Design Optimization and Simulation of Raw Materials Mixing Workshop

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Abstract　Structure of design optimization and simulation system used for raw materials mixing system of steelworks was proposed based on parametric modeling and virtual reality techniques. Design optimization, workshop parametric modeling and material transport simulation were researched; the integrated design automation and simulation system was developed. Application showed that the system leverage the design automation of raw materials mixing workshop.

Key words　optimization;　simulation;　parametric design;　mixing system.

原料混匀料车间的设计优化与仿真

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【摘要】提出了基于参数化建模与虚拟现实技术的钢铁厂原料混匀系统的设计优化与仿真系统的结构。研究了设备设计优化、车间参数化建模和原料输送仿真技术，在此基础上，开发了混匀料车间设计与仿真的集成自动化系统。应用表明，该系统可提高原料混匀料车间的设计自动化水平。

关　键　词　优化；　仿真；　参数化设计；　混匀料系统
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Raw materials mixing workshop is an essential unit in the modern steelworks. In this paper, the relations between the device parameters, system configuration and throughput of raw materials was investigated, the device parameters design and configuration optimization algorithm was presented, the integrated workshop design system was developed applied 3D parametric design and virtual reality techniques. The new design system eliminates detailed drafting from the functional layout to the constructing drawings, greatly improves design automation and shrinks the design cycle. Moreover, the digital mock-up can be used for multiple physics disciplines analysis, to improve the system performance.

1　Structure of the System

Contrary to the traditional CAD for part or product design, mixing system design is typically a kind of factory design. In it there are various types of material processing devices, such as mixing fetcher, stocker, mixing tanker,

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unloading vehicle, discal feeder, tensioning equipment, tune tower, dose stuff facility and adhesive tape transport etc. The parameters of the devices and configuration changes with the throughput, the structure of the devices may be different; the layout is always varied with the shop space. The structure of the system is shown in Fig.1, optimization method is adopted to leverage the devices and configuration design, the detailed structure of devices is designed with parametric model, while the virtual reality was used to simulated system performance. The system is process-oriented, the designer input mixing methods, raw material ingredients, throughput and process of the system, the design optimization system can automatically calculates the device parameters and optimized configuration, generate the parameters files accessible for 3D design sub-system. Shell program acquires devices parameters and reconstruct the devices model according to the CSG history packed in built-in parametric library. Once the devices are produced, the configuration is automatically updated driven by the engineering constraints among the devices in the assembly. All drawings are concurrent with the configurations. When the configurations are updated, the drawings are re-drawn automatically. Meanwhile, the mechanism motions are defined directly onto the configuration, the material transport can be intuitively simulated. With this system, massive repetitious work such as configuring and drafting is carried out automatically, the designers can dedicate to the functional design and decision-making.

2　Design Optimization System

Parameters calculation subsystem is mathematical optimization algorithm. It involves the formulas and epicritic methods used in mixing system design, and non-mathematical design rules. Two solve mechanism are presented: forward method and backward method, the former gets the final ingredients and devices parameters by solving equation sets with given throughput and layout etc, while the latter gets the layout and throughput with the final ingredients through reverse inference engine. The subsystem produces the device parameters file accessible for the design automation subsystem. The shell program acquires the device optimized parameters, and launches CSG process to model the devices automatically. All design parameters can be exported, Microsoft Excel file for design communication.

