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## Exploration of interconnected factory mode: Haier Jiaozhou Air Conditioner Interconnected Factory

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Haier Jiaozhou Air Conditioner Interconnected Factory (“Haier Interconnected Factory” for short hereinafter) was constructed by Haier Group in Haier (Jiaozhou) Innovative Industrial Park with a total investment of 1 billion CNY and a registered capital of 100 million CNY. The factory covers an area of 140 mu or approximately 100,000 m<sup>2</sup>. It is the largest individual building for producing household air conditioners in China at present. To undertake the 2025 China-made and Internet+ strategy, the factory is committed to creating a model factory for the Internet+ industry and plans an annual production capacity of 3 million sets (energy efficiency level of 2 or above) with eight global leading core technologies. Its output per unit area is two times that of the industry. It achieves an annual output value of 5 billion CNY and a tax revenue of 200 million CNY. The factory has built four final assembly lines for indoor and outdoor air-conditioning units, four production lines for evaporators and condensers, construction for heat supply, power supply, water supply, and drainage, plants, office buildings, warehouses, and other ancillary projects. The factory mainly produces packaged, wall-hanging, and window air conditioners using leading fluorine-free frequency conversion technology with highly energy-efficient new-type heat exchangers, optimal refrigerant distribution control, compressor lubricating oil circulation volume control, degradation of formaldehyde technology, Internet of things, and other international technologies.

Haier Interconnected Factory is a user-centered and user-order-driven factory for precise and efficient mass

customization. The main difference between this factory and other traditional factories is that traditional factories are commanded and dispatched by enterprises, whereas interconnected factories (e.g., Haier Interconnected) are directly driven by user order, thus realizing zero distance with users.

Haier Interconnected Factory was constructed by adopting a “two-dimensional strategy,” that is, high efficiency with high precision. The vertical axis is the user value for high precision, and the horizontal axis is the enterprise value and the fusion of end-to-end information for high efficiency. The vertical and horizontal axes are fused and promote each other to provide the best user experience. The greater the value of the user is, the greater the value of the enterprise is.

The core aim of the Haier Interconnected Factory is to interconnect with users, as reflected in “three interconnections.” The first interconnection is that between the total factor and users, with production being driven by user needs instead of according to a previously set plan. The second one is the interconnection between the network device and users. All home appliance products should be connected to the Internet so that they can interact with users directly for acquiring information required in the iteration of driven products. The third one is the interconnection between the complete flow and users. With this interconnection, the formerly closed boundary is broken, and all the resources of the enterprise can be interconnected with users to satisfy user needs.

Starting from the interaction with users, Haier Interconnected Factory has built an interaction platform for all persons and the entire network, realized zero distance and precise interaction between stakeholders and users, and continuously iterated the resolution of products according to user experience from the interaction. Haier Interconnected Factory has achieved the integration of seven platforms of the entire process between the Internet and reality and has opened up complete flow links, such as interactive customization, open design, online and actual

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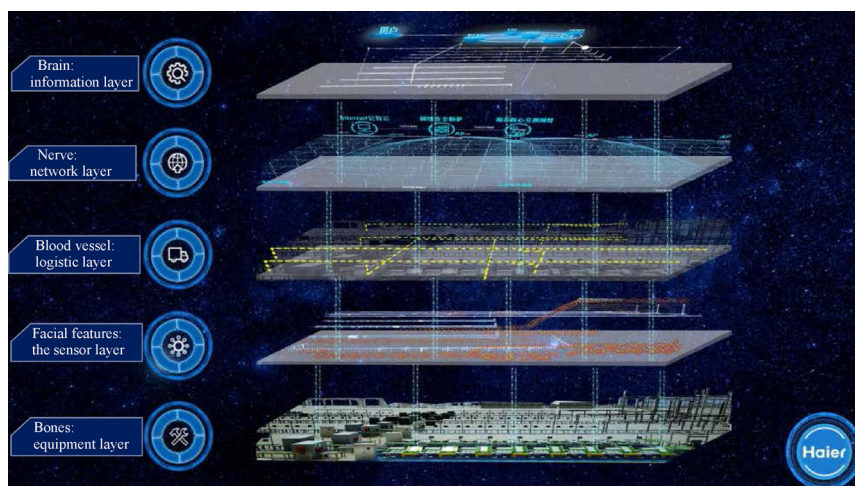
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**Fig. 1** Gate of Haier Jiaozhou Air Conditioner Interconnected Factory



**Fig. 2** Intelligent assembly line of Haier Jiaozhou Air Conditioner Interconnected Factory



**Fig. 3** Five-layer structure of Haier Jiaozhou Air Conditioner Interconnected Factory

marketing, module procurement, intelligent manufacturing, intelligent logistics, and service use, which meet the personalized customization experience of users. For example, in the customization link, new products are mainly produced in the mode of community users “public creation + ordering and pre-sale” so that instead of being consumers and bystanders, users become participants or even the dominant power in product design, research, and development to create real products that meet their needs. In the link of research and development, resources from 200,000 companies are presented in the HOPE platform of open design, which is “the world is our research and development department.” In the procurement link, in the platform of the module manufacturer Haidayuan, the original closed system has become an open one. As long as the module manufacturer has a solution, it can directly interact with users in the Haidayuan platform for their orders. The manufacturing link involves the production of efficient user-driven mass customization. In the logistics link, the product is delivered and fixed according to an appointment through a self-employed Chexiaowei order-taking mode. The service link realizes zero-distance interaction between the “service soldiers” and users through an intelligent cloud service. With the Renren service, update, and steward platforms, the corresponding APP service is offered to users, thus realizing zero-distance interaction with the users.

