Retention control system for the wet-end section in a paper machine.

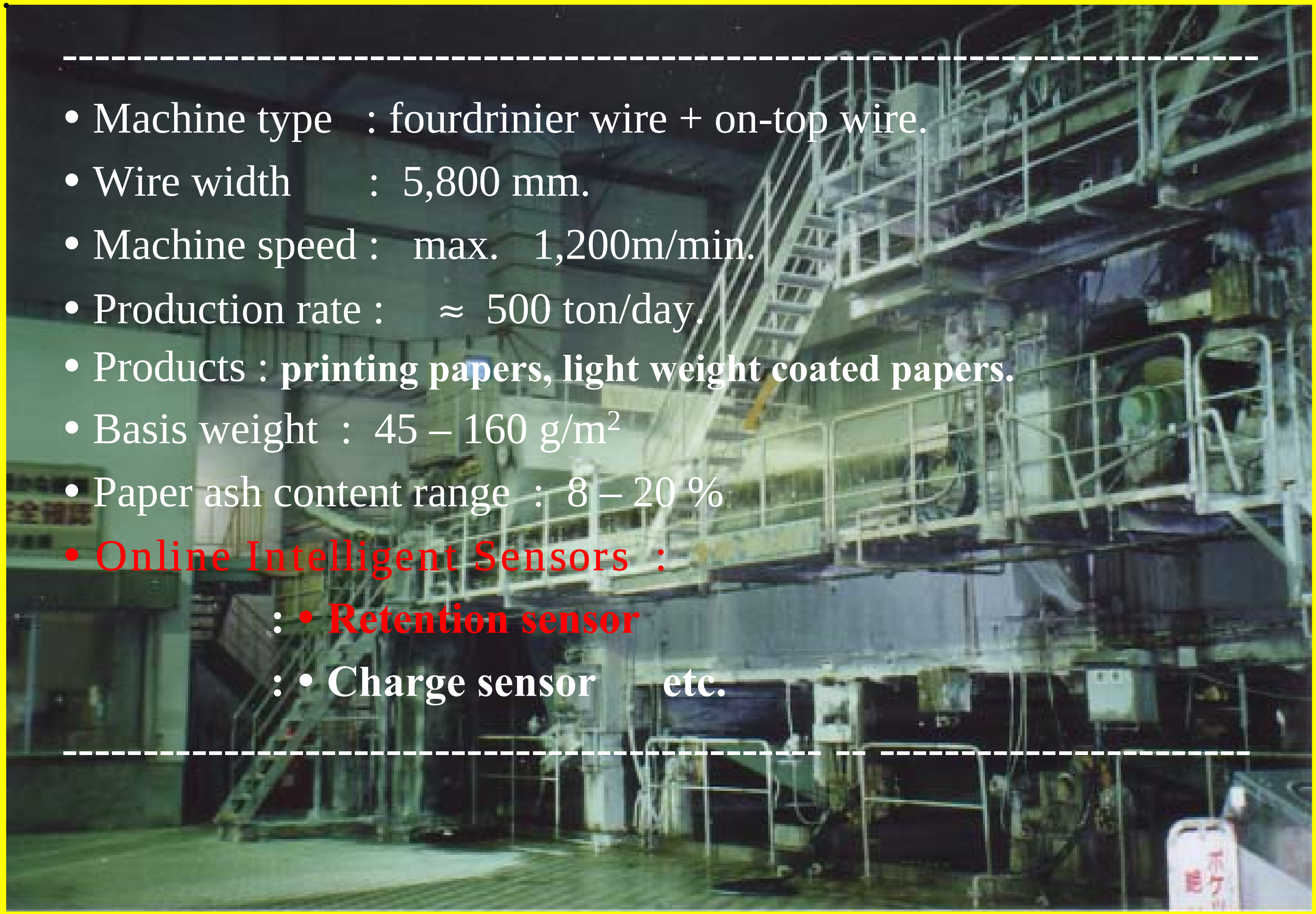
Yoshitatsu Mori, **Pulp and Paper Research Laboratory. Oji Paper Co., Ltd.**

Naoki Imai, **Technology Div. Oji Paper Co., Ltd.**

Yoshinobu Hara, Michiaki Nishimura, Shirou Hirano,
Kure Mill. Oji Paper Co., Ltd.

(E-mail : yoshitatsu-mori@ojipaper.co.jp)

Kure Mill : No.5 paper machine. (wire part)



- Machine type : fourdrinier wire + on-top wire.
- Wire width : 5,800 mm.
- Machine speed : max. 1,200m/min.
- Production rate : ≈ 500 ton/day.
- Products : **printing papers, light weight coated papers.**
- Basis weight : 45 – 160 g/m^2
- Paper ash content range : 8 – 20 %
- Online Intelligent Sensors :
  - : **• Retention sensor**
  - : **• Charge sensor etc.**

