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Washing Advanced Process Control Solutions

Presented by:
Juri Lahtinen
Product manager WSB APC applications
Andritz
Automation Solutions

Tel.: +358 40 860 5068
E-mail: juri.lahtinen@andritz.com
Home: www.andritzautomation.com

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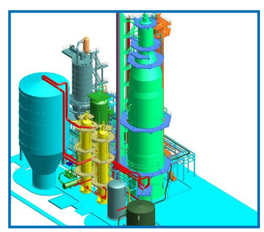
•Engineered Systems

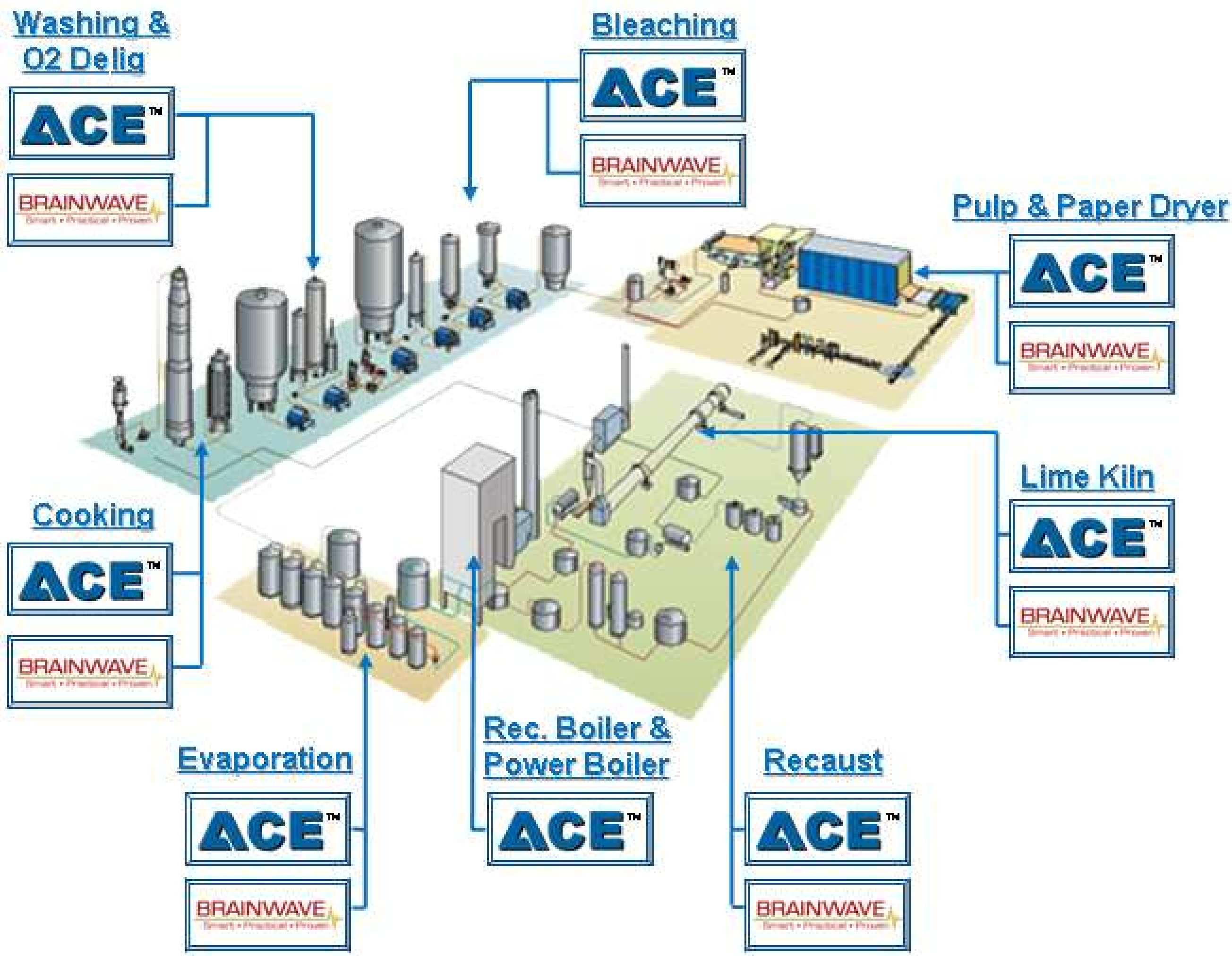
•Advanced Process Control

•Instruments



•Simulation

Andritz APC solutions for the pulp mill



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Advanced Process Control Solutions to Reduce Energy and Chemical Consumption in Brown Stock Washing

