19 AIChE Spring Meeting

15TH GLOBAL CONGRESS ON PROCESS SAFETY

NEW ORLEANS • 2019

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Unique Applications for Embedded Model Predictive Control Technology

Paper 137a

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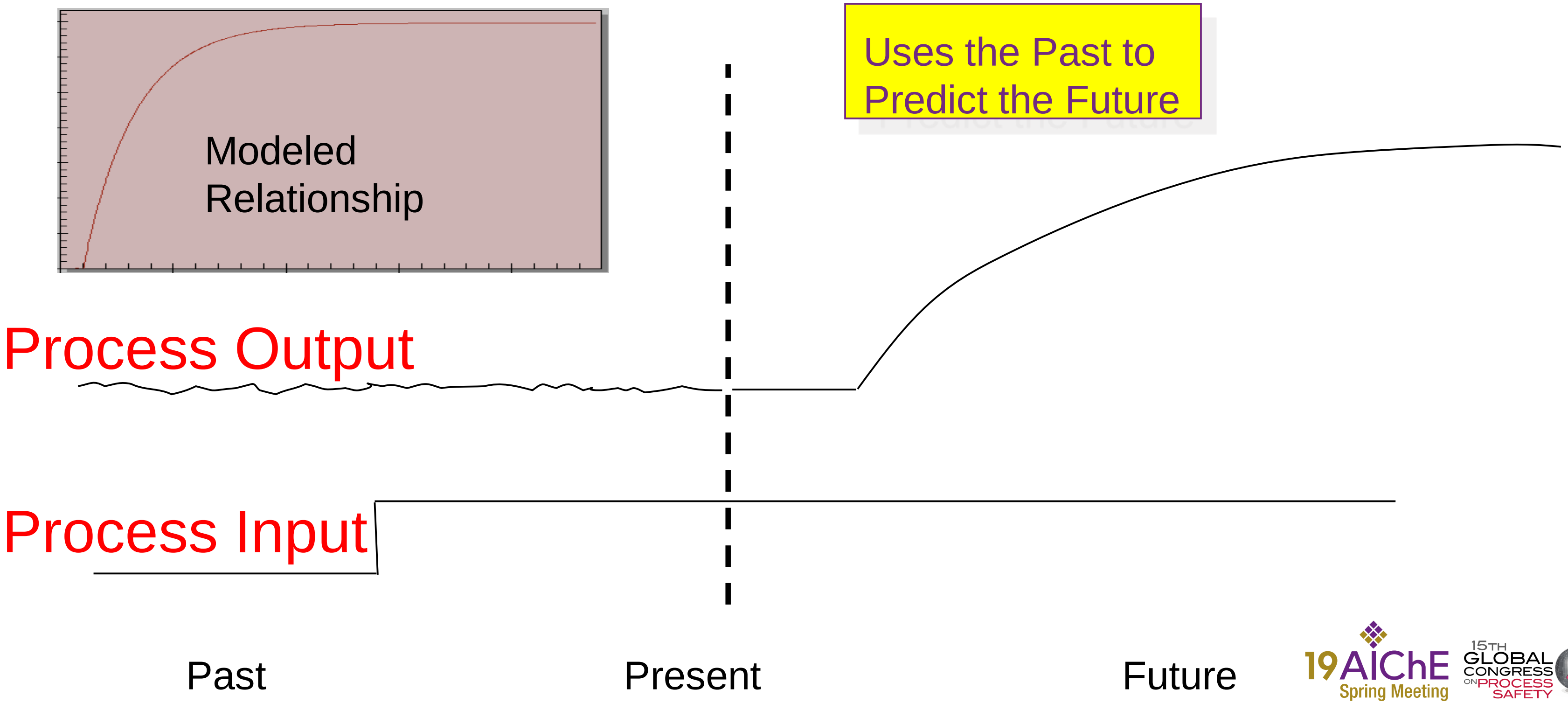
Speaker – James Beall

- Principal Process Control Consultant with Emerson Automation Solutions since 2001
- 37+ Years experience with Petrochemical Process Automation
- Specialist in advanced regulatory control and multivariable control
- Eastman Chemical Company, Texas Operations (1981-2001)

