THE DEVELOPMENT PROSPECT OF SALT MAKING BY THERMAL RECOMPRESSION

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Abstract: The history and present situation of development of salt making by thermal recompression were expatiatesated home and abroad. It also introduces the the working principle of salt making by thermal recompression and analyzes the pros and cons of development of this process in China.

1. INTRODUCTION

Salt making by thermal recompression or mechnical vapor recompression (MVR) is a successful application of heat pump in vacuum salt making industry. It is one of the effective techniques that regenerates energy by means of low temperature vapor. Therefore, more and more attention is being paid to it in salt making industry because of its advantages of energy saving, environment protection and cleanness. In foreign countries, many plants of this kind have been put into operaton.since Escher Wyss Co. invented the process of salt making with MVR in 1917 The largest capacity of the single plant has reached 800,000 t/a so far. During the period of 1984 to 1986, an MVR salt making plant was imported into China by Zhangjiaba Salt Chemical Factory. However, it was shut down after operation for 4 years due to various reasons.

Along with the change of energy policy in China, the task of energy saving and emission reduction has become a key concern by all large scale salt making enterprises. The approach to salt making by thermal recompression is of great importance.

The development of large scale salt making plants has also becomes a focus on the economic operation. The study of salt making by multiple effects combined with MVR is of great concern to the salt making circle.

At present, the process of multiple effect evaporation combined with co-generation of heat and electricity has been applied in most salt plants for the sake of energy utilization in stages since salt making experienced flat pan boiling, single effect vacuum evaporation, multiple effect vacuum evaporation with separate generation of heat and electricity.

We hold that the process of salt making by mutiple effect vacuum evaporation with MVR and co-generation of heat and electricity has a bright future for development in salt making industry.

2.PRINCIPLES OF MVR

2.1 Introduction of principle of heat pump and analysis on energy conversion

In 1820s, Carnot, a French young engineer studied an especiallly important cycle—Carnot Cycle, which laid a theoretical foundation for heat pump technology. Till 1850s, William Thomson, an English physicist, put foward the concept of heat pump according to this. The first application of this concept to practice is the thermal recompression system by Worth, which consists of an evaporator and a compressor diven by turbine. This system emerged in the 19^{th} century.

Heat pump is actually a heat recovery unit. It absorbs heat from a lower temperature heat source and releases heat at higher

temperature heat source after the heat is upgrated, thus, higher grade energy is saved.

The energy conversion in heat pump is realized by a compressor which consumes certain amount of auxiliary energy, such as electricity. Lower temperature heat is absorbed by the compressor and convted into higher temperature heat, becoming higher temperature heat source output. Here, electricity is consumed for the running of compressor. However, the purpose of recovering lower yemperature heat source and making higher temperature heat source ia reached.

2.2 Introduction of salt making by thermal recompression and analysis on energy conversion

In most of the multiple effect evaporation salt plants, vapor from the last effect is removed through a condenser, where part of heat energy is lost and large amount of circulation water is needed. In MVR salt plants, vapor is adiabatically compressed through a compressor which makes P↑ and T↑. The compressed vapor is then led into an evaporator as heating steam. Thus, the latent heat is repeadedly utilized. No live steam is needed with the exception of start up. Normal operation is maintained and only driving force is needed for the compressor.

3. BRIEF DEVELOPING SITUATION OF MVR IN FOREIGN COUNTRIES

In 1970s, the energy crisis sped up the development of MVR, and MVR applied widely in chemical, sugar making, pharmaceutical and petro-chemical industries.

