

# Energy saving and emission reduction technologies integrating energy power and mechanical engineering

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**Abstract.** This paper discusses the importance and application prospect of energy-saving and emission-reduction technology combining energy, power and mechanical engineering in the current energy and environment fields. Firstly, the concept of integration of energy power and mechanical engineering and its significance in energy saving and emission reduction are introduced, and the important role of this technology in realizing sustainable development and meeting the challenge of climate change is emphatically expounded. Subsequently, the application practice of this technology in industrial production, construction, transportation and other fields is analyzed, and its remarkable effects in energy saving and emission reduction are summarized. This paper further discusses the important role of technological innovation and policy support in promoting the development of this technology, and emphasizes the importance of interdisciplinary cooperation and exchange in the process of technology popularization and application. Finally, the future research direction and development trend are prospected, and all parties are called upon to make joint efforts to promote the energy-saving and emission-reduction technology integrating energy, power and mechanical engineering to be more widely applied and popularized around the world, so as to contribute to building a clean, low-carbon and sustainable energy future.

**Keywords:** Energy saving; mechanical engineering; emission reduction technologies; energy power.

## 1. Introduction

In today's rapidly evolving society, fueled by the global economy's swift progress and the continuous rise in population numbers, there arises a mounting demand for energy. Consequently, the spotlight increasingly falls upon energy consumption and carbon emissions as focal points of global concern. According to data from the International Energy Agency (IEA), global energy consumption has surged by nearly 50% since the 1990s, accompanied by a significant uptick in carbon emissions. This presents formidable challenges to both human society and the global environment [1]. Confronted with this reality, it becomes imperative to swiftly implement effective measures aimed at curbing energy consumption and ameliorating the impact of climate change, thereby steering towards sustainable economic development and environmental preservation.

Energy power and mechanical engineering are two disciplines that occupy an important position in the engineering field, and their close combination and integration will provide new opportunities and possibilities for energy conservation and emission reduction [2]. The discipline of energy and power is devoted to the study of energy conversion and utilization technology, while mechanical engineering focuses on the design, manufacture and operation of energy conversion equipment and systems. The combination of the two can not only improve energy efficiency, but also reduce energy consumption and carbon emissions, and contribute to the realization of energy conservation and emission reduction goals [3-4].

The purpose of this paper is to discuss the energy-saving and emission-reduction technology of the integration of energy power and mechanical engineering, and analyze its application and effect in engineering practice. First of all, it will introduce the basic concepts of energy power and mechanical engineering and the significance of integration; Secondly, the development status and importance of energy saving and emission reduction technologies will be summarized; Then, it will focus on the specific technical means and methods of the integration of energy power and mechanical engineering, as well as its application cases in energy conservation and emission reduction; Finally, the research results will be summarized and the future development trend will be prospected, which will provide

reference and suggestions for promoting the application of energy, power and mechanical engineering in the field of energy conservation and emission reduction.

## **2. Integration of energy power and mechanical engineering**

As foundational disciplines within the realm of engineering, both energy and power engineering and mechanical engineering are intricately intertwined, playing a vital role in advancing energy utilization efficiency and realizing the objectives of conservation and emission reduction. The domain of energy and power engineering primarily centers on the mechanisms of energy generation, conversion, and utilization, encompassing various forms of energy such as thermal, kinetic, and electrical. On the other hand, mechanical engineering is primarily concerned with the conception, fabrication, and operation of energy conversion apparatus and systems, encompassing devices like engines, turbines, and heat exchangers [5-6]. The integration of the two can achieve efficient use of energy and reduce energy waste, thus reducing energy consumption and carbon emissions.

First of all, the discipline of energy and power provides rich energy conversion technology and theoretical basis for mechanical engineering. For example, the theories of thermodynamics and fluid mechanics provide important guidance for the design and optimization of energy conversion equipment such as internal combustion engines and turbines. At the same time, new energy technologies such as solar energy and wind energy have also brought new development opportunities for mechanical engineering, and promoted the research and application of renewable energy equipment and systems. Secondly, mechanical engineering provides key equipment and technical support for energy and power discipline to realize energy conversion [7]. For example, generators, turbines, pumps and other mechanical equipment are the core components of the energy power system. Through the innovation and improvement of mechanical engineering technology, energy conversion efficiency and system stability can be improved, energy can be effectively utilized and energy waste can be reduced [8].

