CAPSTONE

Advanced Process Control Solutions

CAPSTONE TECHNOLOGY CANADA

ABOUT THE COMPANY

Mission	Capstone Technology Canada (Inc 2002) is an Advanced Control technology and services company focusing on serving Canada's Oil & Gas industry
Experience	Over 100 years combined applications experience implementing and supporting APC solutions to multiple process industries
Expertise	Advanced process control engineering, model predictive control, multivariate modeling, real-time optimization
System Integrator	Integrator of partner technologies
APC Solution Experience	Extensive APC project experience with RMPC, DMC, Connoisseur, and Capstone Control technology
Locations	Employees located throughout Canada

CAPSTONE SERVICES AND SOLUTIONS

ADVANCED PROCESS CONTROL

Model Predictive Control

Soft Sensors

Real Time Optimization

ANALYTICS

Data Science, Analytic, and Data Mining

Dashboards and KPIs

Data Visualization

ADVANCED PLANNING AND SCHEDULING

Plant-wide Process Scheduling

Feedstock Planning and Scheduling

Debottlenecking and Optimization

APPLICATION DEVELOPMENT

Software Integration and Implementation

Software Development

Team Augmentation

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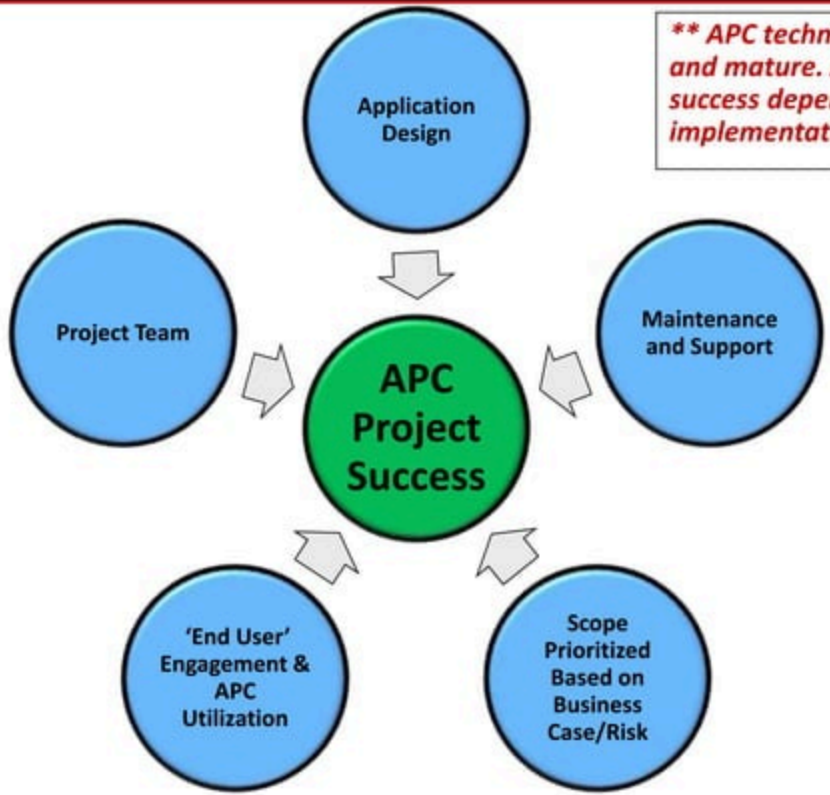
OUR APC PHILOSOPHY
PROJECT CRITICAL SUCCESS FACTORS



***** APC technology is proven and mature. Application success depends mainly on implementation.***

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WHY CAPSTONE?

