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The use of low-temperature potential of the environment in energy-efficient refrigeration supply technologies of the enterprises of GC "Titan".

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Abstract

The paper deals with issues on the improvement of the refrigeration supply system of a petrochemical enterprise in Western Siberia. Using a low-temperature potential of the environment allows for saving on some productions up to 50% of energy resources. It also describes variants of refrigeration supply schemes using new energy-efficient technologies.

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Keywords: petrochemical enterprise; ammonia refrigerating installation; low-temperature potential; energy efficiency; air-cooling units; operating modes.

1. Introduction

A considerable part of heat power resources (HPR) at the enterprises of JSC "GC "Titan" is spent on the cold production, necessary for ensuring the performance of the technical processes of the main productions. So, for example, at the petrochemical enterprise PJSC "Omsk Rubber" the ammonia refrigeration supply system consumes up to 35% of electricity and cooling water system - up to 20% of the total consumption of HPR.

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The special feature of refrigeration supply system at PJSC “Omsk Rubber" is that ammonia refrigerating installations (ARI) remove heat from the intermediate refrigerant (brine), which provides temperature control and flow of primary and supporting technological processes at the level of 266 – 2800 K.

Taking into account the high degree of energy consumption by ARI, it is particularly relevant to resolve the issue on the implementation of the austerity of electricity and water by the use of existing and new energy-efficient technologies in the reconstruction of the operating complex of thermotechnical equipment.

Experience in this field shows that, along with the replacement of obsolete and worn out equipment, the implementation of energy-efficient technologies allows for reducing energy consumption from 20 to 60% and water consumption up to 50%. At the same time, the payback period of the costs of reconstruction is in a range from 1 to 1.5 years.

Since the climatic conditions of Omsk region "provide" negative ambient air temperature for more than 7 months in a year, it is a very promising direction of energy resources saving to use the natural cold in refrigeration supply systems.

2. Study subject and methods

On the basis of the conducted energy audit of the existing ammonia refrigerating equipment and brine supply lines in the technological apparatus of the main productions, technical specialists of JSC "GC "Titan", PJSC "Omsk Rubber" and scientists of Omsk State Technical University has developed a number of measures to reduce HPR for the cold production through the use of low-temperature potential of the environment.

At the first phase of the implementation of the measures, it was decided to use natural cold for cooling of the intermediate refrigerant in the air-cooling units (ACU).

3-year practice of ACU use on brine line showed that the payback period of additional equipment does not exceed 1.5 years, and the consumption of energy resources necessary for the cold production comes down by 25% in value terms.

Further work in this direction was carried out in the framework of improving cooling units of chillers. Using the ideas of combined cooling of ammonia machine condensers described in [1-5], for one of the sections of the refrigeration supply workshop of PJSC "Omsk Rubber" there was a patented refrigerating installation [7] developed, a simplified scheme of which is shown in Fig. 1.

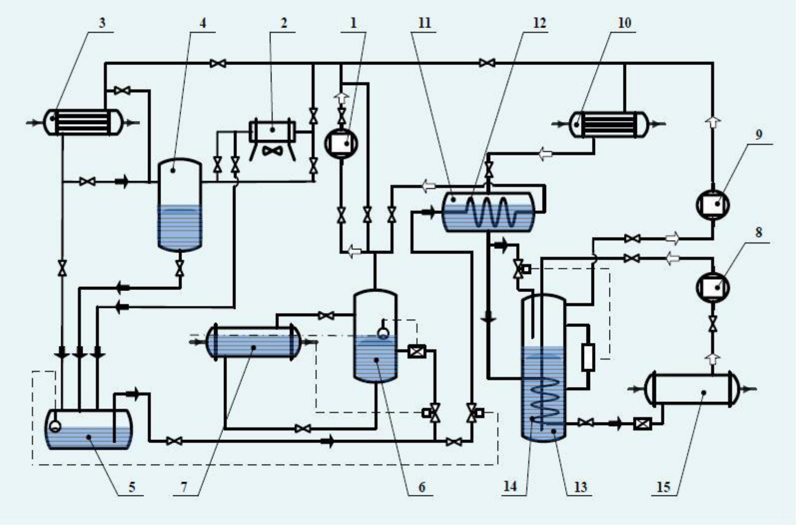

Fig. 1. Refrigerating installation scheme.

The refrigerating installation includes two refrigeration systems.

The first system contains compressor 1, air-cooled condenser 2, water-cooled condenser 3, separating chamber 4, receiver 5, liquid separator 6, evaporator 7.

The second system contains compressors 8, 9, water-cooled condenser 10, receiver – super cooler 11 with coil 12, intermediate vessel 13 with coil 14, evaporator 15.

In addition, the receiver–super cooler 11 is connected by pipelines to the water-cooled condenser 10 and intermediate vessel 13 of the second refrigeration system, and the coil 14 of the receiver –super cooler 11 is connected by pipelines to the pipeline of liquid refrigerant supply to the liquid separator 6 and to the pipeline of vapor outlet from the liquid separator 6 of the first refrigeration system.

The direction of the refrigerant flows movement in both systems is provided by stop valves.

The refrigerating installation operates as follows.