In addition, the integration of energy power and mechanical engineering is also reflected in emerging fields and technological innovation. For example, the development of intelligent energy system, energy storage technology and other new technologies can not be separated from the support and promotion of mechanical engineering. Through intelligent, automatic and other technical means, the optimal control and efficient operation of energy system are realized, which further promotes the realization of energy conservation and emission reduction targets.

The fusion of energy power and mechanical engineering holds immense importance not only in theoretical exploration and technological breakthroughs but also in practical engineering implementations aimed at achieving energy conservation and emission reduction objectives. Looking ahead, as science, technology, and engineering methodologies continue to advance, it is anticipated that the integration of energy power and mechanical engineering will open up broader avenues for development and application, offering promising prospects for the future.

## **3. Overview of energy saving and emission reduction technology**

Amidst the swift evolution of the global economy and the consistent rise in population, the issues of energy consumption and carbon emissions are escalating, demanding immediate action to curtail energy usage and alleviate the repercussions of climate change [9]. Energy conservation and emission reduction technology, serving as pivotal tools in addressing energy and environmental dilemmas, has garnered substantial attention from governments and enterprises worldwide. It has seen widespread adoption and dissemination as a crucial strategy in tackling these pressing concerns.

The concept of energy-saving emission reduction technology includes two aspects: one is energy-saving technology, that is, to achieve energy-saving goals by improving energy utilization efficiency and reducing energy consumption; The second is emission reduction technology, that is, reducing emissions and improving environmental quality to achieve emission reduction targets [10]. These

technologies cover energy production, conversion, utilization and end application, including but not limited to efficient energy utilization technology, clean energy technology, carbon capture and storage technology, energy-saving products and equipment, etc.

Technologies for improving energy efficiency include improving energy conversion efficiency, reducing energy loss and optimizing energy utilization structure, such as heat energy recycling technology, efficient lighting and air conditioning system. Clean energy technology includes technologies that use renewable energy and clean energy to replace traditional fossil energy, such as solar energy, wind energy, hydropower and other new energy technologies.

Carbon capture and storage technology primarily aims to mitigate the release of greenhouse gases, notably carbon dioxide, generated during industrial production and energy utilization. This encompasses processes such as carbon capture, carbon sequestration, and carbon utilization. On the other hand, energy-saving products and equipment encompass a range of solutions, including energy-efficient products, household appliances designed for energy conservation, and intelligent control systems. The objective of energy conservation and emission reduction is realized through the enhancement and modernization of these products and equipment.

Energy-saving and emission-reduction technologies are widely used and promoted in various fields and industries. For example, in the industrial field, the use of energy-efficient equipment and technology can significantly reduce energy consumption and emissions; In the field of architecture, the use of energy-saving building design and materials can effectively improve building energy efficiency and reduce building operating costs; In the field of transportation, promoting clean energy vehicles and intelligent transportation systems can reduce automobile exhaust emissions and traffic congestion. Energy saving and emission reduction technology is an important way to realize sustainable development and meet the challenge of climate change. Its application and popularization will play an important role in promoting economic growth, protecting the environment and improving people's living standards.

## **4. Energy saving and emission reduction technologies integrating energy power and mechanical engineering**

### **4.1 Technical means and methods**

The integration of energy, power and mechanical engineering provides rich technical means and methods for realizing energy conservation and emission reduction. Using intelligent control algorithm and optimization method, the energy system is dynamically regulated and optimized. For example, by establishing an intelligent monitoring system, energy consumption can be monitored in real time, and optimal control can be carried out according to the monitoring results, so as to improve energy utilization efficiency and reduce energy waste.

Integrate different energy forms and energy equipment to build a comprehensive energy system with multiple complementary functions. For example, solar photovoltaic and thermal energy complementary power generation system is used to convert solar energy into electric energy and thermal energy, so as to realize diversified utilization and efficient conversion of energy. Develop and apply efficient energy conversion equipment and technologies to improve energy conversion efficiency and energy utilization. For example, energy conversion equipment such as high-efficiency engines and turbines are adopted to reduce energy losses and emissions and achieve efficient use of energy. Popularize and apply new energy and clean energy technology to replace traditional fossil energy and high pollution energy. For example, renewable energy sources such as wind energy and solar energy are used to replace traditional energy sources such as coal and oil to reduce greenhouse gas emissions and environmental pollution.