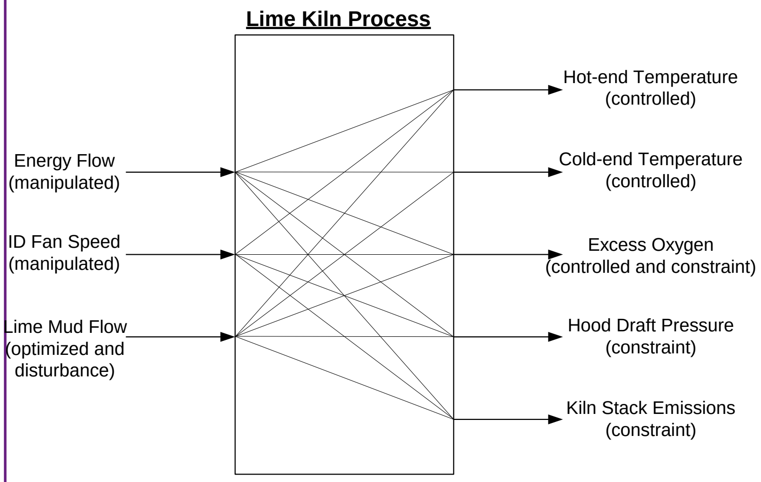
Introduction

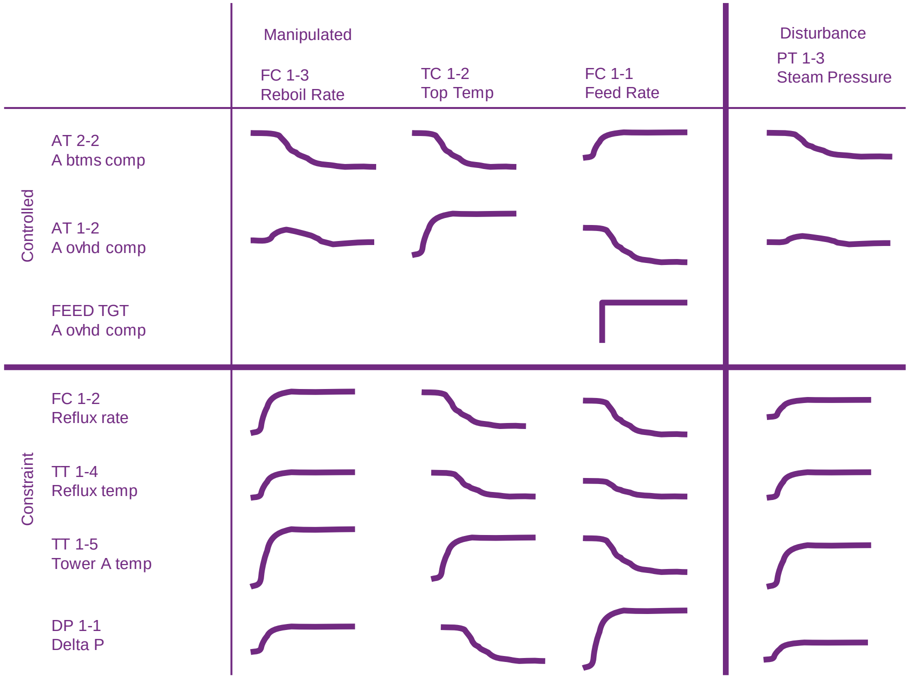
- What is MPC?
- What is Embedded MPC?
- Example Uses of Embedded MPC
- Questions

"MPC": Multivariable, *Model* Predictive Controller



“MPC”: *Multivariable*, Model Predictive Controller



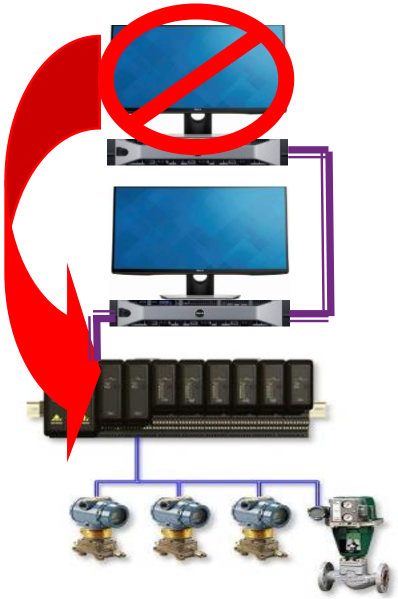


What is *Embedded* MPC?

Embedded MPC:

- NO extra databases
- NO database synchronization issues
- NO watchdog timers
- NO fail/shed logic design
- NO custom DCS programming
- NO interface programming
- NO operator interface development

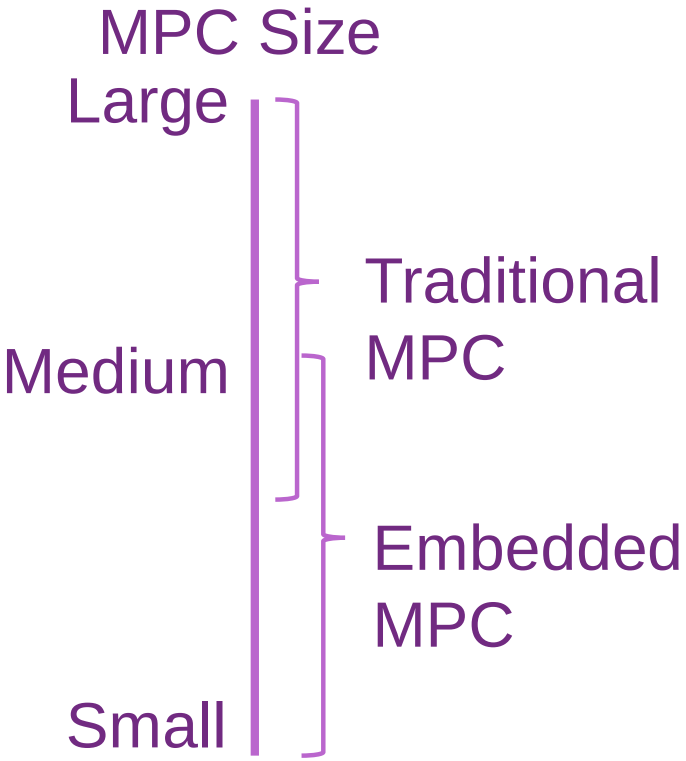
Traditional APC



Embedded MPC:

- Can run in DCS controllers/stations
- Redundant and fast (e.g. 1/sec)
- Integrated operator user interface
- Configuration through standard configuration tools
- Automated step testing and Model ID
- Off-line simulation and testing
- Implementation by plant control engineers