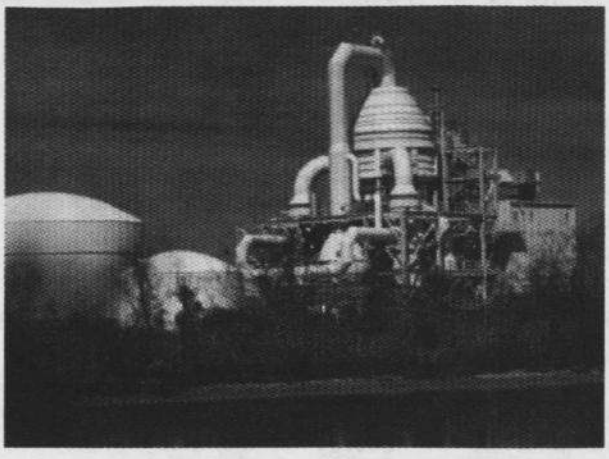
In salt making industry, fully utilizion of the secondary steam's energy for energy saving, consumption reduction and production cost reduction has become the focus. Therefore, MVR has been applied widely in USA and the European countries. In 1917, Escher Wyss, a Swiss company, became the first company who built an MVR salt plant. And in 1979, it built the largest MVR salt plnat with the capacity of 180t/h. Since 1970s, a number of MVR salt plant have been built in Italy, Switzerland, Arstria and Thailand. Literatures had it that those plants are running well. Under the preconditions of treated brine, the electricity consumption is about 150 kw/h, 80% of wich is consumed by the compressor. Live steam is needed as make up steam to heat the feed to be boiling only when the plant is being started up. NaCl content in the product reaches 99.9%.

In 1968, the American Swensen company designed a salt plant which was built in Silo-Marina-Calabria, Italy. The designed capacity was 1.5 milliom t/a. During the design, comparison of thermal balance and material balance for the processes of multiple effects and MVR was made. The comparison resulted in that the process of quadruple-effect evaporation combined with MVR could reach the goal of less investment and power consumption with larger capacity. In this plant, MVR evaporator is 12 m in diameter. Monel clad plate is used as construction materal for the evaporator with two 3×12m heater. Heating tubes are made of B70 copper-nickel alloy(Monel alloy). On top of the evaporator a mesh demister is equipped. The plant building is steel structure.The quadruple-effect evaporators are 8m in diameter. Monel clad plate is used as construction material for the evaporator with2.5X12m heaters. Heating tubes are made of B30 copper-nickel alloy. High pressure steam, 60kg/cm^2(a), 480°C,is used to drive two 10,000kW back pressure turbines. One of which is connected with an AC generator set wich supplies electric power for the whole plant. The other of which is connected with a 11-stage axial-flow vapor compressor which comprsesses vapor from 1.5kg/cm^2(a) to 3kg/cm^2(a). The comression ratio is 2. The cpapcity of the compressor is 250 t/h. The vapor suction pipe is 2m in diameter. All the back pressure steam from the two 10,000kW back pressure turbines are used as the heat source for heating the first effect of the quadruple-effect evaporators.

As the twentieth century became the twenty first, Pimai Salt constructed 4 MVR salt plants in Pimai city, northeast Thailand.The capacities are 100,000t/a, 200,000t/a, 200,000t/a and 500,000t/a respectively. In 2005, a new MVR salt plant with an investment of 23 million Euro was put into operation. Total capacity of Pimai Salt is now 1.5 million t/a.The production can meet the need of chemical industry.

In 1999, Texas Brine Co. constructed an MVR salt plant with the capacity of 700,000t/a in Baytown, which is designed by HPD. Texas Brine Co. is one of the major salt producers in USA. This plant produces high purity salt for use in chloro-alkaline, water

treatment, chemical and human concumption. This MVR salt plant is for the need of high purity salt for chloro-alkaline use.



The MVR sodium chloride crystallizer (700,000t/a) designed by HPD

This plant has made Texas Brine Co. possess the largest MVR salt crytallizer in the world after the plant was built. According information, the production and quality of salt produced from the plant is higher than the HPD designed targets.

A new MVR salt plant(single evaporator with two heaters) with the capacity of 110t/h(900,000t/a) owned by Shintech in New Orleans, Luisiana, USA, was put into operation in July, 2008. This new plant, a turn-key project by HPD, is now running smoothly. The compressor is driven by a 15 MW motor.

Another MVR salt plant designed by HPD will be put into operation in Spain in 2008.

At present, HPD is designing a new MVR salt plant with the capacity of 1,000,000t/a for CNSIC Jintan Salt Chemical Co.Ltd. The plant will be put into operation in 2010.

It can be seen from what has been mentioned above that MVR salt making process has been used as one of the reliable processes for quite a long time in many cases with complete success in foreign countries. Now, in China, salt making with MVR will surely arouse salt making experts and enterprises to pay much attention to MVR along with the development of salt making facilities towards large scale since the concept of recycle economy is being in full swing in China

Feed brine used for MVR is, in most cases, purified brine from which Ca and Mg ions are removed. However, raw gypsum-tye brine which is not purified is used in a few cases.

