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Energy Conservation by Changing Control of ADIP Regeneration Tower

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◎ **Key Words: Rationalization of heating, cooling and heat transfer (heating equipment, etc.)**

◎ Outline of theme

The desulfurization equipment generates gas containing H_2S (hydrogen sulfide). The generated H_2S is removed by having ADIP (Diisopropanolamine) solution absorb it. In order to recover the ADIP solution that has absorbed H_2S, the H_2S density in the ADIS is made 300 to 400 ppm by heating and distilling the solution with the re-boiler that uses low pressure steam as the heat source in the recovery tower.
However, it was difficult to stabilize the H_2S density with conventional control and the recovery was made excessively because the accuracy of the conventional control was bad. Therefore, we tried to stabilize the H_2S density and prevent the excessive recovery by changing the conventional control method. We succeeded in change of control method and we could reduce the consumption of the re-boiler steam.

◎ Implementation Period for the Said Example

- Planning period June, 2006 – December, 2006, Total 7 months
- Implementation period January, 2007 – April, 2007, Total 4 months
- Effect verification period April, 2007 – July, 2007, Total 3 months

◎ Outline of the Business Establishment

Production items	Refinery of petroleum products such as LPG, naphtha, gasoline, jet fuel, kerosene, light oil, heavy oil, asphalt, sulfur, octene, mix xylene, etc.
Employees	348

Yearly energy consumption (actual of 2006)

Converted to crude oil 510,671kL

◎ Overview of Target Equipment Processes

Figure 1 shows the process of gas washing system including ADIP recovery tower.

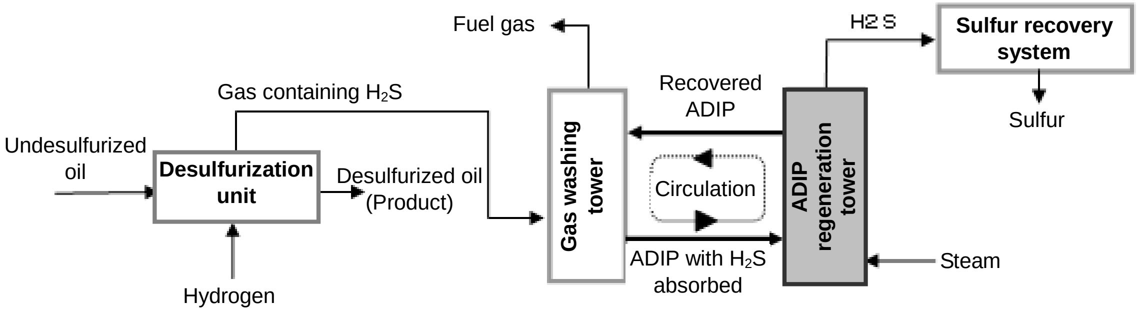


Fig. 1 Process flow of facility

1. Reason for Theme Selection

To regenerate ADIP which has come back from the desulfurization unit with H2S absorbed, it is heated and distilled by the re-boiler using low pressure steam (0.3MPa) as the heat source so that the tower top temperature of the ADIP regeneration tower becomes constant. Based on the past operation result, the target of the H_2S density in the ADIP is set at 300 to 400ppm because if it exceeds 400ppm, the desulfurization unit does not work well.
However, with the current control, the H_2S density in the ADIP does not become stable even if the tower top temperature is kept constant. Even if the tower top temperature is frequently adjusted, the density often exceeds 400ppm, and the regeneration tends to be excessive in order to avoid it.
Therefore, we tried to figure out the way to stabilize the H_2S density and suppressed the excessive regeneration. By this way, we achieved the energy conservation.

