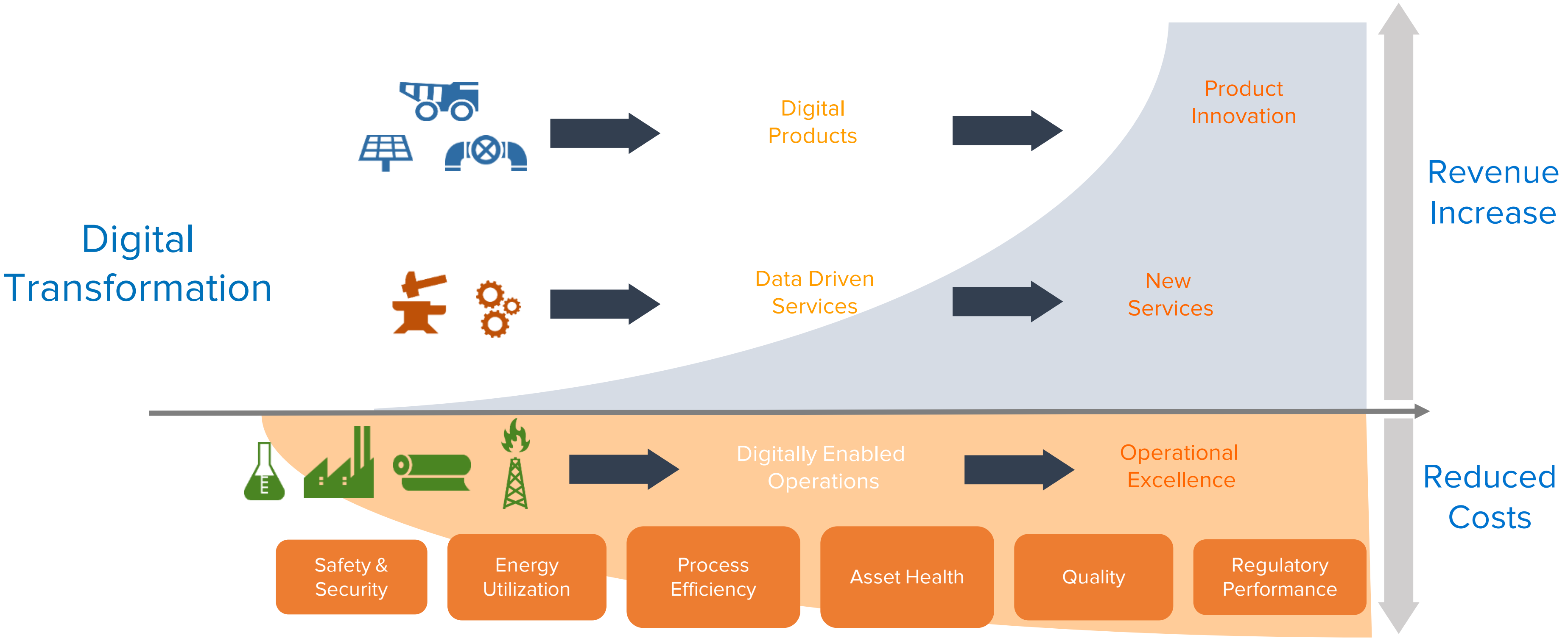
OSIsoft Cloud Offering: Transforming Student Education with the Academic Community Service

