Design of external temperature electromagnetic heating modification for all-steel mechanical tire shaping vulcanizer

Liu Qianwei

(Sinochem (Fujian) Rubber Machinery Co. LTD., Sanming 365599, Fujian, China)

Abstract: The tire curing press plays a pivotal role in the tire manufacturing process, as its performance directly impacts tire quality and production efficiency. With the increasing maturity of electromagnetic heating technology, numerous tire manufacturing and curing press enterprises have begun integrating this technology into tire curing presses to enhance vulcanization efficiency and reduce energy consumption. However, many older equipment models were originally designed without considering the application requirements of electromagnetic heating technology, rendering them incompatible with this method. This study delves into the retrofitting issues of external temperature electromagnetic heating for full-steel mechanical tire curing presses, proposing a practical retrofit design solution. It effectively addresses challenges such as the layout of heating coils on the upper plate and the detachability of mold heating covers. The findings of this research provide valuable guidance for the retrofitting and upgrading of equipment in tire manufacturing enterprises.

Key words: tire shaping vulcanizer; electromagnetic heating technology; external temperature modification; design scheme

Classification number: TQ330.47 **Article number:** 1009-797X(2026)01-0049-05

Document code: B **DOI:**10.13520/j.cnki.rpte.2026.01.015

1 Background overview

1.1 Current status of the tire manufacturing industry

Tyres, as indispensable components of vehicles such as automobiles, airplanes, and bicycles, directly affect traffic safety and ride comfort through their quality and performance. With the vigorous development of the global automobile industry and the increasing awareness of people's traffic safety, the tire manufacturing industry is facing unprecedented high demands. In the tire manufacturing process, the curing process is crucial, as it directly determines the strength and durability of the tires. The tire building and curing press, as a key equipment in the curing process, has a decisive impact on the quality and production efficiency of tires.

Currently, the tire manufacturing industry is undergoing dual transformations of technological innovation and industrial upgrading. On the one hand, the popularization of new energy vehicles and the rapid development of intelligent technology have raised higher requirements for tire materials, structures, and performance, driving continuous innovation in tire manufacturing technology. On the other hand, the concepts of environmental protection, energy conservation, and sustainable development have become deeply ingrained in people's minds. Tire manufacturing enterprises urgently need to explore new paths to reduce energy consumption, decrease emissions, and enhance production efficiency.

1.2 Urgency of electromagnetic heating technology transformation for old equipment

In the tire manufacturing industry, many old tire shaping and curing presses still adopt traditional steam heating methods. This method has problems such as high energy consumption, uneven heating, and high maintenance

Biography: Liu Qianwei (1985-), male, is a senior engineer, primarily engaged in the research, development, and management of rubber machinery equipment.

costs, which severely restrict the improvement of production efficiency and the reduction of costs. With the continuous maturity of electromagnetic heating technology, more and more tire manufacturing enterprises have begun to recognize its unique advantages, such as rapid heating, high thermal efficiency, and precise temperature control. Therefore, applying electromagnetic heating technology to the renovation of old tire shaping and curing presses is of great significance for improving curing efficiency, reducing energy consumption, and lowering production costs.

The transformation utilizing electromagnetic heating technology not only significantly enhances the heating efficiency and temperature control precision of equipment, but also effectively reduces energy consumption and maintenance costs. By optimizing the layout and heat dissipation methods of electromagnetic heating coils, the vulcanization efficiency and product quality can be further improved. Furthermore, electromagnetic heating technology also possesses characteristics of environmental protection, energy conservation, and sustainable development, fully aligning with the development trends and requirements of the tire manufacturing industry.

1.3 Practical application of electromagnetic heating technology in tire vulcanization

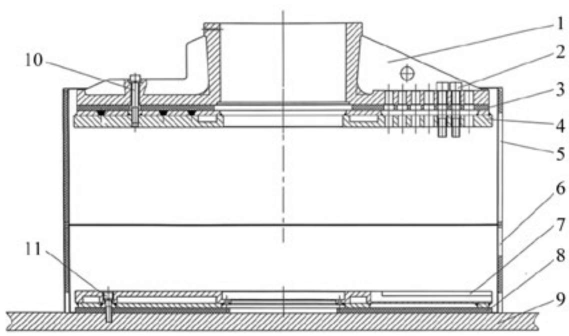
Electromagnetic heating technology is a kind of heating method based on the principle of electromagnetic induction, which converts electrical energy into thermal energy. In the process of tire curing, electromagnetic heating technology can achieve precise heating of tire molds. This heating method has significant advantages such as rapid heating, high thermal efficiency, and precise temperature control, which can significantly improve curing efficiency and product quality. External temperature electromagnetic heating of the curing press involves using electromagnetic heating technology to heat the upper and lower hot plates as well as the mold sleeve of the mold, and then transferring the heat to the tire mold and the tire itself through these components.

