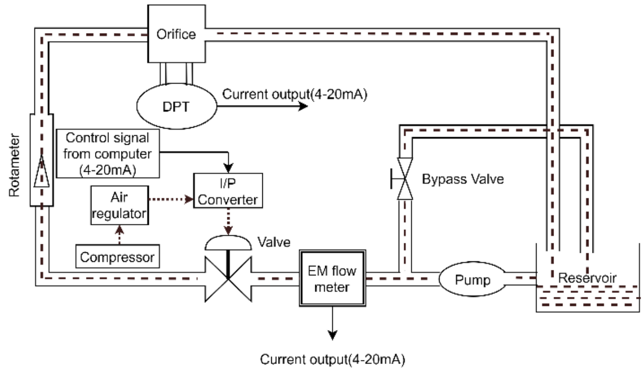
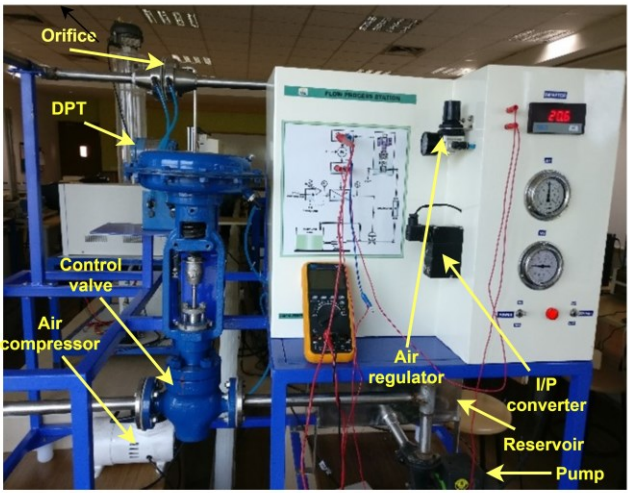
Abstract—**In industrial processes, achieving an efficient flow is paramount as various loops are controlled through flow control. To optimize this flow, it is essential to monitor various influential components such as control valves, flow sensors, as well as input and output parameters to the valve. To maintain the desired flow rate at the outlet of the control valve, it's imperative that the valve's inflow remains higher than the desired output flow rate. In most applications, fluctuations in the inflow rate are typically not considered as a significant factor affecting changes in the output flow which is a key driving component leading to our research objective. This research paper's contribution is estimation of control valve's inlet flow rate without the need for physical sensors and validation of estimated flow rate. This estimator relies on an outflow measurement from an orifice flow meter and employs a first order process with dead time model to deduce the inflow to the control valve. The process model is formulated through data driven system identification, employing the input-output characteristics of the system. Furthermore, a pole-placement-based estimator is developed utilizing real-world data. The novelty of the approach is estimation of the flow rate at valve input which is overlooked by many researchers. To validate the performance of this estimator, it is deployed to compute the inflow in a real-life practical system. The results reveal a root mean square error of 0.029, signifying the accuracy and reliability of the designed estimator. The estimator performed better in terms of reduced root mean square error when compared to other methods.**

Keywords—Control Valve; Estimation; Inflow; Soft Sensor; Flow; Pneumatic Actuator; Flow Rate; Pole Placement.

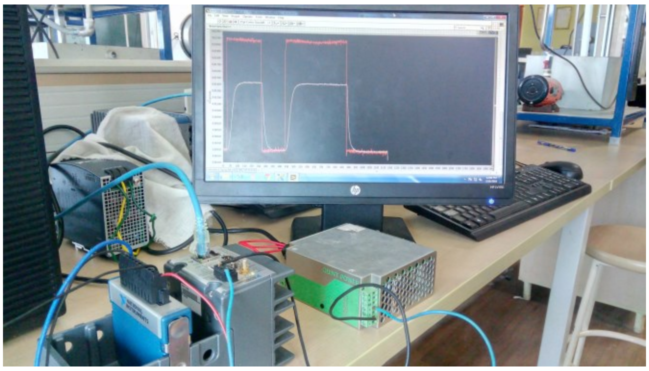

Output flow rate
Inflow rate in (4-20)mA
Is current increasing?
Yes
No
Input current
f(x)
g(x)
Inflow rate in LPH
Actual and Estimated input current
Actual Input current
Estimated input current
Actual Input current (A)
Samples