Dr. Erik Ydstie, Professor, Carnegie Mellon University

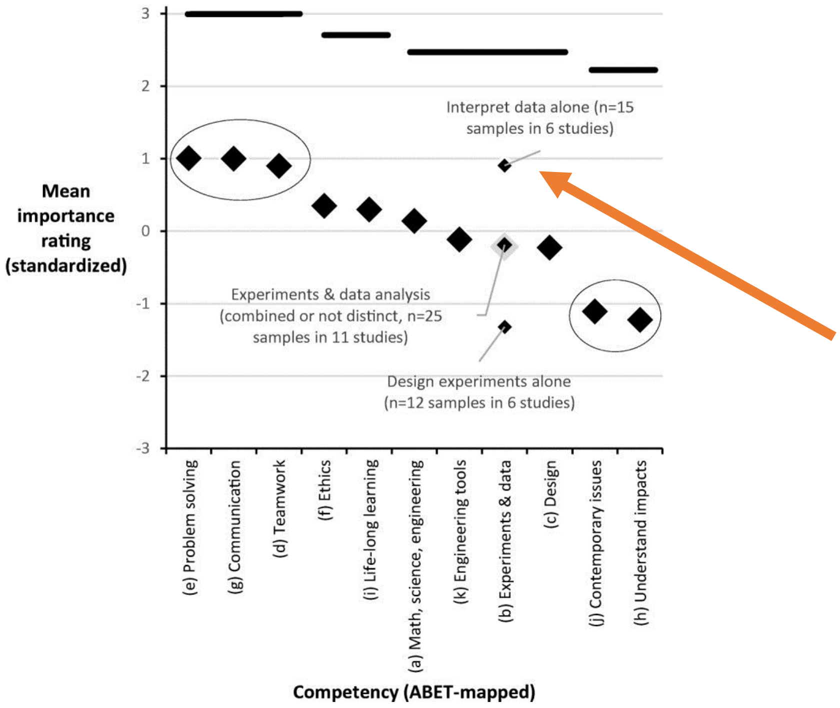
Mr. Zhiyuan Cheng, Process Engineer, Industrial Learning Systems

Dr. Erica Trump, Program Manager, OSIsoft

Engineering Trends: Data-Driven Systems



Need for Data-Focused Engineering Curriculum



Highest-rated competencies include **Problem Solving**, **Communication**, **Interpretation of Data**, **Teamwork**

Passow & Passow, 2017

OSIsoft Academic Community Service

Empowering the workforce of tomorrow with data-focused skills that industry needs

OSIsoft Academic Community Service

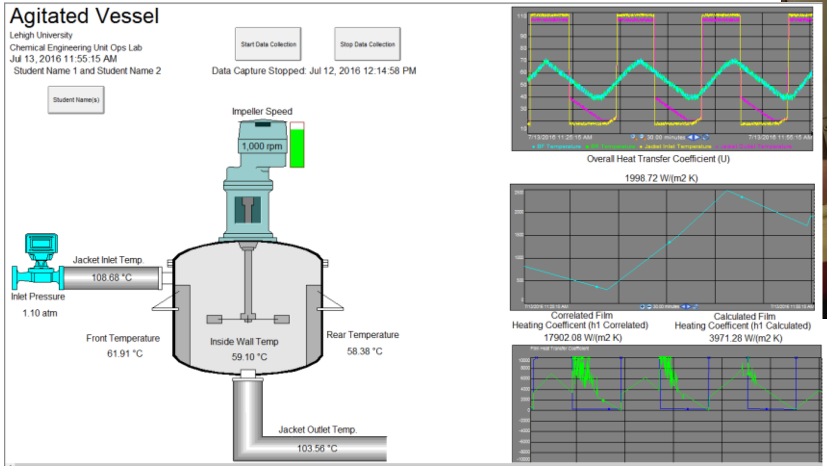
A shared, cloud-based PI System to support **classroom initiatives**

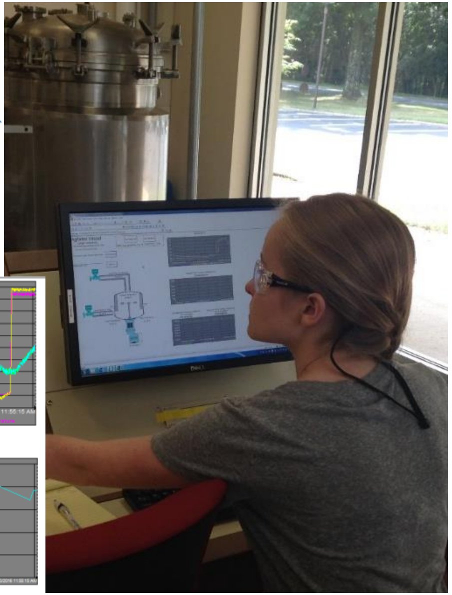
- Minimal on-campus footprint
- Web-based tools to visualize and access data
- No-hassle integration with MATLAB, R, and Python

Chemical Engineering Unit Operations

LabVIEW

Academic Community Service
(Hosted by OSIsoft)

