Discussion on Energy Saving Technology of Pumps and Fans in Thermal Power Plants

Hao Bian *
School of North China Electric Power University, Baoding, China

*Corresponding author e-mail: 576271909@qq.com

Abstract. Pumps and fans play an important role in various sectors of the national economy, and are widely used in metallurgical, chemical, textile, petroleum, coal, electric power, national defense, light industry and agricultural production sectors. Because pumps and fans are general machinery, they are in nationals. The various sectors of the economy are widely used in production and life. From the production point of view, the proportion of power consumption of pumps and fans is very high, and its annual electricity consumption accounts for about one-third of the national electricity consumption, accounting for 40% to 45% of the national industrial electricity consumption. It can be seen that the power consumption of the pump and the fan itself is quite large, which requires the pump and the fan to work under low energy consumption and high efficiency conditions to achieve energy saving. I analyzed and summarized the actual problems encountered in daily production operations, and provided technical support. These technical experiences provide some reference experience for daily operation and equipment management. This paper closely combines the actual situation of thermoelectric enterprises, and focuses on the energy-saving adjustment of pumps and fans with the important auxiliary machines of thermal power plants as the breakthrough. The theory and practice combine the practice design and energy-saving adjustment analysis of thermal power enterprises, so as to adapt to social development well and quickly, to accelerate modernization. Struggle with the pace of construction.

Keywords: Pump and fan, Thermal power plant, Energy saving technology, Technical transformation.

1. Introduction
As the foundation of the national economy, the energy industry is extremely important for the development of society and economy and the improvement of people's living standards. In a fast-growing economic environment, China's energy industry faces the dual pressures of economic growth and environmental protection. Moreover, affected by factors such as capital, technology, energy prices, China's energy efficiency is much lower than that of developed countries, only about 50% of developed countries, more than 90% of energy in mining, processing conversion, storage and transportation and terminal utilization process Loss and waste. It can be seen that the effective use of energy is very urgent
in China. Thermal power plants are the most important energy consumers, accounting for 74% of China's secondary energy structure. In thermal power plants, pumps and fans are the main power-consuming devices, and the existence of "large horse-drawn cars" in these devices, due to the long-term continuous operation of these devices and often under low load and variable load operation. The operating conditions deviate from the high efficiency point, the operating efficiency is reduced, and a large amount of energy is wasted in the terminal utilization. Thermal power plants are large consumers of electricity. According to statistics, the average plant power consumption rate of national thermal power plants is about 7% to 8%. According to the survey data of pumps and fans by various industrial departments, the efficiency of pumps and fans used in China is mostly less than 5% lower than that of similar products in advanced industrial countries. The actual operating efficiency of pumps and fans is generally higher than that of industrial The country is 10% lower. Therefore, in thermal power plants, it is necessary to carry out energy saving (saving) and power consumption reduction of pumps and fans. Vigorously carrying out power saving of pumps and fans is the main way to save power consumption of factories, reduce coal consumption and cost of power generation, and improve the overall efficiency of the whole plant. At present, some pumps and fans of small and medium-sized units in China's thermal power plants still have problems such as low efficiency, mismatched design parameters and host requirements, and low regulation efficiency. Can be dug. Pumps and fans of large units with advanced equipment have higher operating economy, but with the rapid development of electric power industry, the increasing capacity of the unit, the task of peaking the power grid, and the new type The emergence and continuous improvement of high-efficiency speed control mode has played a positive role in the adjustment of these pumps and fans, as well as the power saving and consumption reduction work. Therefore, they also have a strong potential for power saving. Therefore, it is of great significance to carry out energy conservation research on power plant pumps and fans.

2. Analysis of operating conditions and energy saving potential of power plant pumps and fans
At present, the number of pumps and fans used in power plants in China is not only a large number, but also a large number of pumps. The use of a large number of pumps and fans has caused huge power loss. Studies have shown that the annual consumption of pumps and fans is about 6.1% of the national power generation. The power consumed by pumps and fans has greatly increased the operating costs of the plant. There are also many problems in the models used in power plant pumps and fans in China. At present, only a small number of pumps and fans in China's power plants use pneumatic feed pumps, hydraulic couplers and two-speed motors. Most pumps and fans are used. Speed drive, fixed speed drive pumps and fans have serious energy losses. Not only that, when the unit is under variable load operation, the operating points of the pumps and fans are easily deviated from the high efficiency point, resulting in low work efficiency. There are data showing that the operating efficiency of boiler blowers of 50MW or more units in China is less than 70%, and less than 50% is about 1/5. More than 66% of machines using pumps and fans are severely energy intensive during operation and must be retrofitted with energy efficiency. The existence of a large number of pumps and fans with severe energy consumption means that there is great potential for energy saving in the modification of pumps and fans.