Success Factor	Why CAPSTONE?
Project Team	• Extensive experience in APC-specific, Oil & Gas-specific applications • Experienced personnel assigned for entire project lifecycle, including site visits • Local project/support engineers ensures responsive support/training for Operations
Application Design	• Depth of experience enables us to design the optimal solution for your specific application • Multi-platform integration expertise allows for cost effective project delivery • Experience integrating visualization tools with APC systems
Maintenance and Support	• Long-term support of our applications at Canadian and International clients • Same-day response to service calls by a member of our team with extensive process, control, and systems engineering knowledge.
End User Engagement & APC Utilization	• Track record of successful implementations resulting from high end user buy-in • Local presence facilitates effective training, support, and adoption of APC applications • APC and information systems support by our experienced team
Scope Prioritized Based on Business Case/Risk	• Lower project risk through project risk management plan • Demonstrate business value to stakeholders by delivering benefits

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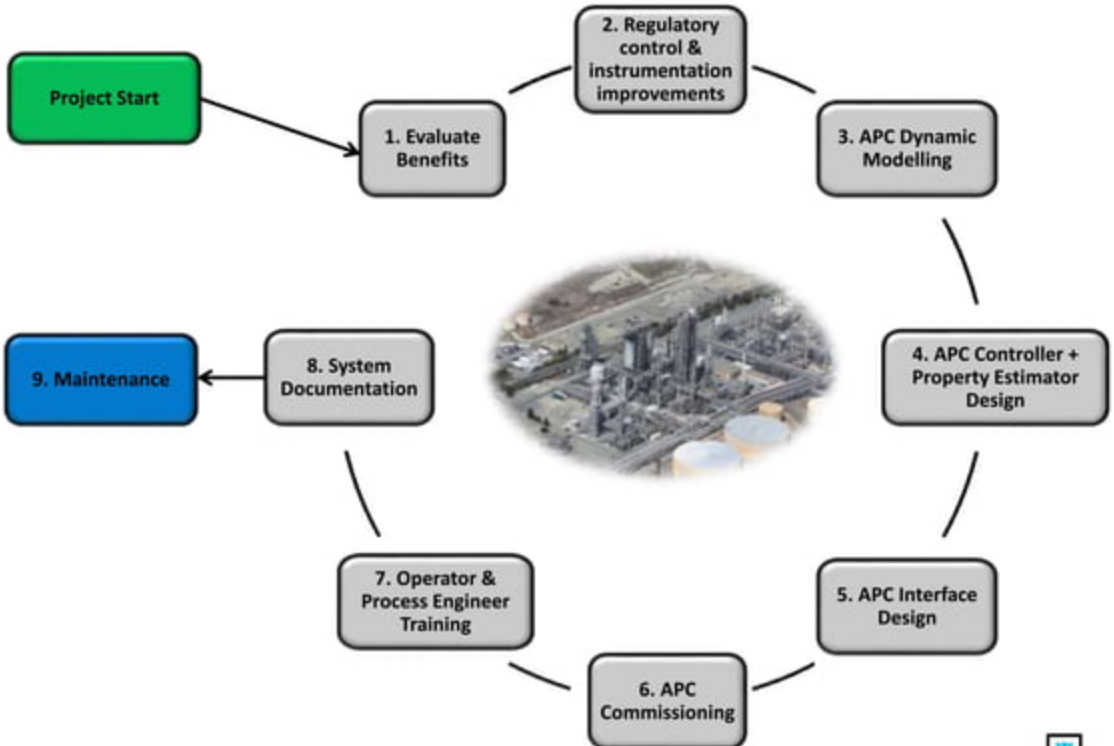
APC PROJECT LIFECYCLE



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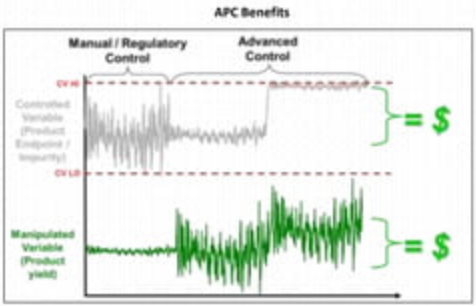
1. BENEFITS ANALYSIS AND PRELIMINARY DESIGN

- Primary Benefits – variability reduction and optimizing operating point
- Identify control benefits by analyzing process areas
- Analyze historical and controlled step test data to estimate variability reduction
- Characterize process capability, mechanical and process constraints
- Identify instrumentation issues (tuning, loop pairing, etc), best operating practices, modes of operation, feed switches, etc.
- Combine the results of the analysis with economic data to estimate benefits



