Report on Energy-Saving Survey

Condition Based Optimum Maintenance and Operation for Heat Exchangers, Cracking Furnaces, Control Loops and Control Valves

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February 25, 2010 In Thailand

Yokogawa Electric Corporation

グリーンIT推進協議会
Green IT Promotion Council

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Background and objective

- **This survey focused on broad category of chemical industry which is the largest energy consumer in production plant category.**
  - **By Energy white book 2006 Japan**

- **This industry is second large CO2 emitter in the category*, thus optimizing maintenance and operation will contribute energy conservation and saving our planet .**
  - ***METI 2007 survey result. METI: Ministry of Economy, Trade and Industry**

- **This survey focused on;**
  - **Large energy consumer: Heat exchanger and cracking furnace**
  - **Energy saving infrastructure: Control loops and control valves**

Introduction of survey company
Yokogawa Electric Corporation

- **Yokogawa's goal is to contribute to society through broad-ranging activities in the areas of measurement, control, and information.**

Fig-1: Environmental management

Fig-2: Environmental solutions and environmentally sustainable products.

Prosafe RS
for environmental safety system

Analyzers
for CO2, NOX, SOX, pH etc measurement

CENTUM VP/CS3000 (DCS)
for efficient production control

Econo-pilot
for energy saving control

Process sensors
and control actuators
for precise measurement and control

InsightSuiteAE
Asset diagnostics and energy saving systems and services.
This system was used in this survey.

Introduction of surveyed company 1
Rayong Olefins Co., Ltd. (ROC)

- One of the leading petrochemical company in Rayong Thailand who produces 1.2 million ton olefin product annually by Yokogawa's CENTUM (DCS) systems. Fig-1

- Main energy consumer within the Siam Cement Group (SCG) Chemicals. Fig-2

- The company has adopted many initiatives for quality(by Total Quality Management practices), productivity (by Total Productive Maintenance practices) and energy management; Fig-3 and the result of this report forms part of their energy efficiency improvement program.

Fig-1: ROC plant view

Fig-2: Siam Cement Group

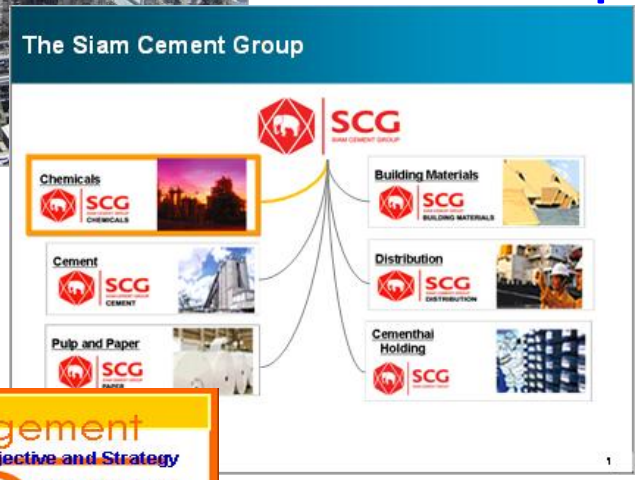


Fig-3: Energy management

Summary of the survey - ROC

Survey Process

- **Step 1**

  -Target selection (Oct.)

  “Heat exchanger” &
  “Ethylene cracking furnace”

  -Related operation and maintenance analysis (Oct.)

- **Step 2**

  Frame work study for energy saving (Dec.)

- **Step 3**

  Energy saving proposal to ROC management (Jan.)

Result of the Survey

Fig-1: Heat exchanger

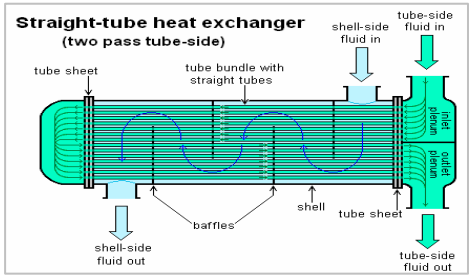


Fig-2 Fouling

Fig-3: Ethylene cracking furnace

Fig-4: Tubes

Current status Quoted from Web shown on the last slide.

- **No tools are available to measure heat performance, thus it was measured by InsightSuiteAE’s diagnostician based on current and past 220,000 data.**

Survey & analysis at ROC

Fig-1: Surveyed heat exchanger & cracking furnaces

Fig-2: Saving frame working

Fig-3: Diagnostics data analysis

Current status and issues
Heat exchangers (HEXs) - ROC

- No heat performance monitoring tools are available for hundreds of HEXs, thus maintenance targets are listed up based on human experiences. (Time Based Maintenance; TBM)

- Suppose current one HEX performance is as blue line on the right, it will trace red dotted line when it is not cleaned or trace green dotted line when it is cleaned at next turn around. And the difference between the two lines is energy loss.

