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Research on the Application of Energy-saving and Consumption-reducing Technologies in Chemical Enterprises

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Abstract: With the rapid development of the social economy, ecological environmental problems become increasingly prominent and attract more attention. As a higher energy-consuming industry, chemical enterprises should take corresponding social responsibilities under these circumstances. Chemical enterprises should increase the application of energy-saving and consumption-reducing technologies in daily production to promote the transformation and upgrading of the industry. Based on this, this paper will analyze the importance of energy conservation and consumption reduction in chemical enterprises, as well as elaborate on the specific role and application status of common energy-saving and consumption-reducing technologies and discuss the application optimization strategies of energy-saving and consumption-reducing technologies in chemical enterprises, to provide some references for practitioners in chemical industry.

Keywords: Chemical enterprises; Energy saving and consumption reduction; Application strategy

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1. Introduction

In the new era, the in-depth implementation of green and sustainable development has put forward higher requirements for the production of chemical enterprises. In this regard, chemical enterprises should actively explore the effective application of energy-saving and consumption-reducing technologies in production. Through the application of energy-saving and consumption-reducing technologies, the production process is optimized, and unnecessary production steps are reduced, to improve production efficiency. At the same time, reducing energy consumption and environmental pollution will also help promote the sustainable development of chemical enterprises and make them more competitive in the market.

2. The importance of energy conservation and consumption reduction in chemical enterprises

2.1. Enhance the economic benefits of chemical enterprises

At present, the process of economic globalization is accelerating, and the competition in the chemical product market is becoming more and more fierce. In this context, enterprises should not only continuously improve production efficiency and product quality, but also pay attention to production costs and environmental protection. Therefore, chemical enterprises should pay more attention to energy conservation and consumption reduction, actively explore ways to reduce energy consumption in production, and further reduce the production cost of enterprises. In this way, chemical enterprises can improve the market competitiveness of their products while gaining more profit margins. At the same time, the application of energy-saving and consumption-reducing technologies can also help chemical enterprises reduce pollution emissions, obtain more government-level policy preferences and market recognition, and realize the effective improvement of economic benefits of chemical enterprises.

2.2. Optimize resource allocation and utilization

With the rapid development of chemical technology and techniques, how to optimize resource allocation and utilization has become a new challenge for chemical enterprises. The application of energy-saving and consumption-reducing technology is to reduce the consumption of raw materials and energy use in chemical production through technological innovation and improvement, thereby reducing production costs and environmental burdens. In chemical production, the selection and use of raw materials have a direct impact on energy consumption and environmental emissions [1]. Adopting new or more environmentally friendly materials can reduce dependence on traditional resources, energy consumption, and waste emissions in the production process. In addition, it is also important to strengthen the control of the production process and the fine management. Enterprises should strengthen real-time monitoring and data analysis and adjust production parameters accordingly to improve resource utilization.

2.3. Follow the appeal for green and sustainable development

At present, green and sustainable development has become an important trend in the development of the chemical industry, and how to reduce resource consumption and environmental pollution by taking effective measures has become a key issue for social enterprises as a “big player” of energy consumption and pollutant emissions. The application of energy-saving and consumption-reducing technologies can effectively reduce the energy consumption and waste emissions of chemical enterprises. In addition, it is also an effective way for chemical enterprises to optimize the production process and improve the efficiency of raw materials and energy utilization. In short, chemical enterprises should take the initiative to assume social responsibilities, increase the application of energy-saving and consumption-reducing technologies in production, and make positive contributions to the realization of green and sustainable development.

3. The specific role of common energy-saving and consumption-reducing technologies in chemical enterprises

3.1. Reduce energy consumption in the production process

Whether it is raw material processing, reaction process, or chemical production links such as separation and

purification, a lot of energy or raw materials need to be consumed. Therefore, enterprises should apply energy-saving and consumption-reducing technologies in these links, which can not only reduce energy consumption and production costs in the production process but also reduce the negative impact of production on the ecological environment. In practical applications, chemical enterprises can reduce energy consumption in the processing of raw materials by introducing advanced equipment, optimizing production processes, or adopting new technologies. Then, low-temperature, low-pressure, high-catalyst, and other technologies are used to improve the reaction efficiency in the reaction process [2]. In addition, in the separation and purification process, advanced technology can also be adopted to reuse the separated waste, reduce the discharge of reactive waste, and maximize the utilization of resources.

