

The Optimization of Amine-Rich Liquor Centralized Regeneration System in Desulphurization

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Abstract: A certain petrochemical company adds a series of amine-rich liquor centralized regeneration equipments, which use heat regeneration techniques to deal with the amine-rich liquor. The device is designed to use low-pressure saturated steam, which is mainly provided by mid-pressure superheat steam that is pressure reduced and decompressed. In order to save the energy which is wasted during the process of decompression, the paper shows the process of the thermodynamic calculation of different materials related, discusses the different methods of energy economization according to Energy Integration Theory, and at last brings forward a feasible scheme after many local reviews. The measurement results indicate that there are many appropriate lower heat sources that have existed in the factory that can produce low-pressure saturated steam instead of the mid-pressure steam. Undoubtedly this is beneficial to energy conservation, environmental protection, and the economization of the production cost.

Keywords: amine-liquor; regeneration; desulphurization;

1. INTRODUCTION

The energy consuming of the petrochemical industry in our country is 30 percents and 50 percents higher than the consuming in developed countries, and the energy utilization degree is very low. Compared to the developed countries, we have a rather obvious disparity. The reasons are complex, such as, the processes of energy transforming are not differentiated according their quality and rundle, the energy systems do not have appropriate optimization collocation and energy integration synthesis. What is more, the surplus heat recycle systems always pay attention to the recycle of the energy quantity instead of energy level and quality. It does not only add the double pressure of energy and environment, but also has a bad effect on the sustaining development of national economy. Consequently, in allusion to the principle of energy rundle consuming, the effective energy economization techniques, such as, using surplus heat to produce steam, strengthening heat transfer, reducing the slag, preventing low dew point erosion, are more than the breaking through points of energy economization and environments melloration, they are also the necessary approach of accelerating the techniques advancement, improving economy profit and enhancing the competition ability of every petrochemical industry.

The paper describes the theme of the heat sources choices to produce low pressure steams instead of mid-pressure steams in the amine-rich liquor centralized regeneration equipments, puts forward many rebuilding projects to select, uses thermal method to rebuild the best project and makes technique economic analysis and proves it to be feasible. The economic benefit of this project is notable.

2. THE ANALYSIS OF THE ENERGY CONSUMING IN THIS CASE

A refinery adds centralized amine-liquor regeneration equipment, which uses heat rebirth techniques to deal with rich amine-liquor. The rich amine-liquor from upriver equipments is transported by the pipe to the centralized amine-liquor equipment, and then the amine-liquor gets into the reborn tower after poor/rich liquor heat exchanger, the heat source of the tower is provided by the low pressure steam, after the quality exchange and heat exchange of amine-liquor, the H_2S in it changed into gas phase. Then the H_2S passes through the air-cooler and the reflux tank on the top of tower. At last these gases are transported to the sulphurs recycle equipment to produce sulphur, while the condensates get top reflux. The sump poor amine-liquor exchange heat with rich liquor in heat exchanger, and return to the upriver equipment to recycle.

The whole equipment is designed to use low-pressure ($143^\circ C$, $0.3MPa$) steam. And the low pressure is mainly from the mid-pressure super heat steam ($250^\circ C$, $1.0MPa$) that has been temperature reduced and decompressed. The amount of the mid-pressure steam is about $31t/h$. Because the mid-pressure superheat steam owns more working value than the low-pressure saturated steam, it is obvious improper in energy consuming. At the same time, the mid-pressure steam mainly depends on the purchase from the power plant, so the equipment increases the energy consuming and production cost, and the optimization is feasible.

There are many surplus heat sources in the refinery, which of them are appropriate to produce low-pressure saturated steam. The utilization of these

heat sources can take the place of purchase of mid-pressure super heated steam. Undoubtedly, the reconstruction of the centralized amine-liquor equipment can reduce the energy consuming and production cost, and then improves economical benefits.

3. THE PRINCIPLE OF HEAT SOURCE CHOICE

There are three main principles to choose proper heat source in this case just as follows:

1) The suitable temperature. Make sure that the minimum temperature margin is more than 20 °C. From the picture below, we can find that the heat exchanging line in the process of water changing to saturated steam is level. The minimum temperature margin is in the point 1. So the quantity of heat, released by the source from the original temperature to the 20 °C more than point 1, is the energy we can utilize in fact.

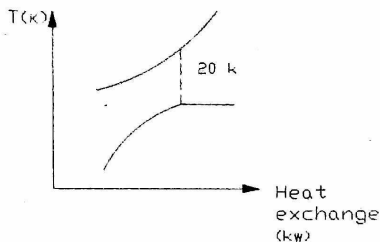


Figure 1: The heat exchanging line of saturated steam in heat source

2) Choose the nearest heat sources. The whole equipment lies in the north of the refinery. But, there are many heat source existed in both the north and the south of the factory. Compared to the north equipment, the distance between the south equipment and the amine-liquor regeneration equipment is longer; moreover, the pipelines have to cross many-fixed facility. So, it is too difficult to construct, and cost much. What is more, because of the long distance and the pressure loss in the process of transporting, we have to super heat up the steam accordingly. In conclusion, we should choose the heat source in the north of the refinery.