Traditional and Embedded MPC

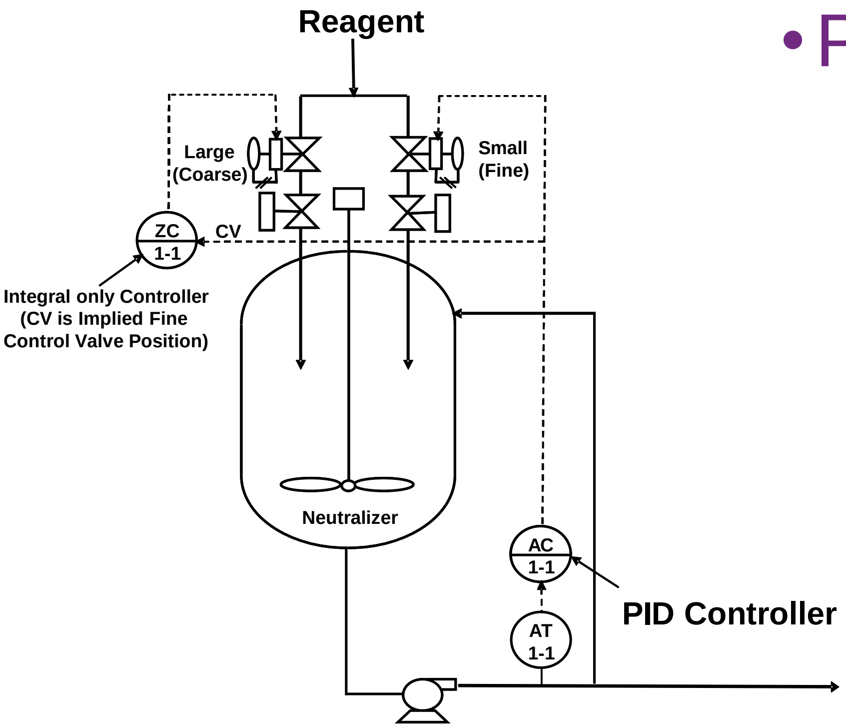


- Traditional MPC
  - Well developed, full featured technology
  - Higher "minimum" project cost
  - Medium to larger req'd for ROI
- Embedded MPC
  - Less features to "fit" in DCS
  - Lower implementation cost
  - ROI for smaller

Examples of Unique Applications

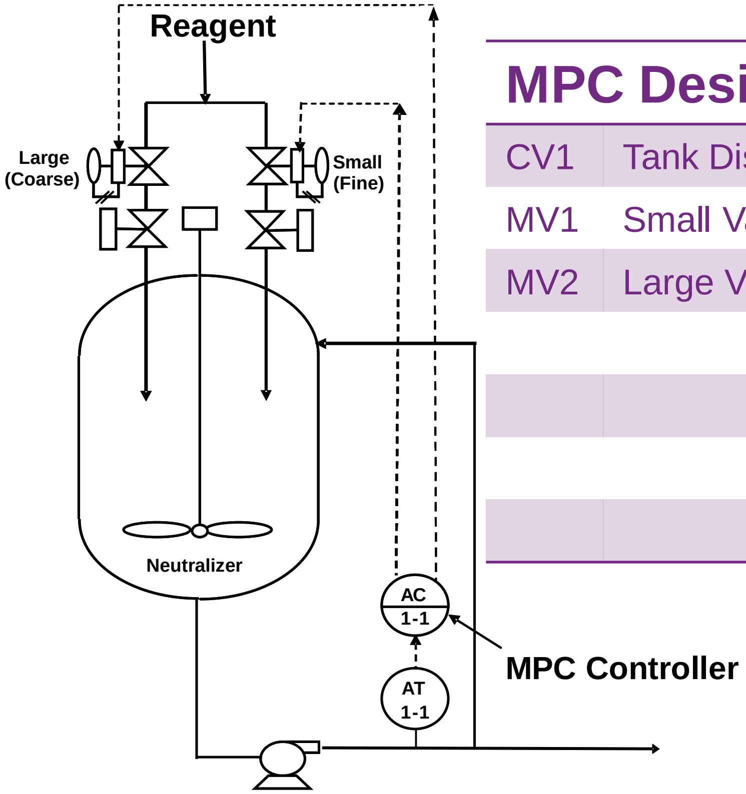
- “Big Valve, Little Valve”
- Dead time dominant SISO
- Feed Forward and Override
- Waste heat steam generator
- Waste heat recovery – steam export

"Big Valve, Little Valve"



- PID Considerations
  - Large PV disturbances can saturate Small valve – loss of control
  - ZC should have "gap" control to eliminate potential Large valve limit cycles

"Big Valve, Little Valve"



