# Introduction to the technical development of hydraulic engineering tire curing presses

Ding Zhentang, Zhang Chengjun, Ji Fugao, Liu Shifa, Liu Xiaodong

(Qingdao MESNAC Electromechanical Engineering Co. LTD., Qingdao 266200, Shandong, China)

**Abstract:** This article briefly introduces the development background, main structure, and process parameters of the hydraulic engineering tire curing press. This curing press has the advantages of realizing mechanization and automation, improving product quality, and reducing energy consumption (note: the hydraulic engineering tire curing press mentioned in this article refers to a single machine. The hydraulic engineering tire curing press unit developed by MESNAC possesses exclusive core technologies and is kept confidential, which will not be introduced in this article).

**Key words:** hydraulic; mechanization; automatic control

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The development of the hydraulic engineering tire curing press has achieved mechanization of equipment operation, simplification of operations, and digitalization of faults. All information is stored in the machine control computer, which can be queried and corrected through the touch screen, reducing downtime and failure rates, and facilitating operation and maintenance.

## 1 R&D background

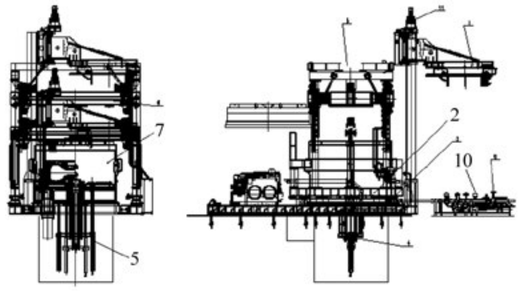
With the construction of China's "the Belt and Road" initiative and the increase in engineering infrastructure projects in various countries, the demand for large construction vehicles continues to grow, and accordingly, the demand for engineering tires has also increased, making it a hot spot in the current tire market. Large tire manufacturers are launching engineering tire projects one after another. Currently, the engineering tire curing presses used by various manufacturers are still mainly mechanical single-tire models. As we all know, mechanical single-tire models have disadvantages such as being bulky, consuming large amounts of power and energy, and having poor tire manufacturing precision. Compared to mechanical models, hydraulic single-tire models can avoid these defects. Since the investment in a single engineering tire curing press can easily reach several million yuan, manufacturers are relatively cautious when launching such projects, and they have an urgent expectation for hydraulic engineering tire curing presses that adopt new structures, technologies, and processes. Qingdao MESNAC Electromechanical Engineering Co., Ltd. has many years of experience in the research and development of hydraulic curing presses, as well as rich practical design experience in large equipment production lines. The expert team is proficient in the overall structural layout, stress analysis of each main component, and curing process, possessing a wealth of research and development foundation and experience. The hydraulic engineering tire curing presses developed by the company are very mature and have been put into practical application. Currently, they are favored and purchased by many domestic engineering tire manufacturers.

## 2 Layout and general introduction of hydraulic engineering tire curing press

Hydraulic engineering tire curing press (Figure 1). It is mainly composed of mechanical, thermal, electrical control,

**Biography:** Ding Zhentang (1969–), male, is a senior engineer and an expert in the rubber and plastics industry, tire industry, and curing press industry. He is a member of the China Polymer Materials Expert Committee and a researcher at the High–Performance Polymers Research Institute of Qingdao University of Science and Technology.

pneumatic control, hydraulic, etc. It is a device that integrates mechanical, electrical, and hydraulic elements, and features high automation capabilities.




1-Manipulator; 2-Mobile frame; 3-Base assembly; 4-Central mechanism; 5-Segmented mold mechanism; 6-Host machine device; 7-Steamer system; 8-Hydraulic system; 9-Thermal pipeline; 10-Pneumatic control system; 11-Electronic control system (Figure 2)