Deliverables, Milestones, and Outcomes

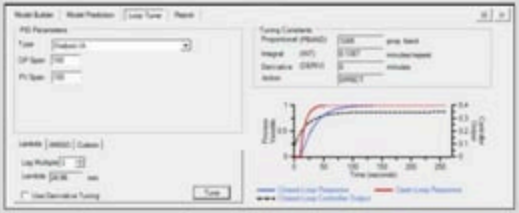
- Completed analysis of operating environment and initial optimization approach defined
- Dynamic control matrix
- Business case defined for each in-scope item
- Prioritized scope by business value & implementation risk
- Input to Phase 2 planning

2. REGULATORY CONTROL + INSTRUMENTATION IMPROVEMENTS

- Re-tune main PID loops (as required) that will interface with APC
- Implement any recommended improvements to instrumentation

Deliverables, Milestones, and Outcomes

- Regulatory control systems are prepared for the APC project



3. DYNAMIC MODELING & STEP RESPONSE TESING

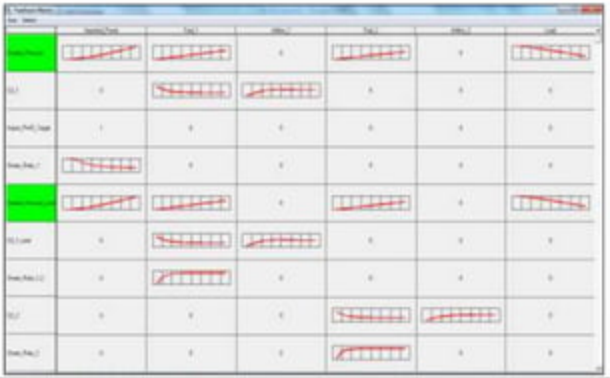
- Develop ***dynamic control models*** by fitting models to bump test data
- Determine ***test plan*** based on the operations analysis performed in Phase 1 and approved by Operations
- Include an experienced Board Operator as part of the project team. This individual often has a positive impact on ultimate 'end user' support.
- Operations is engaged to ensure that the process constraints are respected during the bump tests
- Several modeling packages available: Capstone's own or 3rd party

Deliverables, Milestones, and Outcomes

- Modelling approaches are defined
- Inputs to dynamic control models

4. APC CONTROLLER DESIGN

- Controller matrix is built from models identified during the previous phase
- Input/output tag mapping
- Initial tuning