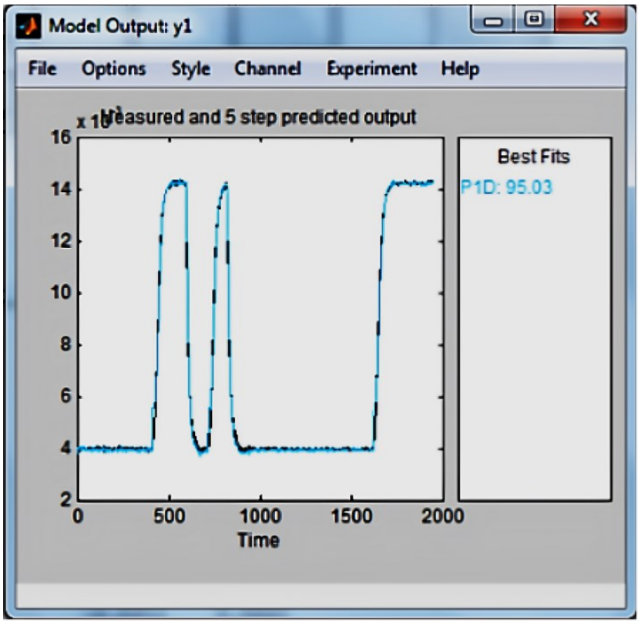

Orifice
DPT
Current output(4-20mA)
Rotameter
Control signal from computer (4-20mA)
I/P Converter
Air regulator
Bypass Valve
Compressor
Valve
EM flow meter
Pump
Reservoir
Current output(4-20mA)


Orifice
DPT
Control valve
Air compressor
Air regulator
I/P converter
Reservoir
Pump

$$P(s) = \frac{0.615}{20s + 1} e^{-10s} + 0.00159$$

$$P(s) = \frac{0.0318s^3 + 0.6357s^2 - 0.364s + 0.0739}{20s^3 + 13s^2 + 3s + 0.12}$$





$$A = \begin{bmatrix} -0.65006 & -0.300012 & -0.0960038 \\ 0.5 & 0 & 0 \\ 0 & 0.125 & 0 \end{bmatrix};\ B = \begin{bmatrix} 4 \\ 0 \\ 0 \end{bmatrix};$$