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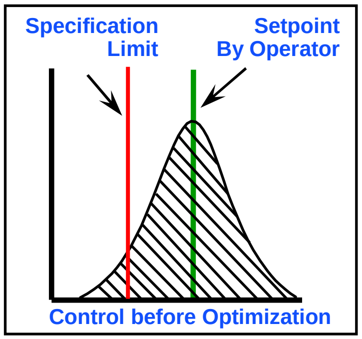
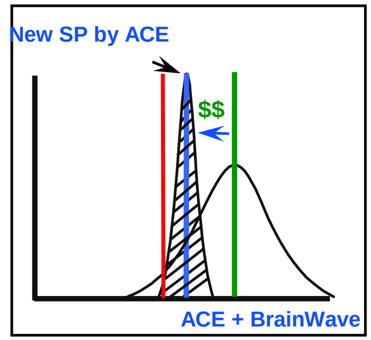
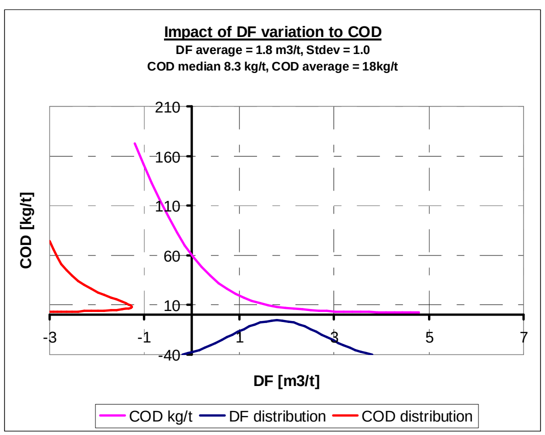
Impact of the process stabilization to decrease costs

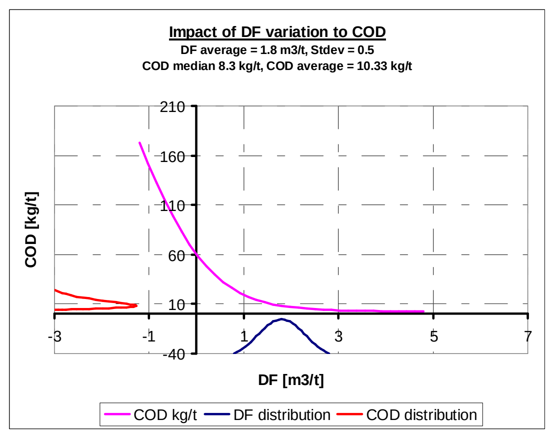
1. With lower standard deviation the setpoint can be moved closer to specification limit (less safety margin).





2. With nonlinear processes controls can reduce costs even without moving setpoint closer to specification limit.





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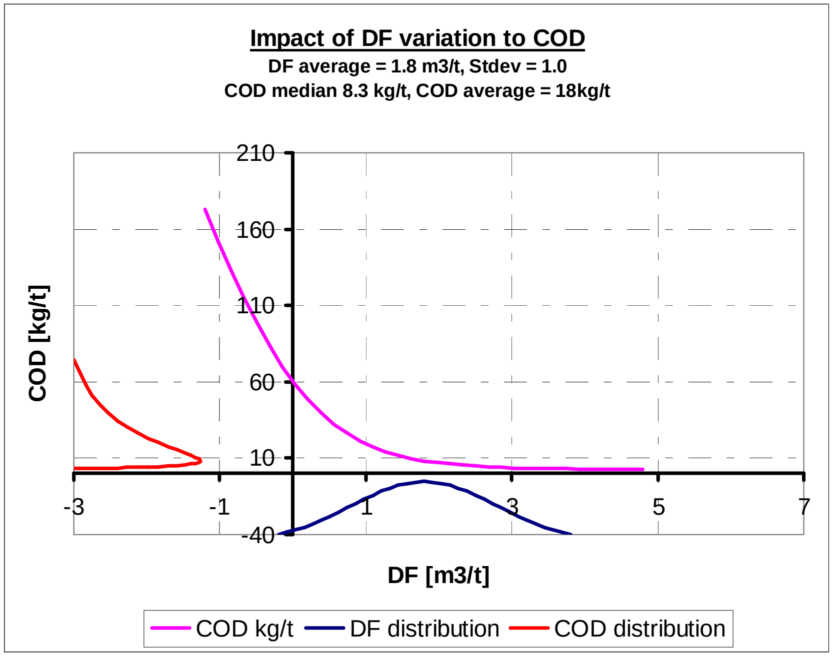
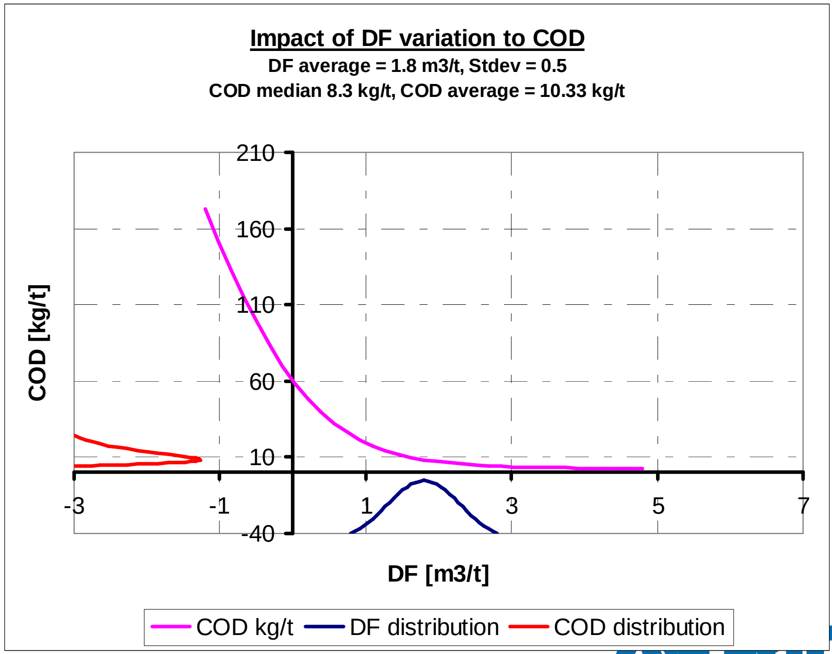
Effect of decreasing variation in nonlinear processes to costs without moving setpoint closer to specification limit