**Figure 1 Layout of hydraulic engineering tire curing press**

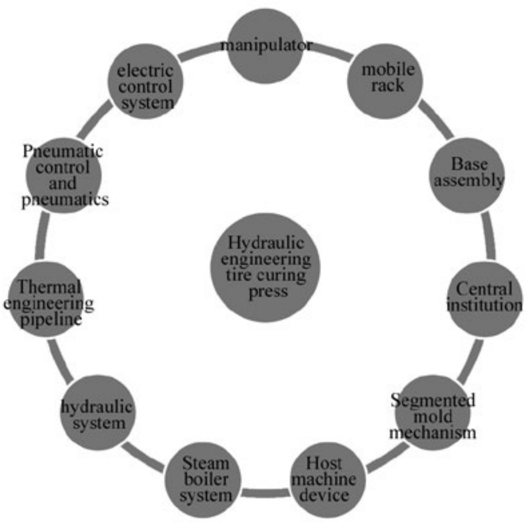



**Figure 2 Main component composition of hydraulic engineering tire curing press**

## 3 Operating principle of hydraulic engineering tire curing press

The mobile frame is driven by a servo gear and rack system to move to the middle position of the steamer system, waiting for the vulcanization to end → After the vulcanization is completed, the force cylinder releases pressure, the internal pressure detection zero pressure switch detects the signal, and the mold clamping mechanism unlocks and opens the mold for the upper vulcanization chamber → The mobile frame is controlled by the electronic control system to move → Reach the designated position → The manipulator tire unloading position is activated, and the manipulator rotates in and out to unload the tire → The manipulator grasps the raw tire, rotates it to the center of the mold, and descends to complete the shaping process → The manipulator rotates out, the safety pin retracts, the upper vulcanization chamber reaches the mold clamping position, and the vulcanization chamber completes mold clamping → After the detection switch detects that the mold clamping mechanism's lock ring is closed, the force cylinder starts to pressurize to the set mold clamping force, and vulcanization begins, repeating in sequence.

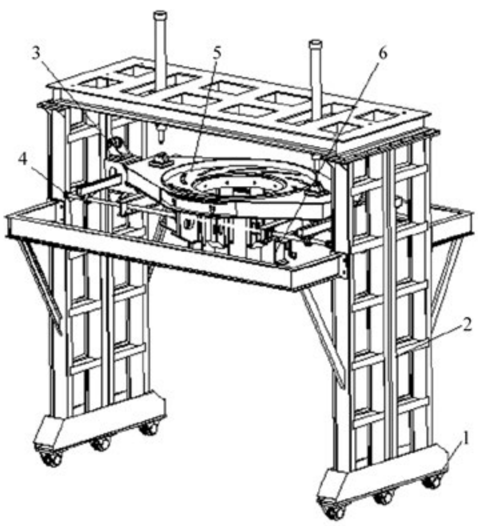
Introduction to the simple process: manipulator descends → claw opens (grasps the green tire) → manipulator ascends → manipulator rotates in → manipulator descends → upper ring descends (finalizing) → claw closes → manipulator ascends → manipulator rotates out → mold closes → mold closing stops, secondary finalizing → mold closes to the end point → vulcanization → vulcanization ends → segmented mold extends → mold opens → mold opening stops, segmented mold retracts → mold opens to the limit → manipulator rotates in → manipulator descends → claw opens (grasps the tire) → manipulator ascends → manipulator rotates out → manipulator descends → claw closes (releases the tire) → manipulator ascends → next cycle.

## 4 Introduction and characteristics of the main structure and key components of hydraulic engineering tire curing press

The hydraulic engineering tire curing press developed by Qingdao MESNAC Electromechanical Engineering Co., Ltd. utilizes proprietary technologies for all key components, having obtained multiple domestic patents for invention and utility models, with several technologies also having been applied for foreign patents. It possesses unique features and advantages, including a brief introduction to the robotic arm, segmented mold mechanism, and electronic control system.

### 4.1 Structure and characteristics of MESNAC electromechanical manipulator

The main function of the manipulator is to grab the raw tire and place it into the steamer. After vulcanization, the tire is removed from the steamer and placed at the designated workstation. The original engineering tire vulcanizer manipulator (Figure 3) is separated into two parts from the host machine, with its own independent frame and pulley block. It is of an overall translational type, where the tire grabber group moves up and down along with the guide rail group driven by the synchronous gear and rack group. The disadvantage of this structure of manipulator is that it occupies independent space and the alignment accuracy is difficult to adjust, resulting in the raw tire being loaded into the steamer eccentrically, which requires re-adjustment to the correct position, otherwise it will affect the vulcanization quality of the tire. However, the hydraulic engineering tire vulcanizer manipulator developed by MESNAC attaches to the moving frame for swinging motion, can move up and down along the column and make circular motion with the rotating arm, and can also move as a whole with the moving frame in a translational manner. The actions of tire loading and unloading are highly precise, without the need for a separate base, saving installation space, achieving automatic tire loading and unloading actions, and improving tire manufacturing quality and work efficiency.