3.2. Promote energy recycling

Chemical production is inseparable from thermal energy, and with the help of energy-saving and consumption-reducing technology to reduce heat energy consumption in the production process, energy recycling can be realized. Chemical enterprises can use waste heat recovery technology to reuse the heat energy in the waste, thereby reducing the loss of heat energy and energy consumption in the production process. At the same time, the application of energy-saving technology can also reduce the waste generated in the chemical production process and make resource utilization. This can convert waste that can only be discharged into the natural environment into production energy, achieve good energy recycling, and reduce pollution in the surrounding environment. This is also an effective way for chemical enterprises to practice the concept of sustainable development, to achieve the coordinated development of enterprise economic benefits and ecological environment.

3.3. Reduce the kinetic energy loss in the production process

In the chemical production process, a large number of equipment needs to run continuously and uninterrupted to ensure the smooth operation of the production process. If the kinetic energy loss is too large, it will not only increase the operating cost of the enterprise but also reduce the production efficiency and product quality. By introducing advanced reactors and continuously optimizing the conditions and environment of the reaction process, chemical enterprises can effectively improve the conversion rate of reactants, thereby improving the quality of chemical products. Enterprises can reduce kinetic energy loss in the production process by adopting high-efficiency and energy-saving equipment, implementing frequency conversion speed regulation technology, and optimizing the heating system. For example, by optimizing the heating system in production and recycling waste heat, steam consumption can be significantly reduced. This also fully proves the effectiveness and feasibility of energy-saving and consumption-reducing technology in reducing kinetic energy loss in the production of chemical enterprises.

4. Common energy-saving and consumption-reduction technologies in chemical enterprises

4.1. Energy-saving transformation technology of equipment

With the rapid development of high and new technology, the production equipment in chemical enterprises also needs to be updated and upgraded, the traditional high-energy-consuming equipment is transformed and upgraded, and high-efficiency and energy-saving equipment are used to carry out production. The energy efficiency ratio of the renovated equipment will be greatly improved, which not only ensures production efficiency and

production quality but also reduces energy consumption. For example, the frequency conversion energy-saving speed regulation technology is to change the power supply frequency of the motor and adjust the speed of the motor, to change the flow rate and pressure of the pump or compressor to meet the actual production demand. The application of this technology can improve the energy loss caused by adjusting the flow rate through valves or baffles in the traditional fixed-speed operation mode, thereby reducing the energy consumption of the motor traction system and improving energy efficiency. In chemical production, centrifugal pumps, compressors, and other large-scale rotating equipment apply frequency conversion energy-saving speed regulation technology, which can effectively reduce power consumption.

4.2. Heat recovery technology

The heat energy recovery system is mainly composed of heat exchangers, steam recovery devices, etc., and its main function is to efficiently collect and utilize the heat energy generated in the chemical production process, to achieve the purpose of energy saving and consumption reduction. The heat exchanger is used to transport the waste heat generated in the high-temperature production process to the low-temperature fluid, to realize the transfer and utilization of heat. The heat exchanger can convert waste heat into other energy such as steam or hot water, and then heat some raw materials and media in production. At the same time, the steam recovery device can recompress and reuse the steam generated in production, reducing the demand for new steam and achieving the purpose of energy saving and consumption reduction. The core of the heat recovery system is to rationally configure and optimize each component to ensure the effective recovery and utilization of heat energy, maximize energy utilization, and reduce energy consumption and emissions in chemical production.

