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22000-ton gantry crane

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1 Overview of the Honghai Gantry Crane

The Honghai 22000-ton Gantry Crane (Model MDGH22000t), referred to as the Honghai Gantry Crane, was the world's largest mobile gantry crane in terms of lifting capacity and adaptability to diverse lifting objects when completed in 2014. With a total height of 148 m, a lifting height of 71.38 m, and a span of 124.8 m, it was independently developed in China, featuring proprietary intellectual property rights. The Honghai Gantry Crane consists of two cranes, each with a lifting capacity of 11,000 tons, achieving a combined maximum lifting capacity of 22,000 tons, equivalent to the weight of 400 high-speed train carriages. This capacity exceeds the largest previously operational mobile gantry cranes by 11 times.

The crane's main structure employs a truss-based design with dual lifting beams and an arch-shaped configuration. Each truss-arch main beam features 48 evenly distributed lifting points, totaling 96 lifting points, each capable of handling up to 300 tons. The base includes 128 pairs of wheel assemblies, while the overall power capacity is 1,800 kW, and the total weight is

14,800 tons, approximately the weight of two Eiffel Towers. Construction utilized 11,000 tons of high-strength steel at a cost of approximately 700–800 million yuan. The gantry crane contract alone was valued at 370 million yuan. The concrete foundation required pile driving to a depth of 46 m, incurring an additional cost of 300 million yuan. Upon completion, the Honghai Gantry Crane was deployed at the Honghua Qidong Offshore Equipment Base for integrated offshore oil platform lifting and launching operations.

The Honghai Gantry Crane was funded by Honghua Offshore Oil & Gas Equipment Co., Ltd. (Jiangsu), a subsidiary of Sichuan Honghua Group. Wuqiao Heavy Industry Group Co., Ltd. was responsible for general contracting and design (Wu, 2013). Jiangsu Huaneng Construction Engineering Group Co., Ltd. and Shanghai Lifting Company carried out construction tasks (China Installation Association, Mechanical Equipment and Lifting Branch, 2014), while Shanghai Chuangwei Construction Engineering Co., Ltd. contributed to the design of auxiliary structures such as lifting brackets and lugs and supported structure installation and equipment positioning (Shi et al., 2014).

The Honghai Gantry Crane facilitates the synchronized construction of submersible hulls, upper decks, and other large offshore oil platform modules onshore. These prefabricated modules are lifted and assembled as complete units in dock basins, transforming offshore oil platform construction. This process eliminates the reliance on shipyard dock resources, enabling a single dock basin to support the concurrent construction of up to 10 offshore oil platforms. This innovation significantly improves production efficiency, reduces costs, and enhances construction safety. It also delivers substantial economic benefits for offshore oil platform manufacturing and offshore oil and gas resource development. The successful development of the Honghai Gantry Crane represents a significant milestone, laying the foundation for future advancements in super-large gantry cranes with greater lifting capacities. It also drives progress in construction technologies for large-scale military and civilian vessels.

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Fig. 1 22000-ton gantry crane.

2 Technological innovations of the Honghai Gantry Crane

2.1 Innovative structure of rigid and flexible support legs

The Honghai Gantry Crane features a truss-arch gantry frame, crane operating mechanism, electrical equipment, and a maintenance hoist. The gantry frame includes an arch-shaped main beam supported by two legs: one rigid and one flexible. The rigid leg is welded to the main beam, while the flexible leg is connected through a hinge, effectively mitigating adverse effects caused by main beam deformation on the structural stability of the frame. Both legs are designed with a lattice-style trapezoidal truss structure. The lower ends of the legs integrate with the support system and operating mechanism, allowing for a maximum operational range of 300 m. The maintenance hoist is suspended from the upper chord beam of the truss-arch main beam.

2.2 High-strength steel truss and uniform load distribution in the lifting system

The truss structure is composed of individual members connected at their ends via hinges and typically arranged in triangular configurations within planar or spatial layouts. This design enhances load-bearing capacity without increasing the cross-sectional area, substantially reducing the weight of the steel framework. Consequently, manufacturing costs are lowered, wind resistance is minimized, and wind performance is improved. The Honghai Gantry Crane's trusses are constructed from high-strength steel, with welded joints ensuring durability. Unlike traditional gantry cranes designed for modular assembly, the Honghai Crane specializes in the integrated lifting of large-scale ships or structural components. This necessitates high lifting capacity and uniform load distribution. The lifting system employs the pulley-lever principle with multiple lifting devices and points to achieve

synchronized and evenly distributed lifting. To reduce the overall center of gravity, the hoisting winches are housed within the truss structure of the supporting legs.

2.3 Roller-based support mechanism

Given the crane's significant self-weight and lifting demands, conventional sliding or rolling friction mechanisms with wheels are unsuitable. Instead, a roller-based support system with high load-bearing capacity and low friction resistance is employed (Yan and Ma, 2017). Each support leg is mounted on 32 roller cars connected via support seats and flanged joints. Hydraulic cylinders and disc hinges within the support seats evenly distribute the load across the roller cars onto the reinforced concrete foundation. Guide wheels installed on the outer sides of the roller cars ensure movement along pre-set tracks. The roller-based support system is complemented by a drive mechanism powered by variable-frequency motor reducers, engaging gears and racks to facilitate smooth gantry movement. Advanced technologies, including sensor detection, program control, and variable-frequency speed regulation, synchronize the motion of the supporting legs and main beam.

2.4 Programmable control technology for enhanced precision and safety

The Honghai Gantry Crane incorporates a motor variable-frequency speed control system based on Programmable Logic Controller (PLC) technology, enhancing precision and safety during operations. The PLC system monitors the status and alarm information of crane components, enabling real-time supervision through computer systems. In case of mechanical failures, the system facilitates prompt response and repair, significantly extending the crane's operational lifespan.

3 Conclusions

Construction of the Honghai Gantry Crane commenced on October 22, 2012, in Qidong, Jiangsu. On August 7, 2014, the No. 1 crane successfully completed its initial lifting operations. By December 9, 2014, the No. 1 crane had undergone assembly, testing, and commissioning, performing its first integrated lift to launch an offshore platform supply vessel.

The development of the 22000-ton Honghai Gantry Crane marks a significant milestone in China's manufacturing sector and has introduced transformative advancements to the global offshore oil platform manufacturing industry, with the potential for substantial economic benefits. Utilizing this cutting-edge equipment and the innovative "onshore construction of offshore oil platforms

” production model, a single dock basin can simultaneously support the construction of up to 10 offshore oil platforms. This approach enhances construction quality, boosts production efficiency, and improves operational safety. By significantly shortening the construction cycle for individual oil platforms, the model reduces the costs associated with shipyards, semi-submersible barges, and cranes, saving substantial labor hours. These cost savings provide direct economic advantages for shipowners, establishing a strong competitive edge in the market. Additionally, the Honghua Offshore Base, anchored by the Honghai Gantry Crane, creates 4,000 to 6,000 local employment opportunities, making a meaningful contribution to the socio-economic development of the region.

Competing Interests The authors declare that they have no competing interests.

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