- Cleaning needs to be judged keeping balance between the loss and maintenance cost. But without performance monitoring the judgement is difficult.

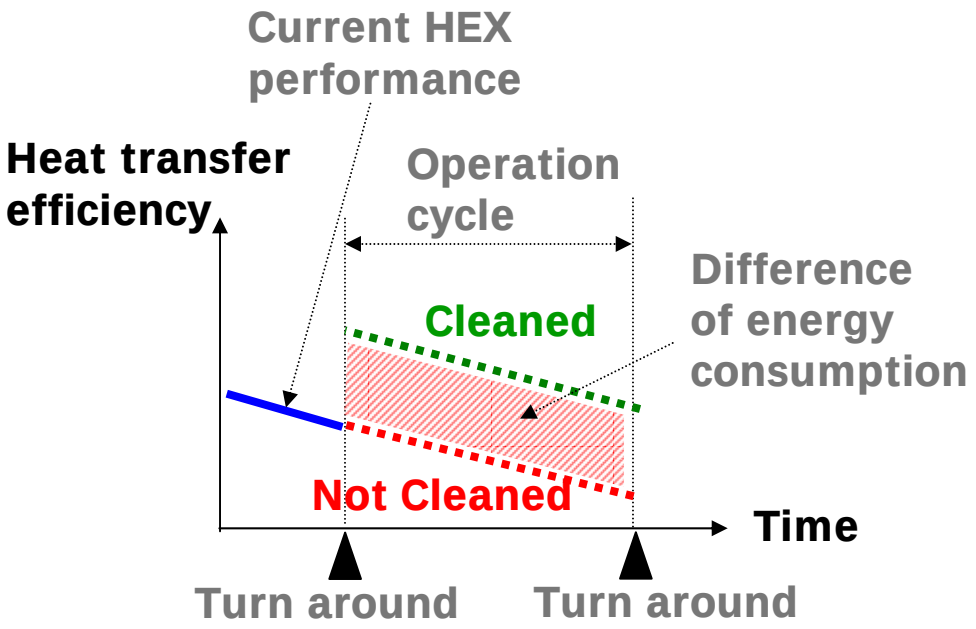


Fig-1: Heat transfer efficiency

Survey process（Detail)
Heat exchangers (HEXs) - ROC

- Current HEXs performance were measured by InsightSuiteAE's "HEXs diagnostician" with past 1 year and 5 months operation data.
  --- Fig-1 (a)

- Future HEXs performance were calculated based on past performance data by newly developed heuristic advanced curve fitting InsightSuiteAE's "Prediction diagnostician".
  --- Fig-1 (b)

(a) Performance measurement based on history data

(b) Performance prediction curves

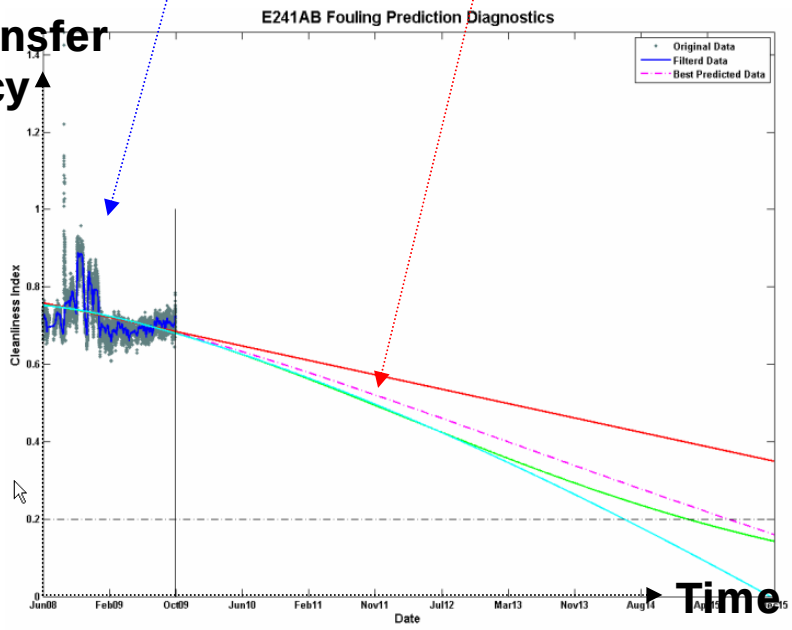


Fig-1: Heat transfer efficiency

Energy-saving proposals and the effect
Heat exchanger (HEXs) - ROC

Proposals

- Execution of cleaning at next turn around maintenance at surveyed HEX
- Introduction of InsightSuiteAE's "HEXs diagnostician" and "Prediction diagnostician" to all HEXs for more saving through plant life-time

