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Analysis on Optimal Design Scheme of Shell and Tube Heat Exchanger with Given Heat Transfer Temperature Difference

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Abstract: In industrial production and processing, the use of heat exchange equipment can realize the heat transfer between materials and achieve the goal of energy saving. At present, heat exchange equipment is used in many industrial production fields. In recent years, in China's social production and life, the awareness of energy conservation and environmental protection has been continuously strengthened, which has also promoted the development and application of relevant energy-saving technologies. Relevant heat exchange equipment can effectively recycle high-temperature and low-temperature heat energy, with remarkable economic benefits. Shell and tube heat exchanger is the most widely used of all kinds of heat exchangers at present. This kind of heat exchanger has simple structure, good stability, wide practicability, low cost, convenient cleaning of heat exchange surface, and can meet the working environment of high strength and temperature. However, in the design of shell and tube heat exchanger, given the heat transfer temperature difference, some problems are easy to appear in the design of heat exchanger. Therefore, it is necessary to try to solve the problems through the idea of optimal design and improve the utilization efficiency of heat exchanger.

Keywords: Given Heat Transfer Temperature Difference; Shell and Tube Heat Exchanger; Optimal Design

Shell and tube heat exchanger is very popular in the market. It has good application effect when it is applied to large-scale, high-pressure and high-temperature environment. For the optimization design of shell and tube heat exchanger, there are also relevant studies in the academic community. In the research, many scholars tend to locate the optimization goal, and reduce the weight of heat exchanger, so as to improve thermodynamic performance, and enhance heat transfer and so on. Under the given heat transfer temperature difference, the shell and tube heat exchanger may have different degrees of heat loss in use, which is not conducive to the realization of the goal of energy conservation and environmental protection. Therefore, it is necessary to continuously optimize the design scheme and ideas in the design of shell and tube heat exchanger to ensure that the shell and tube heat exchanger can work efficiently under the given heat transfer temperature difference.

1. Optimization design idea

As far as the production of modern industrial enterprises is concerned, there are two kinds of heat losses generated by heat exchangers. One is the heat loss caused by the heat transfer temperature difference. This heat loss is mainly generated in the heat transfer boundary of the internal and external specific surface of the heat exchange pipe. For this part of heat loss, the design can be optimized by accelerating the flow rate and optimizing the internal and external surface structure of the heat exchanger pipe. There is also a case of heat loss due to mechanical heat loss caused by flow

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resistance. In many public welfare production and processing processes, there are certain parameters and standard requirements for material quality, type, flow rate, inlet and outlet temperature. Therefore, the extra bright loss can often be calculated. In this regard, based on the annual cost of relevant enterprises, it mainly includes annual depreciation expense of equipment and heat loss cost. In terms of the causes of heat loss of heat exchanger, in the specific design of shell and tube heat exchanger, as long as we grasp the key heat loss part and make appropriate optimization and improvement, we can effectively reduce the heat loss in the given heat transfer temperature difference.

2. Main problems and optimization countermeasures in the design of shell and tube heat exchanger

In the design of shell and tube heat exchanger, the rationality of relevant design structure and the selection of relevant materials will have varying degrees of impact on the heat transfer capacity. Therefore, it is necessary to clarify the main problems in the use of heat exchanger to analyze and study the optimal design countermeasures of corresponding problems.

2.1 The tube side pressure exceeds the shell side pressure

In the design of shell and tube heat exchanger, if the tube side design pressure exceeds the shell side design pressure, and the selected shell side test pressure is still a conventional value, this is problematic. In this regard, it is necessary to check the tightness of the pipe and tubesheet, and to deal with the shell side test pressure, we should start from the following points:

First, increase the shell side test pressure to keep it consistent with the shell and tube test pressure. In this regard, the first step is to calculate the stress value of the shell in the pressure test to ensure that the membrane stress value at all points on the shell side is kept within 90% yield limit at the material test temperature. In addition, relevant flanges, nozzles, etc. .also need to meet the strength standard under pressure test.

Second, after calculation, if the above test method cannot be selected, the test pressure of the corresponding shell side and tube side will be tested at the required test pressure. When the pressure test meets the standard, the shell side will be tested with 1% compressed air containing ammonia volume 1.05 times the design pressure of the shell side.

Third, for heat exchangers with special requirements, the leakage test can be carried out by pressure against pure ammonia, or other side leakage methods can be used.