3) The quantity of heat should be considerable. Not every heat source can be used to produce steam, but some of them can be used to warm up the deoxidized water or super heat mid-pressure steam, such as:

a: There are two heat sources in the viscosity breaking unit, the entrance temperature are 180 °C and 176 °C respectively. It is difficult to produce mid-pressure saturated steam; the quantity of heat can be calculated by the formula below:

$$\frac{180 - 171}{180 - 111} \times 202.5 + \frac{176 - 171}{176 - 117} \times 301.4 = 52 \text{ kgEO/h}$$

The quantity of heat can only produce 1.011ton steam (0.4Mpa) per hour. The output is too small and has little value. But compared to the deoxidized water, the entrance temperature is high, so we can use the two heat sources to warm up the deaerated water. Supposed that the exit temperatures of the two sources are both 150 °C, the recycle energy is:

$$\frac{180 - 150}{180 - 111} \times 202.5 + \frac{176 - 150}{176 - 117} \times 301.4 = 221 \text{ kgEO/h}$$

The amount of the preliminary heating deaerated water is:

$$\frac{221 \times 10000}{140 - 104} = 61.4 \text{ t/h}$$

b: There are another two heat sources in the hydrocracking unit, one of which has a high temperature (240 °C) and a small flux. The exit temperature is about 180 °C, the recycle energy is

$$\frac{240 - 180}{240 - 60} \times 140 = 46.7 \text{ kgEO/h}$$

This energy can be used to produce 0.926 ton mid-pressure steam (0.4Mpa) per hour, it is also unfit to produce steam. Considered that the high temperature of the heat source, we can use it to over heat the mid-pressure steam. Supposed that the overheated temperature is 50 °C, the exit temperature is 200 °C, and then the recycle energy is:

$$\frac{240 - 200}{240 - 60} \times 140 = 31.1 \text{ kgEO/h}$$

This energy can be used to super heat up nearly 12 ton steam per hour.

$$\frac{31.1 \times 10000 \times 4.18}{2857 - 2748} = 11.926 \text{ t/h}$$

According the calculations above, this heat is not fit to produce steam because of their low temperature or less quantity, but they can preheat the deaerated water and over heat steam respectively.

4. THE PRINCIPLE OF SYSTEM CONSTRUCTION

This issue is the optimization of the centralized amine-liquor regeneration system in the north of the refinery. It is also the rundle energy analysis of the refining equipment. To produce the low-pressure saturated steam for the centralized regeneration system instead of mid-pressure superheated steam, we use the surplus heat to produce steam, adjust the surplus steam equipment, recycle flash gas, and reconstruct the boiler combined gas steam generator to recover energy.

1) Make use of the existed facilities as much as possible, and design energy saving methods

according to three levels: no need for investment, a few investments, and a proper investment.

- 2) Pay attention to the match of the energy level.
- 3) Pay attention to the optimization of the system, especially to the heat exchanger networks and steam power system.
- 4) Recover the low temperature heat in the whole factory.

5. THE FINAL CHOICE OF THE HEAT SOURCE

5.1 The emissions from masut hydrocracking heat boiler and SSOT

The combined gases are from three heat boilers in the masut hydrogenation plant and two heat boilers in SSOT. All of these boilers use a gas tube. The steam generator, which was used to recover steam before, has been ceased because the serious of erosion problems in economizer and boiler.

Table1 The calculations of masut hydrogenation plant

Name	Unit	F1310	F1311	F1601)
O ₂	vol%	2.9	1.3	6.6
CO	ppm	68	1046	135
CO ₂	vol%	10.3	11.2	8.2
NO	ppm	76	87	106
NO ₂	ppm	0	0	0
SO ₂	ppm	0	0	0
Gas vol	Nm ³ /h	5372.4	5022.6	4215
350°C enthalpy	kJ/Nm ³	481.2	482.3	475.7
200°C enthalpy	kJ/Nm ³	270.2	270.7	267.3
Enthalpy Recovery heat	kJ/h	1133576	1062782	878406

Table 2 the calculations of SSOT boiler

Name	Unit	F1210	F1410
O ₂	vol%	6.48	6.48
CO	ppm	0	0
CO ₂	vol%	7.53	7.53
NO	ppm	0	0
NO ₂	ppm	0	0
SO ₂	ppm	0	0
Gas vol.	Nm ³ /h	2900	5565
380°C enthalpy	kJ/Nm ³	531	531
200°C enthalpy	kJ/Nm ³	274	274
Recovery heat	kJ/h	745300	745300

$$\frac{5250269}{4.18 \times 10000 \times 50.43} = 2.5t$$

$$\alpha = \frac{781.3 - 640}{2748.8 - 640} = 6.7\%$$

$$10 \sim 20 \times 6.7\% = 0.75 \sim 1.5t/h$$

From the calculations above, these five boiler can recover heat 5250269kJ/h, and these quantity of heat can produce 0.4Mpa medium pressure steam 2.5t/h. In fact, there are some differences between the theoretical value and the practical value, the quantity of the steam may be more than 2.5t/h, about 3.5t/h.

