

# Research on Thermal Energy Efficiency of Energy Power Engineering Boiler Based on Carnot Cycle

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## Abstract

The rapid development of China's economy and science and technology has further promoted the continuous improvement of China's boiler technology. At the same time, the advancement of boiler technology has further boosted the further improvement of China's economic, industrial levels. Today, energy and power engineering have a considerable proportion of the national economy, and energy and power engineering have been applied in all walks of life in China. With the aggravation of ecological problems such as energy crisis and environmental damage, people have begun to pay attention to energy conservation and environmental protection while their living standards have improved. At the same time, with the increase in the cost of environmental protection, industrial enterprises have also paid more attention to energy conservation and emission reduction. Technological innovation in energy has been put on the agenda. This paper discusses and analyzes the energy and power engineering in boilers and energy. First, it introduces the development process of energy and power engineering and then analyzes its specific innovation progress in boilers and energy. It is hoped that it can be a reference for future innovations.

## Keywords

Energy power engineering; boiler; energy; Carnot cycle.

## 1. Introduction

With the improvement of people's awareness of energy conservation and environmental protection, energy power engineering has been widely used in all walks of life in China due to its effect on energy conservation and environmental protection. This is not only an adaptation to the strategic thinking of sustainable development but also to protect the ecological environment. China's ecological resources, especially the shortage of vital energy and non-renewable resources and the gradual increase in the environmental cost of enterprise production, require attention to and strengthen the task of energy conservation and emission reduction. The efficient and reasonable utilization of energy and power engineering in boilers and energy is conducive to promoting economic development [1], effectively reducing the generation of pollutants in the combustion process of boilers and improving air quality and people's quality of life significant research value.

## 2. Carnot Cycle Definition

Carnot proposed the Carnot cycle during his theoretical study of the maximum possible efficiency of a heat engine. Carnot further proved the following Carnot's theorem: the efficiency of all reversible heat engines working between the same high-temperature heat source and the same low-temperature heat source is equal, regardless of the working substance, where  $T_1$  and

$T_2$  are the absolute values of the high temperature and low-temperature heat sources, respectively. Temperature [2]. The efficiency of all irreversible heat engines operating between the same high-temperature heat source and the same low-temperature heat source cannot be greater than that of a reversible Carnot heat engine. Reversible and irreversible heat engines undergo reversible and irreversible cyclic processes, respectively. The Carnot theorem shown in Figure 1 clarifies the limitations of heat engine efficiency and points out the direction of improving heat engine efficiency (increase  $T_1$ , reduce  $T_2$ ), which can be briefly understood as increasing high temperature, reducing the low temperature, and reducing other mechanical friction and heat loss, Make the cycle as close as possible to the ideal Carnot cycle. As shown in Figure 1.

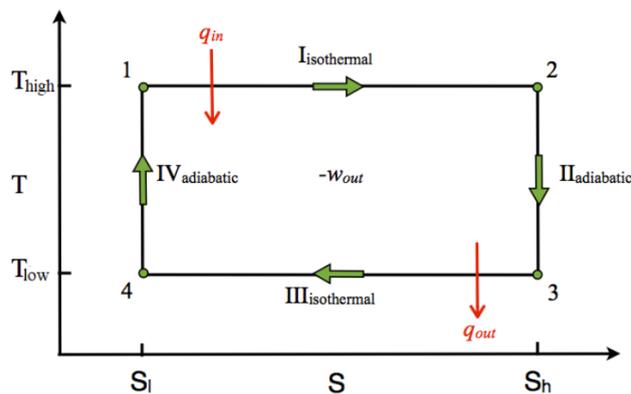


Fig. 1 Definition of Carnot Cycle T in the figure is temperature, S is time

### 2.1. The history of the Carnot cycle

It became the theoretical basis for heat engine research, the limitation of heat engine efficiency, the irreversibility of actual thermodynamic processes, and the research on the relationship between them, leading to the establishment of the second law of thermodynamics.