2. Understanding and Analysis of Current Situation

(1) Understanding of Current Situation

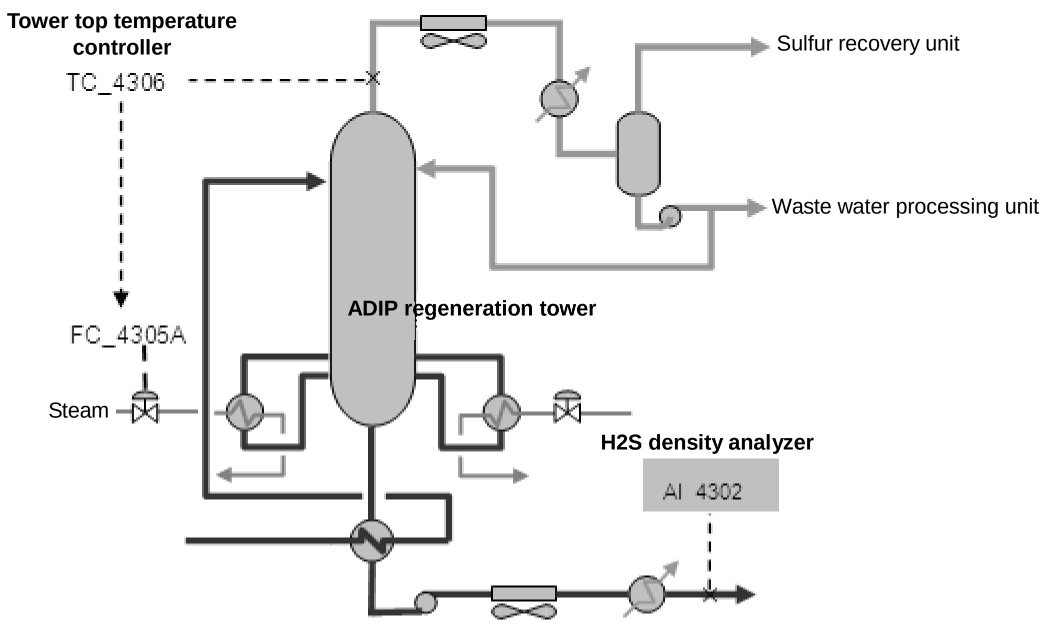


Fig. 2 Control of ADIP regeneration tower

- The operator adjusts the TC_4306 (tower top temperature controller) so that the AI_4302 value (H_2S density in the ADIP) becomes 300 to 400ppm.
- The tower top temperature is frequently adjusted.
- 400ppm(upper limit) is exceeded occasionally.
- There are basically 2 operation modes. The mode processing oil containing much sulfur in the desulfurization unit is called HS mode and the mode processing oil containing less sulfur is called LS mode.

Operating conditions of each mode

Operation mode	ADIP circulating volume (kl/h)	Recovery tower top temperature [°C]
HS	280	97 to 98
LS	250	101 to 102

(2) Analysis of Current Situation (See Fig.3)

- The regeneration is excessive because the H_2S density in the ADIP is not stable.
- The H_2S density in the ADIP is not stabilized by the tower top temperature control.
- There is delay until the adjustment result comes out because the analyzer is batch system and one cycle with which the analyzer renews the analysis result is 20 minutes.