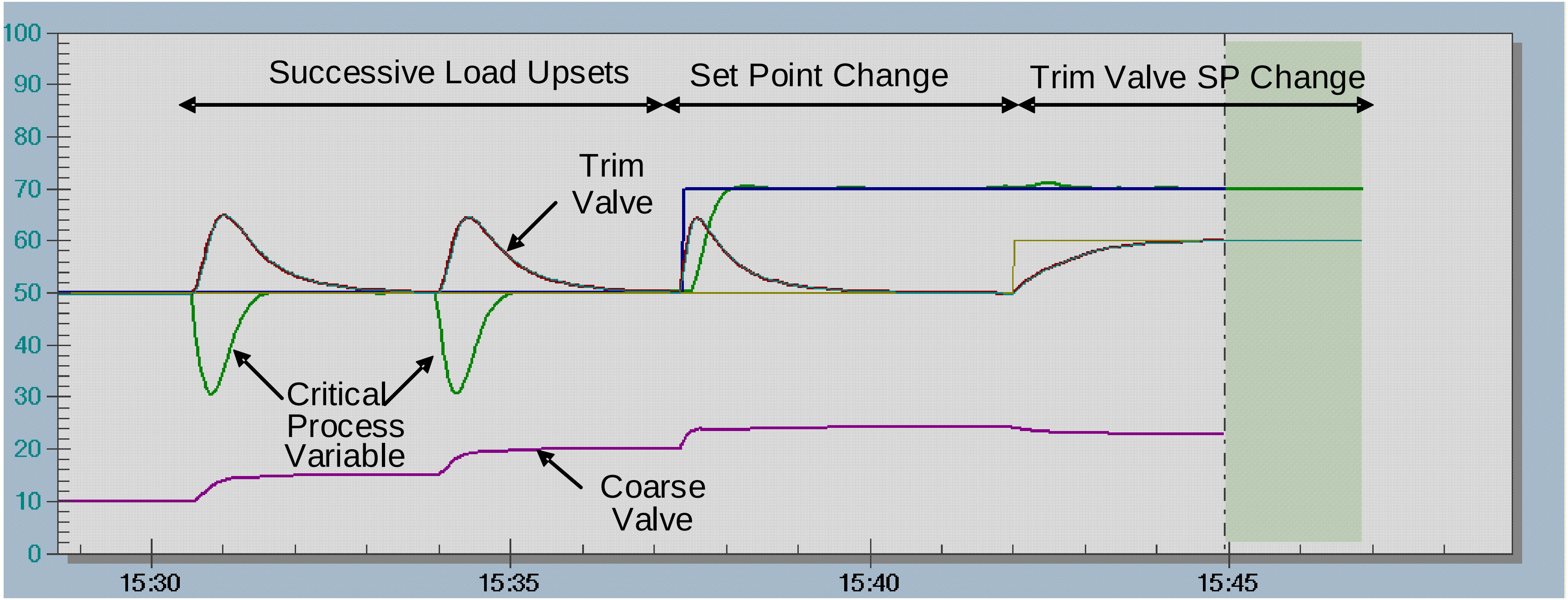
MPC Design

CV1	Tank Discharge pH
MV1	Small Valve
MV2	Large Valve

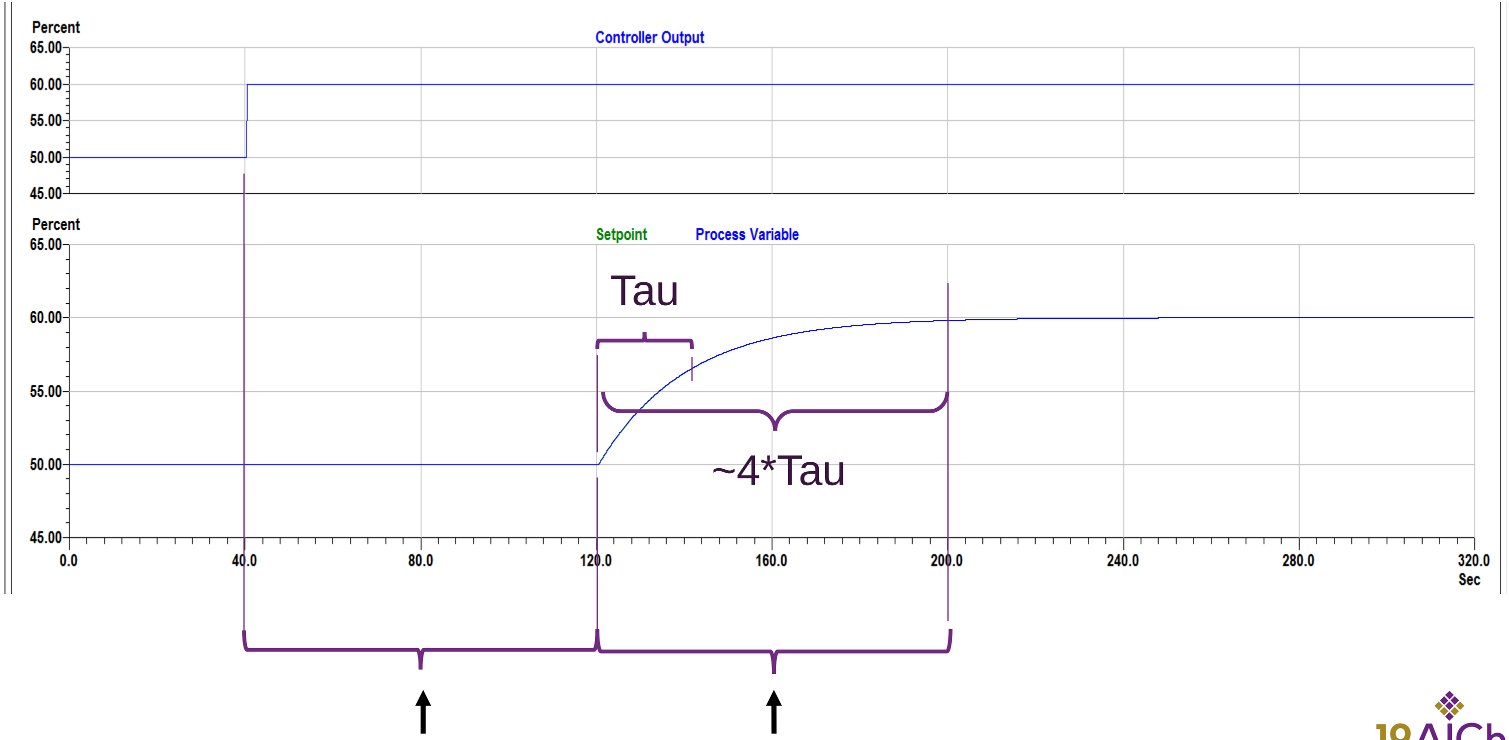
- MPC Considerations
  - Large PV disturbances handled by moving both Large and Small valves
  - Use constraint control on small valve position to eliminate large valve limit cycles