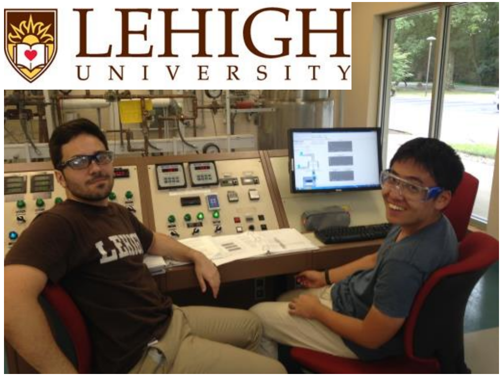




Chemical Engineering Unit Operations

- ✓ Bridge the gap between theory and **practice**
- ✓ Build skills in **data analysis** and **communication**
- ✓ **Industry-oriented approach** to experimental design
- ✓ Promote teamwork and **informed decision-making**

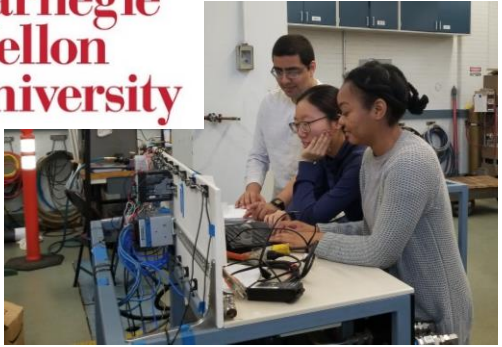
LEHIGH UNIVERSITY



Massachusetts Institute of Technology

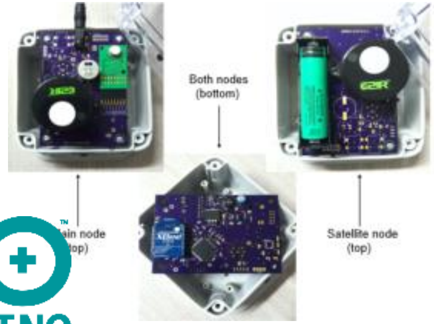
Arizona State University

Carnegie Mellon University



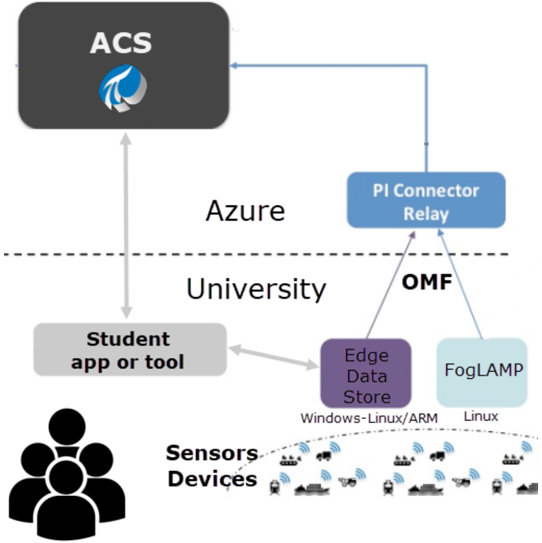
IoT Classroom Projects – Support for Fall 2018!

- ✓ Students create app to collect data and send to OSIsoft's Academic Community Service
- ✓ OSIsoft provides real-time data infrastructure, code examples