In the period when the ambient temperature is higher than the temperature of the cooling liquid (water), the compressor 1 of the first refrigeration system sucks in refrigerant vapor from the evaporator 7 via the liquid separator 6 and pumps in air-cooled condenser 2. There partially condensed refrigerant, passing through the separating chamber 4, is divided into vapor and liquid; vapor goes to the water-cooled condenser 3, then the liquid condensate is discharged into the receiver 5. Hereto also flows the liquid refrigerant from the separation chamber 4. From the receiver 5 the liquid refrigerant, after passing through the stop and control valves, is throttled in the liquid separator 6, connected to the evaporator 7 as communicating vessels.

The second refrigeration system (for lower boiling temperature) operates autonomously in the usual way of the two-step compression with the intermediate vessel 13 and coil 14. The refrigerant vapor, boiling in the evaporator 15, absorbed by the low pressure compressor 8 and pumped under a layer of the liquid refrigerant into the intermediate vessel 13. Bubbling through the layer of the liquid refrigerant, the refrigerant vapor in the saturated state are supplied for suction of the high pressure compressor 9 which pumps them into the water-cooled condenser 10. The condensed refrigerant flows into the receiver – super cooler 11, which serves only as a receiver during this period and then it is divided into two flows. Most of the liquid is supplied to the coil 14 of the intermediate vessel 13, where it is cooled and then enters the evaporator 15. The other portion of the liquid refrigerant is throttled through the solenoid valve into the intermediate vessel 13, creating in it a predetermined liquid level controlled by level sensor.

In the period when the ambient temperature is lower than the temperature of the cooling liquid in the refrigeration system the refrigerant vapor compressed in the compressor 1 enters the water-cooled condenser 3. Then the partially condensed refrigerant enters the separation chamber 4, where it is separated into vapor and liquid. The vapor enters the air-cooled condenser 2 and the condensed refrigerant flows into the receiver 5. From the separation chamber 4 the liquid refrigerant is also discharged into the receiver 5. From the receiver 5 the liquid refrigerant, after passing through the stop and control valves, is throttled in the liquid separator 6, connected to the evaporator 7 as communicating vessels.

The second system (for lower boiling temperature) operates in the same way as in the previous period.

In the period when the ambient temperature is lower than the temperature of the cooled object the installation of the first system operates without refrigerant compression (without the compressor 1 operation). Heated refrigerant in the evaporator 7 in gaseous form enters the liquid separator 6, from which, bypassing the compressor 1, flows into the air-cooled condenser 2 where it is condensed, releasing heat into the environment (the compressor 1, the water-cooled condenser 3 and the separation chamber 4 are disabled by stop valves). Then the condensed refrigerant enters the receiver 5, after which a part of the liquid refrigerant through solenoid valve and level sensor in the required amount enters the separator 6 to maintain the desired outlet temperature of the cooled object, such as brine in the evaporator 7. The other part of the liquid refrigerant enters the coil 12 of the receiver-super cooler 11 of the second refrigeration system, where it boils, supercooling the condensed refrigerant coming from the water-cooled condenser 10 of the refrigeration system.

Formed at boiling in the coil 12, the refrigerant vapor through the relevant opened valves enters the air-cooled condenser 2 of the first refrigeration system.

In the second refrigeration system supercooling of the liquid refrigerant after the water-cooled condenser 10 reduces the throttle losses and increases the specific mass cooling capacity of the refrigerant. This reduces the refrigerant consumption through the low pressure compressor 8 and high-pressure compressor 9 and, consequently, reduces costs for compression work. Reduction in the refrigerant consumption in the first place through the second stage is connected with the transition of a part of the heat load from the coil 14 to the receiver - supercooler 11.

To ensure the refrigerant's movement due to natural circulation of the refrigerant in the first refrigeration system the evaporator 7, and the liquid separator 6, and also the receiver - supercooler 11, the receiver are located at the same level relative to each other, and the air-cooled condenser 2 is located above the evaporator 7.

Such a refrigeration system can reduce the temperature difference between the refrigerant and brine, significantly reduce water consumption, and disconnect the compressors and use the natural cold for an extended period at cooling of the refrigerant in the air condenser.

3. Results and discussion

Based on the calculation study carried out using a mathematical model developed in OmSTU [6], the necessary parameters have been defined for selecting additional thermotechnical equipment and rational sequence of switching on of condensers of the air and water-cooled condensers at different ambient temperatures.

It was found that the optimal modes that provide cold with minimum total consumption of electricity and water are:

with switching on of air-cooled condenser, without compressing the refrigerant, in the ambient temperature range from 228 to 2590K;

with sequential switching on of water-cooled and air-cooled condensers in the ambient temperature range from 260 to 297 0K;

with sequential switching on of water-cooled and air-cooled condensers in the ambient temperature range from 298 to 308 0K.

Thus, at different values of the ambient temperature and cooling liquid temperature, air-cooled and liquid-cooled condensers operate in a different sequence. Ability to change the ratio of the heat loads between the air-cooled and liquid-cooled condensers allows for increasing of the cooling capacity of the ARI both in winter season and in summer season. This provides a more reliable and efficient operation of the installation.

Regulation of the refrigerating installation with air-cooled and water-cooled condensers comes down to the regulation of the condensation temperature, provided that the necessary amount of the refrigerant is supplied in the cooling device at an arbitrary value of the ambient temperature.

Systemic regulation of controlled parameters of the refrigerating installation in accordance with the results of the preliminary optimization study makes it possible to ensure minimum operating costs.

4. Conclusion

Calculation studies show that the use of low-temperature potential of the environment in modernization of industrial refrigerating installations in Western Siberia allows for saving of energy resources in the amount of not less than 50% compared to the costs of operating refrigeration supply systems.

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