The application of electromagnetic heating technology in tire curing has been widely recognized and promoted. Many tire manufacturing and curing press manufacturing enterprises have applied it in the research and development of new equipment and the renovation of old equipment, effectively improving curing efficiency and product quality, and reducing energy consumption and maintenance costs. At the same time, electromagnetic heating technology can also be combined with intelligent and automated technologies to achieve remote monitoring and intelligent control of equipment, further enhancing production efficiency and safety.

2 Analysis of traditional structure and elaboration of electromagnetic heating principle

2.1 Introduction to the structure and principle of traditional steam external heating

Traditional tire shaping and curing presses typically utilize steam heating. The external temperature section is mainly composed of components such as the upper and lower heat plates, mold sleeves, and steam pipes. The steam pipes transport high-temperature steam to the upper and lower heat plates, as well as the mold sleeves of the curing press, transferring heat to the tire mold and the tire itself. The upper and lower heat plates are generally made of metal, with internal steam flow channels designed, and possess good thermal conductivity and high temperature resistance. The outside of the mold is equipped with a heat preservation shield. In all-steel radial tire shaping and curing presses, a significant portion is mechanical structure. Taking the 65-inch mechanical tire shaping and curing press as an example, the specific structure of the curing chamber is shown in Figure 1.



1-Upper support plate; 2-Mold mounting screw; 3-Upper heat insulation plate; 4-Upper heating plate; 5-Upper shield; 6-Lower shield; 7-Lower heating plate; 8-Lower heat insulation plate; 9- Base table panel; 10-Upper heating plate mounting screw; 11- Lower heating plate mounting screw

Figure 1 Traditional steam heating structure

The traditional structure is characterized by the upper heating plate and the upper heat insulation plate being fixed on the upper support plate with screws 10. The upper support plate, upper heating plate, and upper heat insulation plate all have multiple installation holes designed to accommodate different mold specifications. Screws 2 pass through these three components to fix the mold. The lower heating plate and the lower heat insulation plate are directly fixed to the base unit panel with screws 11. High-temperature steam is introduced into the upper and lower heating plates to transfer heat from the plates themselves to the upper and lower parts of the mold. The mold cavity is directly filled with high-temperature steam, eliminating the need for other heat transfer components.

The principle of steam heating is to utilize the high-temperature thermal energy of steam to transfer heat to the tire mold and tire through the upper and lower heat plates as well as the mold sleeve. This heating method has advantages such as uniform heating and stable temperature control. However, it also has issues such as high energy consumption, slow heating speed, and high maintenance costs. In addition, the steam heating method requires the installation of a steam boiler and piping system, which increases the complexity and cost of the equipment.

2.2 Exploration of the basic principles of electromagnetic heating technology

Electromagnetic heating technology is a kind of efficient heating method that utilizes the principle of electromagnetic induction to convert electrical energy into thermal energy. When an alternating current passes through a coil, an alternating magnetic field is generated around it. When a magnetic conductor is placed in this magnetic field, eddy currents are generated inside it. As the eddy currents flow through the magnetic conductor, they overcome the resistance of the conductor and generate heat, thus achieving the purpose of heating.

Electromagnetic heating technology boasts notable advantages such as rapid heating, high thermal efficiency, and precise temperature control. Since electromagnetic heating directly heats conductive materials, it offers high heating efficiency and low energy consumption. Furthermore, electromagnetic heating technology enables precise temperature control and remote monitoring, further enhancing production efficiency and safety.

2.3 Limitations of Traditional Structures in Electromagnetic Heating Applications

The upper heating plate and upper support plate of traditional tire curing presses are usually connected by threads, and both are perforated with rows of holes to accommodate mold installation of different specifications. However, this structure has certain limitations in the application of electromagnetic heating technology. Since both the upper heating plate and upper support plate are perforated with rows of holes, it affects the arrangement and heat dissipation of the heating coils. The heating coils need to be arranged relatively uniformly to achieve even heating effects, but the presence of the rows of holes disrupts the arrangement and heat dissipation of the heating coils, leading to uneven heating and increased energy consumption.