Effect

- Extraction of plant wide bad acting HEXs
- HEXs pumping power saving
- HEXs heat efficiency improvement

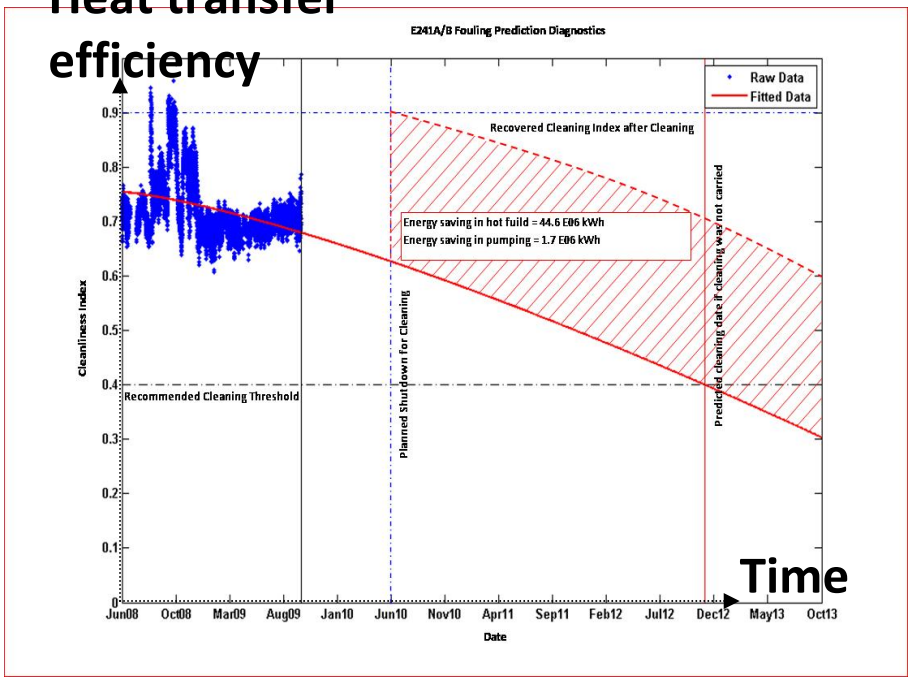


Fig-1: Heat transfer efficiency

Current status and issues
Ethylene cracking furnaces - ROC

- No tools are available for uneven coking tube detection.
- Thus constant volume steam is supplied for de-coking. Even tubes are relatively clean.
- It is likely that this leaves some coking areas after de-coking and it lowers heat transfer efficiency and shorten the next cycle length.