- Balance calculation gives a median value of the controlled variable that is rarely same than average with nonlinear process like washing, bleaching or even consistency control.
- Calculated example from washing where stdev has been decreased to half.
  - Clearly COD average is lower with lower DF variation
  - Savings to customer
- DF distribution has impact on the optimal DF value.
  - Higher variation in DF means higher optimal DF value.





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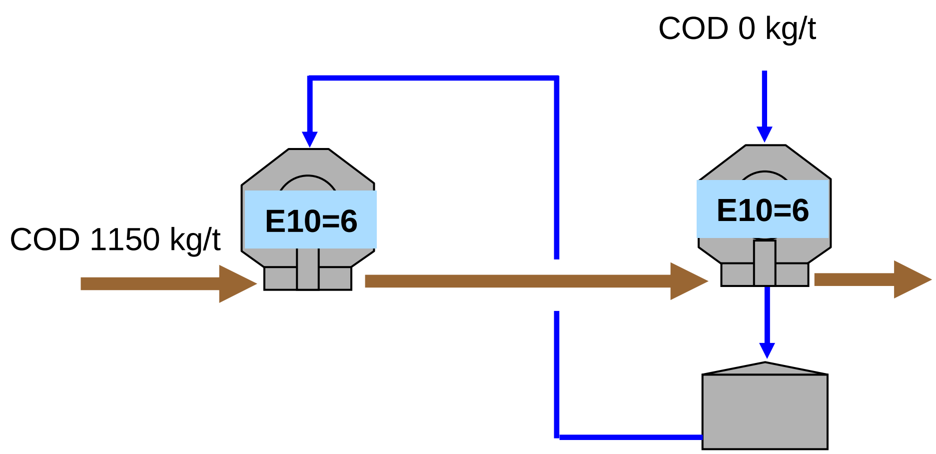
Influence of the DF standard deviation, example

	Case 1	Case 2	Case 3
Dilution factor average	2.5	2.5	2.5
Washer 1 DF standard deviation	1.50	0.75	0.00
Washer 2 DF standard deviation	1.00	0.50	0.00
Washer 1 E10 (Norden efficiency)	6	same	same
Washer 2 E10 (Norden efficiency)	6	same	same
COD to washer 1 [kg/t]	1150	same	same
COD average from washer 1 [kg/t]	256.11	233.81	226.05
COD average from washer 2 [kg/t]	**19.10**	**15.05**	**13.77**
COD std from washer 1	138.7257168	66.92489971	3.01458E-14
COD std from washer 2	15.73849961	6.752955698	3.76822E-15



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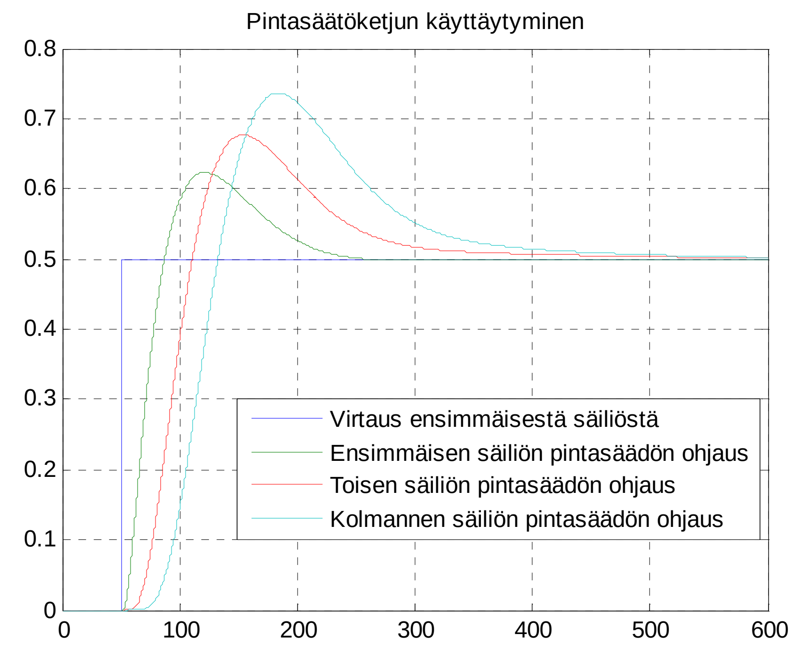
Washing filtrate tank level control strategy

- PI control will always try to reach to it’s setpoint.
- In level control this will mean that if the level decreases the flow controlling the level should go over the equillibrium to drive level back to the setpoint.
- This will mean that in the level control chain the standard deviation always increases going further away from the point that dictates the average flow through put.
- Level control with the integrating term (usually PI control) will increase the standard deviation of the dilution factor in the level control chain.
- Better result can be achieved by using multivariable MPC control with the penalty when moving the flow setpoint.
  - MPC will calculate a control trajectory so that the Flow setpoint changes are minimized.



