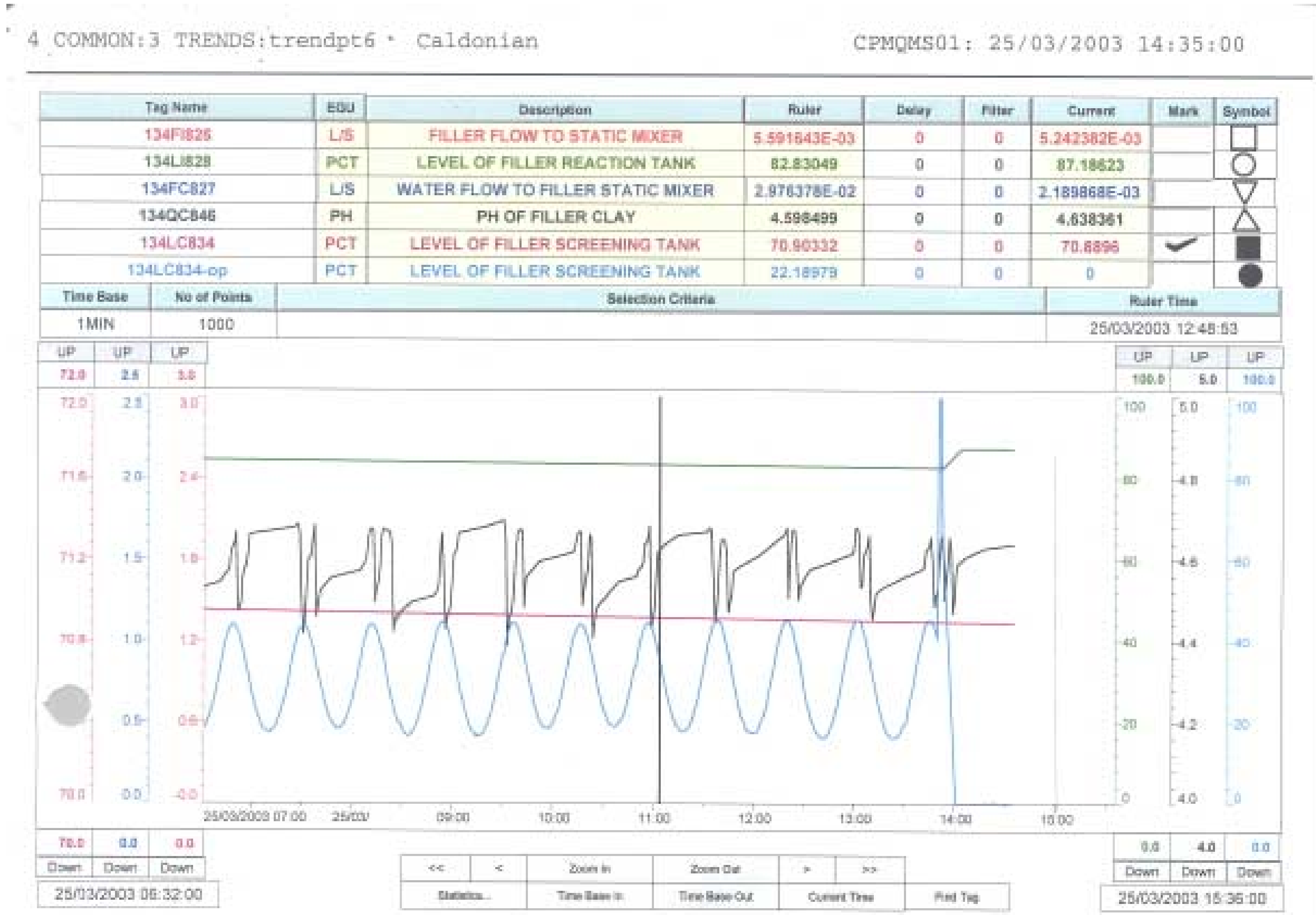
Consultancy – Paper Industry

Stability Improvements

In

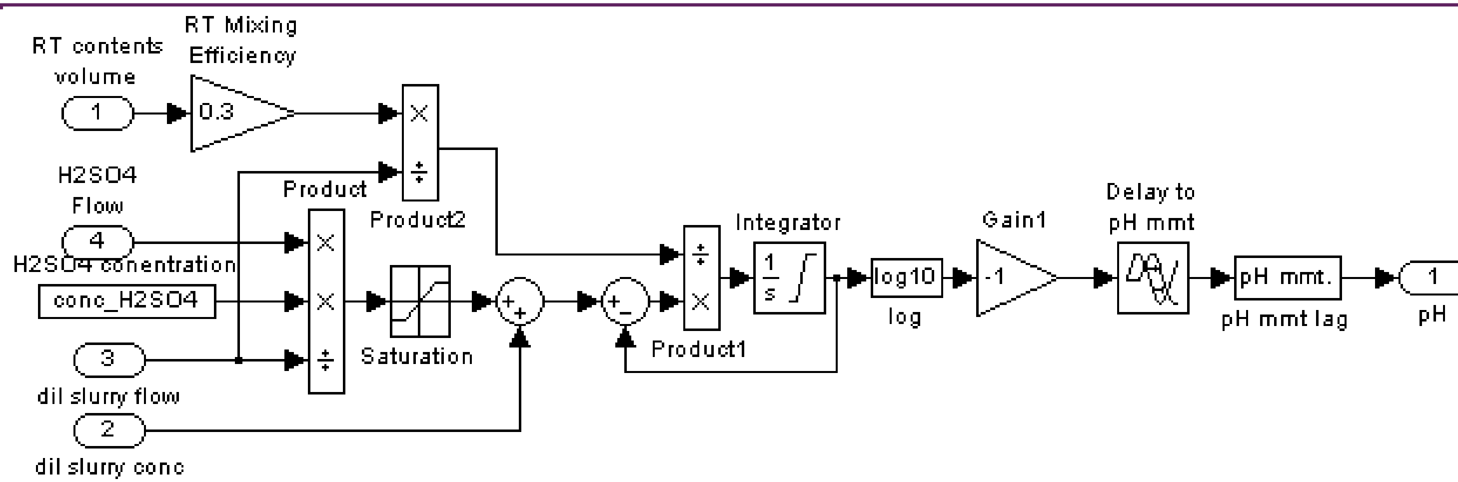
Clay Slurry Prep^{n} Process

Clay Slurry Prep^{n} – pH control



Tag Name	EGU	Description	Ruler	Delay	Filter	Current	Mark	Symbol
134FI826	L/S	FILLER FLOW TO STATIC MIXER	5.591643E-03	0	0	5.242382E-03		
134LI828	PCT	LEVEL OF FILLER REACTION TANK	82.83049	0	0	87.18623		
134FC827	L/S	WATER FLOW TO FILLER STATIC MIXER	2.976378E-02	0	0	2.189868E-03		
134QC846	PH	PH OF FILLER CLAY	4.598499	0	0	4.638361		
134LC834	PCT	LEVEL OF FILLER SCREENING TANK	70.90332	0	0	70.8896	✓	
134LC834-op	PCT	LEVEL OF FILLER SCREENING TANK	22.18979	0	0	0		

Titration Model (pH calculation)



$$Q_{RT} * C_{RT} = Q_{H_2SO_4} * C_{H_2SO_4} + Q_{DS} * C_{DS} \quad \textit{(neglecting RT mixing lag effect)}$$

$$C_{RT} = \frac{Q_{H_2SO_4} * C_{H_2SO_4} + Q_{DS} * C_{DS}}{Q_{RT}}$$

but $\quad Q_{RT} \approx Q_{DS}$

$$\therefore \quad C_{RT} = \frac{Q_{H_2SO_4} * C_{H_2SO_4}}{Q_{DS}} + C_{DS}$$

$$\text{or} \quad C_{RT} = \frac{1}{(1+\tau S)} * \left(\frac{Q_{H_2SO_4} * C_{H_2SO_4}}{Q_{DS}} + C_{DS} \right) \textit{(with RT mixing lag effect)}$$