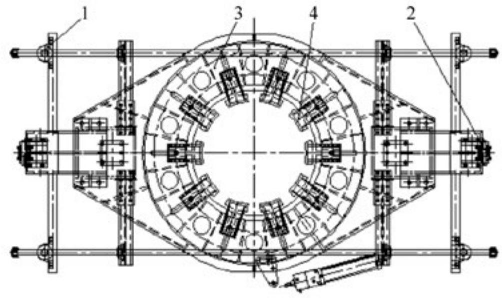



1-pulley block; 2-manipulator frame; 3-guide wheel block;
4-synchronous gear and rack block; 5-manipulator disc; 6-tire gripper block.

**Figure 3 Original engineering tire manipulator**

The original engineering tire mechanical arm grasps the tire components and moves up and down driven by the lifting cylinder, following the same steps for tire loading and unloading (Figure 4).

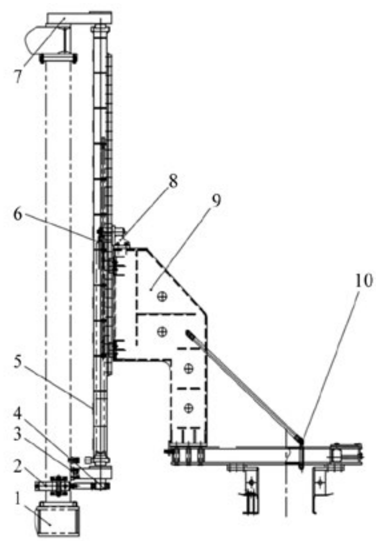
The hydraulic engineering tire curing press manipulator developed by MESNAC (see Figure 5) is installed on a mobile frame and moves along with the frame. The original installation support on the ground is eliminated, reducing the footprint and eliminating the need for multiple alignments during




1-Synchronous gear and rack assembly; 2-Guide wheel assembly;
3-Mechanical arm disk; 4-Tire gripper assembly

**Figure 4 Original engineering tire curing press robotic tire grasping component**

installation, saving both time and effort. Another feature is that the manipulator's large-span stepless adjustment replaces manual specification adjustment, allowing for a wide range of tire specifications and enabling multi-specification replacement.




1-Mobile frame; 2-Oscillating cylinder; 3-Lower connecting base;
4-Gear and rack assembly; 5-Rotating shaft; 6-Lifting cylinder;
7-Upper connecting base; 8-Extension frame; 9-Lifting frame;
10-Tire gripper, etc.

**Figure 5 Structure of manipulator for hydraulic engineering tire curing press**

Introduction to the structure of the manipulator: The swing cylinder 2, lower connecting base 3, and upper connecting base 7 are installed on the moving frame 1; the gear and rack assembly 4 is installed on the swing cylinder and the rotating shaft 5; the rotating shaft is installed on the lower and upper connecting bases; the lifting cylinder 6 is installed on the rotating shaft and the extension frame 8; and the lifting frame 9 is installed on the extension frame 8 and the tire gripper 10.The entire workflow is as follows:

#### 4.1.1 When tire loading

After the moving frame is in place, the lifting cylinder drives the tire grabber to descend to the designated position to grab the tire blank; the lifting cylinder drives the tire grabber to ascend to the designated position, and the swing cylinder pushes the gear and rack combination to drive the rotating shaft to swing to the upper part of the vulcanization chamber; the lifting cylinder drives the tire grabber to descend to the designated position and release the tire blank; the lifting cylinder drives the tire grabber to ascend to the designated position, and the swing cylinder pushes the gear and rack combination to drive the rotating shaft to swing out of the vulcanization chamber.

#### 4.1.2 When tire unloading

After the mobile frame is moved into position, the lifting cylinder drives the tire grabber to ascend to the designated location. The swing cylinder then activates the gear and rack assembly to rotate the shaft to the upper part of the vulcanization chamber. The lifting cylinder lowers the tire grabber to the specified position to grab the vulcanized tire. Subsequently, the lifting cylinder raises the tire grabber to the designated location again, and the swing cylinder activates the gear and rack assembly to swing the shaft out of the vulcanization chamber. Finally, the lifting cylinder lowers the tire grabber to the specified position to release the tire (Figure 6).