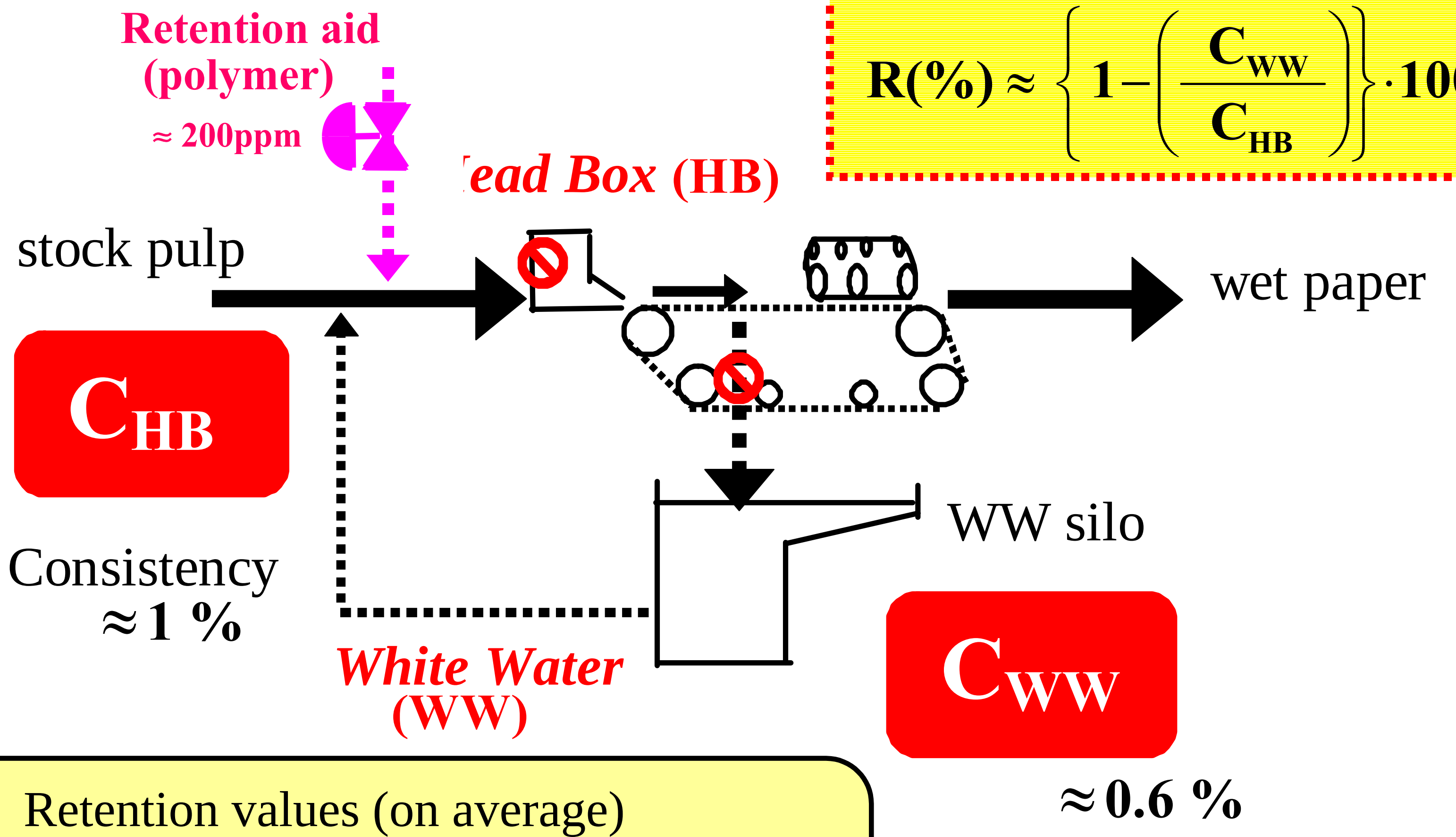
The purpose of the "Retention Control".

- Stabilize the filtration conditions
  of a paper machine.
  - filtrated white water consistency
  - total retention of the wire-part

- Stabilize the operation
  and
  the quality of
  the paper products.

Paper Machine : Retention control

$$R(\%) \approx \left\{1-\left(\frac{C_{WW}}{C_{HB}}\right)\right\}\cdot 100$$

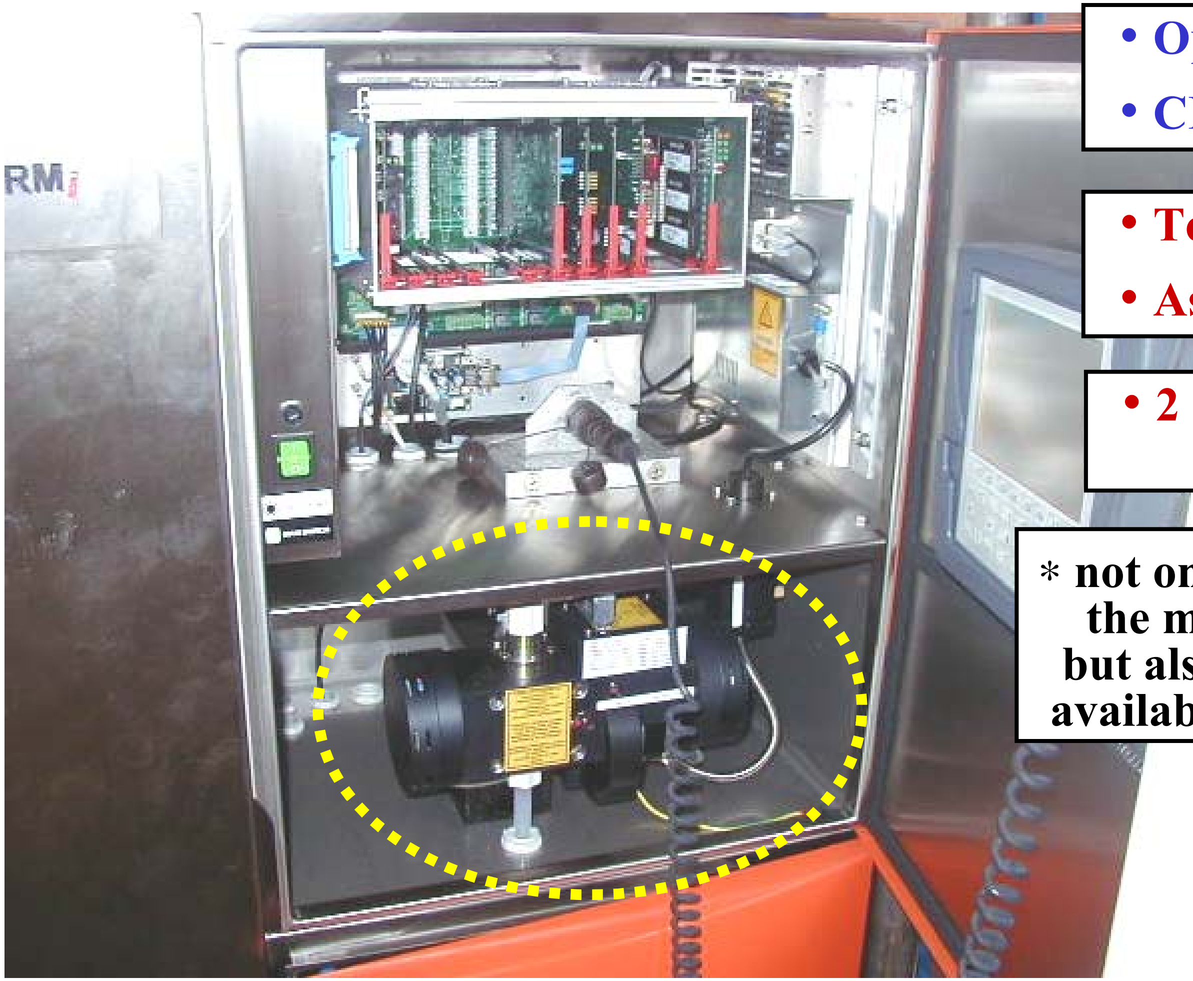


* Retention values (on average)