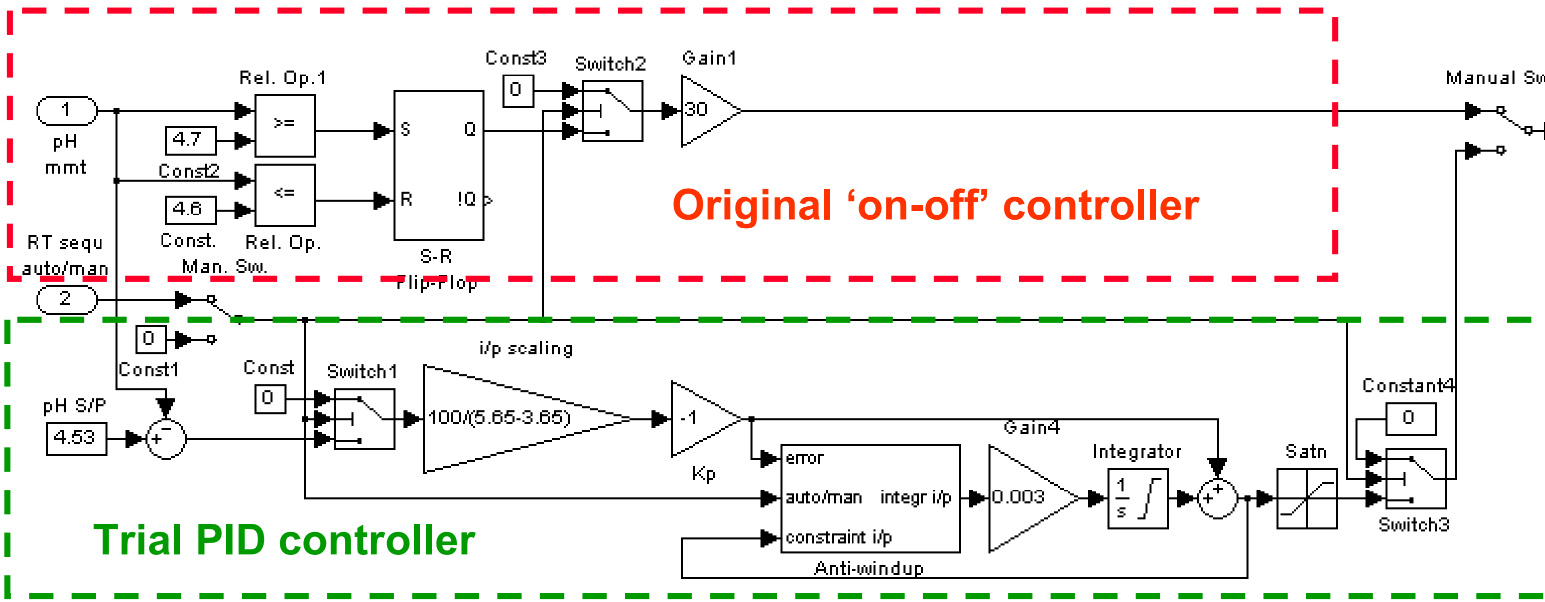
$$\text{where} \quad \tau = \frac{\textit{Volume of RT contents } (t) * \textit{RT Mixing Efficiency}}{Q_{DS}(t)}$$

$$pH = -\log_{10}\left[\frac{1}{(1+\tau S)} * \left(\frac{Q_{H_2SO_4} * C_{H_2SO_4}}{Q_{DS}} + C_{DS} \right) \right]$$

Where:

- RT = *Reaction Tank*
- Q_{RT} = *RT Effluent Volumetric Flow* (m^3/s)
- C_{RT} = *Ion Concentration of RT Effluent Flow* ($\#/m^3$)
- $Q_{H_2SO_4}$ = H_2SO_4 *Volumetric Flow* (m^3/s)
- $C_{H_2SO_4}$ = *Ion Concentration of* H_2SO_4 ($\#/m^3$)
- Q_{DS} = *Dilute Slurry Volumetric Flow* (m^3/s)
- C_{DS} = *Ion Concentration of Dilute Slurry* ($\#/m^3$)
- τ = *First Order RT Mixing Lag*
- pH = *RT Effluent pH*

pH Control Evaluation

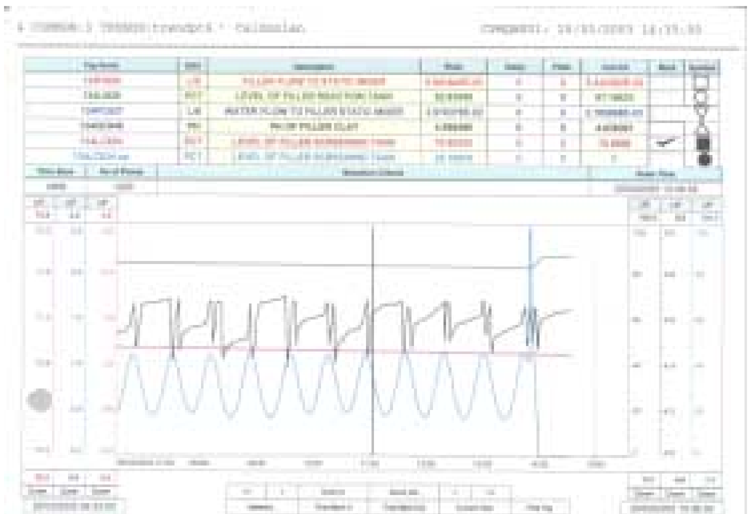


Modelled Controller Features

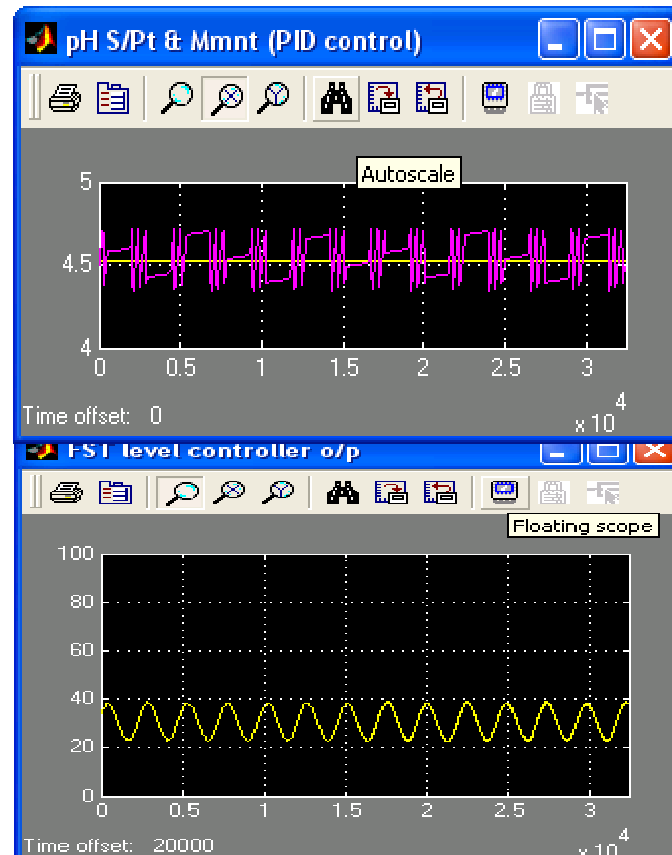
- Ideal PID Controller Structure
- Logic to inhibit controller during RT empty cycle
- Logic to switch between PID & 'bang-bang' controllers
- Current (dilution water) valve requires ~2% open operating point! (for PID controller)