4.BRIEF INTRODUCTION OF DEVELOPMENT OF SALT MAKING WITH MVR IN CHINA

In 1984, approved by the Ministry of Light Industry, the State Salt Industry Administration,

Sichuan Light Industry Department and Zigong Economic and Trade Commission, a salt plant using MVR with the capacity of 100,000t/a was imported by the then Zhangjiaba Salt Chemical Factory. The purpose of the approval of this plant was to enable the salt industry in China to catch up with or reach the world advanced level and it was required that this imported plant be a example from which technical parameters could be accumulated for use in the technical modification of the vacuum salt plants.

The construction of this plant was completed in 1986 and it was put into operation in the same year. Its feed brine was gypsum-type brine without purification. At times of centrally-planned economy, production quota was arranged by the upper relative department. According to statistics, till November, 1989, the accumulated salt production was less than 200,000 tons with effective running time of less than half of the designed figure. The plant did not make any profit. It failed to be an example for the set purpose. Even so, experiences were gained and consensus on MVR was reached. It is written in the Report entitled "Organizing Contineous Operation and Gaining Scale

Profit" submitted to the then Zigong Salt Administration that "the plant is in a state of discontinueous operation. Equipment is corroded. Some electrical devices and instruments fail to work properly. We are worried about all these problems." It is also mentioned in the Report that the process of salt making with MVR is advanced, quality of the product is high and the result of energy saving is obvious. From the figures of this plant obtained during operation, energy consumption is 105.8 kg stand coal per ton of salt produced, which shows the result of energy saving is excellent compared with salt making with multiple effect process.

Along with the increase of the capacity of salt plants in China, the problem that steam and electricity in co-generation system are unbalanced is becoming more and mor obvious. Under the preconditions of no value when surplus electricity is distributed to the power grid, entreprenuers naturally turn theirs eyes to the process of multiple-effect combined with MVR with co-generation of steam and electricity. Hence salt making with MVR becomes a process that is paid much attention to.

5.ADVANTAGES FOR DEVELOPING SALT MAKING WITH MVR IN CHINA

5.1 Simple process makes full use of the energy in vapor

Generally, single stage vacuum evaporation is used for salt making with MVR. Its process is

simple. Apart from a forced circulating evaporator and a vapor compressor, its major equipment includes demister, vapor scrubber, centrifuge, dryer, preheater and condensate tank, etc.No more evaporators, vacuum system, circulating cooling water system, slurry transfer system are used. The land used for the plant is comparatively less than that for multiple-effect plant. MVR is characteristic of the fact that little work is done by the compressor driven by electricity to upgrade the vapor which does not deed to be condensed.

High quality of product

Salt produced with MVR contains NaCl as high as 99.9% with large particle size, which can

meet the requirement of high quality not only for human consumption, but also for special uses such as for prodcing caustic soda by ionic exchange membrane process and for producing metallic sodium.

A more reasonable system

In multiple-effect evaporation with MVR, electricity is used for MVR while multiple-effect

while steam is used for multiple-effect evaporation, which favors the steam-electricity balance. Good foundation is laid for economic operation of the boiler and the co-generation of steam and electricity. It is an ideal selection for the enterprises in which no other electricity is concumed.

Obvious result of energy saving and water saving in compliance with the policy of emission reduction.

It is cearly pointed out in the 11^{th} five-year plan that the major targets for the development of cyclic economy in China are: (1)energy consumption for a unit GDP reduces by about 20%, (2)water consumption for a unit industrial added value reduces by 30%, (3)rate of conprehensive utilization of mineral resources increases 5%, (4) rate of conprehensive utilization of industrial solid waste raises to 60% and (5)total amount of major pollutant discharge reduces by 10%. It is also required that enterprises must speed up technical modification with energy saving and environment protection, positively replace with new equipment that is chracristic of energy saving and emission reduction. The state will direct and encourage enterprises to use new equipment, new process and new technology in favor of energy saving and environment protection.