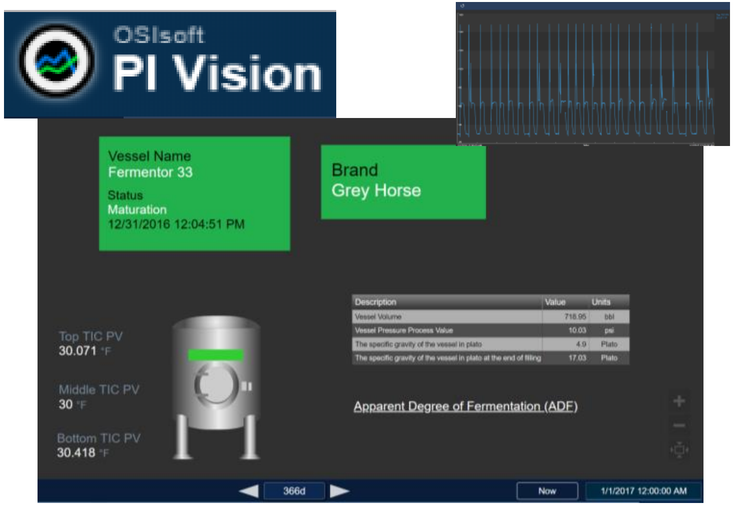
ARDUINO

Raspberry Pi®

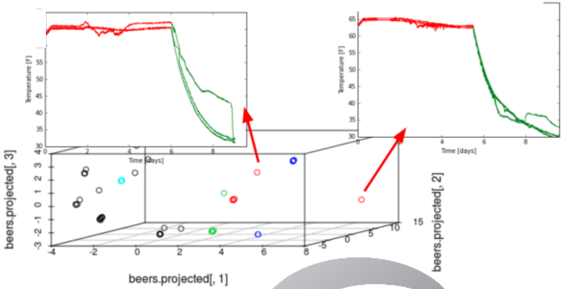


Data science module and real-world datasets

- ✓ PI Vision + Data Science Module
- ✓ Brewery dataset – fermentation vessels, bright tanks, other processing equipment

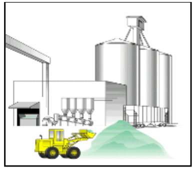


LEHIGH UNIVERSITY



Glass Furnace Model Predictive Control

From Sand to Windshields: CMU-ILS-PPG Project



Objective: Reduce Variations in glass quality using process data and model based control through out the supply chain

PPG INDUSTRIES | Carnegie Mellon University | iLS Industrial Learning Systems

Silicate Sand
Soda-ash
Iron Oxide
++

8 flat glass plants

500 tons/day ea. line

Sand
Soda-ash
+++

mix > melt > form > cool > QC > cut > pack

Siemens/Pilkington Float Process

Flat glass
-Airplanes
-Cars
-Buildings

1000 windshields per day ea. line

Flat glass

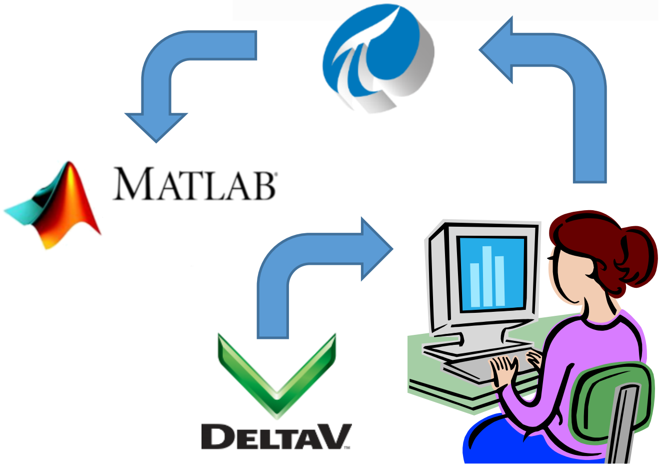
Cut > coat > print > form > QC > laminate > pack

OEM discrete parts manufacturing Float Process

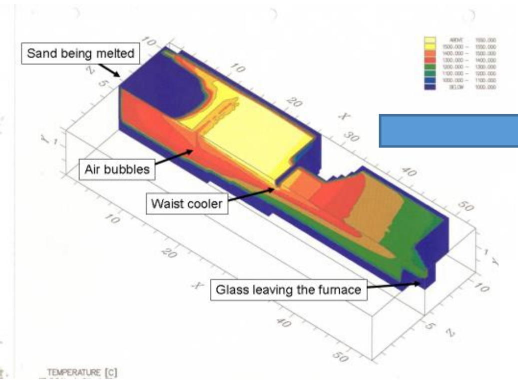
Automotive windshields

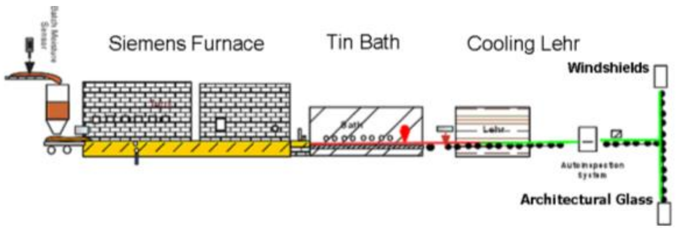
10 windshield lines

Accuracy of shape, color, distortion (optical properties) depend on mix, melting conditions in furnace and operation of the tin bath.