4.3. Water conservation technologies

In the production of chemical enterprises, the water used in production can be optimized through the following water conservation technologies. The first is to strictly manage water resources. Chemical enterprises should strictly monitor the use of water resources in the production process, limit and regulate wasteful behavior, and ensure the rational use of water resources. The second is the use of rainwater and unconventional water resources. Chemical enterprises with large water consumption should set up rainwater collection ponds to treat the collected rainwater as supplementary water for production and improve the utilization rate of water resources. In addition, chemical companies in coastal areas can also introduce desalination water as industrial water to minimize the use of tap water. The third is smart water management. Through the establishment of a smart water management system, chemical enterprises use big data, cloud computing, and other information technologies to achieve real-time monitoring, early warning, and optimal scheduling of water use. Through the monitoring of the amount of new water, steam, and circulating water in each production line, the daily statistical analysis, monthly statistical analysis, year-on-year and month-on-month data analysis, and alarm function of the system are used to continuously improve the production water system.

4.4. Resource recycling technology

Resource recycling is an effective way to achieve energy conservation and consumption reduction in chemical enterprises. By optimizing the ratio of raw materials and improving the utilization rate and conversion rate of production, chemical enterprises can effectively reduce the material and energy consumption of chemical production. In addition, increasing the recycling of by-products and waste generated in the chemical production

process can also improve the efficiency of resource utilization. For example, in chemical production, exhaust gases can be treated by equipment such as absorption towers, condensers, and membrane separators. Wastewater should be treated according to the corresponding requirements using aeration tanks, bioreactors, and membrane separators. The recycling of waste heat requires the use of equipment such as heat exchangers, steam generators, and heat pumps for treatment and reuse. When selecting treatment and recycling equipment, it is necessary to consider the cost comprehensively and to ensure energy conversion efficiency and environmental protection factors [3].

4.5. Fine purification technology

First, chemical companies should choose efficient purification technologies according to the nature of the materials produced. For example, for liquid mixtures with large differences in boiling points, distillation or rectification technology can be preferred in production, using the different boiling points of the components in the material to achieve efficient separation. For solid mixtures, crystallization and recrystallization techniques are used to purify them according to the principle that their solubility changes with temperature. Secondly, chemical enterprises should also introduce advanced purification technology. For example, membrane separation technologies such as reverse osmosis, ultrafiltration, and nanofiltration have the advantages of low energy consumption, easy operation, and no phase change and their application to chemical production and purification can effectively improve the purification effect. Chromatography such as liquid chromatography and gas chromatography takes advantage of the difference in the partition coefficient between the stationary and mobile phases of different substances to achieve efficient and precise separation of production materials [4]

4.6. Intelligent energy-saving technology

With the accelerated digital transformation and upgrading in the chemical industry, the application of various intelligent energy-saving technologies has led to significant energy conservation and consumption reduction in chemical production. Currently, some chemical enterprises have introduced intelligent production systems, which, through the effective utilization of high-tech such as sensors and the Internet of Things, enable real-time monitoring of the operating status of production equipment, process parameters, and product quality. At the same time, chemical enterprises can also utilize artificial intelligence and big data analysis technologies to deeply mine and analyze the collected data, thereby optimizing production plans and process parameters. This not only enables the automation, digitalization, and intelligence of the production process, reduces labor, and improves production efficiency, but also lowers energy consumption and raw material waste through the optimization of production plans and process parameters [5]

5. Application status of energy-saving and consumption-reducing technologies in chemical enterprises

5.1. Chemical process updates are relatively slow

At present, the chemical industry is facing dual pressures of energy and environment, but there are still some chemical enterprises that use traditional production processes and have not kept pace with technological innovation and upgrading. On the one hand, traditional chemical production processes often have low conversion efficiency of raw materials due to their simple technology, resulting in a significant waste of resources. In addition, traditional chemical production processes rely heavily on traditional energy sources such as coal and natural gas.

These energy sources also suffer significant conversion losses during the production process, exacerbating energy consumption [6]. On the other hand, due to slow process updates, many waste gases, wastewater, and solid waste generated during chemical production can only be directly discharged, resulting in low recycling efficiency. This not only increases the production costs of chemical enterprises but also has a certain impact on their social image and sustainable development capabilities.