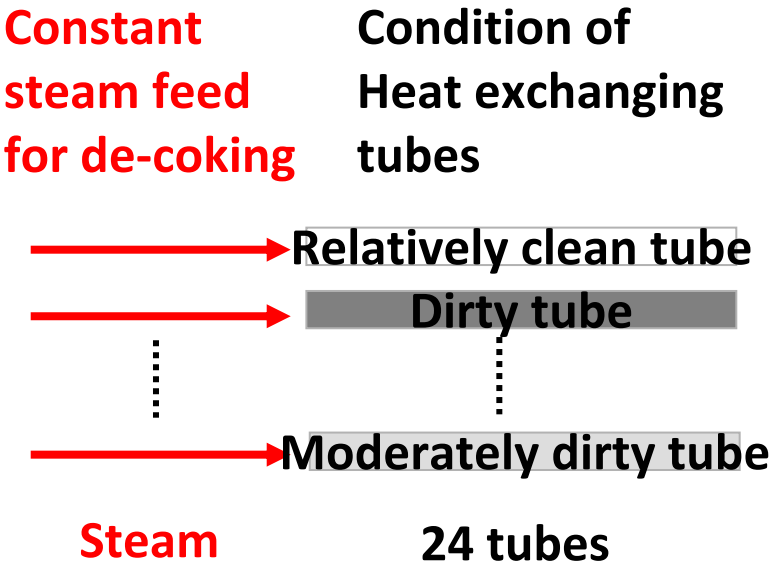


Fig-1: Constant de-coking steam feed

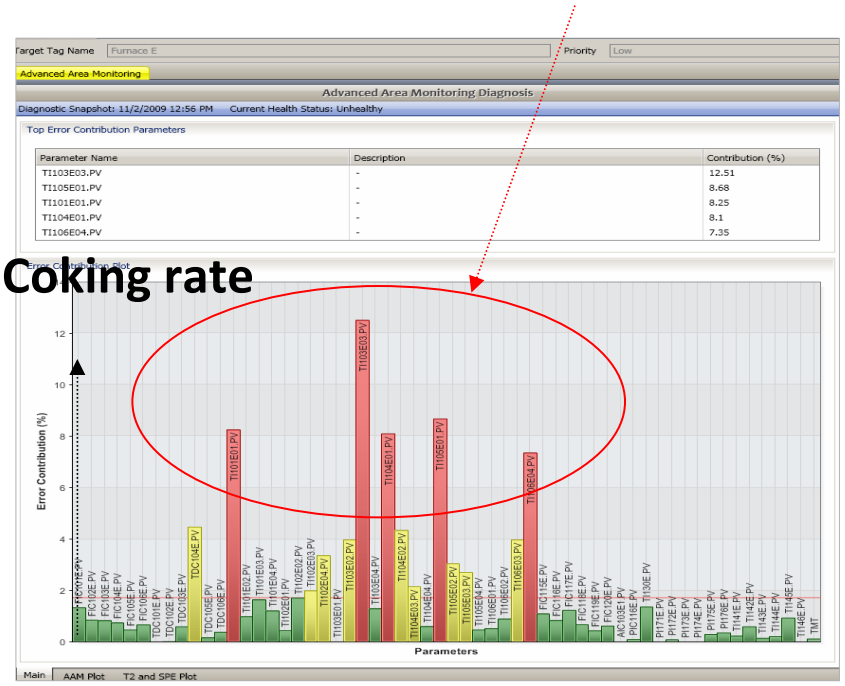
Survey process（Detail）
Ethylene cracking furnaces - ROC

- Coking status survey of 24 tubes was done at a cracking furnace by newly developed MVSA (Multi variable statistical analysis) based InsightSuiteAE's "Smart fault diagnostician"

  ---Fig-1

- Optimum de-coking steam supply methods were studied based on the severity

Red bar shows worst 5 severely coking tubes.



Coking rate

Tube & related process

Fig-1: Smart fault diagnostician

Energy-saving proposals and the Effect
Ethylene cracking furnaces - ROC

Proposals

- Execution of de-coking based on the coking severity at next turn around maintenance at surveyed furnace
  (Additionally "Steam feed optimizer" on Exapilot is used.)
- Introduction of InsightSuiteAE's "Smart fault diagnostician" and "Steam feed optimizer" to all furnaces for more savings through plant life-time.

Effect

- Steam saving at each de-coking
- Annual steam saving by number of de-coking times reduction (by operation cycle length extension)
- Operational energy saving by complete de-coking

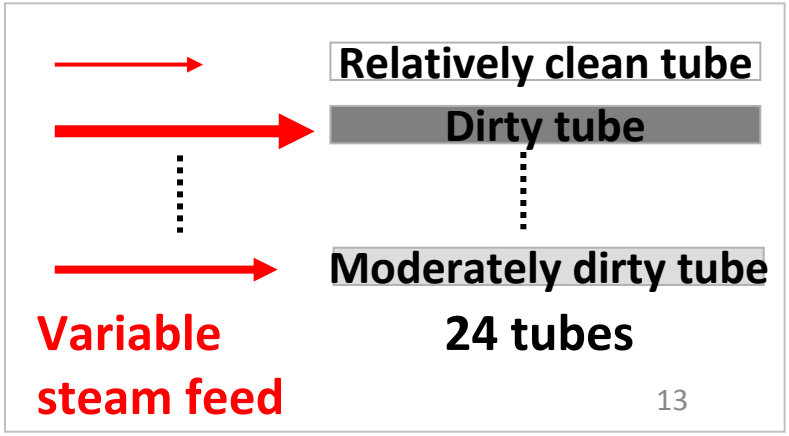
(Indirect effect : Coils and tubes lifetime extension)

Fig-1: Smart fault diagnostician (New)

Tube & related process

Fig-2: Steam feed optimizer

(Severity based de-coking steam feed)



Energy-saving proposals and the effect (Summary) - ROC

Expected Total Effect	Energy-saving Plan	Effect
Saving total (1 HEX & 13 cracking furnaces) •807,000 KWh/y (+1,490,000 KWh/y potential by heat recovery) •290 Ton/y steam •300 Ton/y fuel This is all for ROC report. Yokogawa would like to express appreciation to ROC's collaboration and cooperation on the survey.	**Heat exchangers** •Execution of surveyed HEX cleaning at next turn around •Application of InsightSuiteAE's "HEXs diagnostician" and "Prediction diagnostician" to all HEXs	•Pumping power saving •Heat transfer efficiency improvement •Extraction of Plant wide bad actors
	Cracking furnaces •Execution of surveyed cracking furnace de-coking based on the coking severity at next turn around. •Application of InsightSuiteAE's "Smart fault diagnostician" and "Steam feed optimizer" to all cracking furnaces.	•De-coking steam saving •Number of de-coking times reduction •Operational energy saving