$$C = [0.00768 \quad 0.00922 \quad 0.01476\ ];\ D = [0.00159]$$

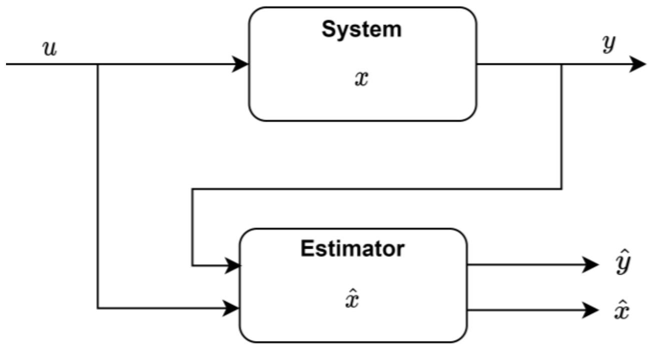
A. Inflow Estimation

$$P(s) = \frac{0.615}{20s + 1} e^{-10s}$$

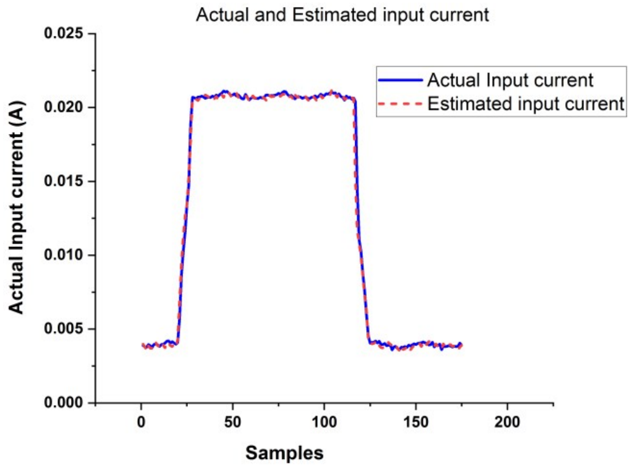
$\hat{x}$

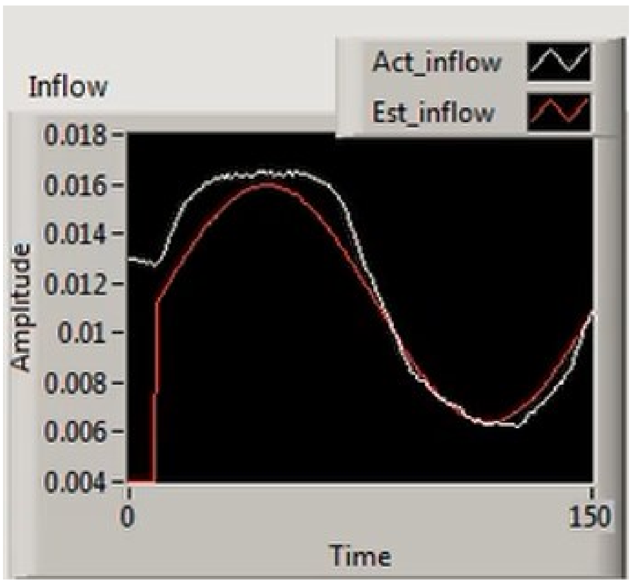
$\hat{y}$

u y



B. Continuous Observer



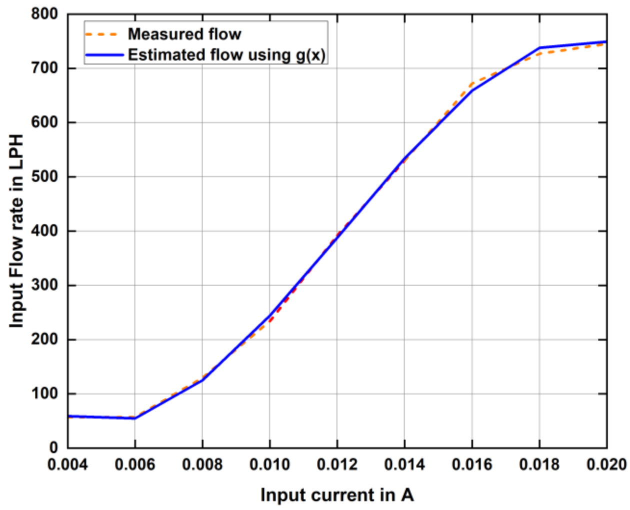


$$\hat{x}(t) = A\hat{x}(t) + Bu(t) + L[y(t) - \hat{y}(t)]$$

$$\hat{y}(t) = C\hat{x}(t) + Du(t)$$

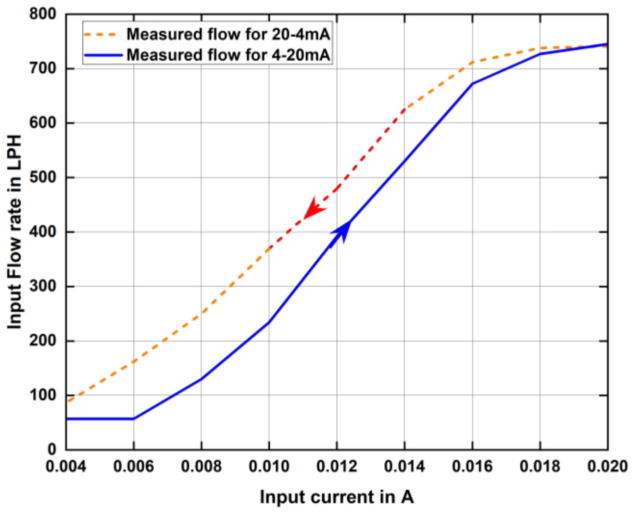
Input Current (mA)	Input Flowrate(lph) for 4-20 mA	Estimated Flowrate(lph) for g(x)	% error

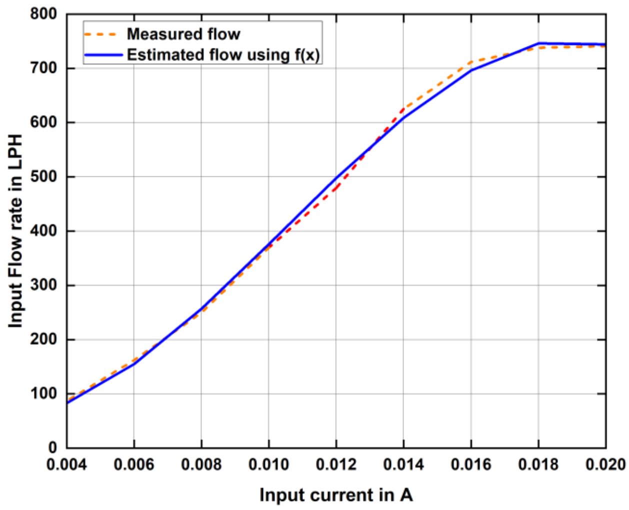
Input Current (mA)	Input Flowrate(lph) for 20-4mA	Input Flowrate(lph) for 4-20mA



$$g(x) = -4.928 \times 10^8 x^3 + 1.798 \times 10^7 x^2 - 1.44 \times 10^5 x + 378.9$$

$$f(x) = -2.835 \times 10^8 x^3 + 8.88 \times 10^6 x^2 - 3.123 \times 10^4 x + 81.23$$





Input Current (mA)	Input Flowrate(lph) for 20-4mA	Estimated Flowrate(lph) for f(x)	% error

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