5.2. High energy consumption of chemical production equipment

Chemical production relies on the operation of various production equipment to achieve chemical conversion and material processing. However, these devices often require a large amount of energy consumption, leading to high overall energy consumption in chemical enterprises. On the one hand, some chemical production equipment was designed to focus on cost and production capacity rather than energy conservation and consumption reduction. Over time, this has significantly increased the energy consumption of chemical enterprises. On the other hand, chemical enterprises have a relatively long cycle for equipment inspection and maintenance, especially for systems involving high-power equipment and key operating links, such as compressors, distillation towers, etc. To ensure daily production, the maintenance frequency is relatively small. Long-term inadequate maintenance of equipment not only increases energy consumption but also accelerates wear and tear and shortens its lifespan [7].

5.3. The quality of chemical production management is not high

The relatively low quality of production management in chemical enterprises may be caused by many factors. For example, some chemical enterprises may still adopt the traditional production and operation management mode, which may have an adverse impact on the production quality and production efficiency of the enterprise. In addition, the imperfect management system is also an important reason, which may lead to the non-standard phenomenon of the production process of chemical products, and managers find it difficult to fulfill their duties. Some chemical enterprises also rely on manual inspection to inspect some chemical products, which may ignore the minor differences in the products and lead to quality problems. Chemical enterprises should increase their investment in chemical production quality management, and introduce advanced quality testing equipment and technology, to improve the accuracy and efficiency of quality testing.

5.4. Waste treatment needs to be improved

The waste generated in the chemical production process is diverse and large and contains high levels of harmful components, so effective treatment and disposal technologies are essential to protect the environment and achieve sustainable development. At present, some chemical enterprises still use the traditional classification method, which is inefficient and has a large human error. At the same time, due to the lack of effective technical means, many wastes are simply stacked or dumped at will, resulting in a large amount of resource waste. In addition, although the relevant environmental protection technology has been rapidly developed in recent years, its application in waste treatment is not widespread enough compared with the scale of chemical production [8]. For example, for the treatment of some special wastes such as heavy metal pollutants and organic pollutants, more efficient and environmentally friendly technical support is still needed. In particular, some wastes in chemical production have potential economic value, such as being recycled as renewable energy.

6. Optimization strategy of energy saving and consumption reduction technology application in chemical enterprises

6.1. Optimizing chemical production technology

In the new era, chemical enterprises are faced with severe resource constraints and environmental pressure. To achieve sustainable development and improve economic benefits and competitiveness, how to optimize chemical production technology has become the focus of the chemical industry. In the utilization of raw materials, chemical enterprises should actively adopt efficient catalysts to improve the conversion rate of raw materials, reduce the accumulation of unreacted raw materials, reduce production costs, and improve product quality. For example, in the production process of synthetic ammonia, ethylene, and other basic chemical products, by using more efficient catalysts, the reaction can be completed under lower temperature and pressure conditions, which can not only save energy but also reduce the generation of reaction by-products, to achieve a more environmentally friendly and more economical production process. In terms of energy conservation, enterprises should continue to improve and optimize the chemical production process, through fine management, and fine-tuning of production parameters, which can effectively reduce the energy consumption in the production process [9]. For example, the use of heat pump technology to recover waste heat in the production process for heating or power generation can significantly reduce energy consumption. In addition, from the perspective of technological innovation, the integration and application of interdisciplinary technology is also an important direction to optimize chemical production process technology. For example, by combining modern information technology such as information technology and big data analysis, intelligent management of the production process can effectively improve the production efficiency and resource utilization of chemical enterprises. Through the analysis and optimization of a large number of production data, enterprises can control the production process more precisely and achieve the purpose of energy saving and consumption reduction.

6.2. Upgrading energy-saving production equipment

In the chemical industry, the design of many traditional production equipment is backward, the energy conversion efficiency is low, and there is also a large amount of energy waste. Therefore, the introduction and renewal of efficient and energy-saving production equipment has become an important way to achieve the goal of energy-saving and consumption reduction.