Introduction of surveyed company 2
Thai Acrylic Fibre Co., Ltd. (TAF)

- **Global top 3 quality fiber producers in Saraburi Thailand who produces 100,000 Ton acrylic fiber products annually by Yokogawa's CENTUM (DCS) systems.**

- **One of the top service providers of acrylic application development.**

- **The company has adopted many initiatives for quality(by adopting the Total Quality Management Practices), environment and safety, and the result of this report forms part of their environmental saving though energy efficiency improvement programs.**

Fig-1: Aditya Birla Group

Fig-2: TPM at TAF

Summary of the survey - TAF

Survey Process

- **Step 1**

  -Target selection (Oct.)

  "Dryer temperature control loops" & "Control valves of entire plant"

  -Related operation analysis (Oct.)

- **Step 2**

  Frame work study for energy saving (Dec.)

- **Step 3**

  Energy saving proposal to TAF management (Jan.)

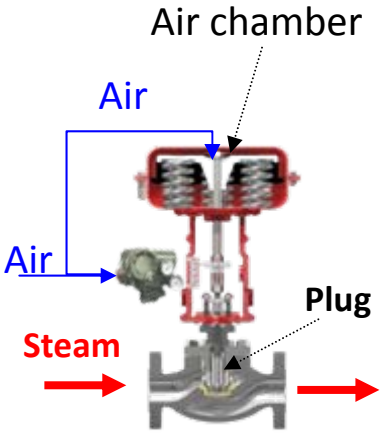
Result of the Survey

Fig-1: Dryer and control equipment

Temperature sensors

Control valves

Fig-2: Control valve



Current status

•Unstable dryer temperature control and over acting control valve were found by InsightSuiteAE 's "Control loop and control valve diagnostician" .

Survey & analysis at TAF

Fig-1: Scrubber

Acrylic fiber thread

Fig-2: Data analysis and energy saving frame working

Current status and issues
Control loops @ dryers - TAF

- Zone temperature controls are fluctuating due to line speed changes. --- Fig-1

- Average zone temperature is set 6% higher than preferable condition to keep required hea capacity. --- Fig-2

Fig-1: Zone temperature

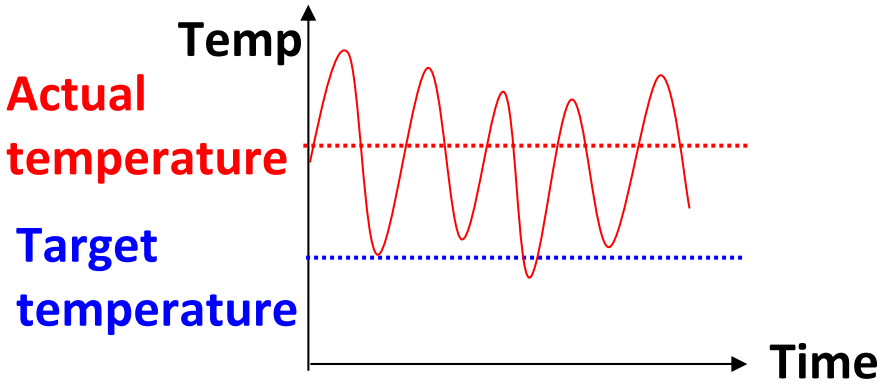
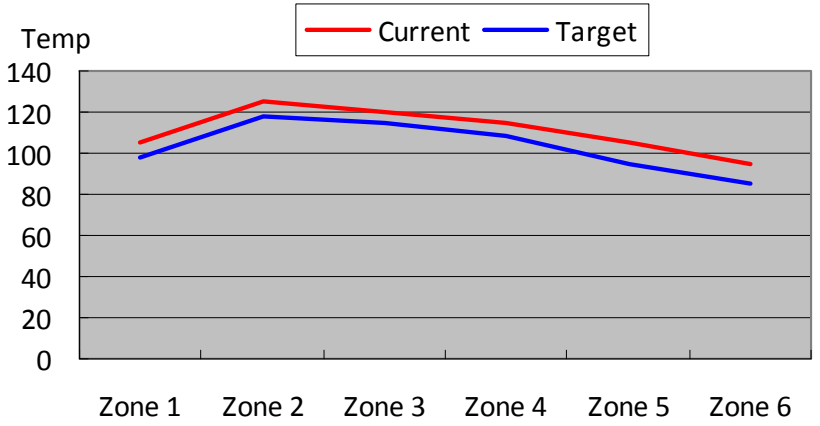