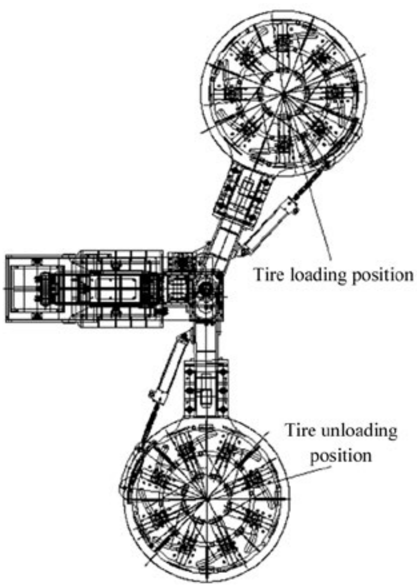
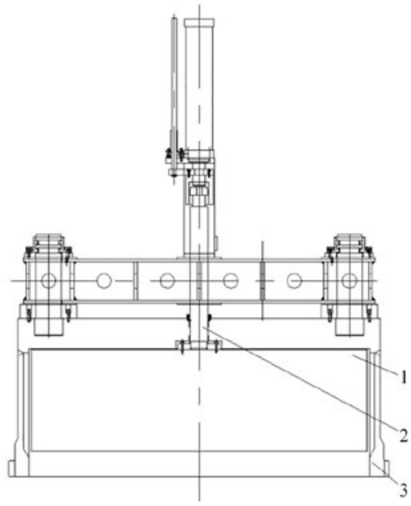



**Figure 6 MESNAC hydraulic engineering tire curing press tire loading and unloading positions**

### 4.2 Brief introduction and characteristics of the segmented mold mechanism structure

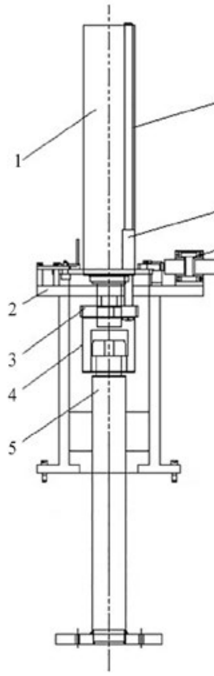
The function of the segmented mold device of the engineering curing press is to cooperate with other mechanical actions. Under the control of the PLC program, it operates the segmented mold blocks of the tire segmented mold to expand and contract. The connection or separation between the segmented mold device and the mold is achieved through the locking and unlocking mechanism on the tire segmented mold device, completing the mutual conversion between the mold's release position and clamping position. Currently, in the original curing press, the segmented mold device adopts an upper-mounted installation method (Figure 7), connected to the top of the mold in the upper curing chamber via screws. The segmented mold device uses a single hydraulic cylinder to provide pressure, a single-guided segmented mold guide rod, and a semi-frame segmented mold bracket. This structure has no problem in semi-steel and all-steel tires. However, if applied to engineering tire curing presses, due to the relatively heavy weight and large diameter of engineering tires, if there are few stress points, uneven stress distribution and poor stability may occur. The biggest drawback of using this structure for mold demolding is the poor connectivity between the segmented mold device and the mold, as well as poor synchronization and low stability, resulting in low overall structural utilization.




1-mold; 2-segmented mold device; 3-upper vulcanization chamber

**Figure 7 Position diagram of the upper-mounted segmented mold device in the steamer**

The structure of the top-mounted segmented mold device is shown in Figure 8.

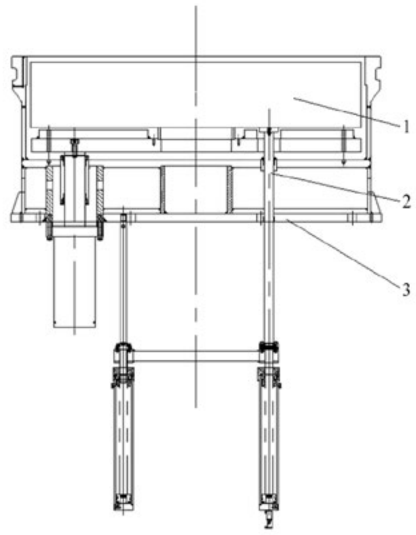



1-Segmented mold cylinder; 2-Segmented mold bracket; 3-Press plate; 4-Lock ring; 5-Segmented mold rod; 6-Guide rod; 7-Unlocking plate; 8-Intermediate trunnion seat; 9-Lock release cylinder, etc.