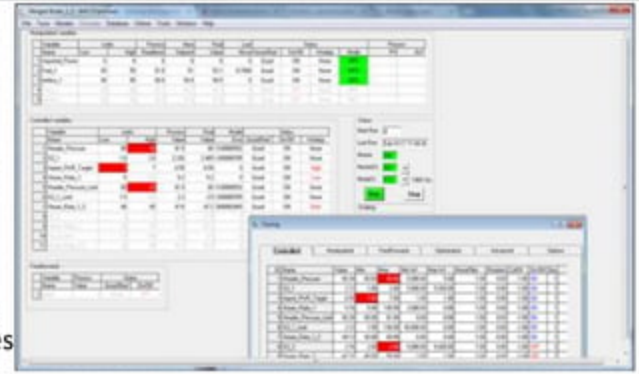


Deliverables, Milestones, and Outcomes

- Map for the control policy has been established

4. CONTROLLER DESIGN - CAPSTONE MODEL PREDICTIVE CONTROLLER FEATURES

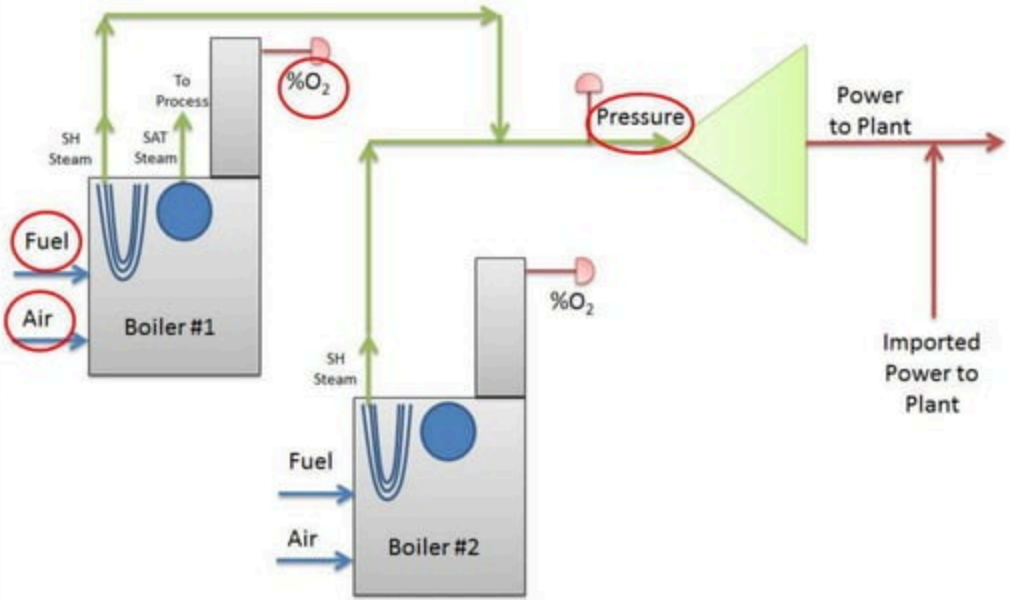
- Unlimited MV-CV pairings
- Predictive constraint control
- Optimization functionality: LP, QP
- Linear models may be used to map a non-linear response space through gain, lag and dead-time adaptation (allows for variable model parameters)
- Runs on Windows and has detailed server-side interface
- Reads/writes OPC
- Internal controller tags available for viewing in visualization tools through MPC data series



Deliverables, Milestones, and Outcomes

- Realize economic objectives for the application design
- Fine Tune the control policy to capture benefits

4. APC CONTROLLER DEMO



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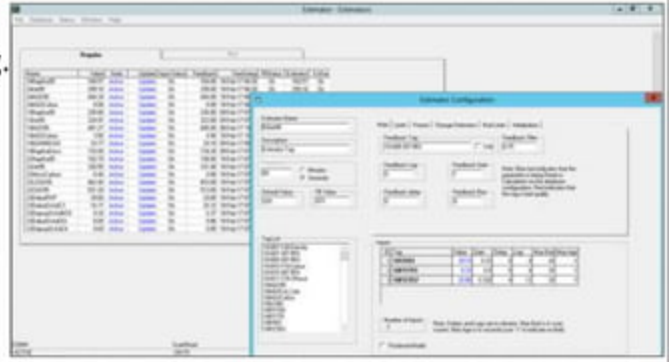
4. PROPERTY ESTIMATOR DESIGN - CAPSTONE PROPERTY ESTIMATOR FEATURES

- Provides a continuous estimate for properties measured infrequently (e.g. analyzer or lab measurements)
- Removes analyzer / lab delay
- Multi-input single output 1st order dynamic models; also supports multivariate gain models (PLS) combined with 1st order dynamics
- Internal estimator tags available for viewing in visualization tools



Deliverables, Milestones, and Outcomes

- Provides dead time compensated, continuous measurement(s) corrected by lab feedback, ready for control deployment.