In the 19th century, or even at the beginning of the 20th century, the low-temperature heat source was usually the surrounding environment. At that time, the scientific and technological means that people knew were limited. They could only convert various energies such as mechanical energy, chemical energy, and light energy into heat energy for release, and there was nothing cheap. The method can absorb and remove heat to obtain low-temperature working fluid, energy depression, "cold energy" [3]. Lowering the environment's temperature is difficult, expensive, or even impossible. However, it is not what it used to be, and many theories, technologies, materials, and processes have undergone significant changes. It is time to re-examine this point of view.

### 2.2. The refrigeration technology is already very mature

and the efficiency of cooling and cooling by removing heat by heat pump technology is already very high. The actual efficiency of the reverse Carnot cycle can even be close to more than 60% of the theoretical value. While maintaining the temperature of the low-temperature heat source  $T_2$ , people can also transfer heat to the high-temperature heat source to intervene in the recirculation. Therefore, if necessary, reducing the temperature  $T_2$  of the low-temperature heat source is both feasible and relatively efficient, even a "by-product" of using the reverse Carnot cycle to obtain heat. After two years of in-depth and systematic research, there is absolutely a way to achieve the perfect goal of economy and efficiency. As shown in Figure 2.

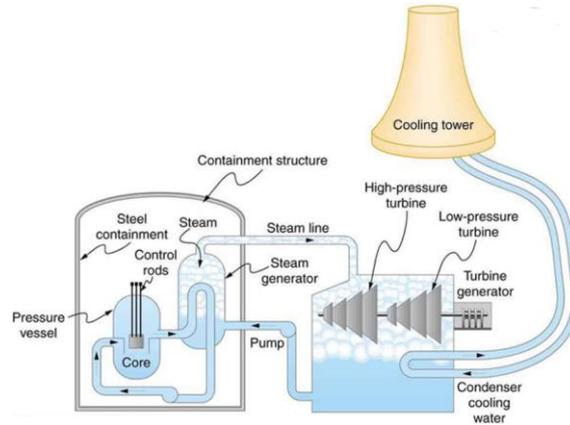


Fig. 2. Application of Carnot Cycle in Energy and Power Engineering

### 2.3. The physical process of the Carnot cycle

Secondly, cheap and commonly used working fluids that can absorb heat have expanded from water and air to many other low-cost and environmentally friendly substances that absorb heat during physical phase transition and chemical decomposition to cool down, such as dry ice, liquid air, and ammonium carbonate. Etc. In addition to considering the energy source, people can also view the selection and replacement of working fluids to adapt to different high and low-temperature heat sources to achieve heat-work conversion. Suppose the temperature  $T_2$  of the low-temperature heat source cannot be lowered. In that case, it is true that the higher the temperature of the high-temperature heat source  $T_1$ , the higher the theoretical efficiency. However, it also means that the quality of the heat-generating energy materials needs to be higher. After the environmental temperature difference increases, the material and heat dissipation problems become more and more prominent, the process becomes more and more complex, the associated issues increase, and the total cost is also significantly increased. The overall Economical is not necessarily high! Taking a rocket engine as an example, if a higher temperature can be achieved to obtain higher thermal efficiency, then the working temperature of the rocket engine will continue to increase, from  $3500\text{ }^\circ\text{C}$  now to increase further if it is grown to  $6000\text{ }^\circ\text{C}$ , also for internal combustion engines, if you blindly increase The combustion temperature and combustion pressure in the cylinder, originally nitrogen in the air is a quasi-inert gas. Still, under high temperature and high-pressure conditions, a chemical reaction can generate nitrogen oxides  $\text{NO}_x$  that cause severe pollution to the environment. The exhaust gas needs to be treated—handling a series of troubles, almost a dead end! Although people are very familiar with the Carnot cycle, the author believes that limited by historical reasons, industrial production conditions, self-knowledge, and other comprehensive factors, even today, the application of the Carnot cycle is far from adequate. As shown in Figure 3.