**Figure 8 Top-mounted segmented mold**

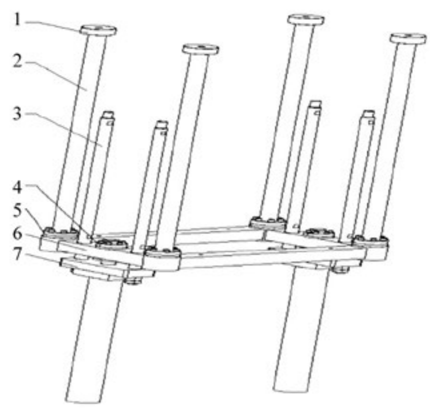
The operating principle is that, driven by the segmented mold oil cylinder, the piston rod of the oil cylinder extends and contracts, allowing the segmented mold to be in the open or closed position, thus completing the work conversion between mold release and mold clamping.

The segmented mold device of the curing press for engineering tires, developed by MESNAC (Figure 9, Figure 10), primarily addresses the issues of poor connectivity, synchronization, and stability between the segmented mold device and the mold due to the top-mounted installation method, single-cylinder pressure supply, single-guided segmented mold guide rod, and semi-frame segmented mold bracket. The segmented mold device adopts a bottom-mounted installation method, with the device installed at the bottom of the lower curing chamber. It utilizes dual cylinders for pressure supply, a dual-guided segmented mold guide rod, and a frame-style segmented mold bracket. This structure offers excellent guidance, uniform force distribution, and high stability, fundamentally solving the problems with the connection between the segmented mold device and the mold, thereby achieving enhanced synchronization and stability.




1-Mold; 2-Segmented mold device; 3-Upper vulcanization chamber

**Figure 9 Mutual positional relationship between the segmented mold and the steamer system**




1-Cover plate; 2-Segmented mold rod; 3-Guide rod; 4-Pressure plate; 5-Heat shield; 6-Segmented mold bracket; 7-Oil cylinder connecting plate

**Figure 10 The frame-type curing press segmented mold device developed by MESNAC**

The working principle of the segmented mold device of the hydraulic engineering tire curing press: It has the function of achieving mold release and mold closure. During mold release, the oil cylinder drives the segmented mold rod to push the segmented mold open. The segmented mold rod cooperates with the locking ring and works under the drive of the mold release and locking oil cylinder. The oil cylinder piston rod extends, and the segmented mold device is in the mold release position, separating from the mold. During mold closure, the oil cylinder drives the segmented mold rod to close the segmented mold. The segmented mold rod cooperates with the locking ring and works under the drive of the mold release and locking oil cylinder. The oil cylinder piston rod contracts, and the segmented mold is in the mold locking position, thus achieving the mutual conversion between mold release and mold closure.

Characteristics of the segmented mold device for hydraulic engineering tires: As can be seen from the figure, the segmented mold device is connected to the bottom of the lower vulcanization chamber through the threaded connection on the upper end of the guide rod. The oil cylinders on both sides work under the guidance of the double guide rods, reducing friction on the cylinder pistons and providing protection. The two oil cylinders push the frame-type segmented mold support, while simultaneously allowing the four segmented mold rods to work synchronously with the mold, thereby improving the connectivity, synchronicity, and stability of this structure. The segmented mold device, featuring a bottom-mounted installation, frame-type support, dual oil cylinder pressure supply, and dual guide rods, provides better overall guidance, more uniform force distribution, higher structural stability, and stronger synchronicity, resulting in higher utilization of the segmented mold device.

## 4.3 Introduction and features of MESNAC electrical control system

### 4.3.1 Mold and capsule control

MES confirms through RFID or mobile phone whether the on-site mold number is assembled as required. After the mold change is completed, the execution parameter download instruction is issued or manually confirmed by the curing press operator. The MES system downloads the curing process parameters to the machine's PLC, which produces according to the process parameters and performs alarm processing according to the control standards. The machine displays parameter changes. After the capsule replacement is confirmed through the mobile phone, MES downloads the capsule barcode number to the machine's PLC, which displays it and controls the equipment according to the maximum allowable number of cured capsules.

### 4.3.2 Production plan control

The curing press and automatic logistics system receive the production specifications, required tire blank specifications and part numbers, and curing rotation angles from the MES via the curing press PLC, and display them as well as control the conveyance of tire blanks. Alternatively, in standalone mode, they execute the production plan that has been downloaded from the MES, including control information such as curing parameters, standards, and tire blank specifications. Mobile phones or automatic logistics systems manage and control production according to the production plan, prohibiting mold loading and production without a production plan. They are also capable of controlling production based on the planned production volume.