“Big Valve, Little Valve”

MPC Performance

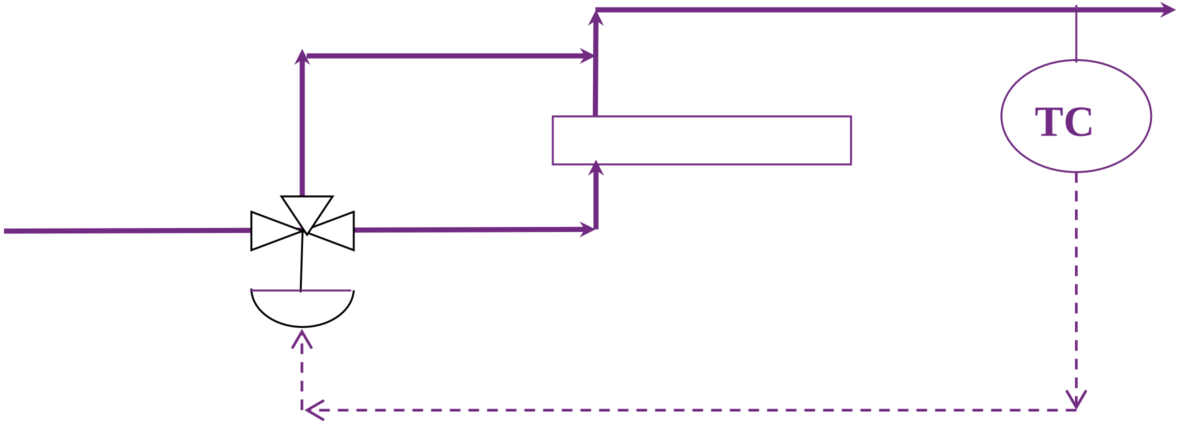


Deadtime Dominant Loops



Dead time >= 4*Tau (definition varies)

Deadtime Dominant Loop

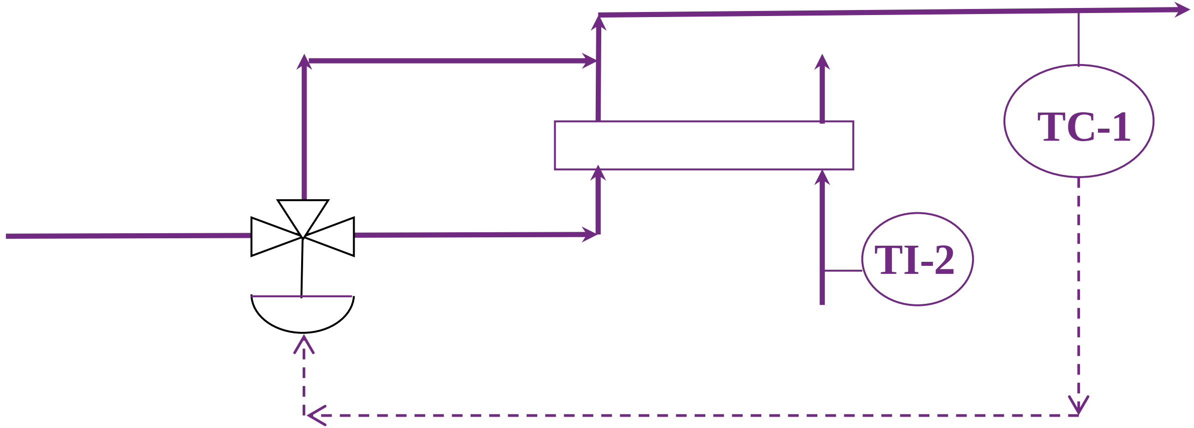


MPC Variables

CV1	Coolant Temperature
MV1	3-Way Valve

- Reactor coolant supply temperature
- “Mixing” temperature response fast (~15 sec Tau)
- Step test revealed 80 seconds of dead time!