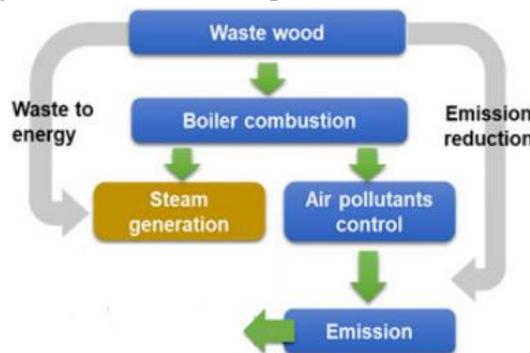


Fig. 3. Energy Power Engineering Boiler and Energy Cycle Process

All heat transfer from a high-temperature heat source to a low-temperature heat source must conform to the Carnot cycle. For example, fuel combustion releases much heat in boilers, and the flame temperature is above hundreds of degrees Celsius, which is a "high-temperature heat source." This heat source transfers heat to the water somehow, causing the water to heat up, boil, vaporize, vaporize, and expand. In thermal power plants, people use the high-temperature and high-pressure steam generated by this process to drive the steam turbine to drive the generator to generate electricity. Still, for heating boilers, this process is ignored, and people give up the opportunity of a heat transfer process to output high-grade energy. Most of the power generated by this process eventually turns into heat [4]. High-grade energy can be easily transmitted and flexibly converted between various modes during use, and more heat can be doubled by driving the heat pump device. Therefore, we should take every opportunity to do as much heat-to-work and heat-to-electrical conversion as possible and strive to improve the conversion efficiency. For a long time, when human beings need electricity, they only use the output work of heat transfer to throw away the heat that must be dissipated to maintain the "low-temperature heat source"; when human beings need heat, they ignore the possibility of outputting high-grade energy, and only use the energy eventually released by the energy material.

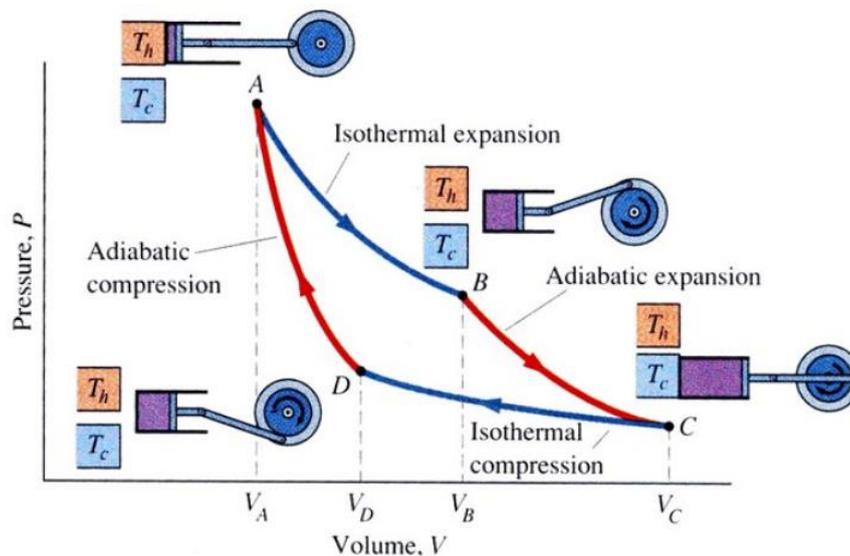


Fig. 4. Carnot Cycle Formula Verification

### 3. Overview of energy and power engineering

Energy and power engineering is a necessary material basis for economic and social development, and it is also a prerequisite for realizing the four modernizations and improving the living standards of the people across the country. With the continuous development of production in modern society and the continuous improvement of mechanization, electrification, and automation, the energy demand is also increasing. Generally speaking, a country's gross national product is roughly proportional to its energy consumption. Energy is the primary source of power. The greater the consumption of energy, the greater the output of products, the more developed the economy, the more prosperous the whole society, and the higher the people's living standards. This is evident from the fact that the total population of the developed countries accounts for one-fifth of the world's population, while energy consumption accounts for about 70% of the world's total energy consumption. Energy and power engineering are closely related to people's clothing, food, housing, and transportation. In order to solve the problem of food and clothing, it is necessary to vigorously develop agricultural production and realize the mechanization, electrification, water conservancy, and

chemicalization of agriculture, which requires a lot of energy [5]. Application of Carnot Cycle Formula Verification in Thermal Engineering.