5. APC INTERFACE DESIGN

- DCS Interface display - used by operators to engage/disengage APC, set targets/ranges, monitor instantaneous performance
- A similar display may be configured in visualization tools for users with no DCS access

Deliverables, Milestones, and Outcomes

- Primary HMI for the Control Room Operator

6. APC COMMISSIONING

- Work directly, on-site with Operations to ensure smooth transition to APC control
- Control Room Operators embedded in project team and support/participate in communicating commissioning activities to stakeholders
- Engage MVs and verify/modify initial tuning
- Tune applications to a satisfactory level of performance where they can remain permanently engaged

Deliverables, Milestones, and Outcomes

- Provide 1-on-1 operator training
- Document benefits obtained

7. OPERATOR & PROCESS ENGINEER TRAINING

- 1-on-1 operator training during previous phase
- Classroom training sessions for operator group
- Operator training focuses on:
  - process objectives, constraints
  - engagement/disengagement procedures
  - how the operator interacts with the interface
- Control Room Operators embedded in project team and support/participate in training sessions
- Process engineers are trained in detail on controller design and architecture

Deliverables, Milestones, and Outcomes

- Training curriculum
- Training courses

8. SYSTEM DOCUMENTATION

- Create detailed engineering documentation (needed for maintenance of the APC system)

Deliverables, Milestones, and Outcomes

- Detailed engineering documentation for the following:
  - Control strategy design
  - System architecture
  - DCS interface
  - Operating procedures

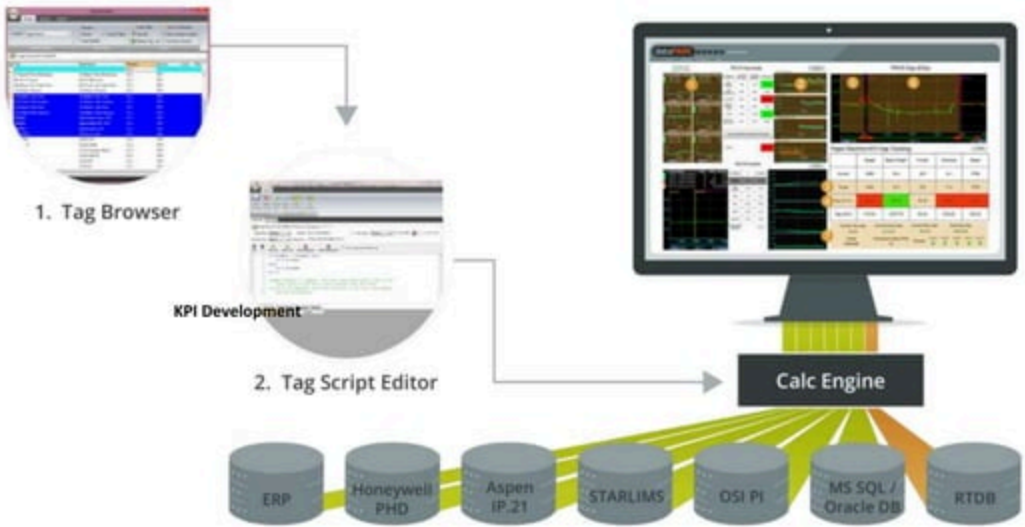
9. LONG-TERM MAINTENANCE

- Long-term performance benefits can be maintained in the absence of significant process changes with monitoring and maintenance
- Model predictive control performance may deteriorate over time due to process changes and if the initial models are no longer representative
- Typical changes may include: Unit revamps, equipment fouling, new or changed product specifications, instrumentation failures, etc

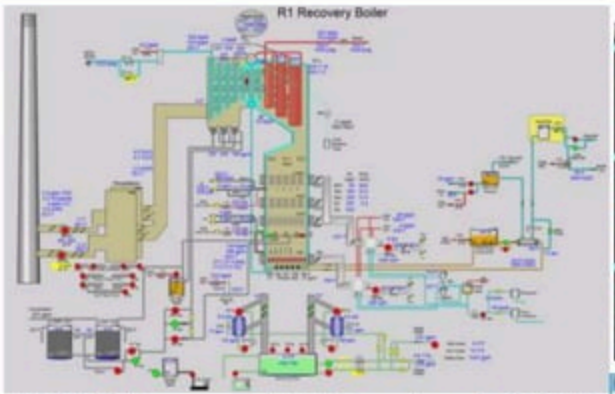
Deliverables, Milestones, and Outcomes

- Periodic monitoring program to ensure the performance and benefits are maintained
- Automated reports to monitor system performance
- Visualization package is often used to calculate, store and display KPIs, some examples:
  - App uptime
  - no. of MVs engaged or wound up
  - Economic benefits
  - Model mismatch size may be treated as SPC variables in visualization package
  - Alarms