First of all, chemical enterprises can introduce automation control technology to reduce energy consumption by optimizing production processes. For example, the real-time monitoring system can monitor various parameters in the production process in real time to ensure that the equipment is operating in the best working condition, thus reducing energy consumption. At the same time, the intelligent production scheduling system can automatically adjust the production plan according to the market demand and the supply of raw materials to avoid ineffective or excessive energy consumption [10].

Secondly, the use of energy-efficient motors and drive systems is also an important direction to update production equipment. For example, frequency conversion speed regulation technology can adjust the running speed of the motor according to actual needs to avoid unnecessary energy consumption. High-efficiency motors, on the other hand, reduce energy consumption and emissions while providing the same power. In addition, it is important to strengthen the management of thermal energy in the chemical production process. Through heat recovery and utilization technology, waste heat generated in the production process can be effectively recovered and converted into useful energy, which can not only reduce energy consumption but also improve overall

efficiency. In addition, in the choice of equipment materials, chemical enterprises should choose to use more durable, easier-to-maintain materials, which can not only extend the service life of the equipment but also reduce the indirect energy consumption caused by maintenance and replacement.

6.3. Improve the management mechanism of energy conservation and consumption reduction

It is a systematic project to improve the management mechanism of energy conservation and consumption reduction in chemical enterprises.

Firstly, chemical enterprises should clarify their energy-saving and consumption-reducing management systems. The leadership of enterprises should have a deep understanding of the actual energy consumption situation in chemical production, and then improve the management system at all levels, establish a scientific energy-saving system, and promote the sustainable development of chemical enterprises. In specific implementation, the leadership of enterprises should attach great importance to energy conservation and emission reduction work, and formulate overall plans and specific goals. Organize employees to study chemical-related regulations and standards, as well as the regulations and management systems of the company, to create a working atmosphere of energy conservation and consumption reduction for all employees [11]. At the same time, it is necessary to arrange for relevant management personnel to supervise and inspect the actual implementation situation, data accuracy, etc., and promptly rectify problems.

Secondly, in terms of energy conservation and consumption reduction management, chemical enterprises need to achieve the following points: They need to carry out energy conservation monitoring on an annual and monthly basis and formulate reasonable energy conservation and emission reduction plans, targets, and economic indicators. To establish a data collection and measurement system to track and manage various energy consumption, power generation efficiency, and other data. To apply efficient and energy-saving technologies and equipment in production to improve energy efficiency. Chemical companies should also adjust and optimize their current management mechanisms. Chemical enterprises should combine their own production process characteristics to enhance the pertinence and effectiveness of energy conservation and consumption reduction management mechanisms, to truly implement energy conservation and consumption reduction into production work.

6.4. Strengthen energy recycling technology

Energy recycling technology is of great significance for promoting the sustainable development of chemical enterprises by improving energy efficiency, reducing energy consumption, and reducing waste discharge. First of all, enterprises should increase the development and application of thermal energy recovery systems. By recovering and reusing the waste heat generated in the chemical production process, energy efficiency can be significantly improved. For example, the application of waste heat boilers can convert waste heat into useful steam for use in production processes or other facilities. Secondly, chemical enterprises should increase the use of renewable energy technologies such as solar energy and wind energy in the production process, which can not only reduce the dependence of chemical enterprises on traditional fossil energy but also reduce environmental pollution. For example, the installation of solar photovoltaic panels and wind turbines has enabled some chemical enterprises to achieve energy self-sufficiency and restore excess renewable energy to the power grid. At the same time, chemical companies should also recycle the waste generated in the chemical production process as energy,

which is an innovative and effective way to save energy. Biotechnologies such as fermentation and anaerobic digestion are used to turn organic waste into biofuel; Or through pyrolysis, gasification, and other technologies to convert difficult-to-treat waste into renewable energy. Refrigeration systems account for a large proportion of energy consumption in chemical enterprises [12]. Therefore, chemical enterprises can adopt frequency conversion technology, heat pump technology, two-phase flow refrigeration, and other new refrigeration technologies to optimize the refrigeration cycle, improve the energy efficiency ratio of the system, and reduce energy consumption.