$$W_{total} = W_{AB} + W_{CD} \tag{1}$$

$$W_{AB} = nRT_h \ln\left(\frac{V_B}{V_A}\right) \tag{2}$$

$$W_{CD} = -nRT_c \ln\left(\frac{V_C}{V_D}\right) \tag{3}$$

Research on the verification of thermal energy by the Carnot cycle formula

$$\frac{V_B}{V_A} = \frac{V_C}{V_D} \left| \frac{W_{CD}}{W_{AB}} \right| = \frac{Q_c}{Q_h} = \frac{T_c}{T_h} \tag{4}$$

The power ratio of the Carnot cycle formula can get the effect e

$$e = \frac{W}{Q_h} = \frac{Q_h - Q_c}{Q_h} = \frac{T_h - T_c}{T_h} \tag{5}$$

In order to further increase the output of agricultural products, a large amount of energy needs to be invested in agriculture. Therefore, to a certain extent, it can be said that the substantial increase in the production of grain and cotton is exchanged for energy. Much bright-colored nylon, doling, artificial wool, and other synthetic-fiber products appearing on the market are also manufactured using energy (coal, oil, natural gas) as raw materials and power. As for living, the wood used in houses is itself a kind of energy, and building materials such as bricks, glass, steel, and cement also consume much energy in the production process. In order to maintain a suitable indoor temperature.

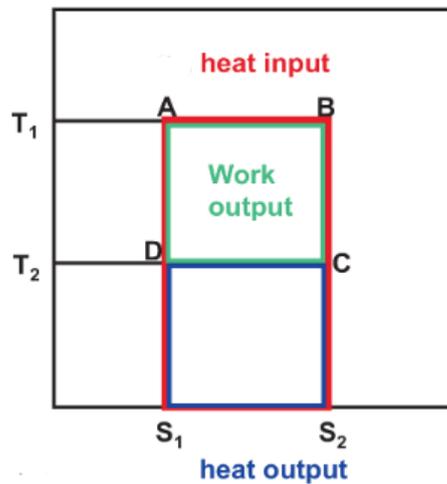


Fig. 5. The power ratio of the Carnot cycle formula can be used to obtain the work effect diagram

heating is required in winter and cooling in summer; for study and work, indoor lighting is required, all of which require energy consumption. As for modern household equipment such as computers, air conditioners, refrigerators, washing machines, electric stoves, electric heaters, etc., it is even more inseparable from energy. In addition, to activate people's cultural and entertainment life, such as watching TV, movies, listening to the radio, recording and playing records, etc all of them do not need energy. As shown in Figure 4.

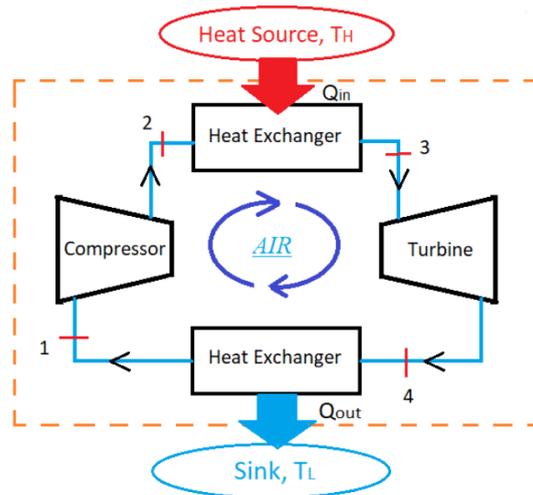


Fig.6. Energy Power Engineering Boiler and Energy Cycle Process

On the issue of mobility, except for walking, energy is inseparable. Without energy, cars, trams, trains, ships, airplanes, high-tech industrialization, etc., will be impossible. The relationship between energy power engineering and national defense is very close. A large amount of energy is needed in the production of various weapons, but energy is also inseparable from the use of various weapons, such as airplanes, land tanks, sea ships, and submarine submarines. And medium and long-range missiles. If the energy is insufficient, national security will not be reliably guaranteed, and the economic construction will not be able to proceed normally. In a word, energy and power engineering issues are directly related to the development the national economy and the improvement of people's living standards. Society is constantly advancing, production is continually growing, and people need higher material and spiritual civilization. Therefore, as China is working on the four modernizations, energy is vital, and solving the energy problem must be regarded as the top priority in developing the national economy, improving people's living standards, stabilizing social order, and safeguarding national security. The main research content of energy power engineering is the energy conversion of energy and power. This project has its characteristics of cumbersomeness and complexity, so the research of this project is relatively tricky. Nowadays, the research involved in energy power engineering mainly includes power machinery, engineering physics science, and fluid mechanical engineering.