### 4.3.3 Process data acquisition

The MES data acquisition system obtains process data for the product by reading specific addresses of the curing press PLC, mainly including curing steps, curing temperature, curing pressure, curing time, setting pressure, mold clamping force, and other data. At the same time, based on relevant technical standards, it judges whether the product meets the process requirements. If it does not meet the requirements, it generates relevant records and uploads them to the real-time database with barcodes attached. The industrial control computer of the curing press unit also saves the same data to the local database for data exchange with the MES system through WEBSERVICE. The local industrial control computer saves at least one month's worth of curing production data.

### 4.3.4 Interaction mode

The interaction mode is shown in Figure 11.

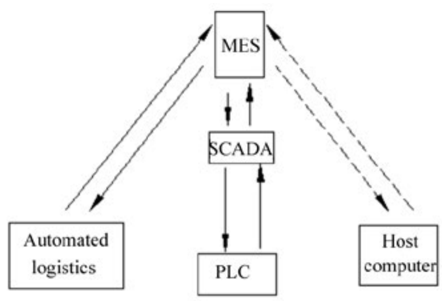



**Figure 11 Interaction mode**

To ensure timely dissemination of production plans and control standards to equipment and ensure timely uploading of equipment production data, MES and equipment engage in data interaction through two methods: interaction between SCADA and equipment PLC, and interaction between MES system and equipment host computer (via WEBSERVICE). Automatic logistics interacts with MES through: logistics data and tire blank outbound information via WEBSERVICE, and automatic logistics interacts with the curing press PLC for tire blank information and related control signal interaction. In principle, the MES system first interacts with equipment PLC through SCADA for control data and acquisition data, and interacts with the host computer via WEBSERVICE as a data supplement in standalone or offline states. The equipment displays, controls alarms, and saves data according to the data downloaded from the MES system, and processes relevant data information for uploading. The specific data interaction format and interaction address will be confirmed by both parties after the equipment arrives on site. Automatic logistics reads the required tire blank specifications of the curing press and delivers them to the required machine as per demand. Upon arrival at the tire storage device, automatic logistics transmits the barcode information upon arrival to the PLC of the bowl vulcanizer. The PLC reserves 20% of its I/O points.

## 5 Specification parameters applicable to hydraulic engineering tire curing press

The specifications and parameters applicable to the hydraulic engineering tire curing press are shown in Table 1.

**Table 1 Specification and Parameter Table of Hydraulic Engineering Tire Vulcanizer Fleet**

| Specifications | Inner diameter of vulcanization chamber/mm | Clamping force max/KN | Model height /mm | Bead diameter |
|---|---|---|---|---|
| 70″ | 1 815 | 7 500 | 330~750 | 20″~33″ |
| 88″ | 2 270 | 9 600 | 500~940 | 20″~33″ |
| 95″ | 2 410 | 9 600 | 500~980 | 20″~35″ |
| 105″ | 2 667 | 13 658 | 600~1070 | 25″~36″ |
| 122″ | 3 100 | 17 200 | 750~1 250 | 24″~36″ |
| 150″ | 3 850 | 24 000 | 1 240~1 400 | 35″~49″ |
| 170″ | 4 320 | 32 000 | 1 000~1 330 | 45″~51″ |
| 188″ | 4 800 | 40 000 | 1 300~1 530 | 45″~57″ |
| 220″ | 5 600 | 58 000 | 1 520~1 960 | 51″~63″ |

## 6 Social and economic benefits

Hydraulic engineering tire vulcanization has been used on-site in multiple tire factories, and has successfully incubated a full series of inch sizes, including 68, 72, 88, 95, 105, 122, 150, 170, 188, and 220. It has received unanimous praise from tire manufacturers and users, and customers are currently placing additional orders.

(1) Advanced functionality: The mobile frame adopts servo motors for precise positioning, and utilizes PLC empty slot modules for networking, wireless communication, and other advanced automation control system functions.

(2) In terms of application costs: Due to the centralized thermal system, there is greater savings in thermal pipelines and thermal losses. Each tire can only save and reduce thermal power by more than 3%, while the investment cost can be saved by more than 30%. In summary, the successful development of the vulcanization cluster production line holds broad market prospects.