Feed Forward with MPC

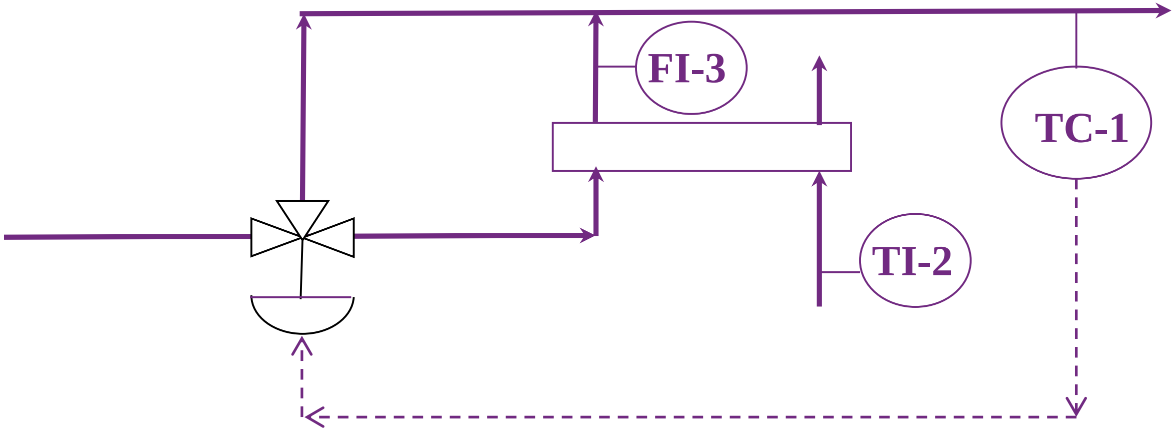


MPC Variables

CV1	Coolant Temperature
MV1	3-Way Valve
DV1	Cooling Water Temp

- Temperature of cooling water impacts outlet temp
- Typically implemented as feedforward to PID (calculate FFWD Gain, dead time, lead-lag
- Use TI-2 as a Disturbance Variable with MPC-simple model

Override/Constraint with MPC

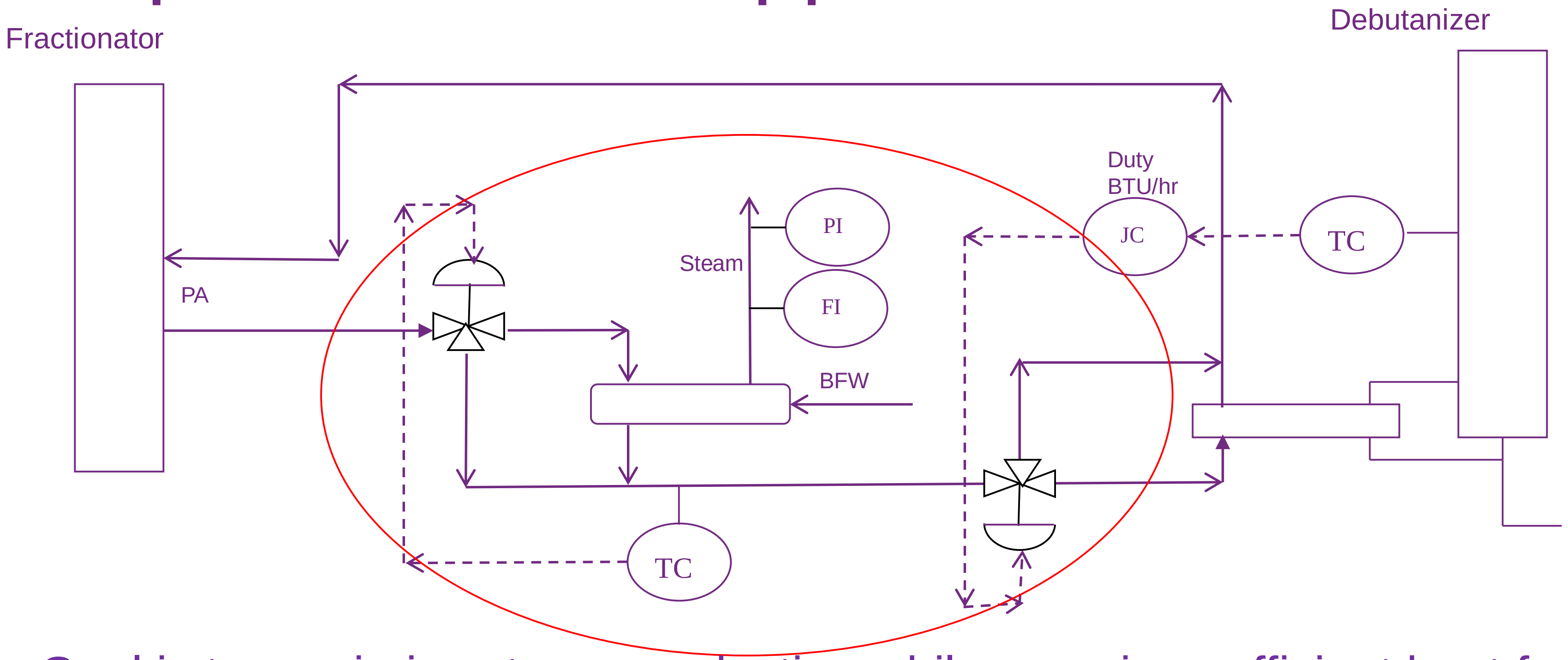


MPC Variables

CV1	Coolant Temperature
CV2	Minimum Tube Flow
MV1	3-Way Valve
DV1	Cooling Water Temp