Since the latent heat in vapor is repeatedly utilized, there is no need for boiler house and the operation cost for circulating water system is saved. Also the land for boiler house and circulating water system is saved.Thermal economy of steam is increased. The discharge amount of waste gas, waste solids and waste water is reduced. This is just required by the state policy of energy saving and emission reduction.Salt making plant with MVR is most suitable for where low price electricity is abundent and water resource is in short.

The readjustment of energy structure in China favors the construction of salt making plants with MVR

Along with the readjustment of the energy structure in China, hydraulic power, wind power and biological power will be

developed on a large scale. The electricity structure will be further optimized The plan of encouraging large-scale plants and restricting small-scale plants will be steadly implemented. And the structure of coal-fired boilers will be further optimized. In the same time, neuclear power will be positively promoted. Electricity price tends to drop. Therefore, the advantages of salt making plants with MVR driven by electricity are more and more obvious.

Obvious effect of environment protection

Due to the fact that vapor is repeatedly utilized there is no discharge of tail gas and cinder from boiler, no discharge of waste water of condesation of steam exhaust from the last effect evaporator in salt making plants with MVR. Air pollution and environment pollution are greatly reduced. Such plants are of high energy saving and environment friendly, which is in compliance with the basic policy of energy and environment protection.

Narrow the gap of salt making techology between China and foreign countries

Salt making with MVR is an advanced process which is of energy saving, environment

Protection, and high quality product. In foreign countries, many such plants are running successfully. Although the first plant imported was a failure, import and absorbing of MVR process so as to promote the advancment of salt making technology in China and narrow the gap between China and foreign countries in this respect are an important issue for Chinese salt makers to be concerned with.

Enhance the competitiveness of the enterprises

The process for salt making plants using multiple-effect evaporation and MVR with co-generation of heat and electricity can reach the gaol of reasonably utilizing the resources, reducing production cost, increasing economic result and enhancing the competitiveness of the enterprises.

Condition for construction of salt making plants with MVR is more and more mature

Compared with the condition when Zhangjiaba Salt Chemical Factory imported the salt plant with MVR, the level of management, quality of the personnel, capacity of the plant, automation has been greatly enhanced. This is a solid foundation for contruction of salt making plants with MVR which require careful management and smooth operation.

Surplus self-generated electricity to the grid does not create any value

At present, the connection of surplus electricity generated by the power station owned by the

enterprises to the grid doesnot create any value, but on the contrary, certain amount of money has to be paid by the enterprises.The utilization of this surplus electricity is one of the effective ways for the reduction of production cost..

6.DISADVANTAGES FOR DEVELOPING SALT MAKING WITH MVR IN CHINA

6.1 Lessons drawn from failure

Shade has been cast on us because of the failure of the first imported salt plant with MVR with various reasons.

6.2 The key equipment, vapor compressor, has to be imported

Such type of vapor compressor cannot be made in China at present. Its use and maintemance lack better undstanding. Cost for import the compressor and its spare parts is high.

6.3 Scrubbing of vapor needs to be further studied.

The heat source for salt plant with MVR comes from the vapor which is adiabatically compressed by compressor. The quality of vapor entering into the compressor is very high, or otherwise, it will influence the safe operation of the compressor, resulting in failure of the running of the whole system with great loss.

6.4 Feed brine for salt plants with MVR in foreign countries or imported into China is purified for the removal of Ca and Mg ions. Brine treatment will increase the production cost. Under the conditions of the same price for salt regardless of its quality with no competiveness on the market. However, in foreign countries, a few salt plants with MVR are running smoothly with untreated gypsium-type brine.

6.5 The quality of the personnel needs to be upgraded.

6.6 Stable power supply has to be ensured.

7. CONCLUSIONS

Salt making process with MVR is an advanced and reliable process.Along with the enhancement of management level, quality of personnel, plant capacity and automation, there will be no problem at all to master it. The spreading and application of salt making process with MVR will favor the promotion of the advancement of Chinese salt making process, the shortening of the gap between China and foreign, and the increase of competitiveness of Chinese salt making enterprises on the international market. The state policy of energy saving, consumption reduction and emission reduction will favor the enterprises to select the construction of salt making process with MVR. Also the state policy of encouraging the newly-built salt plants with the capacity of over 600,000t/a can solve the problem of unbalance of steam and electricity, which will promote the development of salt making process with MVR in China.