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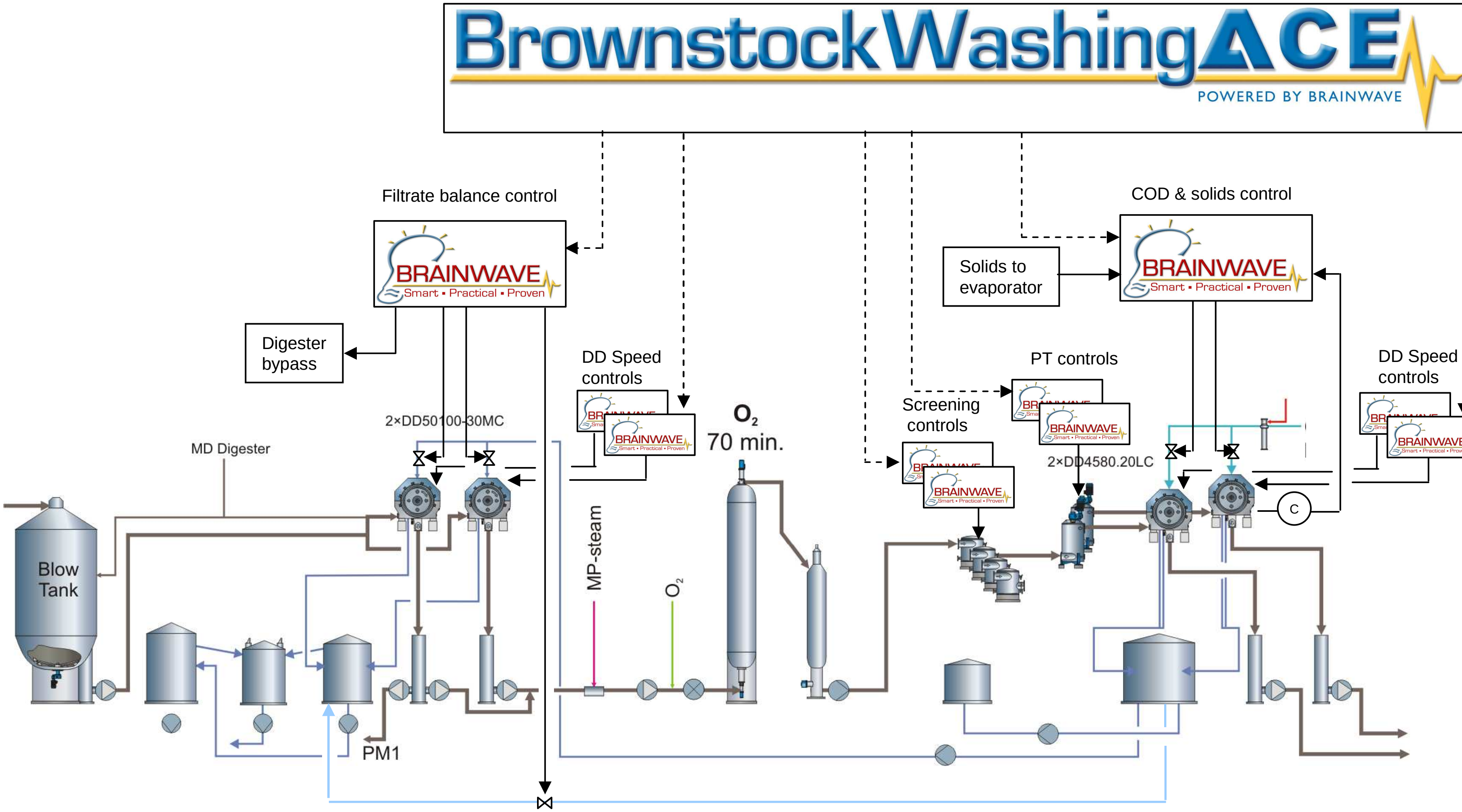
Brownstock Washing Advanced Process Controls

- Brownstock ACE & Brainwave controls can be divided to single equipment advanced controls and washline advanced controls.
- Examples of equipment advanced controls:
  - Diffuser washer load controls
  - DD washer rotational speed controls
  - Wash press torque controls
  - Screening consistency optimization
  - Pressure thickener controls
  - Intermediate tank level controls
  - Consistency controls
  - ...
- Wash line advanced control:
  - Filtrate balance controls
  - COD and dry solids to evaporator controls.
  - Wash line DF optimization.
- Both of these utilizes Brainwave and ACE functionality.

BrainWave & ACE for Brown Stock Washing

BrainWave & ACE Controls



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Single equipment Advanced controls

- Often Advanced control is considered only as higher level controls and operation of equipments are not optimized.
  - With complicated brownstock line some disturbances can have so big impact that even good higher level control can be in troubles if equipments in disturbances are not operated well.