Develop and utilize energy storage technology and recycling technology to realize energy storage and reuse. For example, using battery energy storage technology to store solar energy and wind energy, and using waste heat recovery technology to recover waste heat in industrial production, reducing energy waste and environmental pollution (Figure 1). Popularize and apply energy-saving

products and equipment to reduce energy consumption and emissions. For example, promote products such as high-efficiency and energy-saving lamps, energy-saving air conditioners and energy-saving appliances, reduce the energy consumption of households and enterprises, and achieve the goal of energy conservation and emission reduction.

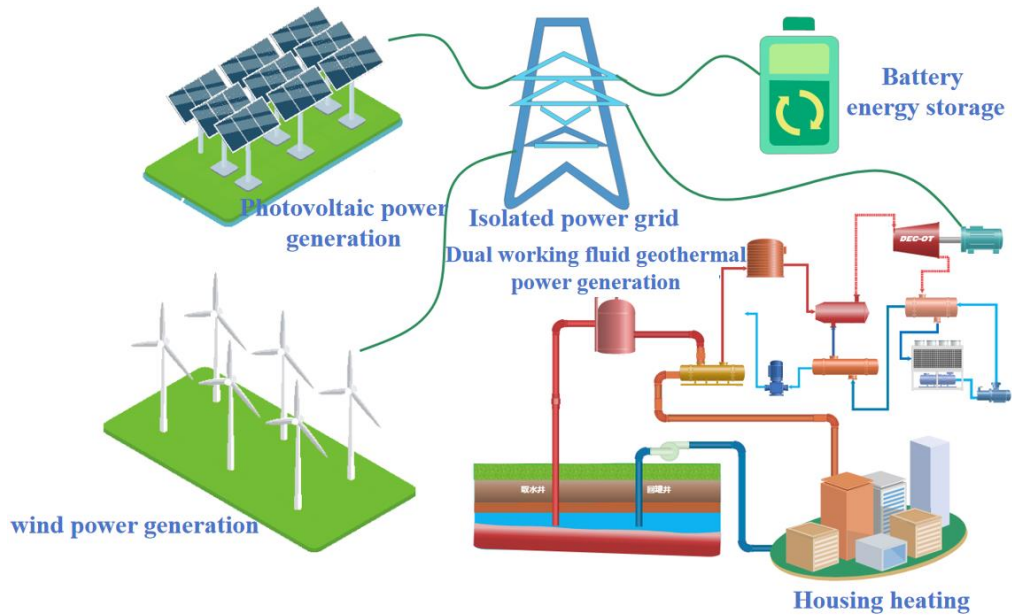


Figure 1 Wind-solar energy storage geothermal energy utilization system

Through examining the particular technical approaches and methodologies of integrating energy power and mechanical engineering in the context of energy conservation and emission reduction, we can achieve optimal energy utilization, minimize energy wastage, and offer crucial support and assurance in attaining the objectives of energy conservation, emission reduction, and sustainable development.

4.2 Advantages and applicability of different technologies in energy saving and emission reduction

In the field of energy conservation and emission reduction, different technical means and methods have their own advantages and applicability, so it is very important to choose the appropriate technology for different scenarios and needs. The advantages and applicability of different technologies in energy saving and emission reduction are shown in Table 1.

Table 1 Advantages and applicability of different technologies in energy saving and emission reduction

| technology                                       | superiority                                                                       | applicability                                                                                                  |
|--------------------------------------------------|-----------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------|
| Intelligent control and optimization technology  | Fine monitoring and dynamic optimization; Improve energy utilization efficiency.  | Industrial production, construction management, etc., to adapt to the scene of great changes in energy demand. |
| Design technology of comprehensive energy system | Diversified utilization of energy forms to improve energy utilization efficiency. | Large industrial parks, urban energy systems, etc.                                                             |
| Efficient energy conversion technology           | Improve energy conversion efficiency and reduce energy consumption.               | Various energy conversion equipment and systems, especially large-scale equipment.                             |

|                                                     |                                                                                 |                                                                                     |
|-----------------------------------------------------|---------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| New energy and clean energy application             | Replace traditional energy sources and reduce emissions                         | Various scenes and industries, especially suitable for resource-rich areas.         |
| Energy storage and recycling                        | Realize the storage and reuse of energy and improve the utilization efficiency. | Scenes with large energy fluctuations and frequent demand changes                   |
| Application of energy-saving products and equipment | Reduce energy consumption and emissions                                         | Home, business and other scenarios, especially suitable for updating old equipment. |

Intelligent control and optimization technology can realize fine monitoring and dynamic optimization regulation of energy system, improve energy utilization efficiency and reduce energy consumption and emissions. It is suitable for industrial production, building management and other fields, especially for scenes with large changes in energy demand, such as air conditioning systems with large seasonal changes.