VISUALIZATION



VISUALIZATION EXAMPLES



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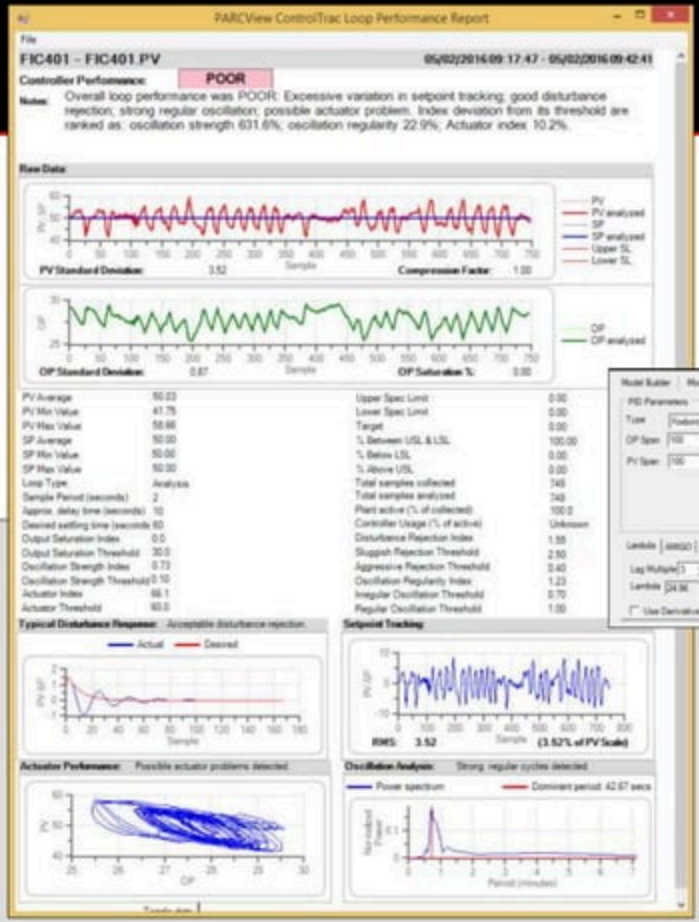