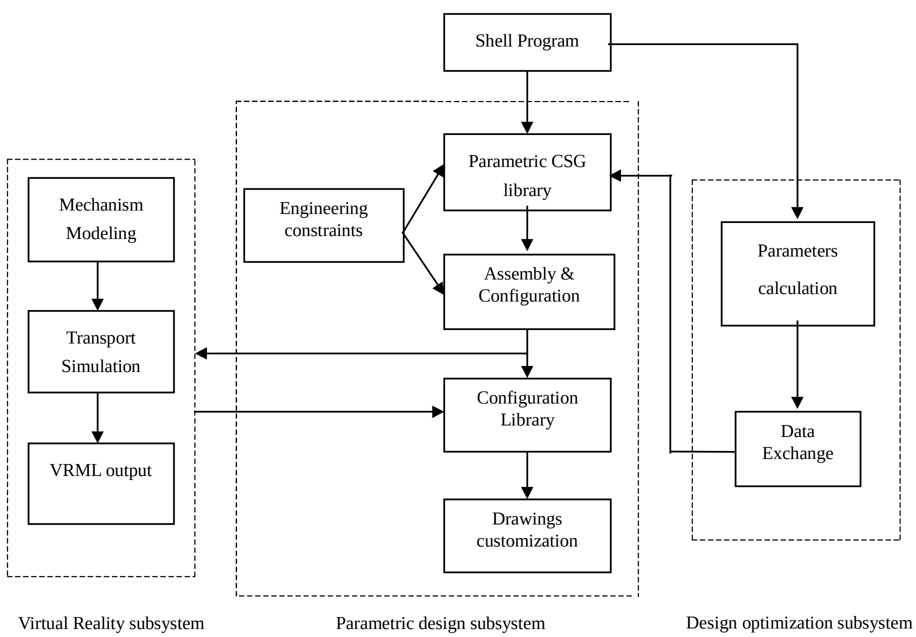

Fig.1　Structure of design automation of blending system

3 Parametric Model and Configuration Design

Parametric design is about extraction, expression and calculation of the geometric constraints, and about construction of parametric geometry [1], which needs establish geometry constraints in advance. At first some dimensions are assigned as the key parameters, the other dimensions are interrelated with the key dimensions by geometric constraint set. All interrelations represent an algebra equation set, of which the driving parameters are known, while the driven parameters are the unknown. When the driving parameters are given, the other dimensions can obtain. A complex component may involve many CSG nodes and Boolean operations, including lots of constraint equation sets. A standard CSG modeling history of the component should be presented, and built in the low-level library. The shell program performs the CSG process and regenerates the part model. Diving parameters and CSG control the final structure of the components. When the driving dimensions changes, the shell program will transmit the latest parameters to CSG history, 3D model will be updated automatically. The low level library includes all devices and components in mixing system, the designer can modify driving dimensions easily to get the new design. Thus, the repetitious design work is remarkably eliminated and the design cycle was greatly shrunk. The low level library features as follows: 1) Driving parameters and the range of them can be assigned according to the design requirements; 2) Design is graphically interactive, 3D models can be previewed when parameters modification, which helps intuitively change model parameters; 3) Driving parameters can be changed directly in configuration, which makes the influence of the modification on the whole configuration easy to be found.

Fig.2 Parameters calculation subsystem

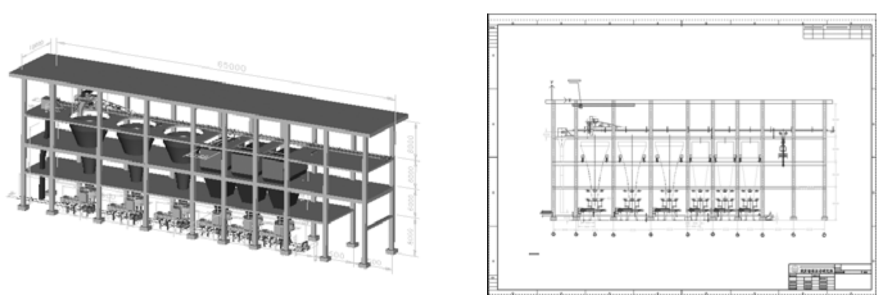

Fig.3 3D configuration and shop drawings

The rules of different configuration are fully different correspondingly. When the driving dimensions of components are modified, the rules are still kept to maintain the configuration. Two dimensional drawings concurrently related with 3D configuration. Configuration library of blending system includes spatial relation and assembly constraints. When the components and the configuration is modified, the shop drawings will regenerated automatically, and the drawings can be exported into AutoCAD with DXF or DWG formats. In AutoCAD all graphic units and objects can be edited, and communicated. The drawings automatic generation reduces 90% amount of drafting work, the efficiency thus is substantially improved.

4 Virtual Reality-based Simulation

Virtual reality subsystem provides the evaluation framework of the configuration, which consists of two parts: VR environment generation and human-machine interaction. There are 2 kinds of VR-based engineering design approaches [2, 3]. One is enhanced visualization technique, which put the CAD model generated by alien systems into the VR environments; the designer used the processing tools to enhance the living scene. The other is VR-CAD system, which allows the user directly design model in VR environment. Here the former approach is applied, the running environment of the mixing system is established and parameterized, the control parameters can be modified to get various scene models. The configuration of the blending system was put into the produced environment, the motion such as translation, rotation and constraints of freedoms of the rigid body are defined onto the mechanism joints. It is solved with ADAMS solver to get the mechanism motion. The interference of the motion path can be dynamically found, and the necessary torque provided by driving motors was estimated, and the rationality of materials transport, the layout of devices and space efficiency can be easily evaluated. VR-based simulation has the designer dedicated into the innovative design and optimization in 3D versatile information environment.

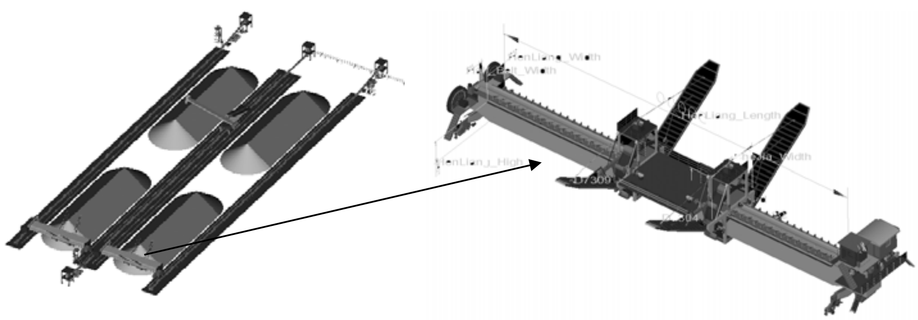

Fig.4 VR design environment

5 Conclusion

VR-based design automation system is the powerful tool of factory design. It can help improve design quality and shrink design cycle. The design automation system of the steel factory blending system has already been used in a famous steel design & research institute, proved to greatly improve design automation and reduce delivery time of factory design.

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