Comprehensive energy system design technology can realize diversified utilization and complementary supplement of energy forms, and improve energy utilization efficiency and system stability. It is suitable for large industrial parks, urban energy systems and other scenes, especially for areas with rich energy resources but various types.

Efficient energy conversion technology can improve energy conversion efficiency and reduce energy loss, and reduce energy consumption and emissions. It is suitable for all kinds of energy conversion equipment and systems, especially for scenes of high energy consumption equipment such as large power plants and industrial production lines.

The application technology of new energy and clean energy can replace traditional fossil energy and use clean energy, and reduce greenhouse gas emissions and environmental pollution. It is suitable for various scenes and industries, especially for areas with rich resources and serious environmental pollution, such as the application of clean energy such as solar energy and wind energy.

Energy storage and recycling technology can realize energy storage and reuse, improve energy utilization efficiency and system flexibility. It is suitable for scenarios with large energy fluctuations and frequent demand changes, such as the storage and utilization of renewable energy.

The application technology of energy-saving products and equipment can reduce energy consumption and emissions by replacing and upgrading existing equipment. It is suitable for families, enterprises and other scenes, especially for updating old equipment and purchasing new equipment.

To sum up, different technologies have their own advantages and applicability in energy saving and emission reduction, so it is necessary to choose appropriate technical means and methods according to specific conditions to achieve the best energy saving and emission reduction effect. In practical application, it is necessary to comprehensively consider factors such as technology cost, environmental impact and policy support to select the most suitable technology path.

## **5. Case analysis and empirical research**

A chemical enterprise introduced intelligent control and optimization technology and established an energy management system to realize real-time monitoring and dynamic optimization of production process. The system integrates sensors, data acquisition system, intelligent algorithm and remote monitoring platform, which can monitor the energy consumption, production parameters and process flow of production equipment in real time, and adjust the production operation mode in real time according to the monitoring results, so as to improve energy utilization efficiency and reduce energy consumption and emissions. Before and after the introduction of the energy management system, a detailed empirical study was carried out, mainly comparing the energy consumption, production efficiency and economic benefits before and after the application of the system.

After the introduction of energy management system, the energy consumption of production equipment has been significantly reduced through real-time monitoring and optimal regulation of the system. For example, in the operation of the original production line, there is a certain degree of energy waste due to unreasonable equipment parameter setting or unexpected factors in the production process. After the introduction of energy management system, the system can find and identify these problems in time, and adjust the production parameters through intelligent optimization control means, thus minimizing the waste of energy. Empirical research shows that energy consumption has decreased by more than 20% on average (Figure 2).