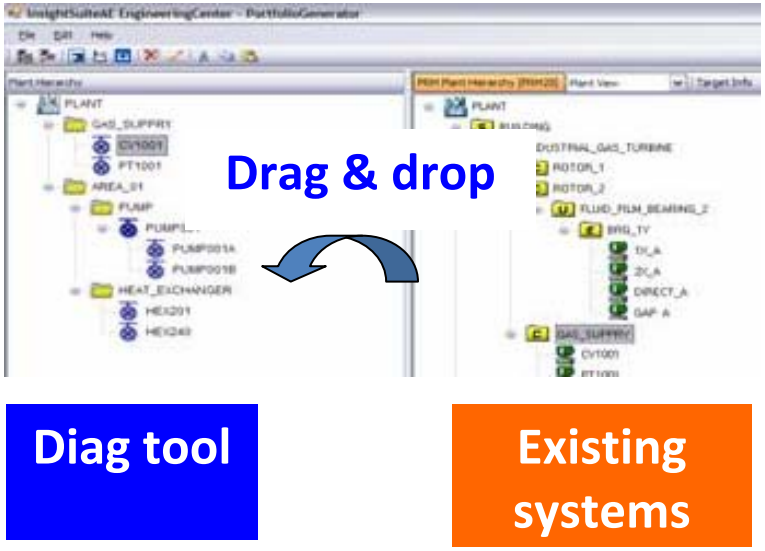
Fig-2: Dryer zone temperature pattern



Survey process (Detail)
Control loops @ dryers - TAF

- 6 zone temperature controllability measurement by InsightSuiteAE 's "Control loop diagnostician" and "Control valve diagnostician".
- 10 min. to start the measurement by existing CENTUM CS3000 DCS system engineering data reuse. Fig-1
- Measured the controllability every 10 min for 1 month, and studied steam reduction by loop stabilization.

Fig-1 Engineering data import from existing systems



Energy-saving proposals and the Effect
Control loops @ dryers details - TAF

Proposals

- Execution of tuning of control valves and loops at surveyed dryer by tuning simulator "TuneVP" Fig-1,2
- Introduction of InsightSuiteAE's "Control loop diagnostician", "Control valve diagnostician" & "TuneVP" to all other dryers for more savings through plant life-time

Effect

- Drying steam saving by lowering zone temperature pattern
- Air compressor power saving

  (Indirect effect: Less product quality variance)

Fig-1: TuneVP (Tuning simulator)

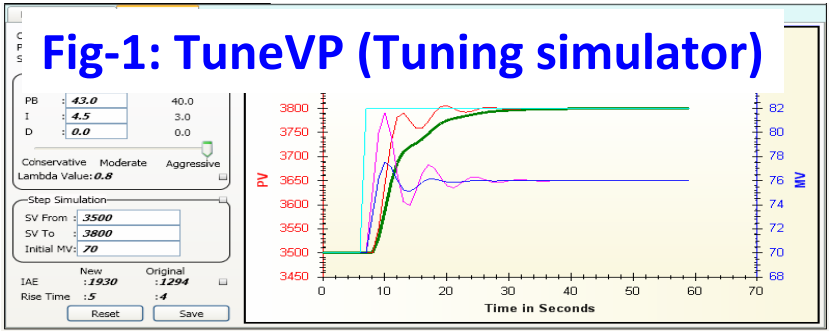
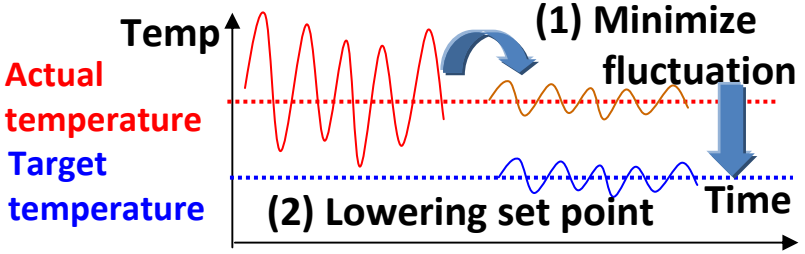
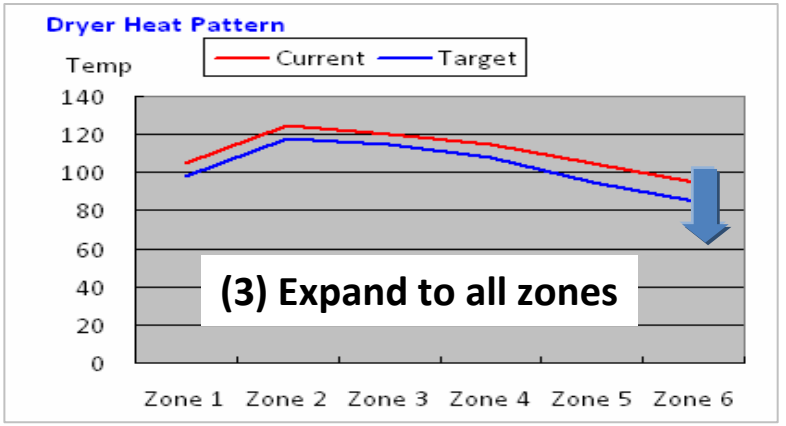