Haier Interconnected Factory continues to upgrade its basic competence building, especially competence in flexibility, digitalization, and intellectualization. The entire factory has built a five-layer structure of equipment, sensor, logistic, network, and information layers, thus forming an interconnected digital architecture to guarantee real-time interconnection between the factory and users.

The equipment layer applies automation equipment for the first time in the industry. These automation equipment are not simple and possess the following characteristics: flexibility for task matching to personalized orders, integration for matching among various equipment and between the former and latter processes to form a status close to zero inventory in the entire composition that satisfies the personalized orders of users, and interconnection for primary interaction competence among various equipment.

The sensor layer can sense temperature, humidity, position, and pressure, similar to the five sense organs of human beings. Over 15,000 sensors are set primarily with 40 million sets of data produced daily, which play two main functions: real-time monitoring of the operating situation of the entire interconnected factory and giving alarms and real-time early warning for automation equipment based on the sensor set in the equipment to guarantee that the equipment can run soundly and be maintained in the manner of big-data prediction before malfunctions.

The intelligent logistic mode is built in the logistic layer

for the entire factory logistic construction. A large number of ground automatic guided vehicles (AGVs), aerial power and free chains, intelligent industrial equipment carrier vehicles, and intelligent stereoscopic warehouses are arranged. These advanced technologies have achieved co-innovations through open platforms with first-class resources to achieve maximum efficiency and inventory optimization through intelligent logistics to intelligently respond to the mixed-line production of user-driven personalized order mass customization. Pieces of equipment between the final logistic assembly and AGVs can automatically interact. AGVs can be intelligently adjusted according to the final assembly situation, which is an innovation in the industry.

In the network layer, the network of the Jiaozhou Interconnected Factory layout is designed in accordance with the industrial network architecture—from optical fiber broadband and industrial switches to the wired network and wireless network layout. A high-speed, safe, industrial network that can instantly deliver millions of orders to the factory with timely responses is thus formed.

The information layer, which functions similar to the brain of a human being, is the most crucial layer. This layer is also user driven and realizes transverse and seamless integration between ERP and PLM, iMES, and SCADA. Therefore, information can be delivered instantly. On this basis, the connections of the vertical equipment layer, sensor layer, logistics, and equipment are realized, and all nodes can be interconnected in real time.

The preceding architecture indicates that the capacity of Jiaozhou Interconnected Factory is larger than that of traditional factories, and its capability to meet user customization with high flexibility and high quality is better. The factory has realized a transformation from production based on the prediction of the production inventory to the production of user-centered real orders. Every order has its own master. User customization orders account for 20%, and customer orders account for more than 50%, which are in continuous improvement. Products are delivered from the factory directly to the user, with the number of working capital turnover days (CCC) being – 10, thereby achieving a zero inventory and zero operating costs. The overall efficiency of Jiaozhou Interconnected Factory has improved significantly. The product development cycle has been reduced by more than 50%, the delivery cycle has been shortened by more than 50%, the operating costs of the entire flow have decreased by 20%, the product defective rate has been reduced by 10%, and the energy utilization rate has increased by 5%. In the aspect of quality, Jiaozhou Interconnected Factory has achieved a transformation from the warranty period to the guarantee period, with welding quality level being < 6 ppm, which is 20 times ahead of the industry level. While improving competitiveness, the interconnected factory also makes joint co-innovations with first-class resources, such as the first innovated intelligent finished product

distribution center, automatic punching wear bushing machine, air distribution center, domestic core technology robot applications, and other technologies in the industry.

Changes in the Haier Interconnected Factory mode have also promoted the leading status of Haier air-conditioning technology and management levels. (1) With household air conditioner self-cleaning technology, ultra-quiet technology, annular air-blowing technology, new frequency conversion technology, and environmental protection refrigerant technology, the Haier air conditioner has won the second class prize of the National Science and Technology Progress Award, which is in the international level. (2) The Haier Interconnected Factory mode has been mentioned in the “IEC Future Factory White Paper” and “Manufacturing Power Study.” The factory has become a national intelligent manufacturing comprehensive demonstration and has been selected as a member unit of the national team for intelligent manufacturing standardization

general technology. The excellent case award of the 2016 National Industrial Internet Application and the Shandong Industrial Outstanding Contribution award were awarded to Haier Interconnected Factory. Furthermore, the factory has been identified as an intelligent interconnected factory in Qingdao, staying in the international leading level in the field of air-conditioning intelligent manufacturing.

Through its continuous exploration of interconnected factory models, Haier has softened and clouded the interconnected factory mode and built the original, independently innovated, industrial Internet platform in China, namely, COSMOPlat. A new user-centered industrial ecology has thus been formed under the community economy. This new ecology not only serves the continuous upgrading of the 108 factories of Haier but also helps other companies rapidly achieve transformation and upgrading to intelligent manufacturing.