$R_{pulp} \approx 70\ \%$ $R_{ash} \approx 40\ \%$

$R_{total} \approx 60\ \%$

wire part



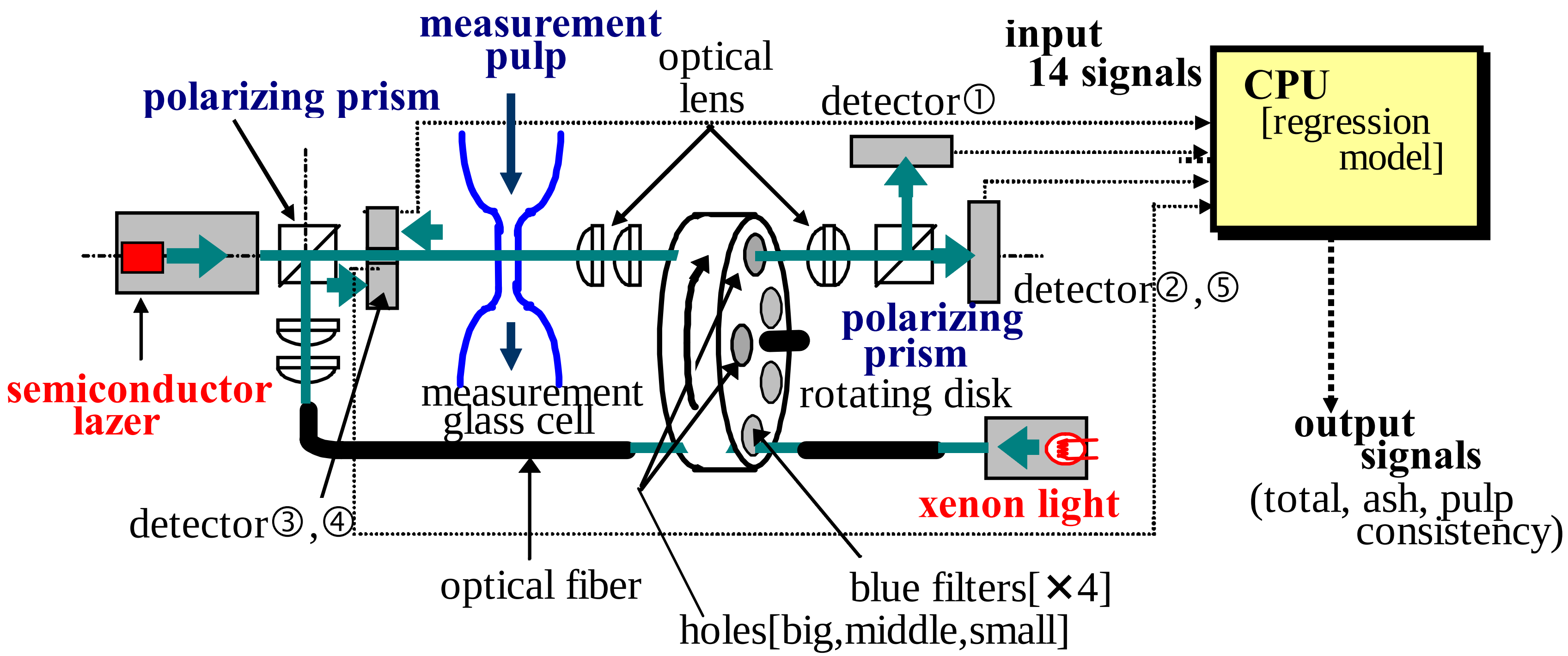
- Optical sensor.
- CPU unit.

- Total conc. 1.5% ↓
- Ash conc. 0.8% ↓

- 2 systems.
  (HB & WW)

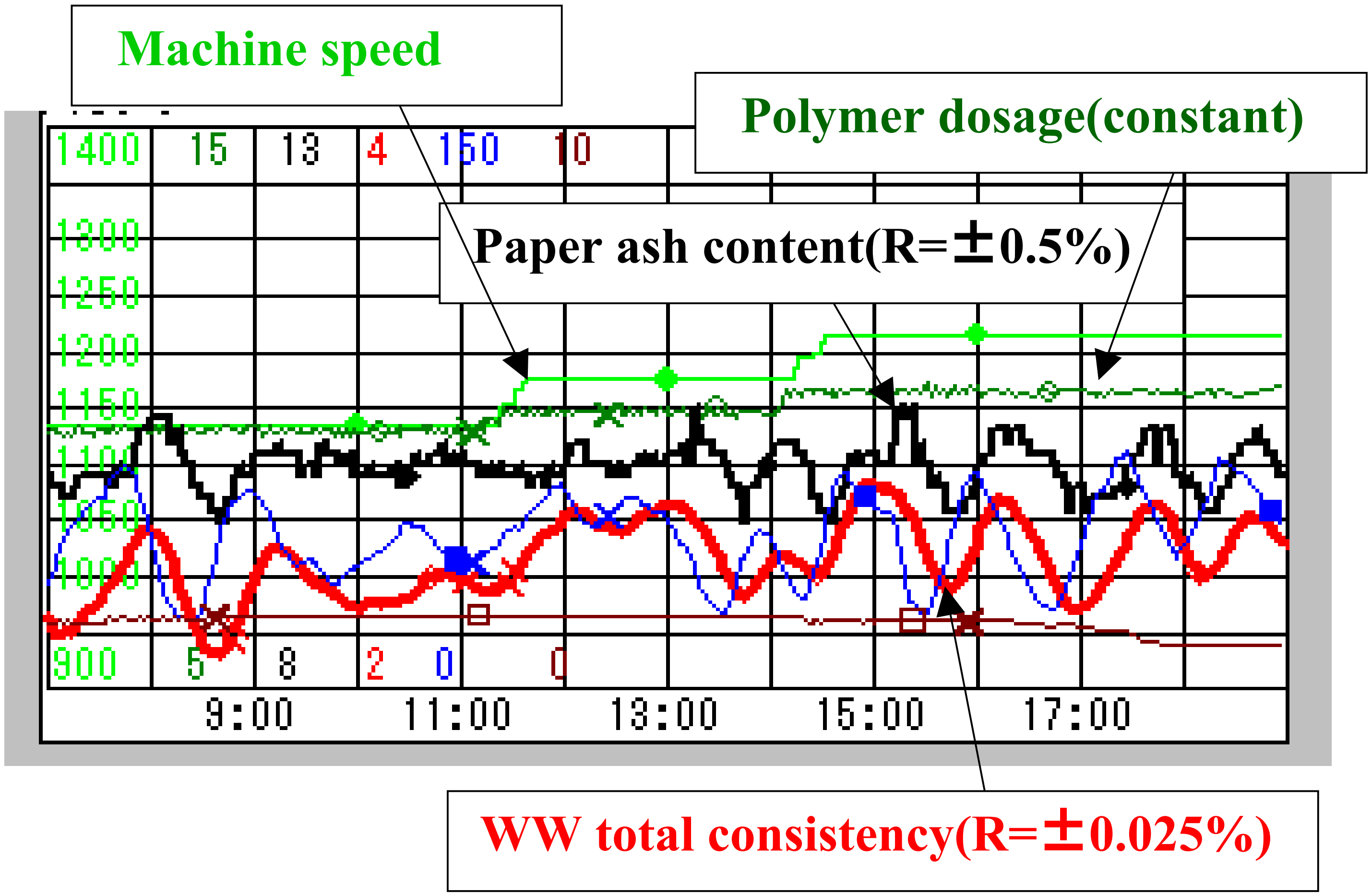
* not only to use for only the monitoring sensor but also use for available control system.