5.2 The second hydrogen production equipment

The hydrogen production equipments are popular in petrochemical industry. Its process is: the H₂ manufacture raw materials are hydrogenated, dechloridized, desulfurized, and then mixed with medium pressure steam. The mixture enters into the conversion furnace, reacts with each other under the conditions high temperature and activator. After the medium temperature transforming, the product is raw hydrogen with low content. After the purification of the raw hydrogen, the hydrogen units can use the product. But the medium temperature transforming gas (340°C) is only used to warm-up the deaerated water (104°C) of the 3.5Mpa boiler. The gas with high temperature and high pressure has large potentials of doing works. It is wasteful to warm-up the deoxidized water with a low temperature. If we can decrease the calefaction temperature of the deaerated water, then we can use the exrescent energy to produce 1.0Mpa steam.

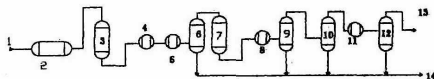


Figure 2: The flow circuit diagram of the second hydrogen production

- 1—steam and raw oil
- 2—waste heat oven E102
- 3—medium temperature conversion R103
- 4—raw material heat exchanger E104
- 5—3.5MPa boiler feed water heater E105
- 6—1st water segregator
- 7—low temperature conversion R105
- 8—feed water heater E106
- 9—2nd water segregator
- 10—3rd water segregator
- 11—water cooler
- 12—4th water segregator
- 13—production H₂
- 14—PSA

According the calculation related, the technical gas from medium temperature conversion R103 can produce 0.6MPa steam 10~20t/h, at the same time, it

can reduce the duty of the air-cooler, water cooler, and the evaporation capacity of the 3.5MPa boiler.

5.3 The continuous reforming regeneration

The continuous reforming regeneration equipment has 1.0MPa saturated emission water 10~20t/h (Summer10t/h, Winter20t/h), most of which enters into the condensate evaporating drum. The equipment is near with hydrocracking unit. If we can flash out steam (0.3MPa) to meet the needs of hydrocracking unit, then we will save the steam (0.6MPa) cost in it for regeneration system.

1.0MPa saturated water (heat content 781.3kJ/kg) can flash out 0.34MPa steam (saturated steam heat content is 2748.8kJ/kg, saturated water heat content is 40kJ/kg), the flashing rate is:

$$\alpha = \frac{781.3 - 640}{2748.8 - 640} = 6.7\%$$

Flashing steam is:

$$10 \sim 20 \times 6.7\% = 0.75 \sim 1.5\text{t/h}$$

Because of the steam existed in the saturated water, the practical steam is 1.5~2t/h, so it can save 0.6MPa steam 1.5~2t/h which is needed originally in the hydrocracking unit.

6. THE REBUILDING PROJECTS

1) Resuming the combined gas surplus heat boiler, what is more, warm-up deoxidized water and rise the ejecting gas temperature to avoid the dew point corrosion of the economizer and the boiler itself.

2) Add a new 1.0MPa steam generator between E104 and E105. Some of the heat in E105 can produce medium pressure steam. The other part of the heat in E105 can preliminary heating deaerated water.

3) Add a flash vaporized in the continuous reforming condensate drain system to produce steam.

7. TECHNICAL ECONOMIC ANALYSIS

The amine-rich liquor centralized regeneration equipment is designed to purchase 1.0MPa steam 30t/h from the power plant. The price of the steam is about 80 yuan per ton; the running time is 8000 hours every year. So the cost in all is 2000 thousands yuan a year.

If we can recover the surplus heat to produce steam, optimize the steam generation system, use the flash gas, and reconstruct the combined gas surplus heat boiler, we can produce 20~30t/h low pressure saturated steam instead of the purchase of 1.0MPa steam, we can save 1.0MPa steam 16~25 ton per year. The economic benefit each year is:

$$16 \sim 25 \times 80 \times 10000 \div 2 = 6.5 \sim 10 \text{ million yuan}$$

8. CONCLUSION

According to analysis above, It is feasible to recover the surplus heat to produce steam, optimize the steam generation system, use flash tank to make gas, and reconstruct the combined gas surplus heat boiler. The low-pressure saturated steam is transported to the amine-rich liquor centralized regeneration equipment. It will reduce the cost of the energy of the public project, and can bring about significant economic and social benefits. What is more, the invest recycle time is short. It is really worthwhile to be popularized in many chemical plants.

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