Traditionally, there is a significant gap between the insulation cover and the mold. When replacing the mold, there is no need to disassemble or assemble the insulation cover, and the distance between the insulation cover and the mold varies depending on the mold's specifications. However, electromagnetic heating requires strict control of the distance between the heating coil and the mold to ensure effective heating and the effectiveness of the heating range.

Therefore, traditional structures need to be redesigned and optimized for the application of electromagnetic heating technology, and some components need to be replaced for the modification of electromagnetic heating technology.

3 Design of external electromagnetic heating renovation scheme for all-steel mechanical tire curing press

3.1 Design of electromagnetic heating installation scheme for upper hot plate

To address the limitations of traditional structures in the application of electromagnetic heating technology, our company has specifically developed a new installation scheme for the electromagnetic heating upper hot plate. This scheme eliminates the need to process row holes for different specifications of mold installation on the heating coil plate, ensuring uniform arrangement of the heating coils and guaranteeing the heating effect. Additionally, it can also accommodate the installation of molds of different specifications. The specific design idea is as follows:

(1) Firstly, according to the size and heating requirements of the curing press, design appropriate coil plate shapes and

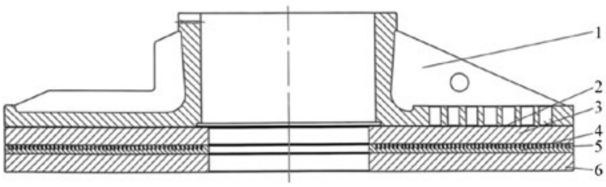
sizes to ensure that the heating coils can be evenly arranged without affecting the heating effect. At the same time, check the wiring and insulation of the heating coils to ensure safety and reliability.

(2) Electromagnetic heating technology eliminates the need to introduce steam into the upper heating plate, meaning that the new upper heating plate does not require additional processing of flow channels. To ensure heat transfer efficiency, the upper heating plate is designed as a solid plate, with precision requirements such as flatness and parallelism consistent with the original upper heating plate structure.

(3) The upper heat shield is designed for thickness and hole opening according to the technical requirements of electromagnetic heating.

(4) To reduce electromagnetic radiation and mitigate the heating effect of the heating coil on the upper support plate, a magnetic isolation plate can be added between the upper support plate and the upper heat insulation plate.

The schematic diagram of the design is shown in Figure 2.



1-Upper support plate; 2-Magnetic isolation plate;
3-Upper heat insulation plate; 4-Upper coil plate; 5 - Heating coil;
6-Upper heating plate

Figure 2 Schematic diagram of the electromagnetic heating upper heating plate structure

3.2 Design of electromagnetic heating scheme for lower heating plate

The electromagnetic heating scheme for the lower heating plate is relatively simple to design. Since the lower heating plate usually does not need to accommodate molds of different specifications, as they are all installed in the T-slot of the lower heating plate, the design can be directly based on the original structure. The specific design approach is as follows:

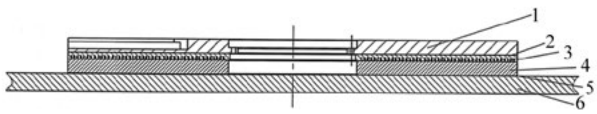
(1) Firstly, according to the size and heating requirements of the curing press, select the appropriate size and specifications of the electromagnetic heating plate.

(2) Electromagnetic heating technology eliminates the need to introduce steam into the lower heating plate, meaning that the new lower heating plate does not require additional processing of flow channels. To ensure heat transfer efficiency, the lower heating plate is designed as a solid plate, with precision requirements for flatness, parallelism, and other aspects consistent with the original lower heating plate structure.

(3) The thickness and hole design of the upper heat shield are carried out according to the technical requirements of electromagnetic heating.

(4) To reduce electromagnetic radiation and mitigate the heating effect of the heating coil on the base unit panel, a magnetic isolation plate can be added between the lower heat insulation plate and the base unit panel.

The schematic diagram of the design is shown in Figure 3.