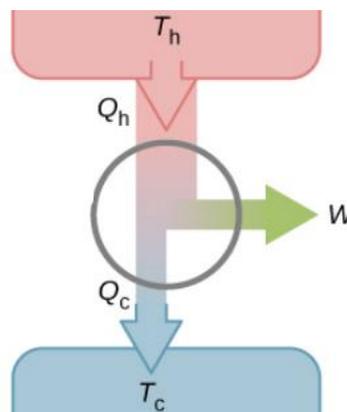


Fig. 7. Carnot cycle formula work flow image

Nowadays, the research and application of energy and power engineering mainly focus on strengthening automation, which requires colleges and universities to cultivate comprehensive senior talents with a solid foundation, extensive knowledge, and high innovation ability. In actual development and innovation, energy power engineering has become an essential power energy source, which requires strong professionalism. The continuous development of this

project is bound to play an essential role in environmental protection and further development of the national economy. Huge boost.

## **4. Development direction of energy and power engineering**

### **4.1. The direction of energy and power engineering ideas**

China's current national conditions with few energy resources and low utilization rate require further in-depth development and utilization of traditional energy sources and acceleration of related research on improving the efficiency of traditional energy development and utilization, which are the current research focus of China's energy power engineering. Since the energy development and utilization of the energy market in the future will mainly focus on renewable energy, to ensure sufficient energy supply for economic development, professionals need to continue to accelerate the research on new renewable energy to ensure the sustainable development of China's economy. In addition, in professional learning, professionals should combine theory and practice, carry out scientific research and industrial practice while learning basic knowledge, obtain intuitive scientific and technological theoretical achievements, and realize resource protection and sustainable economic development...

### **4.2. Environmental protection direction of energy and power engineering**

Environmental pollution seriously threatens the average production and life of human beings and restricts the development of the social economy. Environmental and energy issues have become the primary issues that China is focusing on today, and it is necessary to avoid the phenomenon of environmental pollution for economic development; in addition, it is necessary to strengthen the management of the environment, and all projects must strictly comply with environmental assessment standards; actively improve the economic development model, Eliminate and prohibit equipment and products that pollute the environment and consume too much energy; increase your investment in this area, and improve rules and regulations.

### **4.3. Application direction of coal clean technology**

On the one hand, energy power engineering is used to purify the coal before combustion and the processing of civil coal. On the other hand, the coal after combustion is purified, and the coal after combustion in large power plants is treated with an electrostatic precipitator to ensure the dust removal rate.

## **5. Innovation progress of energy power engineering in boiler and energy**

### **5.1. Innovation progress of energy power engineering in energy**

China has a vast territory, but it lacks resources and has a considerable population. There is a big gap between the per capita resources and the world average. Therefore, energy and power engineering play a vital role in energy. The utilization of energy in energy power engineering can significantly improve resource utilization rate, effectively reduce resource waste, thereby saving resources and alleviating the current energy shortage problem. In addition, new energy can be fully utilized in the application process, for example, the use of energy power engineering in the use of fans, focusing on two aspects of ventilation and ventilation, and the government has also increased funding for research and development.