Low consistency pulp and ash sensor
(*Metso Automation/*Finland : *RMi*)



Low consistency pulp and ash sensor
(*Metso Automation/*Finland : *RMi*)

DCS Operation Room (*Kure* Mill : No.5 paper machine)

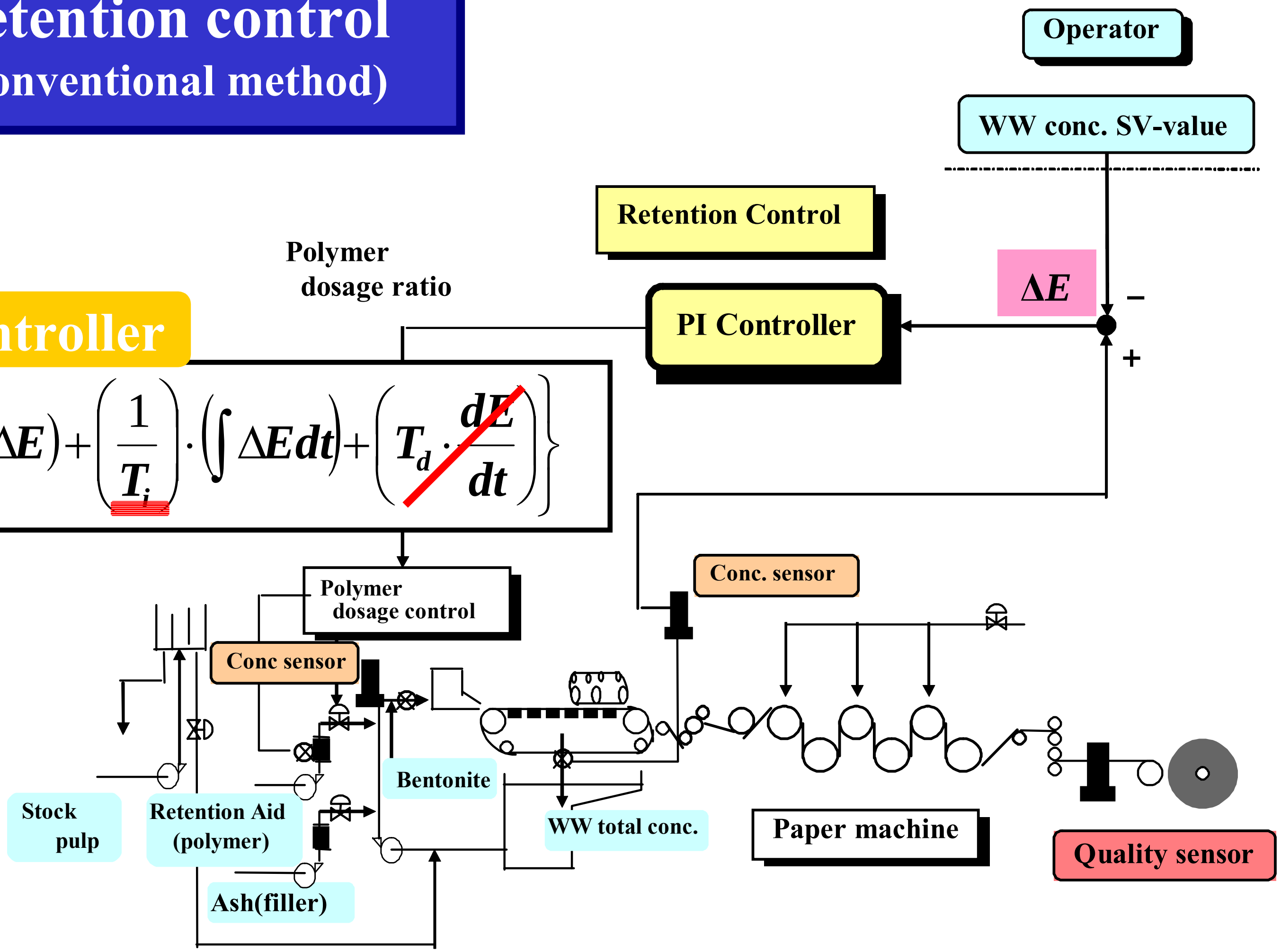


No **retention control**