3. Pump and fan energy loss analysis

3.1. Mechanical loss.
The mechanical loss (expressed by the power Pm) includes the power lost by the shaft and the shaft seal, the shaft and the bearing and the impeller disc, and is generally expressed by Pm1 and Pm2, respectively. 
\[ \Delta Pm1 \propto nD^2, \text{ related to the bearing, the structure of the shaft seal, the type of packing, the} \]
\[ \text{machining process of the journal and the fluid density, about 1\% to 3\% Psh.} \]
\[ \Delta Pm2 \approx D25n^3 \]
When the impeller rotates in the cavity, the energy consumed by overcoming the frictional resistance between the fluid in the cavity and the cover is called the disk friction loss power.
3.2. Volume loss.
There is a gap between the impeller and the inlet position seal ring during the rotation of the pump and the fan, because the impeller position exit position is high pressure and the inlet position is low pressure, there will be some fluid passing through the gap at the exit position and re-joined back to the impeller inlet. Part of the volume loss is mainly caused by the leakage of the seal ring. There is a gap leak in the other stage spacers, although it is not a volume loss, but it also seriously affects the overall efficiency. For example, the loss caused by gap leakage will cause the pump and fan pressure and flow rate to decrease, which will seriously affect the working efficiency. The power loss caused by leakage can be calculated by the following formula: \( \Delta N_3 = \Delta Q \times \Delta N / 102 \) formula \( \Delta Q \) indicates the fluid leakage amount, unit Is m3/S, \( \Delta N \) represents the differential pressure mechanical loss power on both sides of the gap.

3.3. Flow loss.
When the pump and the fan are working, the friction caused by the fluid and the flow wall surface, the flow path geometry changes, the flow velocity changes to generate vortices, and the impact caused by the impact caused by the deviation from the design conditions. Flow losses and the geometry of the flow components, wall roughness, fluid viscosity and flow rate, operating conditions and other factors are closely related.

Friction loss and local loss When the flow is in the square of the resistance, the loss is proportional to the square of the flow.
Impact Loss When the flow rate deviates from the design flow rate, at the inlet and outlet of the blade, the flow rate changes such that the flow angle is not equal to the mounting angle of the blade, resulting in an impact loss.

4. Pump and fan energy saving measures

4.1. Scientific and rational selection.
After effectively clarifying the flow and head required by the pump and the fan, due to the full consideration of the operation of the device and the related factors such as the power supply voltage and frequency fluctuations, the calculated relevant flow and head will generally increase the margin. The wealth is chosen to be 10%, while the head wealth is chosen to be 15%. If the richness of the pump and fan selection is relatively large, throttling will occur during the actual operation, resulting in reduced work efficiency. In this regard, in the process of selecting the pump and fan model, it is necessary to strictly select the required flow rate and head, and select an effective and appropriate rich factor to meet the optimal efficiency point operation requirements. The selection of high-efficiency and energy-saving products is the premise and basic measures for energy saving of pumps and fans. Eligible companies can use energy-efficient pumps and fans, which is the most basic premise and measure for energy conservation. Power plant enterprises should have a comprehensive understanding of the performance of pumps and fans at home and abroad. When selecting, we should make a comprehensive evaluation of the performance of pumps and fans, and choose the optimal type. Therefore, we should widely understand the production and product quality of pumps and fans in China (including foreign countries if necessary), such as the overall evaluation of the variety, specifications, quality and performance of pumps and fans, etc. Secondly, according to the specific conditions of the pump and the fan, a reasonable driving and adjustment mode is determined, and a new and efficient prime mover is selected. Regardless of whether the prime mover uses an electric motor or a small steam turbine, there is also a problem of high operating efficiency. Generally, the prime mover has the highest rated power. Therefore, the margin of the optional prime mover should be as small as possible, and keep its regular load near the rated power, so that the overall operation of the unit can be efficient to improve the overall operating efficiency of the unit.
4.2. **Ensure the quality of installation and maintenance of pumps and fans.**

The dynamic and static clearance of the pump and the fan should be minimized under the condition of ensuring safe and reliable operation, because the leakage of the high-pressure side fluid to the low-pressure side increases with the increase of the gap, which reduces the volumetric efficiency of the pump and the fan. In addition, the eccentricity of the rotor, in addition to affecting safe operation, also causes friction of the eccentric dynamic and static components, resulting in a rapid increase in dynamic and static clearances and reduced efficiency. The flow resistance loss of the fluid in the pump and the fan is related to the shape of the flow channel and to the roughness of the blade and the flow channel. Tests have shown that the inner wall of the cast iron pump is painted. The pump efficiency can be increased by 2% to 4% due to the reduced relative roughness, which reduces the frictional resistance loss of the disk. After the rough surface of the over-flow part of the inner wall of the pump, the impeller cover and the inner part of the impeller is polished by the grinding wheel, the efficiency of the pump can be obviously increased by about 10%. Pumps or fans due to flow channel fouling, dust accumulation, or due to wear, cavitation, etc., change the original profile of the flow channel, or make the wall surface uneven, will cause the performance of the pump or fan to deteriorate, the efficiency is reduced, so it should be cleaned or repaired in time.