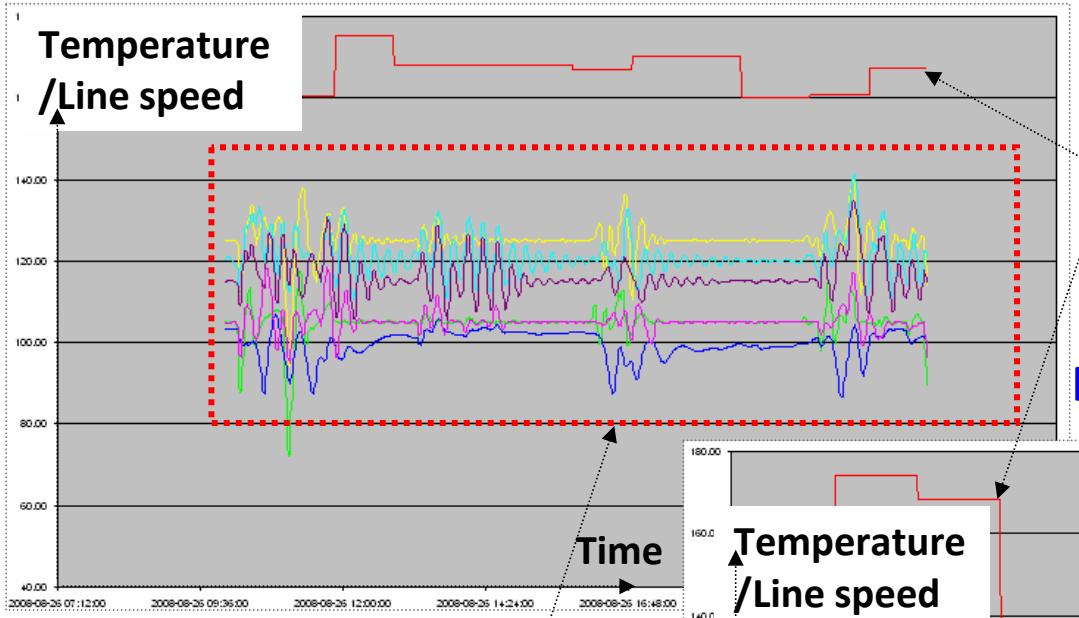
Fig-2: Expected tuning result





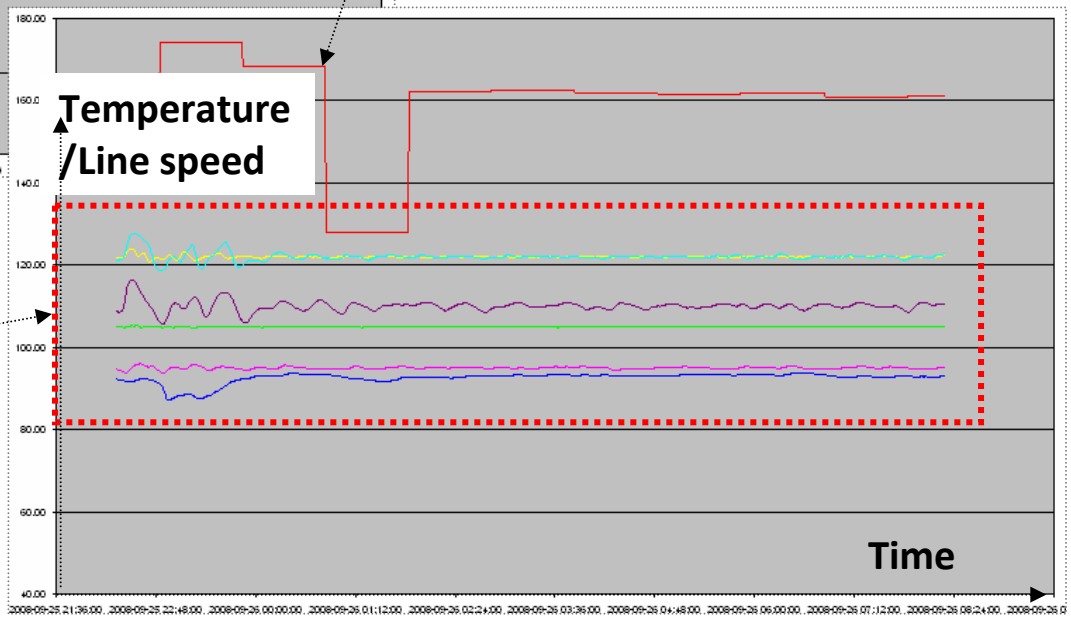
Energy-saving proposal and the Effect
Control loops @ dryers details - TAF

