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DEVELOPMENT OF A NEW INTELLIGENT CONCRETE SPREADING TECHNOLOGY

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Abstract: *The concrete spreader is one of the key equipment for producing concrete components in the construction industry. Its performance directly affects the product quality and production efficiency of precast concrete components, which in turn affects the industrialization progress in construction. Due to manual operation, waste of concrete and low spreading efficiency, it is difficult to achieve accurate spreading operation for complex prefabricated components. It is necessary to develop new technologies to improve the stability, accuracy and intelligence level of the concrete spreader for producing complex prefabricated components. This paper proposed a new intelligent concrete spreading technology based on BIM (building information model) information parsing techniques, stabilized and precise concrete spreading techniques, grid casting model planning techniques, motion control techniques with heavy-loading and vary-loading, and advanced detection and control techniques. This new technology breaks through the bottleneck that restricts the stability, refinement and intelligent development of concrete spreading for prefabricated components and promoted the overall development process of construction industrialization.*

Key words: *PC components, concrete spreader, industrialization of construction*

1. Introduction

With the continuous improvement of the industrialization level of construction, higher requirements are placed on the performance of concrete spreading machines. Internationally renowned companies and universities, such as EBAWE, AVERMANN, VOLLERT, SOMMER, etc., have begun to study modern technologies such as advanced application, optimization design and intelligent control of concrete spreading machines. In China, the main researches are users, manufacturers and researchers represented by SANY, NHI, Hebei Xindadi Electromechanical Manufacturing Co., Ltd., Anshan Heavy Mining Machinery Co., Ltd. and many universities, focusing on investigating the mechanical structure, automatic control and operating efficiency of the spreading machine [10].

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With the progress of construction industrialization in China, the PC component production line equipment need to be improved and upgraded [1, 3, 4, 7]. As the key equipment in the production line, the performance of concrete spreader (shown in Figure 1) determines the technical level of the entire production line [8]. This paper proposed a new technical framework for intelligent concrete spreading machines, including data communication between the spreading system and the BIM system, the pre-production planning of concrete components, the precise control of the spreading machine and the intelligent and advanced production techniques, improving the concrete spreading technologies towards modernization, automation, precision and intelligent development.

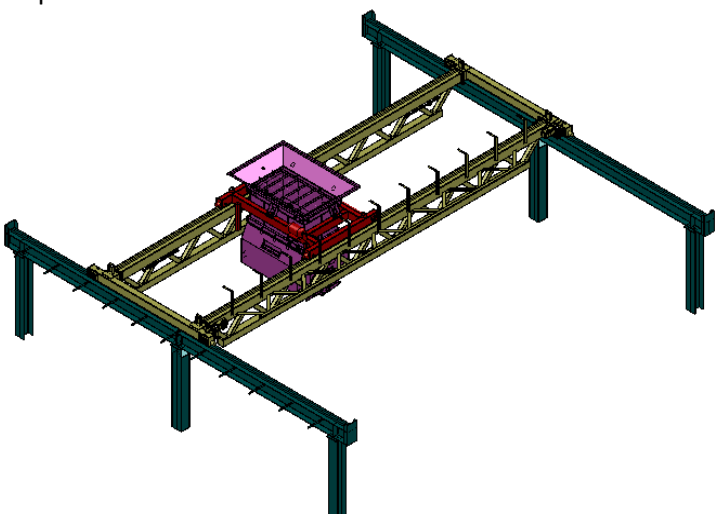

Fig. 1. *Concrete spreading machine*

2. Current Problem with Concrete Spreading

Most of the buildings in China are shear wall structures, and the diversified and individualized building design leads to the different shapes and dimensions of the separated components. As a result, the mold design cannot be standardized, and the placement of the mold can only be completed manually. Without the component dimension data integrated into the concrete spreading process, it is difficult to achieve standardized and accurate spreading performance.

There are differences in water-cement ratio, aggregate gradation, slumping degree and collapse degree with concrete produced from different mixing stations, and even different batches of concrete from the same mixing station, which leads to different adaptability of concrete spreading machine and affects concrete outflow quantity and quality.

The concrete spreading machine includes cart, trolley, hopper, screw conveying device, dispersing device, pneumatic system and lubrication system, etc. In the spreading process, it is necessary to implement advanced coordinated and planning control for distribution carts, spreading trolleys, screw motors, dispersing devices and pneumatic gates.