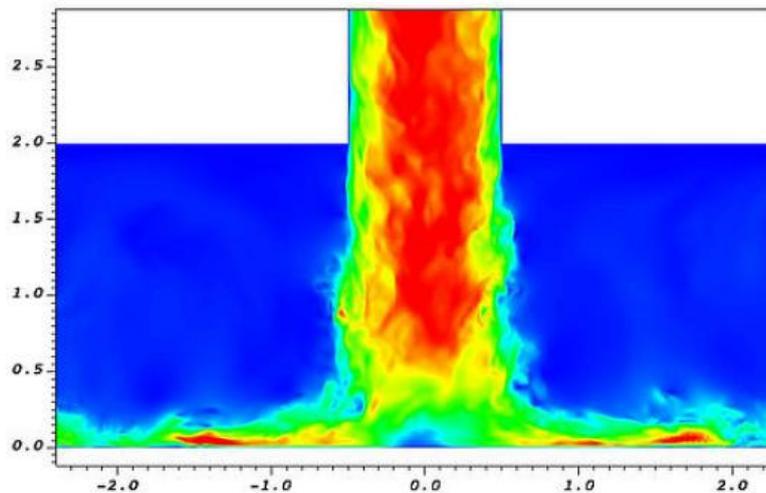


Fig. 8. Carnot Cycle Formula Thermal Engineering Computer Simulation

Support and intensify the transformation and upgrading of power generation facilities and industrial furnace facilities. Pay attention to the reform and innovation of energy power engineering in the application of industrial boilers and power stations, promote the improvement of traditional energy supply methods, and find solutions to China's energy shortage problem under the circumstance that China's industrial production is increasing. The demand for new energy is increasing. Ensuring energy supply for economic development.

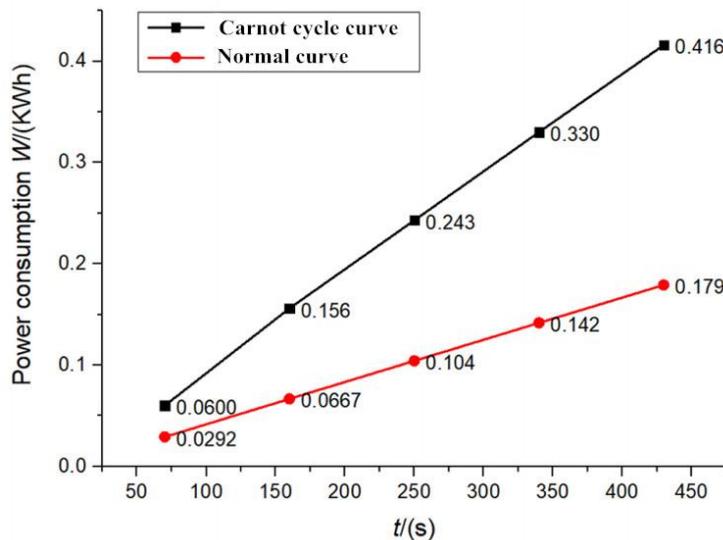


Fig.9. Simulation and comparison test of Carnot cycle curve

### 5.2. Innovative progress of energy power engineering in boilers

The boiler is an essential facility for converting heat energy produced by burning fuel into production energy in the industrial production process. All kinds of gas pollution will be produced, and more energy consumption will significantly impact economic development and environmental protection. Although the country has invested a lot of technology and funds to effectively deal with the serious pollution problems caused by the boiler production process and obtained much theoretical knowledge of technical facilities, it is of little significance in practical application. In the future, it will mainly focus on improving sensing technology and internal combustion engine. In order to ensure the regular operation of the motor in the boiler, the double-cross limiting control system is first used to control the proportion of air combustion to ensure that when the boiler is burning, the control fan is used to Provide

sufficient oxygen support for combustion, so that the boiler has sufficient oxygen for combustion.

## 6. Conclusion

With the rapid development of China's economy and the continuous progress of industrial production, people's daily life and the average production of enterprises have a great demand for energy. However, in the process of industrial production and the combustion process of boilers, it will consume much energy and have a significantly destructive effect on the natural environment. The application of energy power engineering in boilers and energy has achieved good results in China. In the future, further innovative research will be carried out to flexibly and effectively achieve maximum energy conservation and environmental protection as possible. It is also necessary to promote the application of energy and power engineering and combine its characteristics to promote the acquisition of new achievements, prevent the situation of hindering economic development due to the shortage of resources, and promote the sustainable and healthy development of China's economy.

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