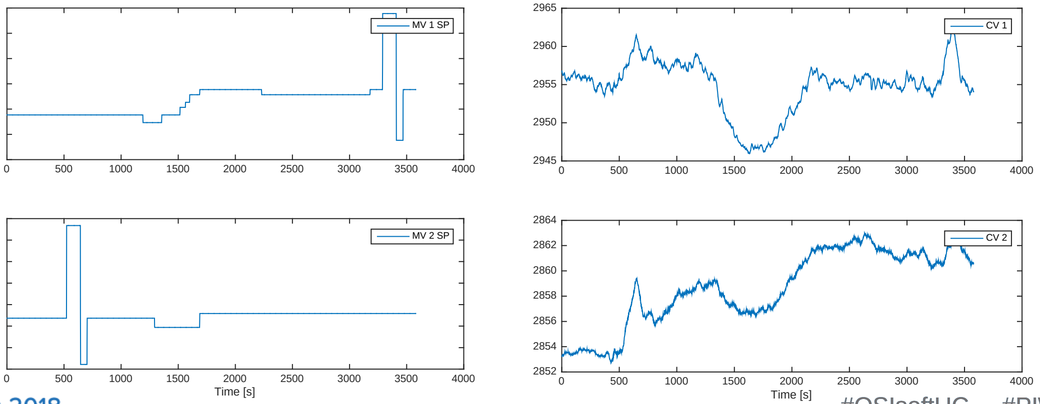


Furnace Control Basics





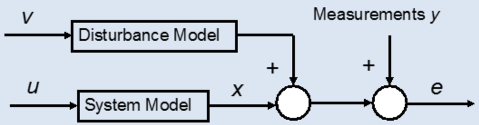
1. Run furnace at steady state
2. Run Bump tests
3. Collect data in PI
4. Estimate models using ILS open and closed loop identification scheme
5. Tune and simulate MPC models off-line
6. Implement MPC on Furnace



Data collection and Modeling

Step 1: Bump tests and data collection in PI
Step 2: Modeling using ILS software for system ID
Step 3: MPC design implementation and testing

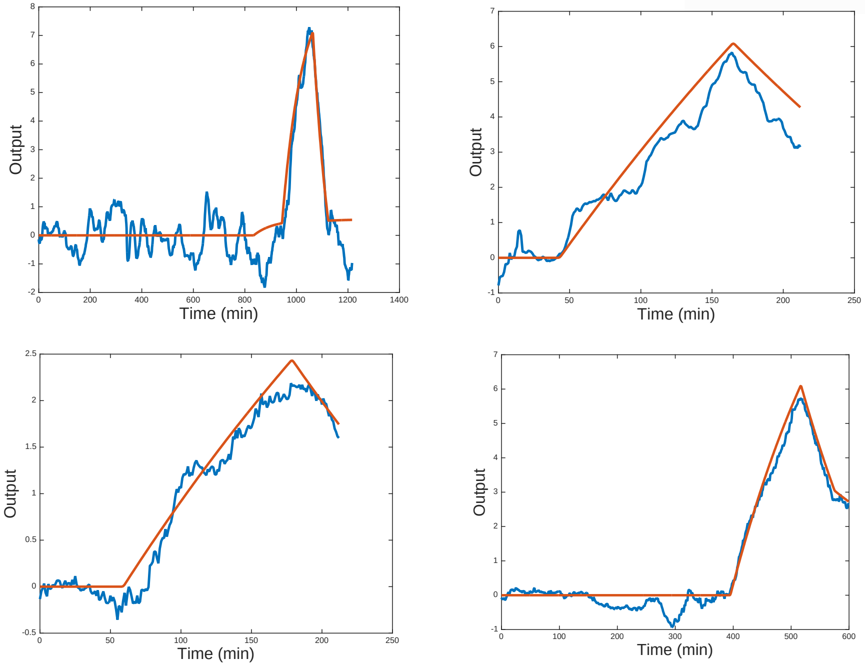
ILS Algorithm solves the problem



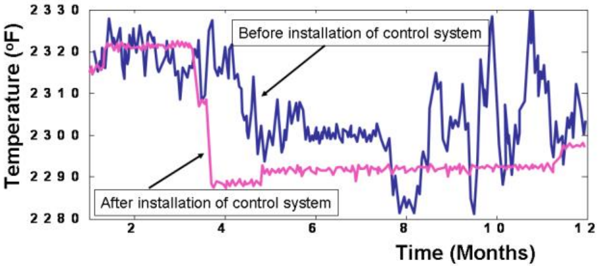
$$\hat{y}(t) = \underbrace{G_p(s)u(t)}_{\text{System}} + \underbrace{G_d(s)v(t)}_{\text{Disturbance}}$$