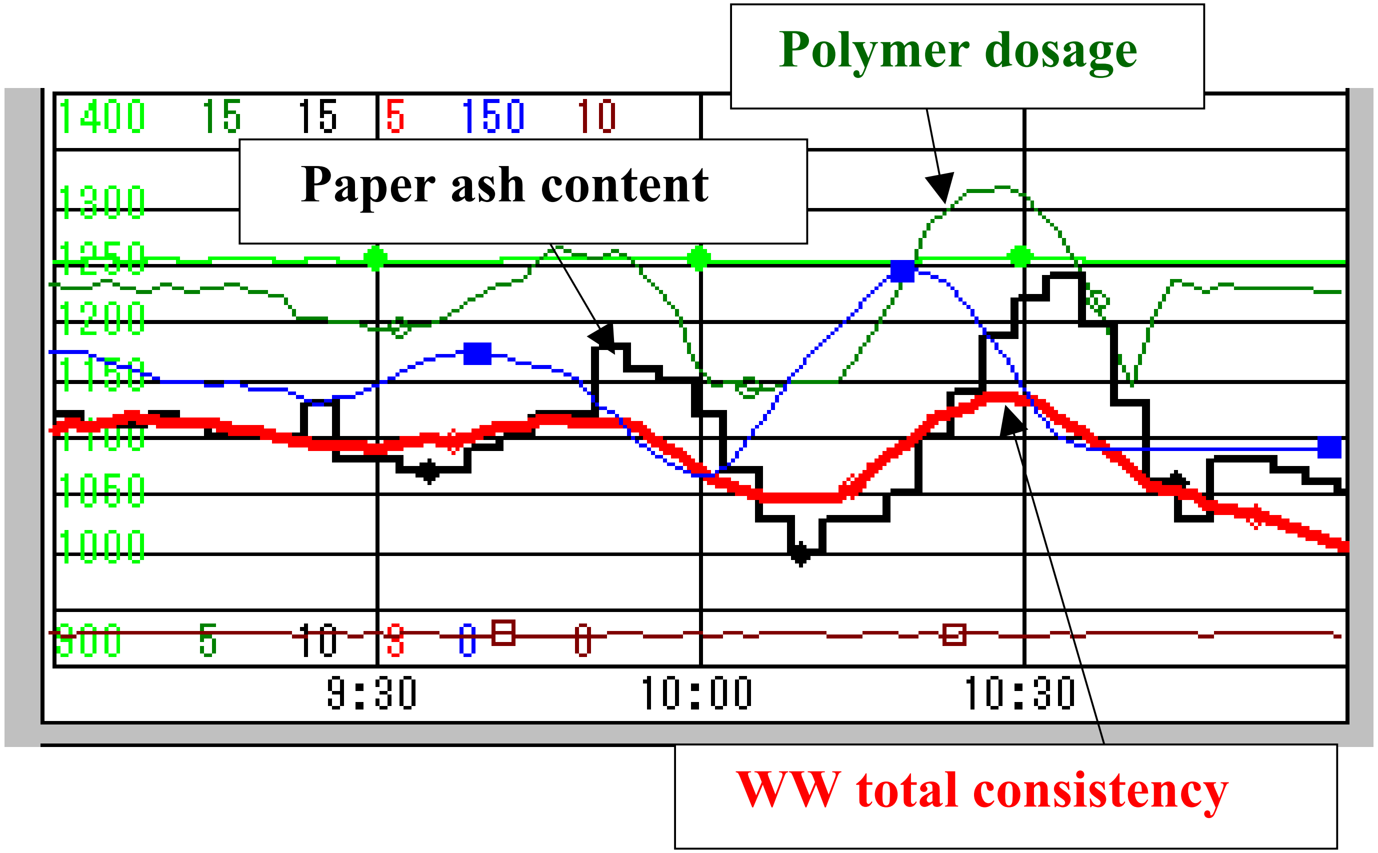
Retention control
(conventional method)

PI(D) controller

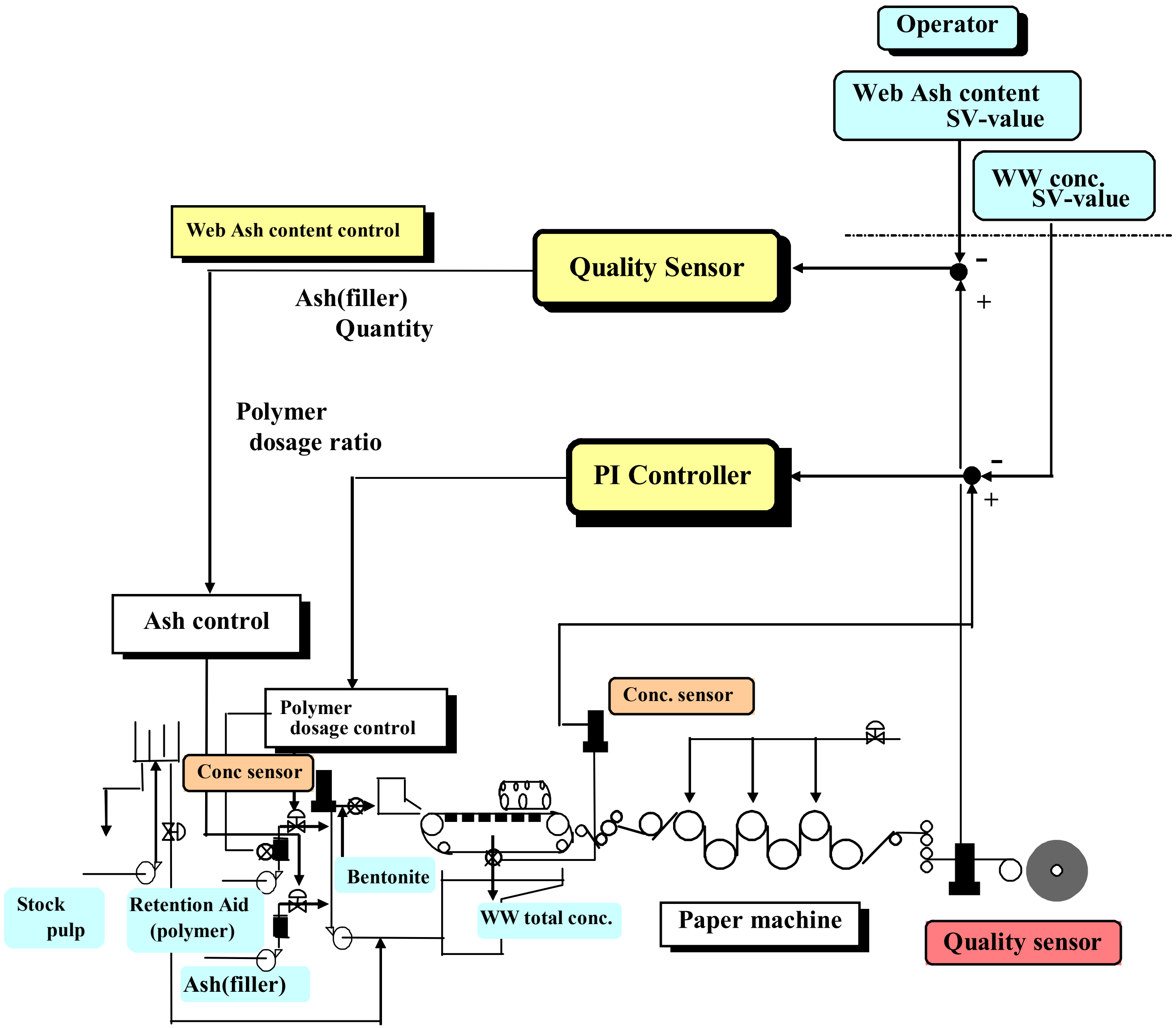
$$M = K_p \cdot \left\{ (\Delta E) + \left(\frac{1}{T_i}\right) \cdot \left(\int \Delta E dt\right) + \left(T_d \cdot \frac{dE}{dt}\right) \right\}$$