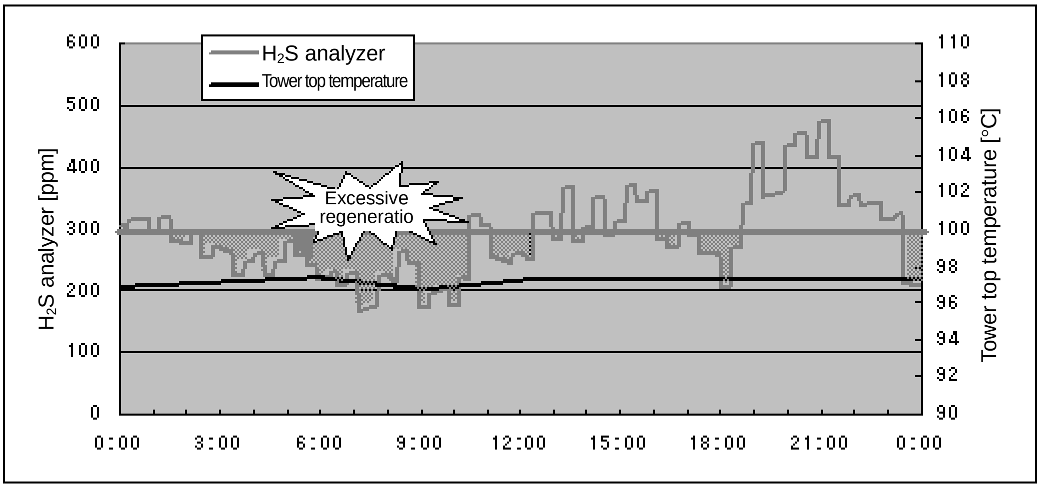


Fig. 3 Change of H_2S density when controlling the tower top temperature

3. Progress of activities

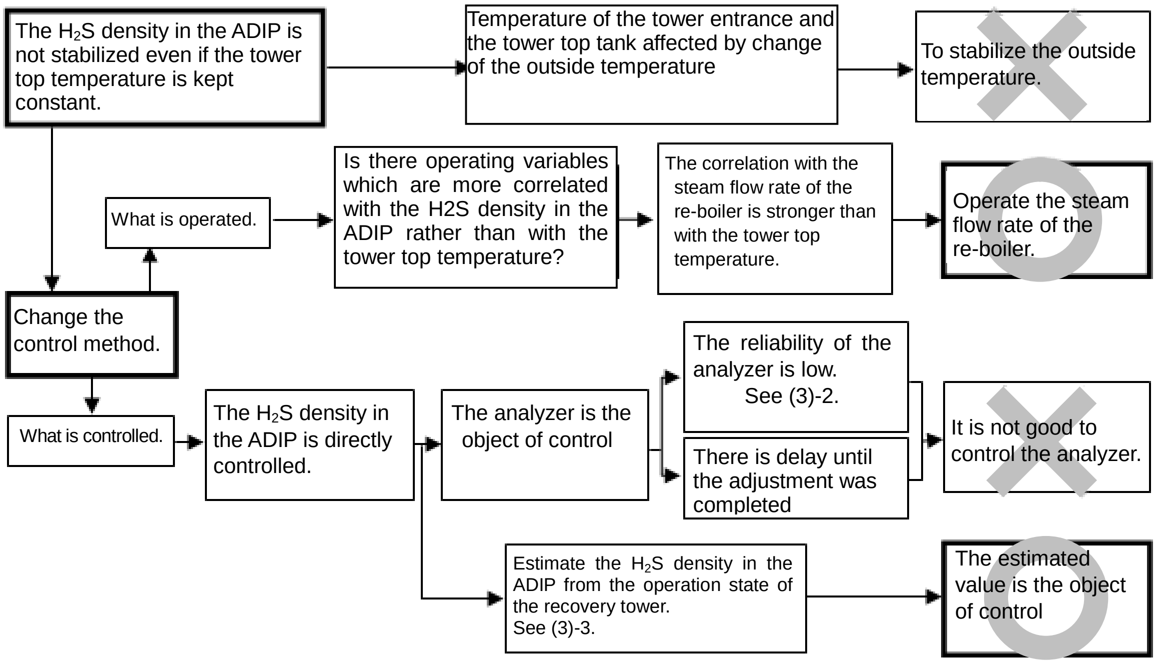
(1) Implementation Structure

Targets such as cost-down, energy conservation, etc. were set to be achieved by individual improvement activities of the TPM voluntary conservation team.

(2) Target Settings

The achievement of energy conservation is expected by controlling excessive regeneration with stabilizing the H_2S density in the ADIP.

(3) Problem Points and their Investigation



(3)-1 Correlation between the H_2S density in the ADIP and the operation variables around the regeneration tower.

Our Quality Assurance Division collects ADIP samples once a week and analyzes the H_2S density in the ADIP (hereafter called the labo value). We tried to calculate the correlation factor between the samples and the collected operation data around the regeneration tower when the samples were taken. We used Excel for this calculation.

Tower top temperature	Tower top pressure	ADIP circulation volume	Re-boiler steam
0.598	0.511	0.706	0.724

(3)-2 Reliability of the on-line analyzer

We compared the labo value of the samples and the value of the on-line analyzer.