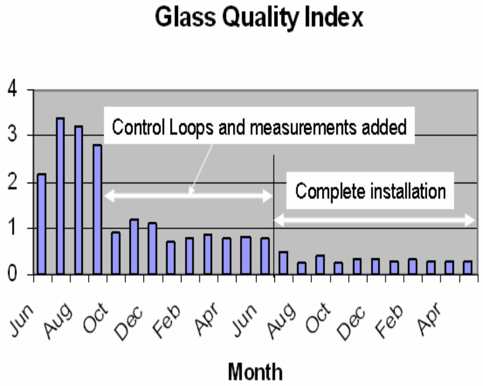
$$\min_{\text{Model Parameters}} \sum_{t=T_1}^{T_2} (y(t) - x(t))^2$$

Model Identified by ILS code



Results from previous implementation





- Yield improved by 3-5%
- Excellent operator acceptance
- Maintainable and expandable
- Implemented on several PPG plants

Heat Exchanger Control Experiment at CMU

Objectives: To teach students how to collect and visualize data using PI vison. To implement and tune PID controllers on a real system

- Two coupled heat exchangers
  - Steam to generate hot water
  - Hot water cold water
- Measurement and controls linked to PI vision
  - 6 thermocouples
  - 2 flow measurements (hot cold water)
  - 2 block valves
  - 2 control valves

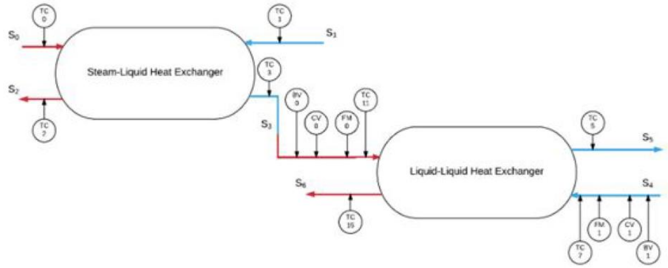


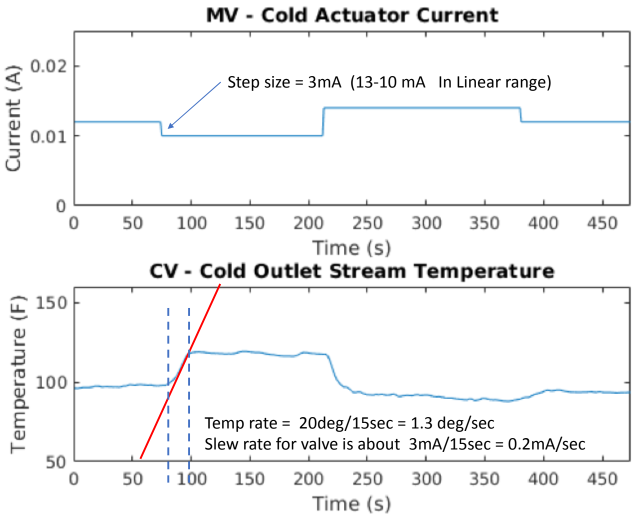
Figure 1. Heat exchanger system. TC: thermocouple, CV: control valve, FM: flow meter

Project Description (Groups of 4 students)

1. Carry out step response experiments in the lab while PI is collecting data.
2. Download data from PI to MATLAB using Dr Erica Trump's procedure
3. Develop a Simulink Model, include
   a) Slew rate constraints for the valve
   b) Valve constraints for operating range.
   c) Valve characteristics (The current polynomial fit only works in the range 9-20 mA)
   d) Heat exchanger dynamics (first order dead time model)
4. Simulate model and tune parameters to match to data as closely as possible (calculate mean square error and generate plots)

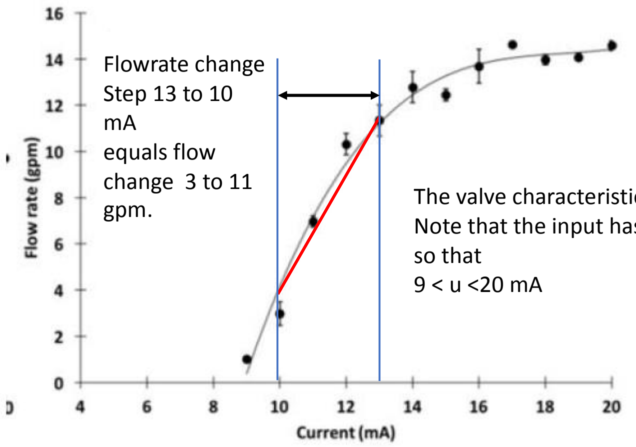
Data collection and Modeling

PI Data Downloaded



Temperature rise rate is constrained by the rate of change of the valve opening. Since we are in the linear rage this means that valve leads to flow change