PI-feedback control by retention aid

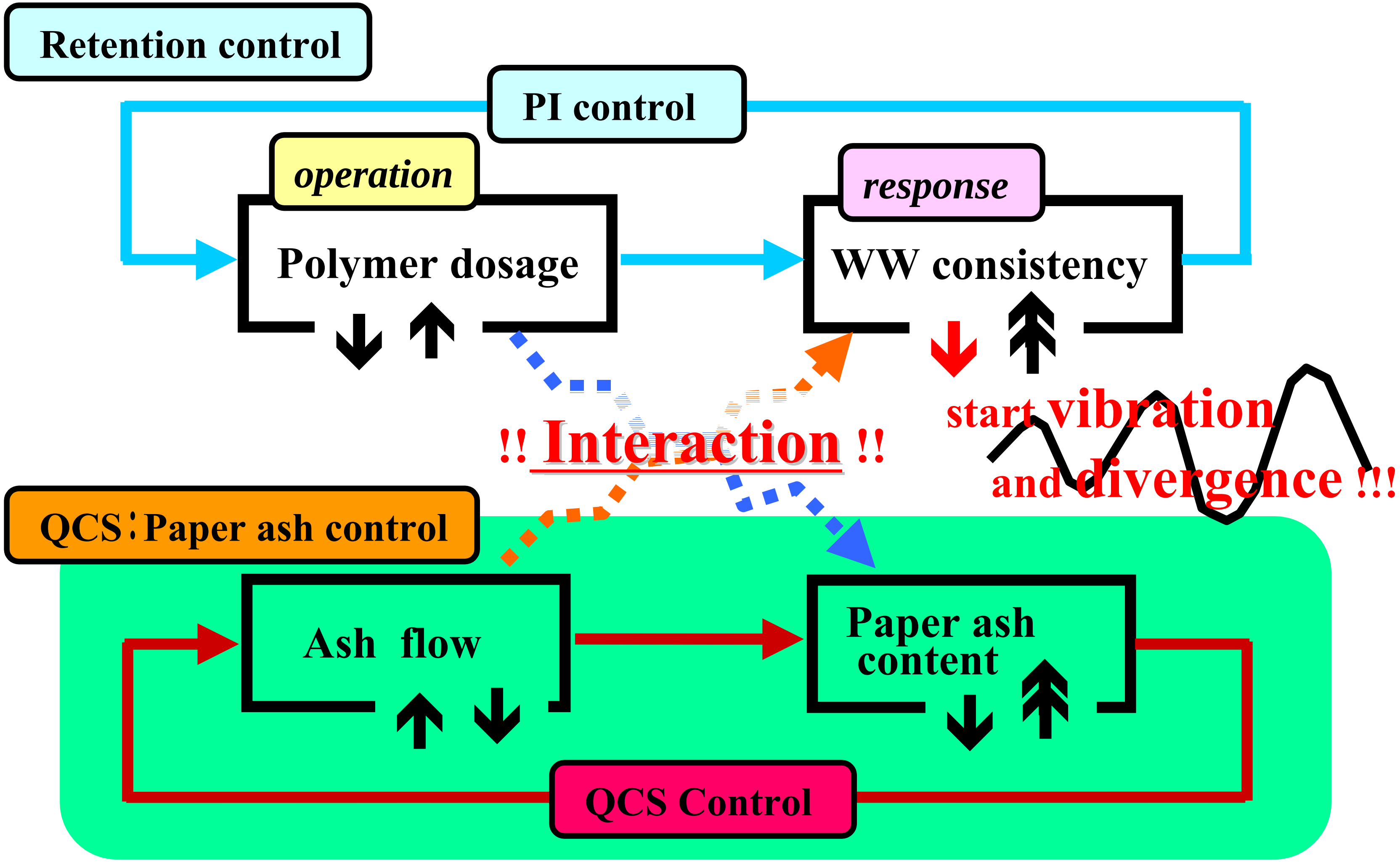


Control result ： PI-feedback control



Interaction with PI-feedback control

ex. Cause of the vibration by mutual interaction.



-- Problems --

- *strong **Interaction***

  "Retention PI-control" *(WW consistency) of* ***DCS***

  and

  "Paper Ash content control"

  of ***QCS*** *(Quality Control System)*

-- Method of approach --

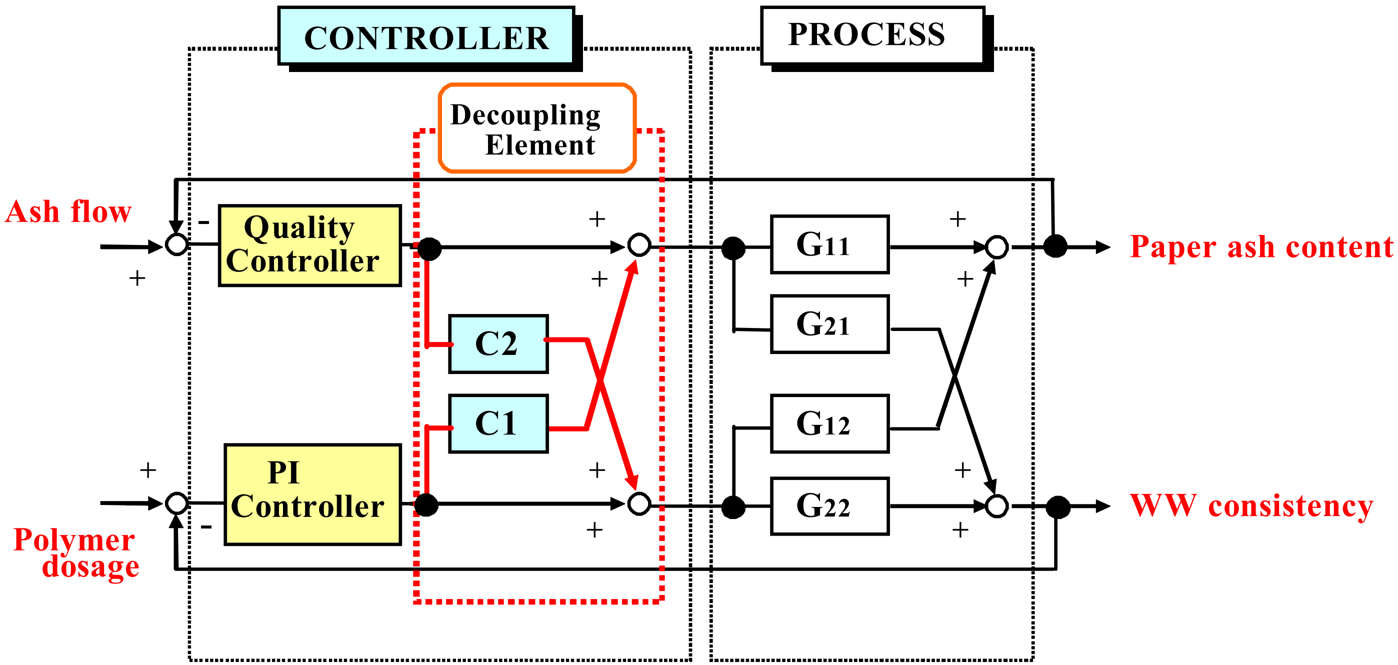
◆ ***conventional "PI-control"***

+ "Decoupling control".