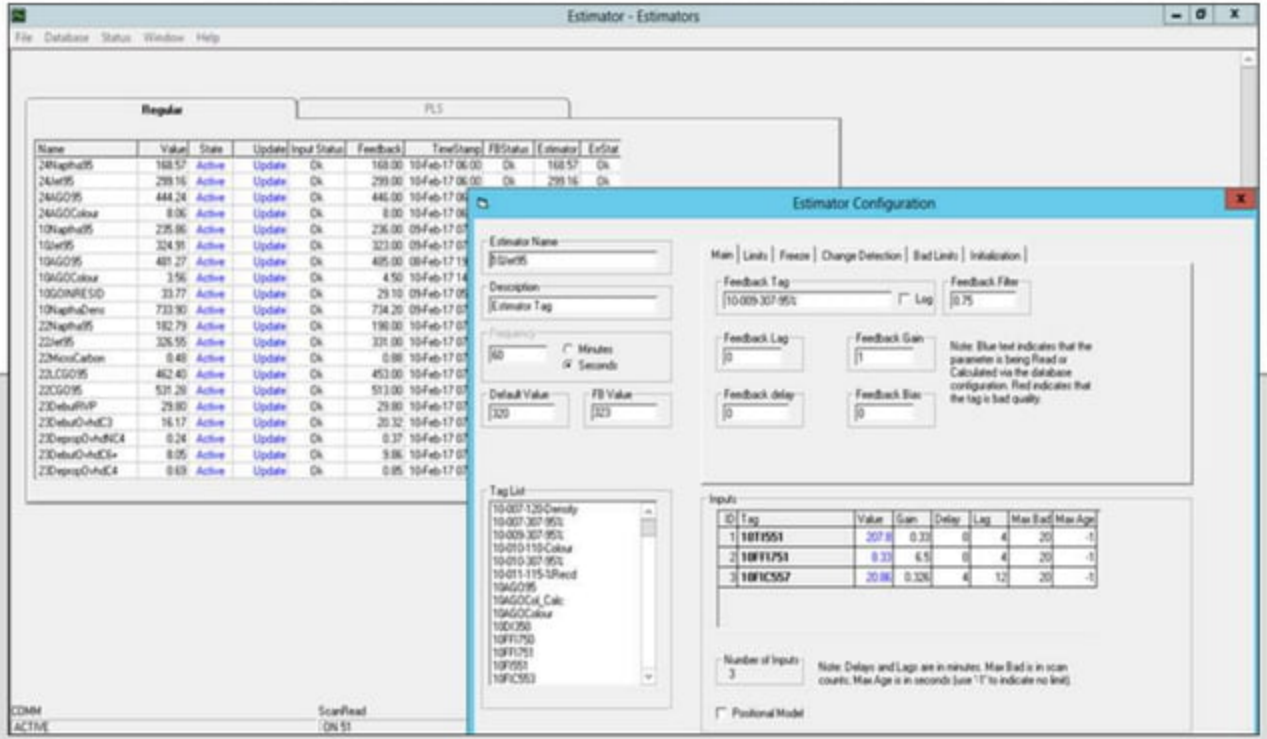
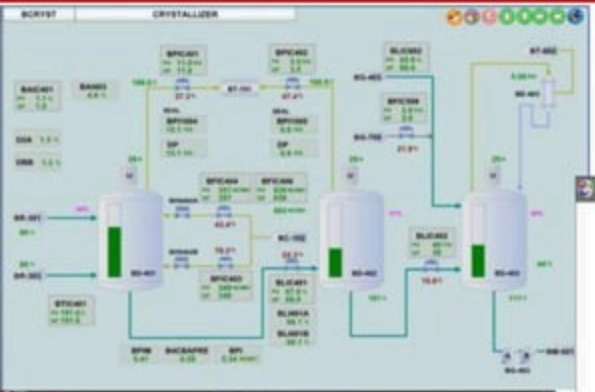
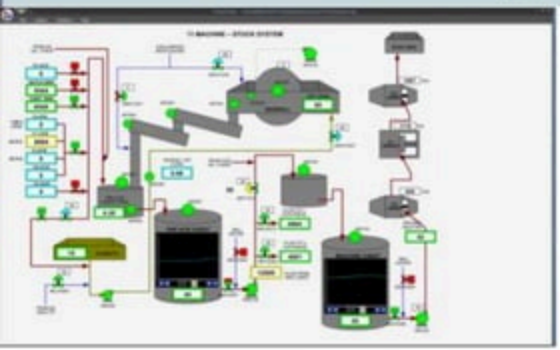
APPENDIX