- Example from screening could be that knotter motor load goes high and operator decreases the inlet consistency setpoint.
  - Consistency setpoint will stay low usually much longer time than it is needed. This might lead to poor washing and unusually high carry over to bleaching.
  - This can be improved by first improving consistency control then changing setpoint so that the disturbances are taken account

- Common to all single equipment ACE controls are that they are designed to
  - stabilize the process → get rid of the variation.
  - Try to run close as possible to constraint by taking account the performance of process (or control).
  - Manage disturbances → during disturbance give extra safety margin and when disturbance is gone reduce safety margin. Operators tends to leave big safety margin for a long time.

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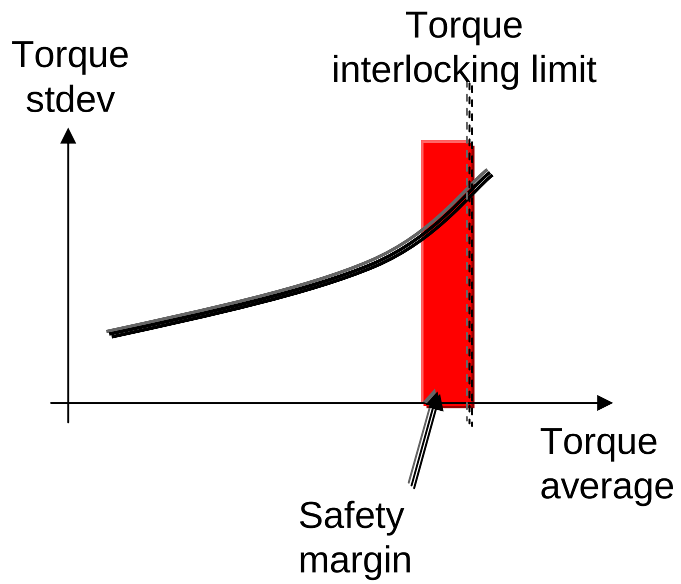
Single equipment advanced controls, Wash press example

- Wash Press (and DD) has usually goal that
  - Outlet consistency are maximized so that the torque and feed pressure will stay under some limit.
- If torque or feed pressure increases usually variation of that variable increases.
- Also some disturbance (feed consistency) can increase variation of torque or feed pressure.

- In Wash press ACE solution
  - There is a model between Torque stdev and average (setpoint) that is updated online.
  - Based on the Standard deviation model the needed safety margin is calculated so that there is very small change for torque to go to the interlocking limit.
  - This way safety magin will be minimized and and it will be changed according the current performance of process (controls).
  - This will maximize the outlet consistency as well.
- Same principle is applied to many control strategy throughout the washing line.



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Examples of the benefits got from single equipment advanced controls

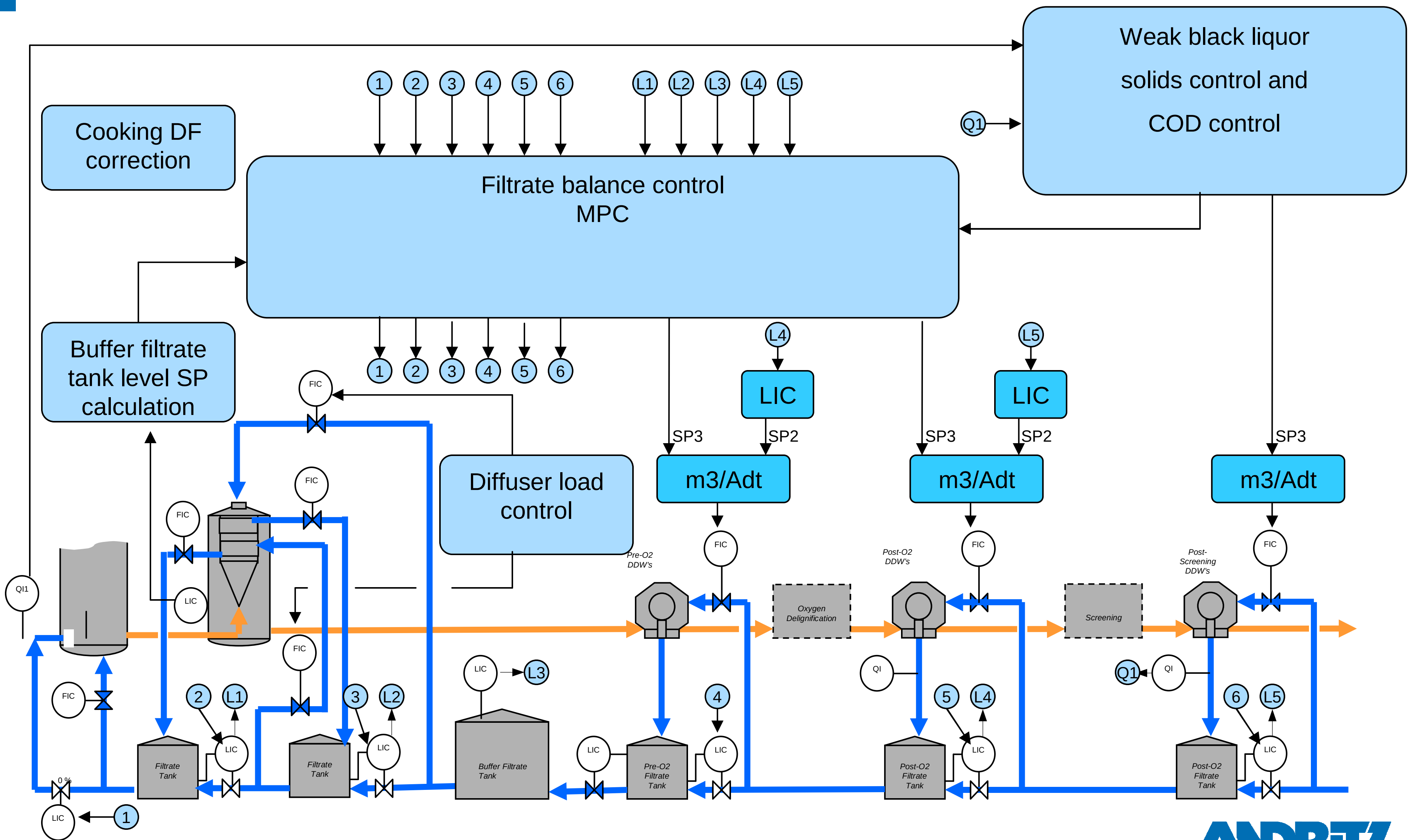
- Diffuser load control
  - Average Consistency +1%
- DD Washer rotational speed control
  - Average Consistency +1% - +3%
- Washpress torque control
  - Average Consistency +3%
- Screening consistency optimization
  - Knotter interlocking frequency -80%
  - Screening feed consistency +0.5%
- Pressure thickener controls
  - Average outlet consistency 6.5% -> 8.2%
  - Average outlet consistency 4.5% -> 5.7%

