PlantPAx® MPC
Simple Model Predictive Control Embedded in Logix
Agenda

- What is Model Predictive Control?
- Lab Overview – Go!
- Course Feedback
## What Makes MPC Different

<table>
<thead>
<tr>
<th>PID</th>
<th>MPC</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SINGLE INPUT - SINGLE OUTPUT CONTROLLER</strong></td>
<td><strong>MULTIPLE INPUT - MULTIPLE OUTPUT CONTROLLER</strong>&lt;br&gt;Control strategy based on a centralized approach. All variables are simultaneously considered.</td>
</tr>
<tr>
<td><strong>CONTROL BASED ON CURRENT ERROR</strong></td>
<td><strong>PREDICTIVE CONTROL</strong>&lt;br&gt;Controller action based on current and anticipated future PV deviations from target</td>
</tr>
<tr>
<td><strong>POOR ABILITY TO HANDLE PROCESS DELAYS, &amp; NON-LINEARITIES</strong></td>
<td><strong>COMPENSATES FOR PROCESS DELAYS &amp; NON-LINEARITIES</strong></td>
</tr>
<tr>
<td><strong>POOR ABILITY TO HANDLE DIFFERENT TYPES OF DISTURBANCES AND SET-POINT SIGNAL FORMS</strong></td>
<td><strong>OPTIMAL CONTROL FOR ALL TYPES OF DISTURBANCES AND SET-POINT SIGNAL FORMS</strong></td>
</tr>
<tr>
<td><strong>POOR ABILITY TO HANDLE CONSTRAINTS</strong></td>
<td><strong>PREDICTIVE HANDLING OF CONSTRAINTS</strong></td>
</tr>
</tbody>
</table>

*We do this because it makes processors money:*<br>
*Higher production, yields, efficiency and product quality*
MPC Opportunities

- Coating Oven
- Distillation Column
- Compressor
- Chemical Reactor
- Boiler
- Furnace
- Dryer
- Drilling Rig
- and many more
Making Control Scheme Smarter

Traditional Control Architecture

- High / Low Select Logic, Gain Scheduler
- Decoupling, Override Control
- PID

Architecture with MPC

- MPC
- PID

Easier to design and maintain

PID left in the scheme or direct output control
How a Receding Horizon works

The Task: Minimize $J$ by calculating $MV$ over the Horizon

$$J = CV_{Coef} \sum_{k=1}^{Horizon} (CV(k) - CV_{SP}(k))^2$$
$$+ MV_{Coef} \sum_{k=0}^{Horizon-1} (MV(k) - MV_{SP}(k))^2$$
$$+ MV_{MoveSupp} \sum_{k=0}^{Horizon-1} (\Delta MV(k))^2$$

- measured
- calculated (predicted)
- calculated and sent out as MV
PID vs MPC variables

- CV – Controlled (Process) Variables: objective and/or constraints
- MV – Manipulated Variables: PID targets or outputs that MPC adjusts to meet objectives
- DV – Disturbance Variables: affects CVs, but is independent of controller
A MPC Project

• Design the MPC Application:
  • Controlled Variables: What are we trying to do better, what is in the way/limits this today?
  • Manipulated Variables: What can we adjust to affect this result today?
  • Disturbance Variables: What do you watch out for that causes / forecasts a change?

• Perform Plant Testing (set up trends/logs for above variables)
  • Individually step each MV & DV (as possible) within safe limits to see changes in CV’s.

• Develop MPC models based on identification of above data
• Develop any calculations necessary to support MPC goals
• Implement/integrate and test application, train operators and turn-on!

Measure Improvement!
MPC in Integrated Architecture®

FactoryTalk® ProductionCentre®, FactoryTalk® Historian, Pavilion® Real-Time Optimization™ …

Pavilion8® MPC, Software CEM®, VOA®, Asset Management, …
Rockwell Software Studio 5000®, PlantPAx® MPCBuilder

- PlantPAx® MPC
  - IMC, CC, MMC
  - FuzzyLogic
  - Soft Sensor® (AOI)
  - PID, PIDE
  - Motion
  - Discrete
PlantPAx® MPC Lab Setup

Lab Files:
- Oven.ACD
- OvenDataSet.CSV
- Oven_ModelReady.mpc
- Oven_SimulationReady.mpc
- Oven_ExportReady.mpc

Controller

1756-MPC Module with firmware
Dynamic Identification
Curing Oven MPC – 2MVs, 4DVs, 2CVs

Combustion gas suction

MV0

DV3

Suction_Flow

CV0

Oven_Press

CV1

Ambient_Temp

Hot_Air_Temp

DV2

Atmospheric pressure (constant)

MV1

DV0

DV1

DV3

Metal strip

Combustion gas exhaust

Hot air inlets

Metal strip

Heating Chamber

Gas Supply

Pressure (constant)

Hot Air Supply

Gas Valve

Hot_Air_Temp

Hot_Air_Press

Gas_Valve

Air_Flap_Valve

ambient_Temp

Suction_Flow

Oven_Temp

Oven_Press

rpm constant

Combustion gas circulation

Oven_Temp

Suction_Flow

Metal strip
MPC Configuration & Settings

OversampleDT – MPC frequency 0.5 seconds

- **SPValueReq**: True
- **SPProg**: 0%
- **ROC**: 10%/s
- **Scale**: 100%

**MV0**
- **Gas_Valve**

**MV1**
- **Air_Flap_Valve**
- **Hot_Air_Temp**
- **Hot_Air_Press**
- **Ambient_Temp**
- **Suction_Flow**

**CV0**
- **Oven_Temp**

**CV1**
- **Oven_Press**

**DV0**
- **DV1**
- **DV2**
- **DV3**

**SPTrajectoryReq**: True
- **CVSPTrajectory**
  - 0 s 310 °C
  - 6 s 310 °C
  - 21 s 340 °C
  - 50 s 340 °C
  - 65 s 310 °C
  - 260 s 310 °C

**ZoneReq**: True
- **ZoneHiLimit**: -1 Pa
- **ZoneLoLimit**: -20 Pa

**setpoint**
- **rack temperature**
- **keep pressure within limits**

- **SPValueReq**: True
  - **SPProg**: 0%
  - **ROC**: 10%/s
  - **Scale**: 100%

- **MV0**
  - **Gas_Valve**

- **MV1**
  - **Air_Flap_Valve**
  - **Hot_Air_Temp**
  - **Hot_Air_Press**
  - **Ambient_Temp**
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- **CV0**
  - **Oven_Temp**

- **CV1**
  - **Oven_Press**

- **DV0**
- **DV1**
- **DV2**
- **DV3**
Do not skip Faceplates
Thank you