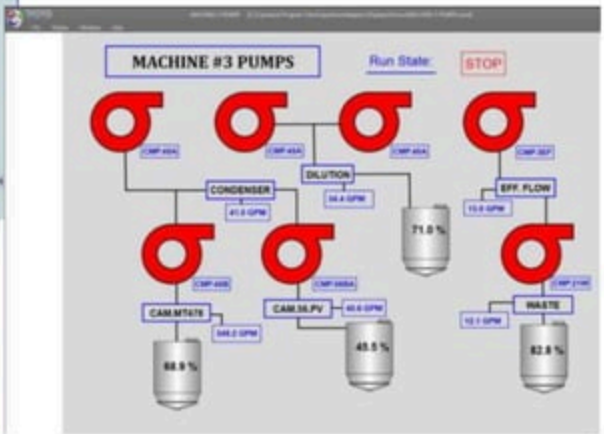

PARCView ControlTrac Loop Performance Report
File
FIC401 - FIC401.PV
05/02/2016 09:17:47 - 05/02/2016 09:42:41
Controller Performance:
POOR
Notes:
Overall loop performance was POOR: Excessive variation in setpoint tracking; good disturbance rejection; strong regular oscillation; possible actuator problem. Index deviation from its threshold are ranked as: oscillation strength 631.6%; oscillation regularity 22.9%; Actuator index 10.2%.
Raw Data:
PV
PV analysed
SP
SP analysed
Upper SL
Lower SL
PV Standard Deviation: 3.52
Compression Factor: 1.00
OP
OP analysed
OP Standard Deviation: 0.87
OP Saturation %: 0.00
PV Average 50.03
PV Min Value 41.75
PV Max Value 58.66
SP Average 50.00
SP Min Value 50.00
SP Max Value 50.00
Loop Type: Analysis
Sample Period (seconds) 2
Approx. delay time (seconds) 10
Desired settling time (seconds) 60
Output Saturation Index 0.0
Output Saturation Threshold 30.0
Oscillation Strength Index 0.73
Oscillation Strength Threshold 0.10
Actuator Index 68.1
Actuator Threshold 60.0
Upper Spec Limit 0.00
Lower Spec Limit 0.00
Target 0.00
% Between USL & LSL 100.00
% Below LSL 0.00
% Above USL 0.00
Total samples collected 749
Total samples analysed 749
Plant active (% of collected) 100.0
Controller Usage (% of active) Unknown
Disturbance Rejection Index 1.55
Sluggish Rejection Threshold 2.50
Aggressive Rejection Threshold 0.40
Oscillation Regularity Index 1.23
Irregular Oscillation Threshold 0.70
Regular Oscillation Threshold 1.00
Typical Disturbance Response: Acceptable disturbance rejection.
Actual
Desired
Setpoint Tracking
RMS: 3.52
(3.52% of PV Scale)
Actuator Performance: Possible actuator problems detected.
Oscillation Analysis: Strong regular cycles detected.
Power spectrum
Dominant period: 42.67 secs
Model Builder
Model Prediction
Loop Tuner
Report
PID Parameters
Type
OP Span
PV Span
Lambda
Use Derivative Tuning
Tune
Tuning Constants
Proportional (PBAND)
prop. band
Integral (INT)
minutes/repeat
Derivative (DERIV)
minutes
Action
DIRECT
Time (seconds)
Closed Loop Response
Open Loop Response
Closed Loop Controller Output

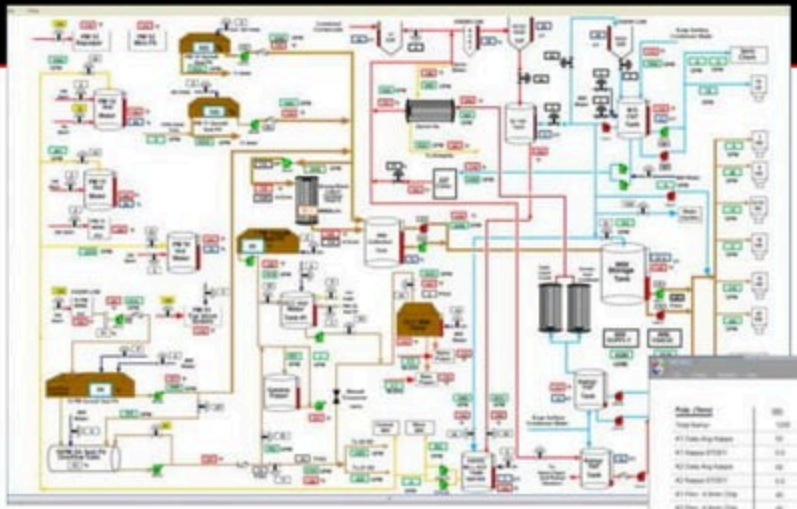
PROPERTY ESTIMATOR DESIGN - CAPSTONE PROPERTY ESTIMATOR FEATURES




CRYSTALLIZER




MACHINE #3 PUMPS
Run State:
STOP
DILUTION
CONDENSER
EFF. FLOW
WASTE
71.8 %
88.9 %
45.5 %
82.8 %



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