2.2 Baffle layout of horizontal condenser

In the shell and tube heat exchanger, the medium of the horizontal condenser is mainly the coexistence of liquid and gas, and the corresponding baffles need to be arranged on the left and right. If it is arranged up and down, it is difficult for the condensate to be discharged. Especially when the condensate level is higher than the gap under the upper baffle, it will lead to the phenomenon of liquid seal, resulting in steam flow, which is not conducive to the effective heat transfer of the equipment.

For this reason, in the layout of the baffle plate of the horizontal condenser, we should try the left-right layout, and ensure that the included angle between the highest and lowest positions of the baffle plate can reach 90 degrees, and the depth of exhaust and liquid discharge should not be less than 15mm.

2.3 There is no heat treatment for the large connecting pipe or split partition of the pipe box

In the design of shell and tube heat exchanger, there are generally two types of tube box design of heat exchanger. One is not to heat treat the tube box; There is also the need for heat treatment of the pipe box. Whether heat treatment should be carried out or not requires specific analysis of specific problems.

First, heat treatment shall be carried out after welding for split diaphragm pipe boxes welded with carbon steel and low alloy steel and pipe boxes with holes greater than one-third of the inner diameter of the cylinder, so as to eliminate the stress generated during welding.

Second, for austenitic stainless steel pipe boxes, no heat treatment can be considered. However, if it has high corrosion resistance requirements or is used in high temperature environment, it is necessary to discuss the use of heat treatment methods.

2.4 The heat exchange tube is not standardized as required

In the specific quality standard document of heat exchanger, the relevant grade tube bundle of heat exchanger is specified. In the design, it is necessary to specify the tube bundle grade of the heat exchanger. Generally, class I heat exchange tubes belong to high-precision cold drawn heat exchange tubes, which are mostly used in occasions without

phase change heat transfer or prone to vibration; Class II heat exchange tube is an ordinary cold drawn heat exchange tube, which is more suitable for occasions without vibration. Only by selecting the heat exchange tube of the corresponding level, can we ensure that the deviation between the tubesheet and the tube hole, baffle and so on is small, and ensure that the design accuracy meets the standard.

Given the heat transfer temperature difference, the relevant heat loss can be basically determined. The design optimization process of shell and tube heat exchanger is relatively complex. In the design, it is necessary to grasp the relationship between relevant factors and consider the influence of relevant parameters. The application of shell and tube heat exchanger can heat the wet air in the tube side to a specific temperature, which mainly depends on the heat release of shell side fluid in heat exchange. In the specific heat exchanger design optimization, the shell side fluid sensing membrane coefficient and shell side pressure drop will also have an impact on the shell and tube heat exchanger, but this impact is not obvious and can be ignored. In the specific design optimization process, it is also necessary to fully consider the relevant working conditions and environment, and do a good job in the necessary basis for the analysis of the optimization process, so as to ensure the applicability and rationality of the optimization design.

3. Conclusion

Shell and tube heat exchanger plays an important role in heat transfer in practical application. Given the heat transfer temperature difference, the shell and tube heat exchanger mainly needs to solve the problem of heat loss in the heat transfer process. Therefore, it is necessary to grasp the main problems and causes of heat loss in the heat transfer process, and take targeted solutions and optimization methods. Through the optimization design, the transmission efficiency of shell and tube heat exchanger can be significantly improved, so that the related heat transfer process can achieve better energy-saving effect.

References

1. Shi Y, Zhao W, Yuan Y, et al. Effect of corrugated pitch on shell side flow performance and resistance performance of plate and shell heat exchanger. Light Industrial Machinery 2021; 39(05): 32-36.
2. Li G, Wang S, Sun Z, et al. Simulation and optimization of spiral baffle heat exchanger based on coal water slurry preheating coal gasification. Coal Chemical Industry 2021; 49(04): 41-46.
3. Du S, Xu Z, Wang R, et al. Application of (fire accumulation) method in heat exchange network optimization of low-grade industrial waste heat utilization. Chinese Science: technical science:1-11[2021-10-09].http://kns.cnki.net/kcms/detail/11.5844.TH.20210825.1600.002.html.
4. Wang F, Rong R. Comparison of tubesheet structure types and calculation methods of medium fixed tubesheet heat exchanger. Shandong Cemical Industry 2021; 50(16): 190-192.
5. Hao H, Wen J, Zhao X, et al. Study on the performance of new corrugated serrated fins of negative pressure low temperature plate fin heat exchanger in superfluid helium system. Journal of Xi'an Jiaotong University 2021; (11): 1-7.
6. Men J, Qiu J, Chen X. Optimization strategy of regional integrated energy system based on advanced adiabatic compressed air energy storage. Journal of Nanjing University of Information Engineering (Natual Science Edition) 2021: 1-11.