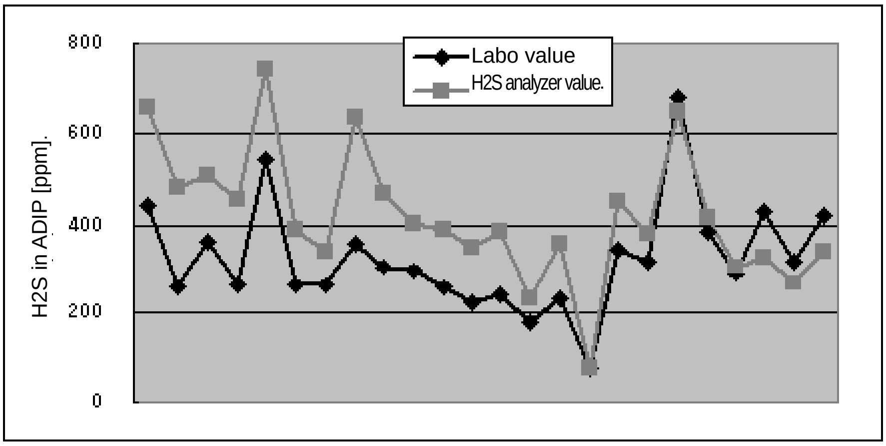


Fig. 4 Comparison of labo value and analyzer value

From the Fig. 4, it can be used for understanding the tendency such as up and down. If the difference between the labo value and the analyzer value is constant, it can make reliable by taking some difference to the value.However, as the difference deviates much, it cannot make reliable as absolute values.

(3)-3 Estimation of H_2S density in ADIP from the operation state of regeneration tower

When the samples were collected, we also collected operation variables around the regeneration tower and conducted the regression analysis using Excel. Using its result, we created a formula and estimated the H_2S density in the ADIP.

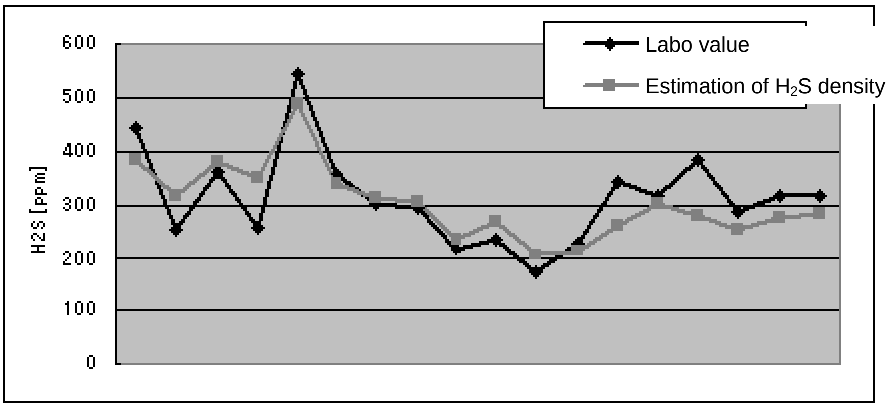


Fig. 5 Comparison of labo values and estimated values

From Fig.5, we were convinced that we could approximately estimate the H_2S density from the operation state of the regeneration tower.

4. Details of Measures

Considering the result of the study, we decided to estimate the H_2S density in the ADIP and control the flow rate of the re-boiler steam so that the density becomes constant.

Although the estimation formula obtained using Excel can be used, there is a specialized software package called RQE which can guess the nature of things from the operation variables. There is a merit in using this software because it can automatically correct the estimation formula if there is deviation in the estimated values.

We introduced the RQE and estimated the H2S density in the ADIP.

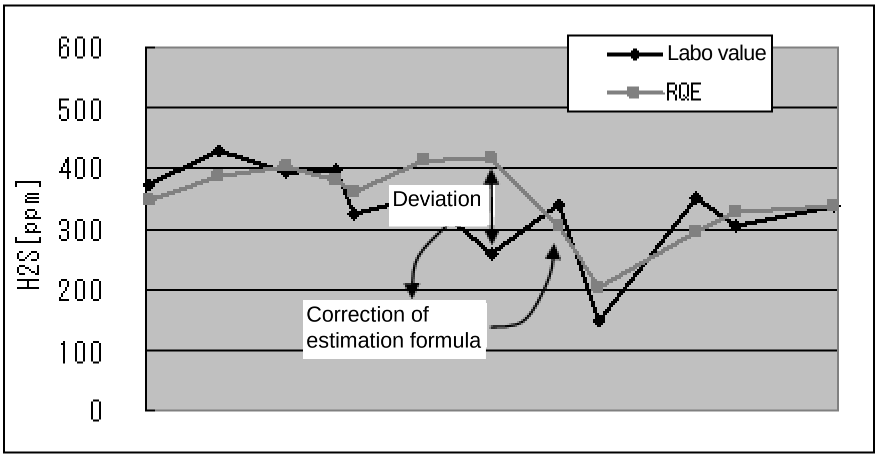


Fig. 6 Comparison of labo value and RQE estimation value

Using the values estimated by RQE, we established new control.