Since the cart and the spreading trolley are heavy-loading and vary-loading with concrete, the operation process is complicated and requires high level of operation.

Due to the above reasons, there are many problems such as manual operation, concrete waste, high failure rate, and low spreading efficiency in the concrete spreading process of the PC component production line. The problems are even worse when producing complex prefabricated components.

3. Key Technologies Applied in Intelligent Concrete Spreading Machine

It is necessary to develop new technologies to improve the stability, precision and intelligence level of the concrete spreader for producing complex prefabricated components.

The new intelligent concrete spreading technology was proposed based on BIM information parsing techniques, stabilized and precise concrete spreading techniques, grid casting model planning techniques, motion control techniques with heavy-loading and vary-loading, and advanced detection and control techniques. The technical framework is shown in Figure 2.

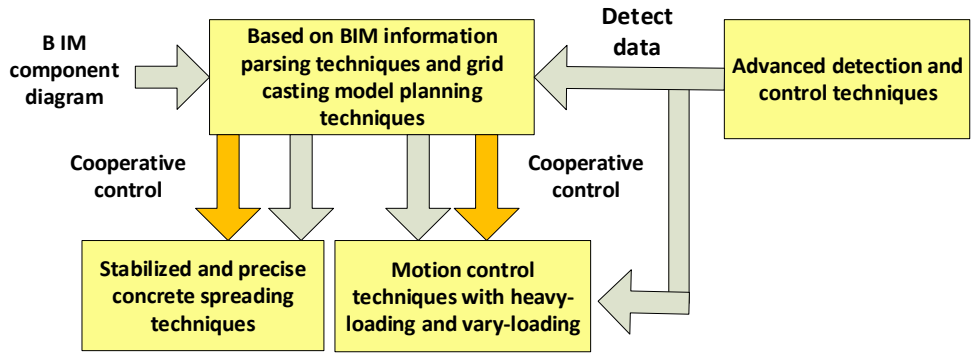

Fig. 2. *Technical framework for intelligent concrete spreading machines*

3.1. Stabilized and precise concrete spreading techniques

Based on the discrete element method, fluid mechanics method and optimization theory, the shape of the scattering device [2], the screw structure and the spreading outlet are optimized, including the comb arrangement and comb spacing of the stirring rod, the parameters of the inner diameter and the pitch of the screw, the size and quantity of the spreading outlet, etc.

The screw wear model is established to forecast the wear condition, realizing the reliable operation monitoring of the spreading machine [2, 5, 9]. The technical framework is shown in Figure 3.

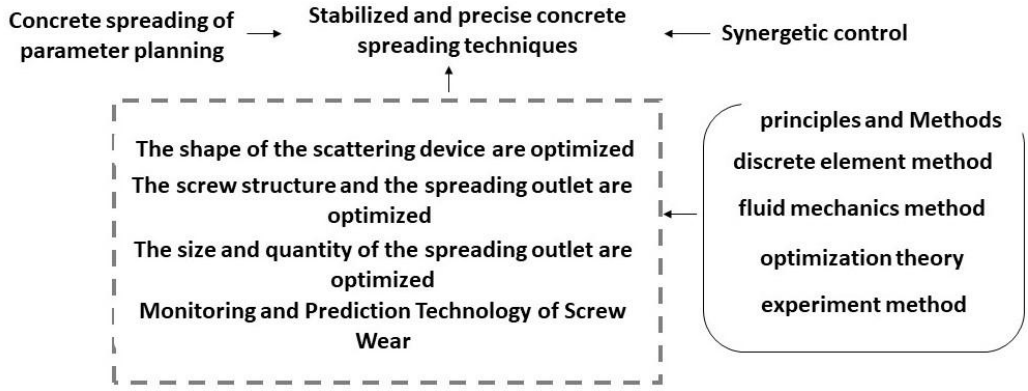

Fig. 3. *Technical framework for stable and accurate concrete spreading*

3.2. Motion control techniques with heavy-loading and vary-loading

By referring to the lightweight structural design of the wing, the weight of the trolley can be reduced under the condition of meeting the rigidity requirement. By establishing the model between the hopper mass and the speed, the influence of the mass change on the spreading speed is compensated under the condition that the hopper is full of concrete, and the operating accuracy of the spreading machine is improved; The micro-dynamic motion control technology of the concrete spreader is proposed by establishing the relationship model between the signal pulse width of the motor and the static and dynamic friction of the moving device, and the micro-dynamic motion control technology is designed based on the pulse width modulation method. The performance of the intelligent spreading machine for complex precast concrete components is adjusted based on experimental debugging.