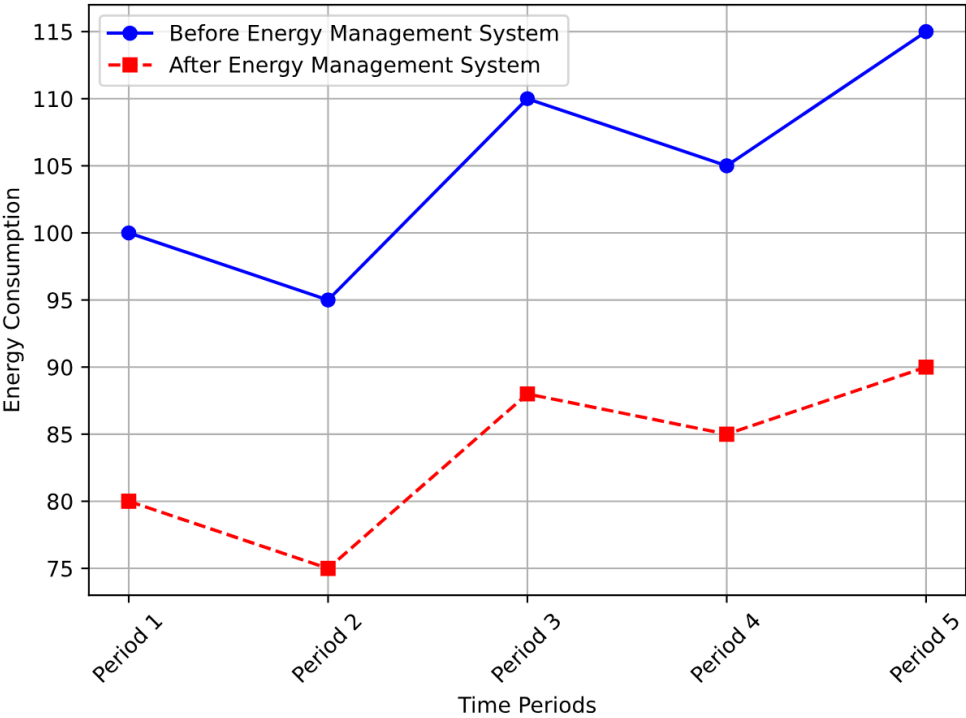


Figure 2 Energy consumption before and after the introduction of energy management system

After the introduction of energy management system, the energy utilization efficiency of production equipment has been improved, the stability and controllability of production process have also been enhanced, and the production efficiency has been significantly improved. Empirical research shows that the production efficiency has increased by more than 15% on average (Figure 3).

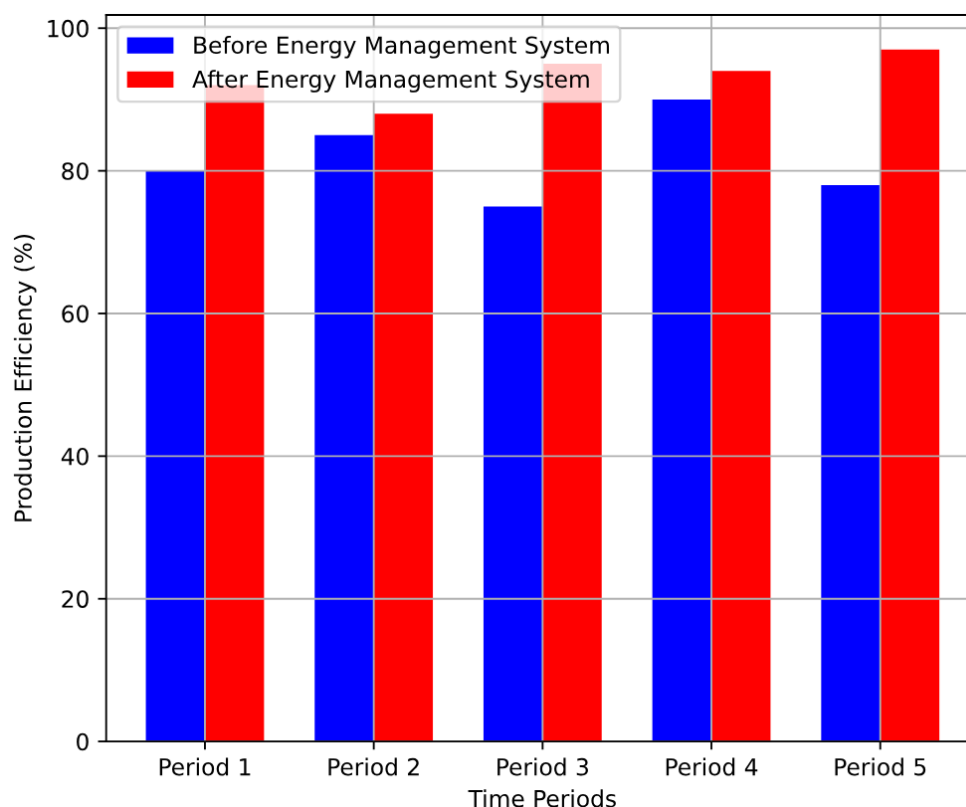


Figure 3 Production efficiency before and after the introduction of energy management system

By reducing energy consumption and improving production efficiency, enterprises save a lot of energy costs and production costs, and at the same time improve the quality and competitiveness of products. The empirical research shows that the economic benefits brought by the introduction of energy management system far exceed the input cost of the system and bring considerable economic returns to enterprises.