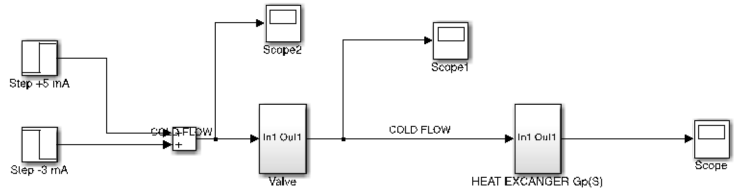
Valve Characteristic



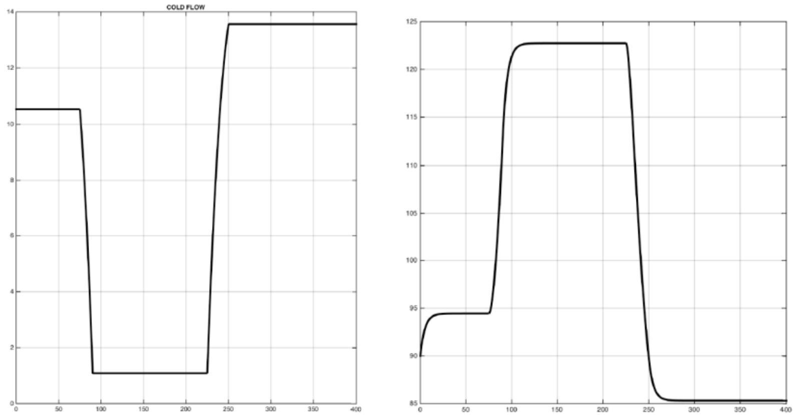
Flowrate change
Step 13 to 10 mA
equals flow change 3 to 11 gpm.

The valve characteristic.
Note that the input has to be limited so that
9 < u <20 mA