4.3. **Reduce pump and fan internal losses, improve pump and fan efficiency.**

Pumps and fans generate various energy losses in the process of converting the mechanical energy of the prime mover into the mechanical energy of the fluid. These losses can be divided into three parts: mechanical loss, volume loss and flow loss. Due to the complexity of the fluid movement inside the pump and the fan, the above various losses can not be calculated theoretically to obtain accurate results, mainly relying on the test method to determine, and then the semi-empirical and semi-theoretical calculation formula is summarized. To increase the efficiency of the pump and the fan itself, it is necessary to reduce the above losses.

1) The mechanical efficiency of the pump and the fan depends mainly on the geometry of the pump and the fan impeller, which is determined by the specific speed value. Therefore, the following points should be noted:
   1) Select or design a pump with a high head (full pressure) (For fans, the pump (fan) with a higher speed and a smaller impeller diameter D2 should be selected or designed to avoid the selection or design of such pumps (fans) with low speed and large D2).
   2) When selecting or designing a high-lift (full-pressure) low-ratio pump (fan), multi-stage pumps (fans) can be used, or the outlet mounting angle of the impeller blades can be appropriately increased to avoid using a large D2. Achieve high lift (full pressure).
   3) Reduce the roughness of the outer surface of the impeller cover and the inner surface of the pump casing, which can reduce ΔPm3, thereby improving the efficiency of the pump and the fan. Reducing the volume loss of the pump and the fan and increasing the volumetric efficiency mainly start from two aspects: one is to reduce the flow cross section of the leakage flow formed by the dynamic and static gaps; the other is to try to increase the flow resistance of the leakage flow path.

2) In order to reduce the flow loss inside the pump and the fan and improve the flow efficiency, the following points should be noted when designing or modifying the pump and the fan:
   1) Reasonably determine the flow velocity value of each part of the overcurrent component.
   2) Try to avoid or reduce the occurrence of de-flow in the flow channel.
   3) It is necessary to reasonably select the inlet and outlet angles of each flow-through component to reduce the impact loss of the fluid.
   4) The overcurrent channel should be changed as gently as possible; avoid sharp corners, sudden turns and enlargement in the flow channel.
   5) The surface of the runner should be as smooth and smooth as possible, avoiding casting defects such as sticky sand, flash, and burrs.

5. **Conclusion**

From the perspective of energy conservation, the energy saving of power plant pumps and fans will be an economical method for power plants in China. From the efficiency of the pump and the fan, we can easily find that its power saving potential can be dug. From the improvement direction of pumps and fans, the large-capacity development of power generation units and the new high-efficiency technology advancement have contributed to the role of power saving. Therefore, we should fully understand the
importance of pumps and wind turbines for sustainable development and economic benefits from a strategic perspective, enhance the sense of urgency and responsibility, combine the actual situation, conscientiously sum up experience, actively explore and innovate, and continuously improve the energy-saving management level of power plants. Energy savings from pumps and fans is a comprehensive economic issue. It is influenced by various conditions and factors such as design, manufacture, piping system design and status, selection, selection of prime mover, selection of operation mode and adjustment mode, installation, overhaul, operation management and investment cost. The above analysis of the different methods of pump and fan energy-saving transformation, in fact, far more than the above several methods, in the actual application should be specifically analyzed according to the specific situation, through the technical and economic analysis to select the best transformation method, in order to receive energy-saving The effect of consumption.

Acknowledgements
Natural Science Foundation.

References
[1] Zhang Liangyu. Pumps and Fans [M]. Beijing: China Electric Power Press, 2005.
[2] Energy Saving Research on Power Plant Pumps and Fans[J]. Liang Guofu. Volkswagen Technology. 2006(02).
[3] Research on Energy Saving Technology of Power Plant Pumps and Fans[J]. Liu Minli. Inner Mongolia Petrochemical. 2009(23).
[4] Discussion on Energy Saving Technology of Power Plant Pumps and Fans[J]. Han Zhiyu. Electronic Technology and Software Engineering. 2014(05).
[5] Discussion on Energy Saving Technology of Power Plant Pump and Fan[J]. Liu Jian. Shandong Industrial Technology. 2017(07).