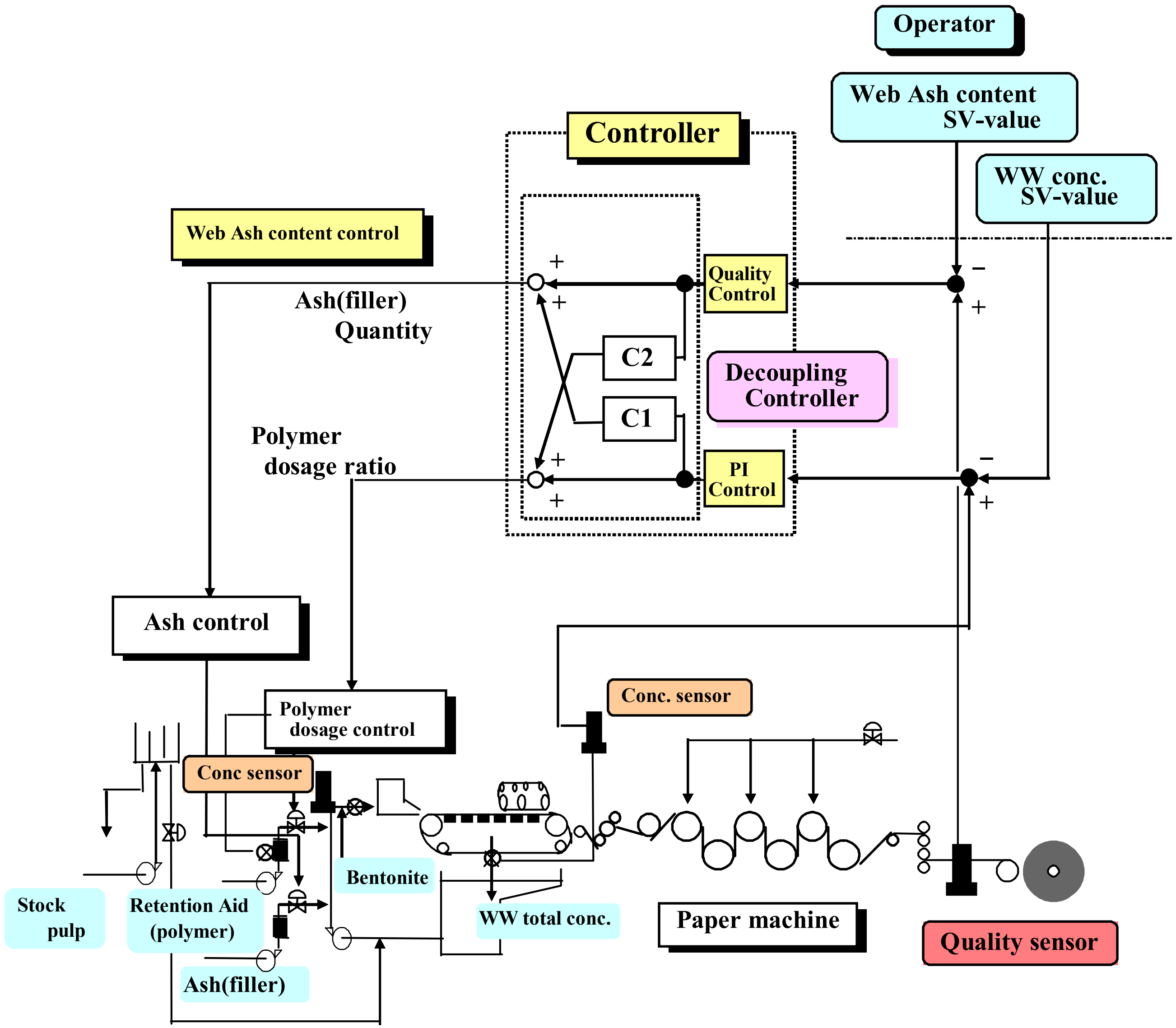
Transfer functions of the process

control item / *operation*	Quality Sensor control Ash content	WW total consistency
Ash flow	$G_{11} = \frac{+K_{11} \cdot e^{-126 \cdot S}}{1 + 75 \cdot S}$	$G_{21} = \frac{+K_{21} \cdot e^{-90 \cdot S}}{1 + 780 \cdot S}$
Polymer dosage	$G_{12} = \frac{+K_{12} \cdot e^{-174 \cdot S}}{1 + 828 \cdot S}$	$G_{22} = \frac{-K_{22} \cdot e^{-192 \cdot S}}{1 + 1164 \cdot S}$

Decoupling control



$$\begin{cases} C1 = -\dfrac{G_{12}}{G_{11}} = -\dfrac{+K_{12}\cdot(1+75\cdot S)}{+K_{11}\cdot(1+828\cdot S)}\cdot e^{-48\cdot S} \\ C2 = -\dfrac{G_{21}}{G_{22}} = -\dfrac{+K_{21}\cdot(1+1164\cdot S)}{-K_{22}\cdot(1+780\cdot S)}\cdot e^{+102\cdot S} \end{cases}$$



PI-control + Decoupling control

Decoupling control elements "*C1*" and "*C2*"

- Strategies to "**Robust**" and "**Simplify**" the Decoupling Controller ……

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① "Steady-State Controller".

$$C2 = -\frac{+K_{21}\cdot(1+1164\cdot S)}{-K_{22}\cdot(1+\ 780\cdot S)}\cdot e^{+102\cdot S} \approx -\frac{+K_{21}\cdot(1+1164\cdot S)}{-K_{22}\cdot(1+780\cdot S)}$$