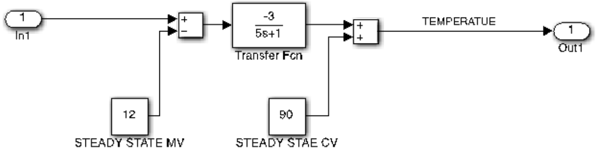
Simulink Model of Heat Exchanger



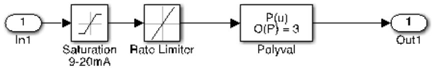
Simulation validation



Heat exchanger system



Valve system

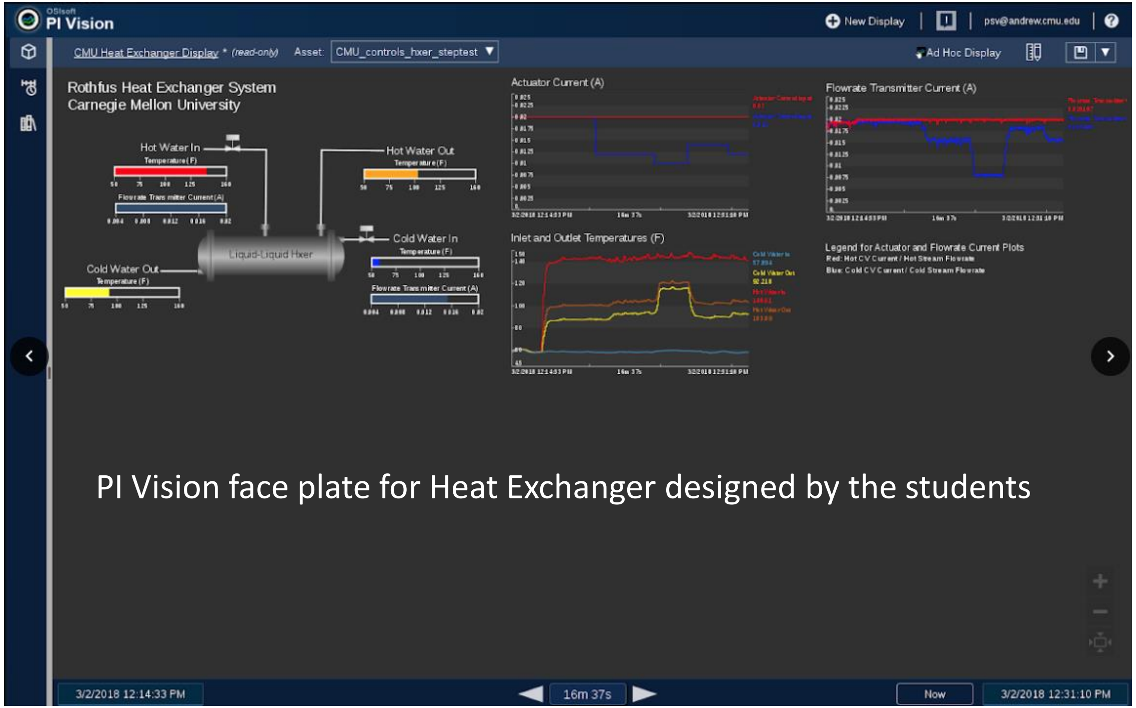


From PI data students find

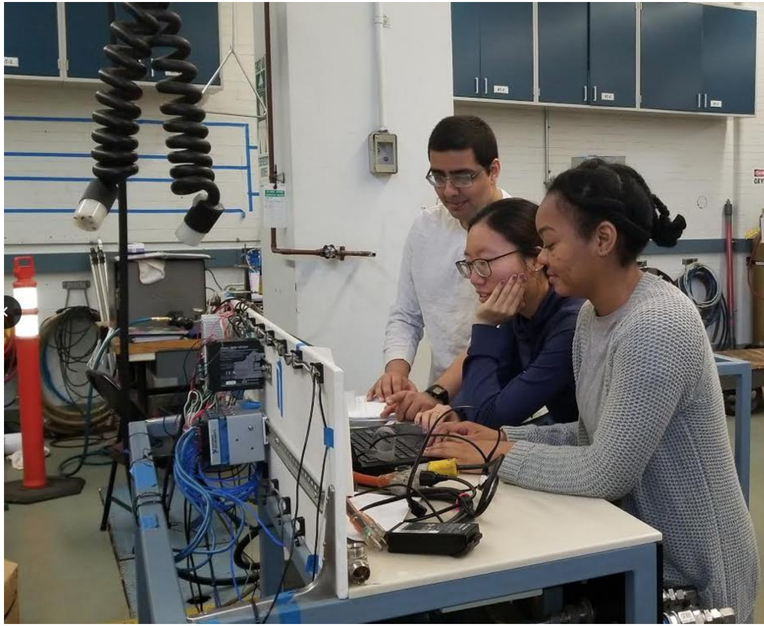
Slew rate	0.2 mA/sec
Valve constraints	9 mA <MV<20 mA
Valve characteristic	$F = 0.0150u^3 - 0/85x^2 + 16x - 85$
Transfer function	$G = \dfrac{-3}{5s+1}e^{-1.5s}$

Next steps:

1. Design and simulate PI controller
2. Implement controller on HX
3. Collect PI data and analyze



PI Vision face plate for Heat Exchanger designed by the students



Our design team at work

- Praveer Vyas
- Chrystear (Sicong) Liu
- Diane Ngounou

Control project carried out by 76 students in teams (~ 4students per team)

- **Session 1:** Collect data, transfer to MATLAB, design and simulate closed loop
- **Session 2:** Run closed loop control test, collect data and analyze

Students follow industrial project in parallel with their HX project

Conclusions

- PI system storage and data visualization helps in developing model predictive controllers in industry by streamlining work processes and providing direct data upload to state of art modeling systems based on global optimization code developed at CMU and licensed by ILS.
- PI System/PI Vision used to teach students at CMU state of art data storage and visualization
- System successfully used to model nonlinear heat exchanger system in the Rothfuss Laboratory in the Dept. of Chem. E.
- Control Experiment in progress. Data collected via PI Vision
- Industrial data used in teaching process control. More case-studies would be helpful, especially real time data from process industries.

Questions

Please wait for the **microphone** before asking your questions

State your **name & company**

谢谢

Merci

Danke

Спасибо

Gracias

Thank You

감사합니다

ありがとう

Grazie

Obrigado

Optional: Click to add a takeaway you wish the audience to leave with.