3.3. Grid casting planning and intelligent spreading control technology based on BIM analysis

Based on the visualization features of BIM, the compatibility data of complex precast concrete components is extracted, according to which the components are identified using vector map. The mathematical model of the machine, spreading process and prefabricated components is established by combining numerical analysis and experiment results, including the relationship model between the screw speed and the concrete discharge speed, the component quality prediction model, etc. The self-learning algorithm is adopted to improve the prediction accuracy of spreading quality model. Optimization theory is used to realize the path planning of digital spreading, by calculating the optimal parameters setting of spreading motion control and quality control. The intelligent control strategy is designed to implement the intelligent cooperative control of the operating speed, screw speed and output port number. The schematic diagram of grid casting model planning for concrete spreading is shown in Figure 4.

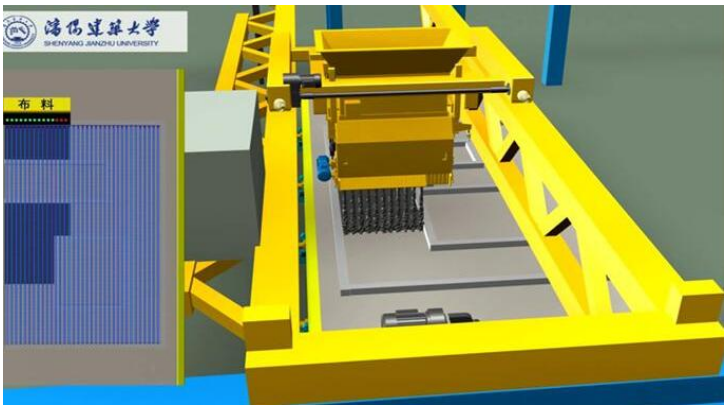

Fig. 4. *Schematic diagram of grid casting model planning for concrete spreading*

3.4. Advanced detection technique for precision concrete spreading

The pre-calibration position of the spreading machine is accurately positioned by the coded locators and laser displacement measurement [6]. The feedback data of the uniformity of the concrete spreading can be obtained by detecting the thickness of components by laser ranging. According to the feedback results, the spreading system will calculate the amount of spread concrete and perform accurately re-spreading on the defect area. The technical framework for advanced detection technology in intelligent spreading system is shown in Figure 5.

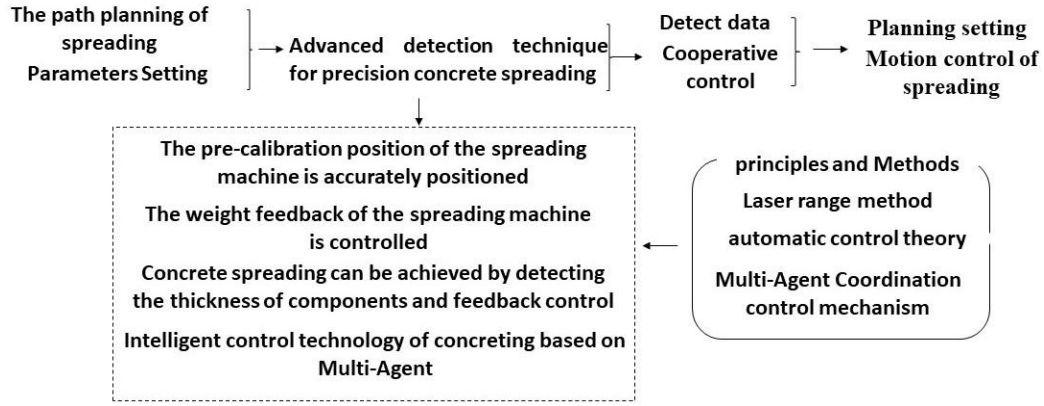

Fig. 5. *Technical framework for advanced detection technology in intelligent spreading system*

4. Conclusion

The proposed intelligent concrete spreading technology could greatly reduce the manual operation and improve the automation level of PC component production line. The production quality is improved by reducing the component dimensional error. Through the integration of component data analysis, production path planning, accurate

spreading, heavy-duty micro-motion control and component dimension detection, the intelligent framework of the whole system is realized, and the system coordination is improved. This new technology breaks through the bottleneck that restricts the stability, precision and intelligent development of concrete spreading for prefabricated components and promoted the overall development process of construction industrialization.

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