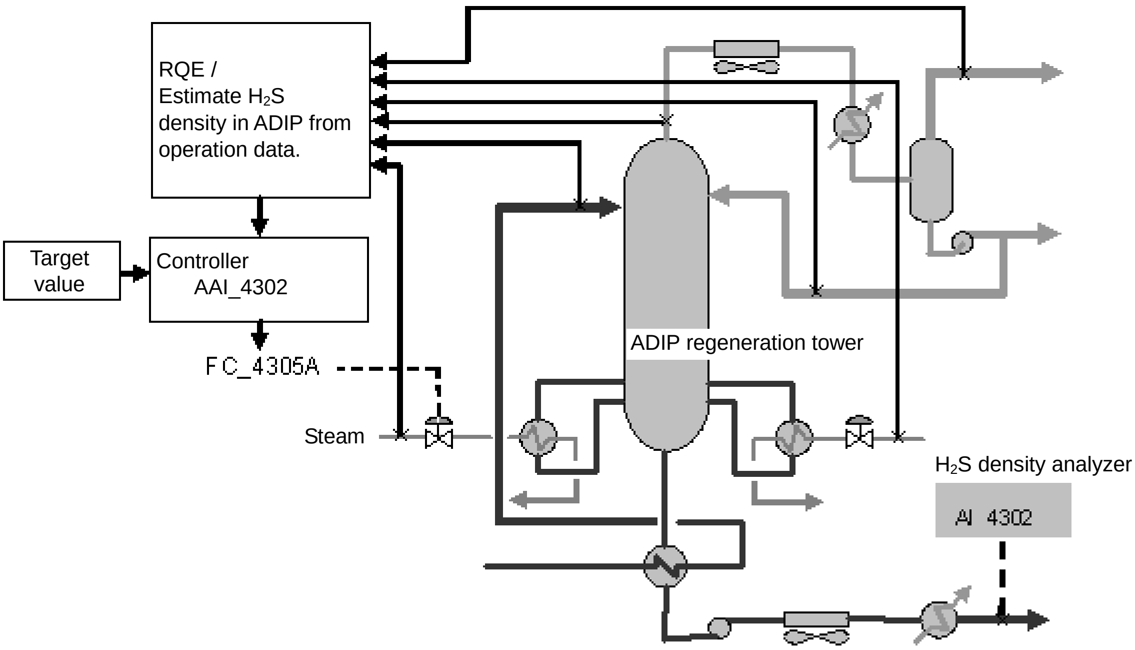


Fig. 7 RQE control

By measuring the temperature, pressure and flow rate around the recovery tower, the H_2S density in the ADIP is estimated by RQE.

The result is taken into the controller (AQAI_4302) and the re-boiler steam is operated by the PID control.

5. Effects achieved after Implementing Measures

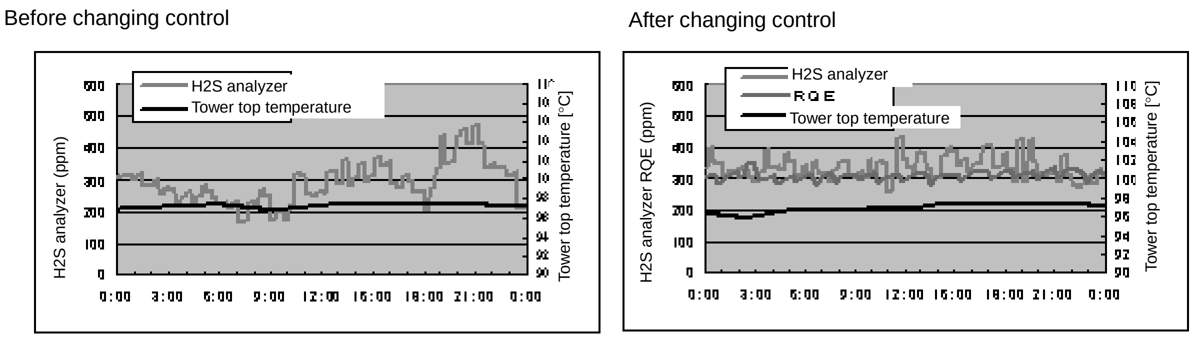


Fig. 8 Comparison of before and after changing control

After changing the control, we could stabilize the H_2S density in the ADIP and contain the excessive recovery (Fig. 8).