Validation of Model pH Dynamic Data

Plant data over a 9 hour period



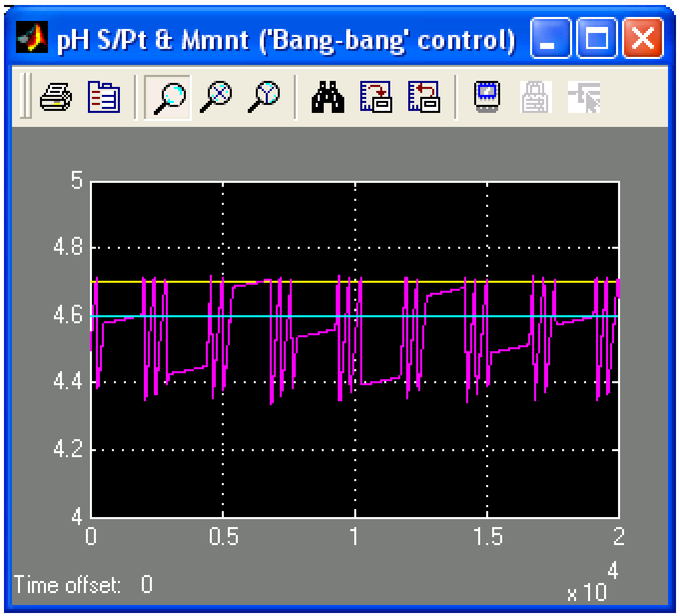
Model data over a 9 hour period

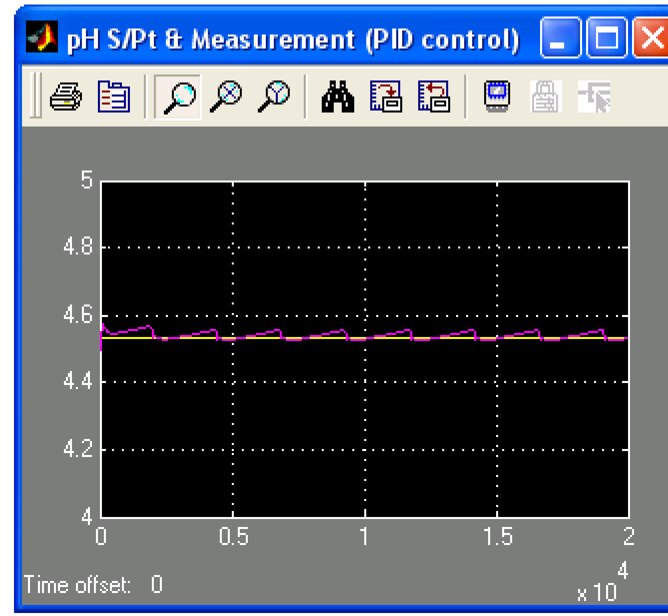


Imperatives for PID pH Control

- Key Issues:
  - H_2SO_4 flow ***must be stopped*** during RT empty cycle
    - logic from RT level limit switches to close/open valve
  - pH control ***must be suspended*** during RT empty cycle
    - the integral action must be suspended (for empty cycle)
  - (Current) oversized H_2SO_4 valve ***must be changed***
    - select valve in (max. C_v) range of 3 to 6
  - Start-up PID parameters (from model) must be used

pH Control Comparison





<u>Current 'On-Off' Control</u>

pH 'Trigger' points at

- 4.7 (H_2SO_4 on)
- 4.6 (H_2SO_4 off)

Peak to peak pH amplitude

0.38 pH units

Reduced by >90%

<u>PID Control Alternative</u>

pH set point at

- 4.53

Peak to peak pH amplitude

0.03 pH units