$$\approx -\frac{+K_{21}}{-K_{22}} = +\textit{constant.}$$

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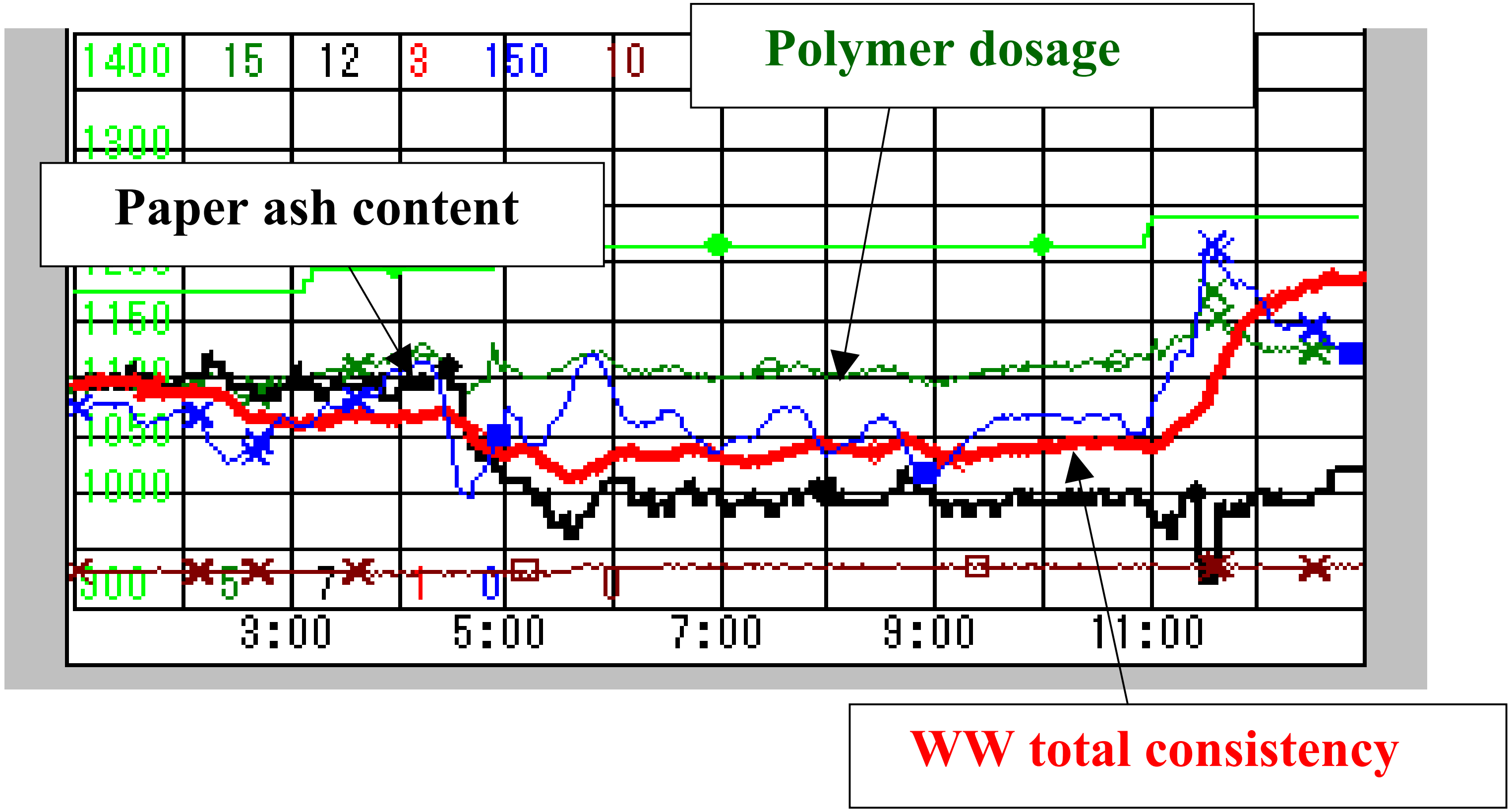
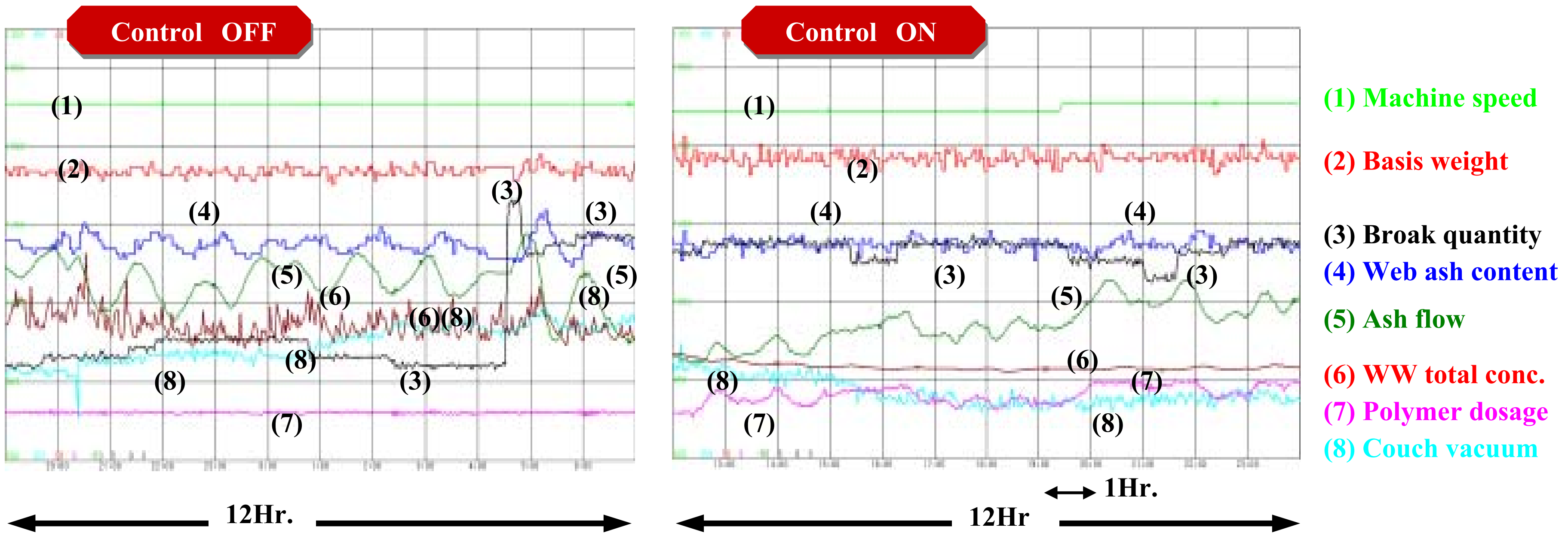
② "Partial Decoupling controller".

$$C1 = -\left(\frac{+K_{12}}{+K_{11}}\right)\cdot\frac{(1+\ 75\cdot S)}{(1+828\cdot S)}\cdot e^{-48\cdot S} \approx -0$$



PI-control + Decoupling control

PI-control + Decoupling control result



- Stabilize the total consistency, ash flow of the wet-end section of a paper machine, and the ash content of the paper products.
- To alleviate the interaction problem, utilized a “decoupling controller” together with the “PI feed-back controller”.

Summary

➢ control result *(1sigma : standard deviation)*

	Before	*After*	*Reduction* (%)
• WW consistency(%)	0.015	0.006	▼59 %
• Paper ash content (%)	0.13	0.10	▼21 %
• Ash flow (liter/min.)	9.49	7.56	▼20 %

END

Thank you for your attention.

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