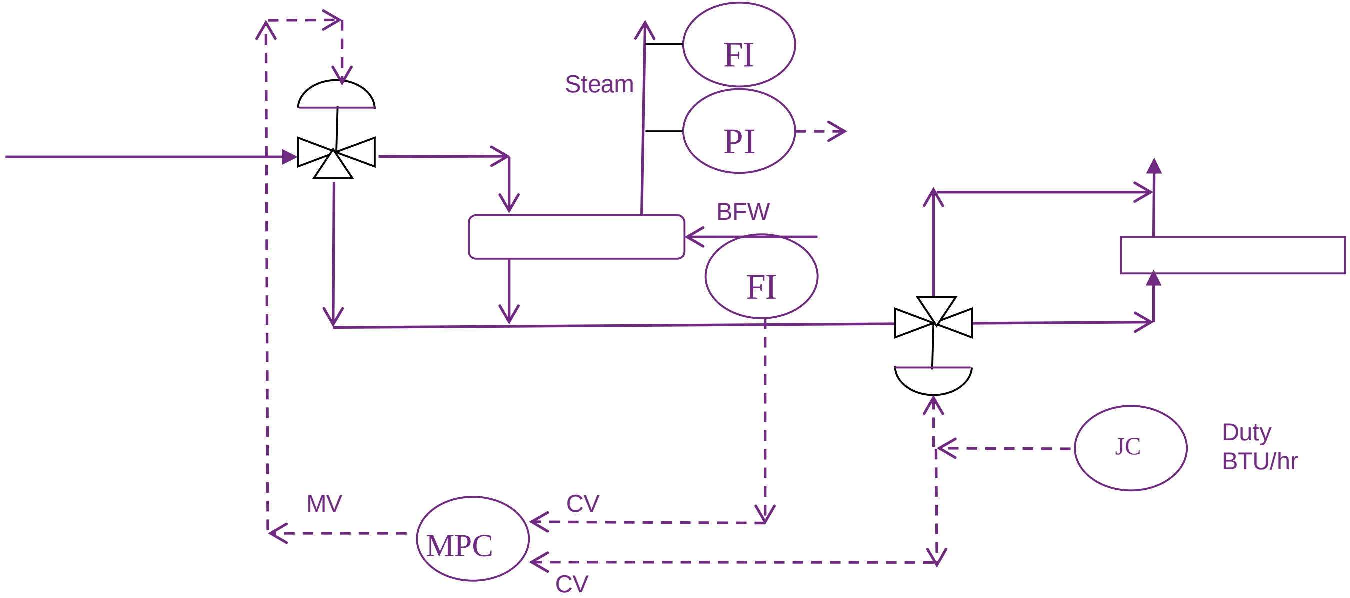
- Suppose there is a minimum flow through exchanger tubes, FI-3, to avoid fouling
- Typically done with 2 PID's and a hi/lo selector
- Implement as a Constraint Variable (LV) with MPC

Optimize Small Applications



Goal is to maximize steam production while ensuring sufficient heat for debutanizer reboiler. Also, handle limited BFW supply.