Fig-1: Control loops tuning trial (Before)



Disturbance: Line speed change (+ interference from up stream zones to down stream zones.)

Fig-2: Control loop tuning trial (After)



Dryer temperatures

Zone 1, Zone 2
Zone 3, Zone 4
Zone 5, Zone 6

Additional effect by stable loop control
Control valves - TAF

Current

- Average control valve travel/cycle is 12% which is higher than expected, thus they are consuming more instrument air.

Proposals

- Execution of tuning of control valves and loops

Effect

- Instrument air saving (Compressor and dryer power saving)

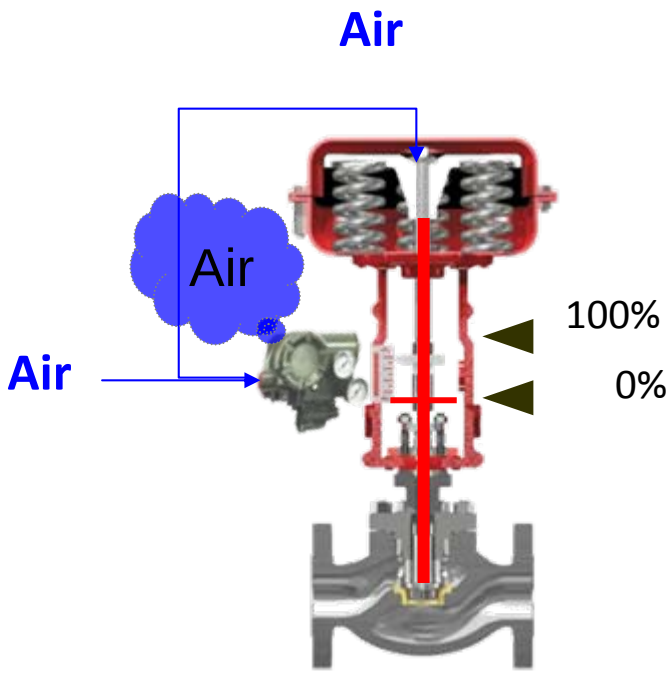


Fig-1: Control valve

Energy-saving proposals and the effect (Summary) - TAF

Expected Total Effect	Energy-saving Plan	Effect
•Saving total Current load (2 lines) • 3,100 Ton/y steam • 6,400 KWh/y Potential (5 lines) • 7,800 Ton/y • 16,000 KWh/y This is all for TAF report. Yokogawa would like to express appreciation to TAF's collaboration and cooperation on the survey.	Control loops @ dryers and valves •Execution of tuning of control valves and loops at surveyed dryer by tuning simulator "TuneVP". •Application of InsightSuiteAE's "Control loop diagnostician", "Control valve diagnostician" & "TuneVP" to all other dryers and loops for fine tuning	•Drying steam saving by lowering zone temperature pattern •Air compressor power saving •(Indirect effect: Less product quality variance)

Suggestions

- **Adoption of practical energy saving approach**
  - Ease to use asset diagnostic by software system - *InsightSuiteAE*
  - Vast process measurement data to be online asset performance information
  - Big potential of energy savings by day to day routine operation and maintenance practice.
- **Key elements in energy saving**
  - Environment friendly energy saving products and solutions
  - Day to day local support force for plant life-time improvement
  - Professional consultation for real achievement
- **Summary**
  - In Green IT host countries, Yokogawa's DCS systems (CENTUM and other production control systems), which are energy saving basis, are running at 176 plants in Singapore and 364 plants in Thailand.
  - Yokogawa is ready to contribute for energy saving and global environment conservation by its solutions and global network.
  - For your company and country's prosperities, please let Yokogawa collaborate with you.

Source reference of figures and photos

- **Slide 6**
  - **http://www.duraloy.com/petrochemicals.html**
  - **http://www.johnzink.com/products/burners/html_jz/burn_jz_prod_ethyl.htm**
  - **http://commons.wikimedia.org/wiki/File:Straight-tube_heat_exchanger_2-pass.PNG**