Figure 9 shows the steam weight in Kg per 1KL of ADIP circulation volume.

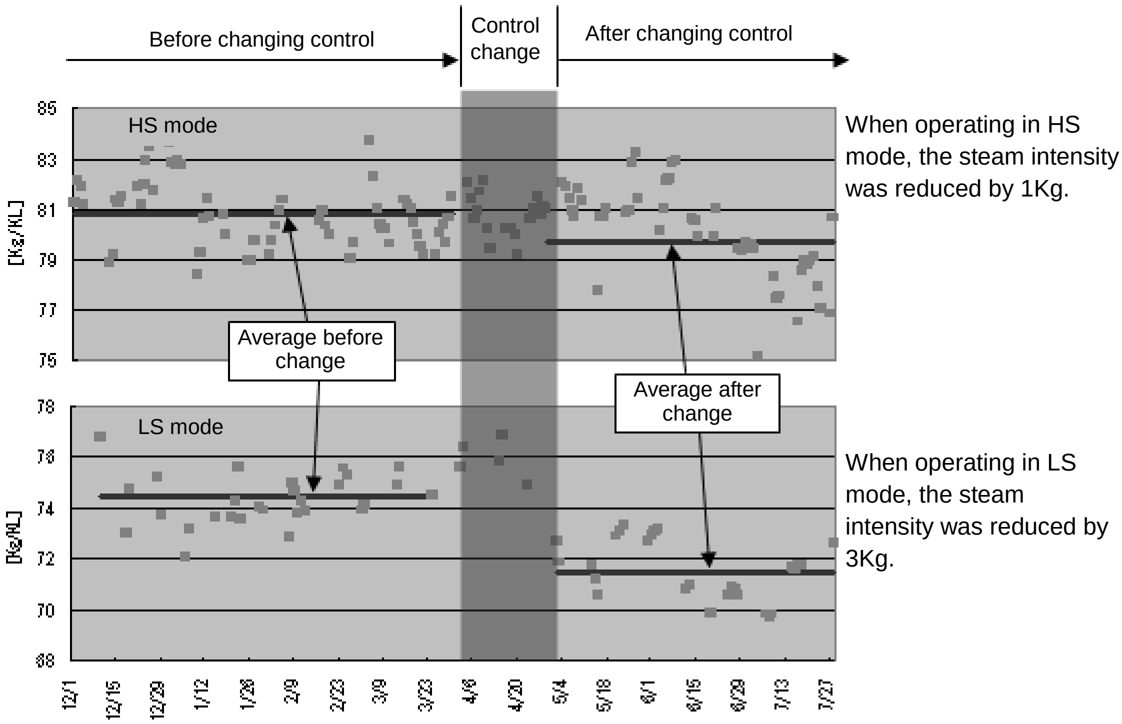


Fig. 9 Change of steam intensity in each operation mode

Merit

HS mode ADIP circulation volume 280KL/H (2/3 of a month)

LS mode ADIP circulation volume 250KL/H (1/3 of a month)

Steam reduction in a year

$$((1\times280\times24\times30\times2/3)+(3\times250\times24\times30\times1/3))\times12\div1,000=3,772.8 \text{ Ton/year}$$

Low pressure (0.3MPa) steam ¥2,100/Ton (fuel oil equivalent)

3,772.8×2,100=¥7,922,880

The energy conservation was approx. 8 million yen.

6. Summary

We could establish the new control by estimating the H_2S density in the ADIP from the operation state. As the H_2S density was stabilized, we no longer have to adjust it so frequently as before. We did all this with zero investment cost (all were done by software measures).

7. Future Plans

Although it depends on the desulfurization unit, we are to gradually increase the H_2S density in the ADIP and intend to achieve further energy conservation.