Optimize Small Applications

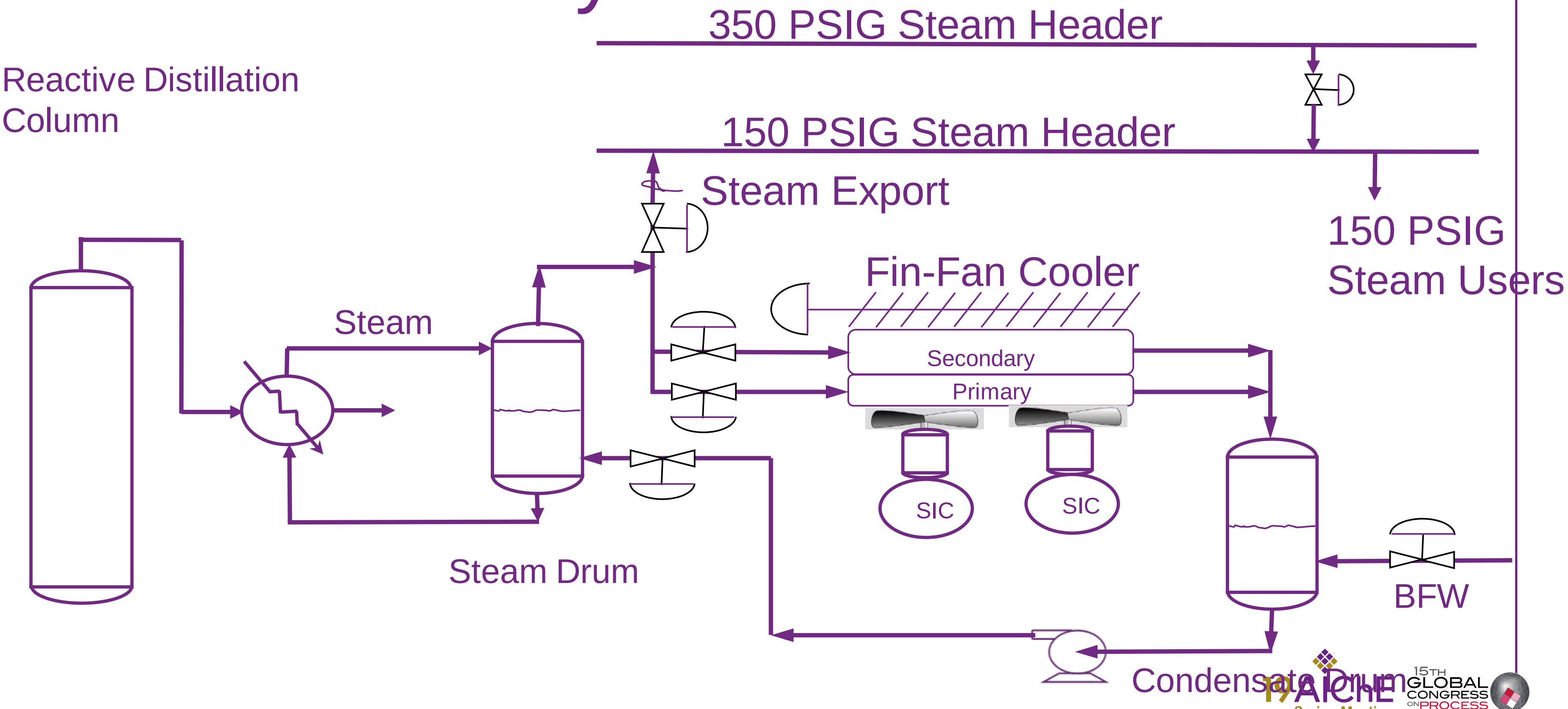


Objective: Maximize steam production

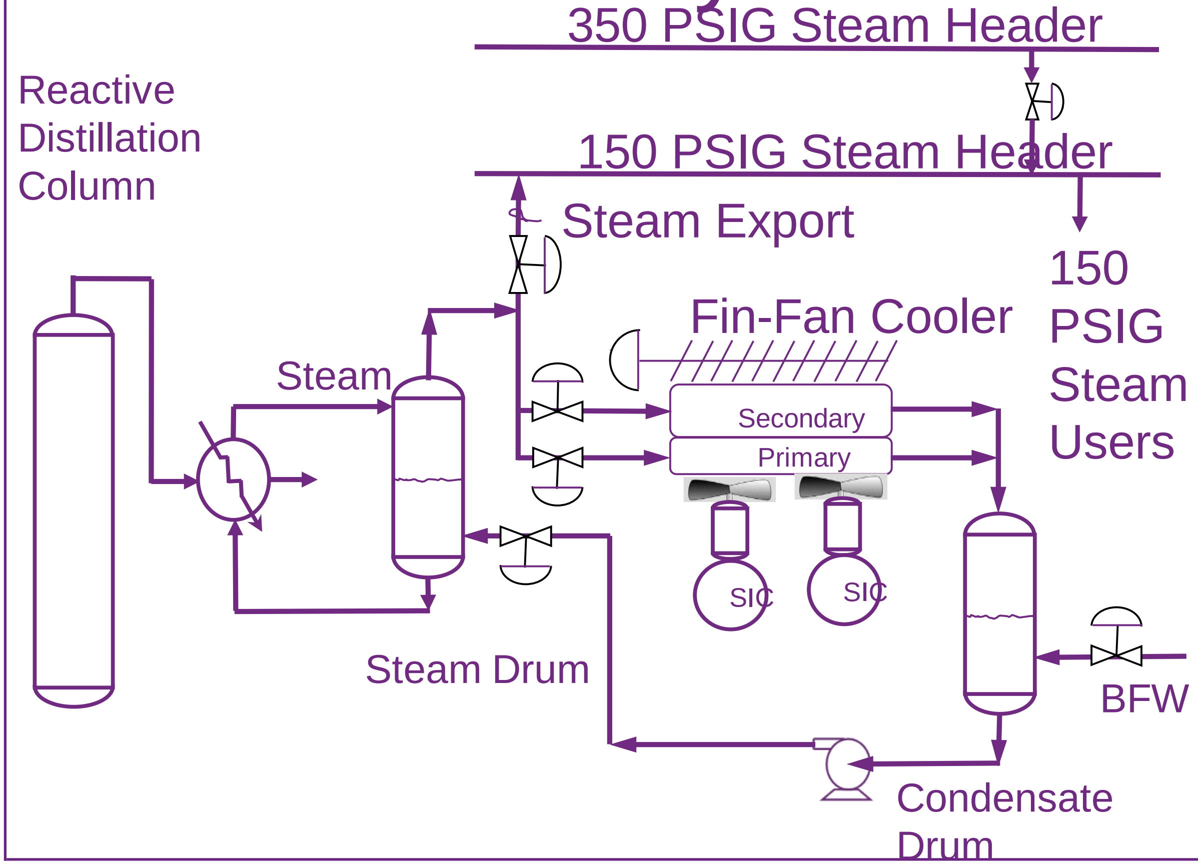
Implementation time: 2 days

Benefit: $120K/year

Heat Recovery



Heat Recovery



MPC Variables

CV1	Steam Drum Pressure
CV2	Cond. Drum Pressure
CV3	Steam Export Pressure
CV4	350-150 PRV Position
MV1	Steam Export Valve
MV2	Steam Valves to Cooler
MV3	Total Fan Speed

Heat Recovery

- Plant personnel learned about MPC application selection, MPC design and commissioning
- Identified a steam valve that had excessive leakage at shutoff
- Increase average steam export ~3000 lb/hr = $240K/year, repair of leaking steam valve $200K/yr benefit
- Benefit
  - Implementation time – 2 weeks
  - Benefit – $440K/yr
  - Payback period – 3 weeks

Summary

- Traditional MPC is well developed, full function technology but requires a high minimum investment requiring larger projects to provide ROI
- Embedded MPC has less features but is easy to implement, low implementation cost and executes fast resulting in smaller projects to provide ROI
- Each technology has a “best fit”, so utilize each technology where they provide the best ROI

Questions