Wash line controls

Filtrate balance controls and COD / solids controls

- Main targets
  - Stabilize filtrate balance
  - Stabilize the Carry over (COD, sodium) from washing to the following O2-stage or bleaching stage
  - Stabilize Weak Black Liquor Solids
  - Help minimizing the use of wash water
- Measurements
  - Normal wash liquid flow measurements,
  - Buffer and filtrate tank level measurements, and
  - Refractometers (COD) or Conductivity measurements
- Controlled variables
  - Wash water amount in all washers
  - Washer bypass amounts

Washing ACE, example of wash water controls



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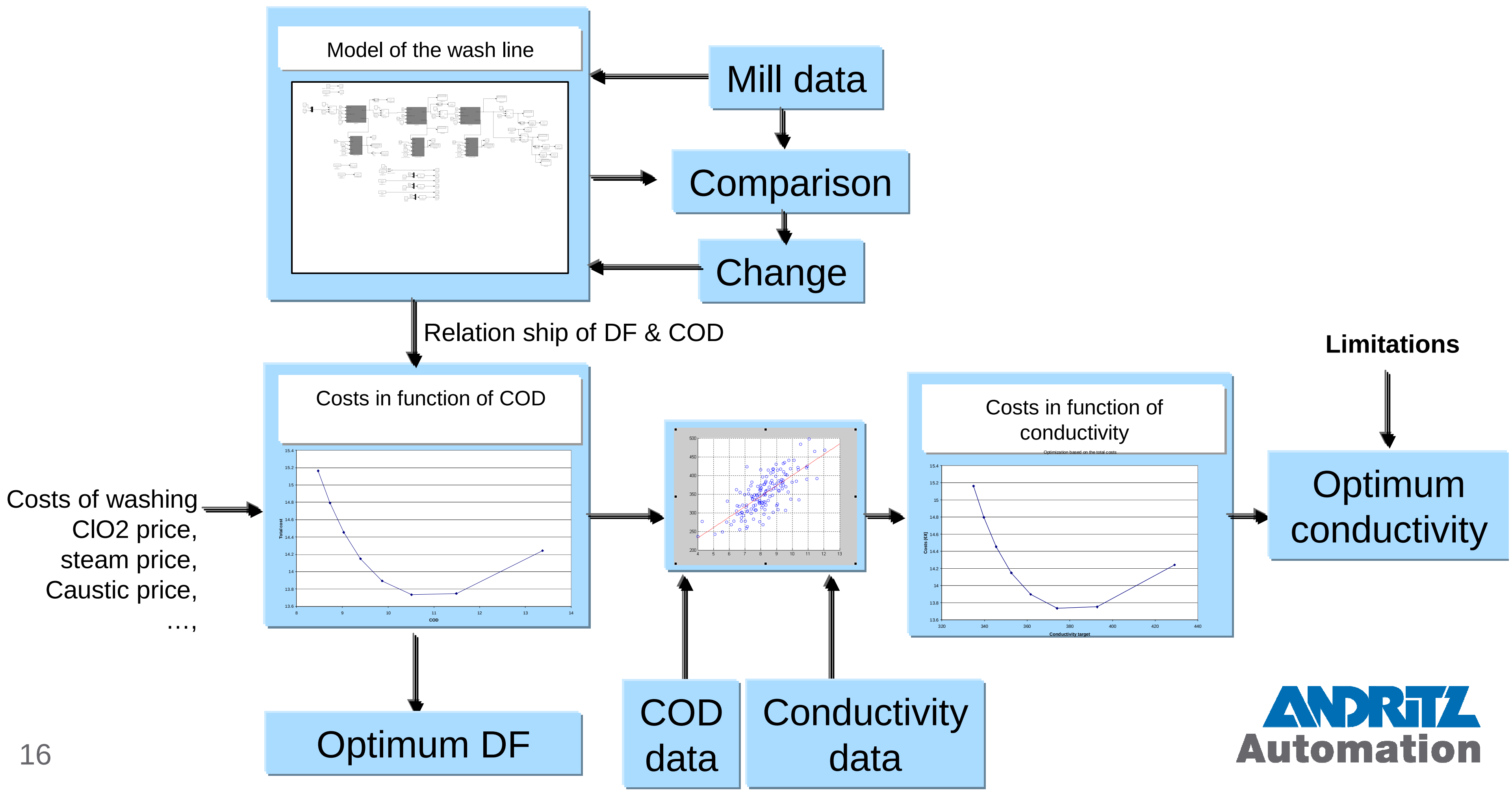
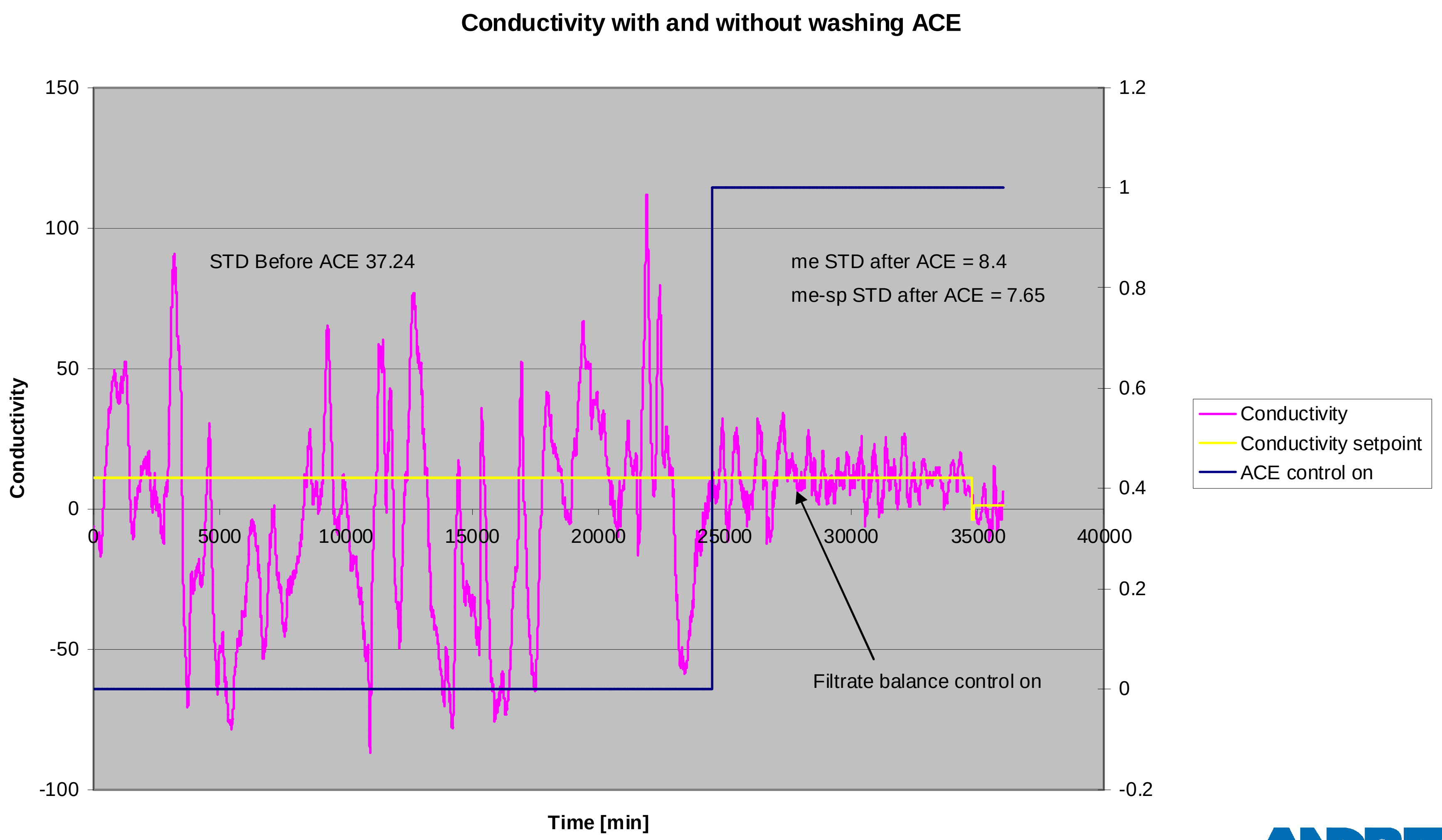
Washing COD / conductivity target optimization