6.5. Use green energy to carry out production

In daily production, chemical enterprises should increase the use of renewable energy. Chemical enterprises can install solar photovoltaic panels in the factory area to convert solar energy into electricity for lighting, power, and other needs in the production process. In areas rich in wind energy resources, chemical companies can invest in the construction of wind power facilities to convert wind energy into electricity for energy needs in the production process. Chemical companies can also consider using other renewable energy sources such as geothermal energy and biomass energy to meet the energy demand in the production process [13]. Using the above green energy to carry out production can not only reduce the energy consumption of chemical enterprises but also reduce the pollution of the environment. In addition, with the rapid development of high and new technology, chemical enterprises should also increase the application of intelligent and automated production equipment and technology in the production process, to achieve the minimum energy consumption and obtain the maximum production efficiency.

6.6. Increase the promotion and use of scale inhibitors

First of all, the use of scale inhibitors can improve the heat transfer efficiency of production equipment. In the chemical production process, heat exchangers, boilers, and other equipment need to carry out heat exchanges. With the increase of the use time of the equipment, a scale layer will be formed inside the equipment, thereby reducing the heat transfer efficiency. The use of scale inhibitors can effectively prevent or reduce the occurrence of this situation, and maintain the efficient heat transfer performance of the equipment, thus reducing energy consumption. Secondly, scale inhibitors can also reduce the maintenance and replacement costs of equipment. Scaling of chemical equipment not only affects heat transfer efficiency but also may lead to equipment damage or performance degradation. In this regard, chemical enterprises should regularly let relevant staff use scale inhibitors for cleaning and maintenance, to extend the service life of equipment and reduce production disruption and maintenance costs caused by equipment damage or performance degradation [14]. In addition, the use of scale inhibitors also helps to improve the safety and stability of chemical production. Equipment scaling may lead to safety hazards such as pipe blockage and equipment overheating. By using scale inhibitors, these risks can be reduced to ensure the safe and stable operation of chemical production.

7. Challenges and prospects for the application of energy-saving and consumption-reduction technology in chemical enterprises

7.1. Challenges in the application of energy saving and consumption reduction technology in chemical enterprises

Although energy saving and consumption reduction have become an important reform trend in the transformation and upgrading of chemical enterprises, their application in actual production still faces some challenges. On the

one hand, energy-saving and consumption-reduction technologies are often accompanied by high research and development and introduction costs. For chemical companies, this means a lot of money needs to be invested in upgrading production technology, which may put pressure on the finances of some companies. On the other hand, some chemical enterprises have problems such as failure to implement the management responsibility for energy conservation and consumption reduction, imperfect quota index system for product energy conservation and consumption reduction, and insufficient supervision, inspection, and assessment. If chemical enterprises do not pay enough attention to energy conservation and consumption reduction, it will easily lead to the internal management organization is not perfect, and the staff is not strong awareness of energy conservation and consumption reduction [15]. In addition, in the fierce market competition environment, some chemical enterprises may pay more attention to the actual economic benefits but ignore the long-term value of energy saving and consumption reduction technology.

7.2. Prospects for the application of energy saving and consumption reduction technology in chemical enterprises

With the continuous progress of science and technology, the actual use cost of energy saving and consumption reduction in chemical enterprises will be gradually reduced, and its application effect will also be significantly improved. In the future, chemical enterprises will have more opportunities to obtain advanced energy-saving and consumption-reduction technologies at a lower cost, thus reducing energy consumption and emissions in the production process. At the same time, the relevant government departments will further improve the policies and standard systems of energy conservation and consumption reduction, and provide more clear guidance and support for chemical enterprises. Through policy guidance and standards, chemical enterprises will be encouraged to strengthen the management of energy conservation and consumption reduction and improve energy efficiency. Chemical enterprises will also accelerate the pace of intelligent and digital transformation, and use modern information technology to improve the automation and intelligent level of production processes, to reduce energy consumption and emissions through precise control and optimized scheduling and other means to achieve green production and sustainable development.

Disclosure statement

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