1-Lower heating plate; 2-Lower coil plate; 3-Heating coil;
4-Lower heat insulation plate; 5-Magnetic isolation plate; 6-Base unit panel

Figure 3 Schematic diagram of the hot plate structure under electromagnetic heating

3.3 Design of electromagnetic heating scheme for mold sleeve

The mold sleeve, as a core component in the tire vulcanization process, has a direct impact on tire quality and vulcanization efficiency due to its heating effect. The traditional steam heating method involves directly injecting high-temperature steam into the mold sleeve cavity, whereas the electromagnetic heating method requires a specially designed electromagnetic heating shield to heat the mold sleeve. Since electromagnetic heating necessitates strict control over the distance between the heating coil and the magnetic conductor to ensure effective heating and heating range, a set of electromagnetic heating shield is only suitable for molds of the same external dimensions. When the mold dimensions change, the corresponding size of electromagnetic heating shield needs to be replaced. Of course, it is also possible to directly wrap the heating coil around the mold's outer wall, but this solution requires each mold to be equipped with a set of electromagnetic heating coils, with no interchangeability, resulting in high cost investment, and the heating coil may affect the replacement of tread blocks. Our company has designed a detachable electromagnetic heating shield that allows for interchangeability between molds of the same size. The specific design idea is as follows:

(1) Firstly, based on the actual external dimensions of the auxiliary mold, the shape and size of the electromagnetic heating shield are carefully designed to ensure that the heating coil can evenly surround the mold sleeve, thereby achieving a uniform and efficient heating effect.

(2) Secondly, securely install the designed electromagnetic heating coil inside the shield. The key to this step is to ensure a fixed distance between the heating coil and the mold sleeve to achieve uniform heating. At the same time, it is also necessary to carefully inspect the wiring and insulation condition of the heating coil to ensure the safety and reliability of the entire system.

(3) Next, add a layer of insulation cotton to the shield to replace the traditional insulation shield. Due to the addition of the electromagnetic heating shield, the original insulation shield cannot be installed.

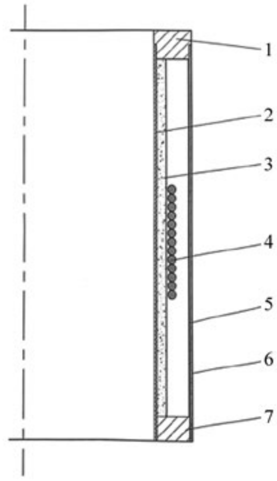
(4) To reduce electromagnetic radiation, a magnetic shielding plate can be added to the outside of the shield.

(5) Since the electromagnetic heating shield corresponds one-to-one with the mold size, it is only suitable for switching between molds of the same size. The shield can be fixed to the mold and disassembled and assembled together with the mold. When replacing the tread blocks of the tire mold, the electromagnetic heating shield can be removed.

The schematic diagram of the design is shown in Figure 4.

3.4 Summary

From the above design scheme, it can be seen that the original components that need to be removed for the external temperature electromagnetic heating modification of the all-steel mechanical tire curing press include the upper heating plate, upper heat insulation plate, lower heating plate, lower heat insulation plate, upper heat preservation shield, lower heat preservation shield, etc. The external temperature steam pipeline system can be removed; the components that need to be redesigned and produced include the upper heating plate, upper heat insulation plate, upper coil plate, upper magnetic isolation plate, lower heating plate, lower heat insulation plate, lower coil plate, lower magnetic isolation plate, mold sleeve electromagnetic heating shield, as well as the supporting electronic control and temperature control systems.



1-Upper support plate; 2-Inner support plate; 3-Insulation cotton; 4-Heating coil; 5-Magnetic isolation plate; 6-outer support plate; 7-lower support plate

Figure 4 Schematic diagram of the electromagnetic heating shield structure of the mold sleeve

4 Conclusion and Future Outlook

Through research on the electromagnetic heating transformation of the external temperature of all-steel mechanical tire curing press, a feasible transformation plan has been proposed, which solves problems such as heating coil arrangement, mold interchangeability, and electromagnetic radiation. After verification in cooperation with tire factories, the design structure is feasible and meets the usage requirements. The transformation plan has significant advantages in terms of heating effect, installation convenience, mold adaptability, cost-effectiveness, safety, maintainability, and environmental friendliness, providing an important reference for tire enterprises in equipment transformation.

The future application of electromagnetic heating technology in tire curing presses holds broad prospects. By optimizing the heating coils, efficiency and accuracy can be improved, and energy consumption can be reduced. Combined with intelligent technology, remote monitoring and intelligent control can be achieved, enhancing production efficiency and safety. This solution can also be applied to other specifications of curing presses to verify its applicability. The tire manufacturing industry will place greater emphasis on environmental protection, energy conservation, and sustainable development. New structures, as an environmentally friendly and energy-saving heating method, will play an important role. Strengthening technological research and development will drive industry progress.