COD kustannus optimointi

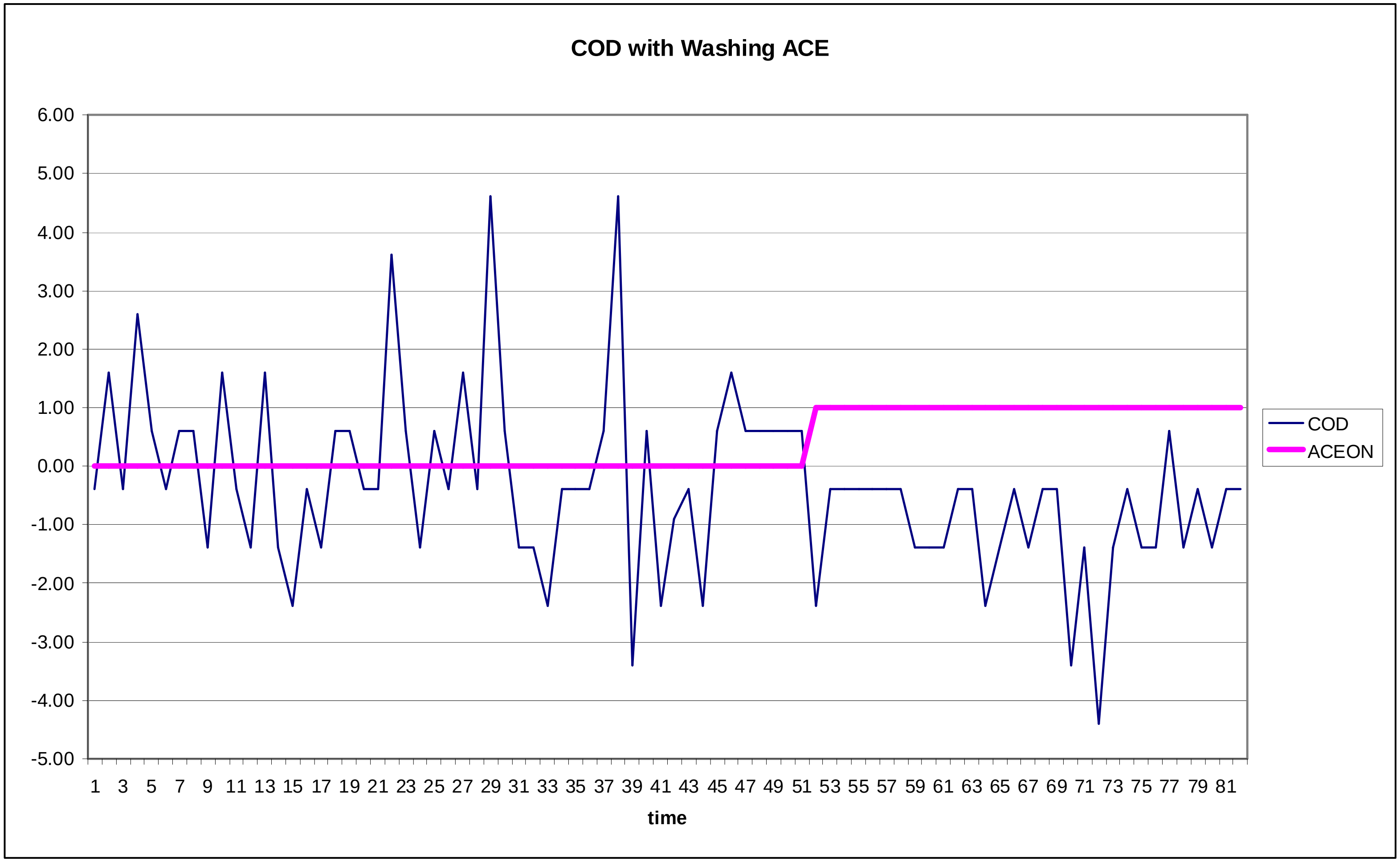
- COD Target optimization is used to drive process to lowest costs



Conductivity with ACE controls



Washing ACE, impact to COD values



ACE and Brainwave Conductivity control

- Conductivity control is the last control that can be turned ON after line start up
- Example here shows that Conductivity control have been turned ON only 13 minutes after start up.
- Control has also stabilized the conductivity very fast.

Washing ACE results in mill X

- 600 000 t/a mill
- Solids to evaporator increased 0.6% in solids%
- Fresh water usage reduced 10%.
- Evaporator steam yearly savings 270k€

- COD std decrease 79%
- COD average decrease 20%
- Savings from the bleaching chemicals 169k€
- Savings from the sodium losts 47k€
- Savings from lost of organic fuel 70k€
- Savings from lost of urea savings in waste water treatment 10k€

- Total yearly savings = 567k€

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We accept the challenge!

Thank you for your attention!

Contact:
Juri Lahtinen
Product manager WSB APC applications
Andritz
Automation Solutions

Tel.: +358 40 860 5068
E-mail: juri.lahtinen@andritz.com
Home: www.andritzautomation.com

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