The introduction of intelligent control and optimization technology and the establishment of energy management system are of great significance for improving the energy utilization efficiency of industrial enterprises, reducing energy consumption and emissions, and improving production efficiency and economic benefits. This case provides strong empirical support for the practical application effect of energy-saving and emission-reduction technology integrating energy, power and mechanical engineering in industrial production.

## 6. Conclusion

The integration of energy power and mechanical engineering provides rich technical means and methods for energy saving and emission reduction. Through technological innovation and application, we can realize efficient use of energy and reduce energy consumption, effectively reduce emissions, and provide strong support for achieving the goal of energy conservation and emission reduction. This technology has achieved remarkable energy saving and emission reduction effects in industrial production, construction, transportation and other fields. For example, in the field of industrial production, the introduction of intelligent control and optimization technology can realize the refined management of production process and reduce energy consumption and emissions; In the field of architecture, the use of energy-saving building materials and equipment can improve building energy efficiency and reduce building energy consumption and carbon emissions. Technological innovation and policy support are important factors to promote the development of energy-saving and emission-reduction technologies integrating energy, power and mechanical engineering. The government and enterprises should strengthen technology research and innovation, formulate supporting policies and regulations, and provide more support and guarantee for technology application and promotion. The

energy-saving and emission-reduction technology integrating energy, power and mechanical engineering involves many disciplines and fields, and it is necessary to strengthen interdisciplinary cooperation and exchange to jointly promote technological innovation and application. Engineers, scientists, policy makers and other parties should strengthen communication and cooperation to jointly solve energy and environmental problems. Future research and practice should continue to strengthen technological innovation and policy support, promote the application and popularization of technology, and realize the coordinated and sustainable development of economy, society and environment.

## References

- [1] Jí Jaromír Kleme, Varbanov, P. S. , Pawe Ocoń, & Chin, H. H. (2019). Towards efficient and clean process integration: utilisation of renewable resources and energy-saving technologies. *Energies*, 12(21), 4092.
- [2] Ma, R. , & Lin, B. (2023). Digitalization and energy-saving and emission reduction in chinese cities: synergy between industrialization and digitalization. *Applied energy*, 2023(1), 345.
- [3] Cai, X. , Liu, Y. , & Jiajia ZhaFeipeng TanBingyao ZhangWeibin YanJiangqi ZhaoBingan LuJiang ZhouChaoliang Tan. (2023). A flexible and safe planar zinc-ion micro-battery with ultrahigh energy density enabled by interfacial engineering for wearable sensing systems. *Advanced functional materials*, 33(29), 11.
- [4] Deng, J. , Wang, X. , Wei, Z. , Wang, L. , & Chen, Z. (2020). A review of nox and sox emission reduction technologies for marine diesel engines and the potential evaluation of liquefied natural gas fuelled vessels. *Science of The Total Environment*, 766(1), 144319.
- [5] Yuan, F. , Cui, L. , Ding, P. , & Jing, W. (2020). Chlorine-free emission disposal of spent acid etchant in a three-compartment ceramic membrane reactor. *Chinese Journal of Chemical Engineering*, 28(1), 271-278.
- [6] Gholami, F. , Tomas, M. , Gholami, Z. , & Vakili, M. (2020). Technologies for the nitrogen oxides reduction from flue gas: a review. *Science of the Total Environment*, 2020(714), 714.
- [7] Hoang, A. T. , Foley, A. M. , Nizetic, S. , Huang, Z. , Ong, H. C. , & Olcer, A. I. , et al. (2022). Energy-related approach for reduction of co<sub>2</sub> emissions: a critical strategy on the port-to-ship pathway. *Journal of cleaner production*, 2022(25), 355.
- [8] Huang, C. J. , Liu, A. F. , Hu, K. W. , Chen, L. C. , & Huang, Y. K. (2019). A load-balancing power scheduling system for virtual power plant considering emission reduction and charging demand of moving electric vehicles:. *Measurement and Control*, 52(5-6), 687-701.
- [9] Braz, C. J. F. , Jéssica R. M. da Silva, Wellen, R. M. R. , & Rabello, M. S. (2021). The investigation of the stress cracking behavior of pbt by acoustic emission. *Polymers for Advanced Technologies*, 32(12), 4787-4804.
- [10] Yu, Y. , Jin, Z. X. , Li, J. Z. , Wu, Y. C. , & Jia, L. (2020). An air pollutant emission reduction path of china's power industry. *Atmosphere*, 11(8), 852.