Study of the Belt Conveyor Design Platform in the Power Plant Based on the Multidisciplinary Collaborative

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ABSTRACT

In order to solve the low speed of information transmission, inefficient design and long development cycle in the design process of the belt conveyor in the thermal power plants, a multidisciplinary collaborative design System of the belt conveyor is put forward. With the analysis of the information requirement, integrated information model is established with systems accepted by user's requirements through the network transmission protocol. Project managers can discuss and develop plans through the structure of distributed-centralized. By the framework of information interaction and conflict resolution, professional design personnel can exchange their information and finish the design of the belt conveyor collaboratively..

Introduction

Belt conveyor is the main equipment in the thermal power plant transportation system. It transfers coal from coal unloading and Stockyard system to the boiler. It has features with distant distribution in space, large number and interactions.

During the design process for belt conveyors, designers calculate parameters based on the given conditions and finish different sections, including model selection, engineering drawing and parts information management. Designers need translate the design information to other parts associated with the whole design and modify the structure of the belt conveyor according to the feedback. Because of the manual work, there are many defects in the traditional design process of information communication. It inevitably results in slow transmission for information and low design efficiency, etc. The lack of an intuitive three-dimensional model of the information exchange, results in the communication of design process being not easy to articulate, which affects the quality of information communication and reduces the design efficiency (Zhang and Huang, 2010; Wang, *et al.*, 2010).

There are a lot of contacts between conveyers and transfer stations, since the structure of ribbon conveyers are distantly distributed. Therefore the design of different parts and the professional design of different ribbon conveyers need sufficient information exchange to achieve proper designing. Multidisciplinary collaborative design is necessary for design of belt conveyors (Zhang, *et al.*, 2010).

The computer technique is increasingly used in the thermal power plant, and the application of belt conveyor was researched by many scholars (Alspaugh, 2004; Lodewijks, 2002; Yu, 2008; Xie, 2009). Much of the application study was about a single belt conveyor based on the traditional thought of the serial design. In the process of the serial design: design-modeling-analysis-remodeling-reanalysis, the downstream design personnel is difficult to step in early design which lead to low speed of information transmission, inefficient design and long development cycle. Also due to a lack of intuitive 3D model for communication in the expression of information, information communication is not easy to express clearly, which leads to affect exchange of quality, reduce design efficiency and disadvantages to improve enterprise competitiveness.

The belt conveyor in thermal power plants is spatial distributed and transited through the transfer station which has certain relationship. Its design process has the following features:

(1) the system composition is complex. The design process is the coupling of subsystem of multiple disciplines such as mechanical, civil engineering, HVAC and water supply, between which coordinate activities are needed to maintain the consistency of the product model;
(2) the design process is complex. It not only contains successively design task existing on the vertical axis of time, but also contains influence in design task on certain moment with design personnel in various fields fully exchanging information through communication activities;
(3) the system behavior is complex. The requirement of the overall performance is higher than the demand for a single module. Through consultation, decision-making and other activities, the design process will achieve the overall optimal target.

In this paper, a multidisciplinary collaborative design platform for the thermal power plant belt conveyor is established based on the research of the distribution characteristic and multidisciplinary collaborative design thought (Gurses and Xiao, 2006; Rosenman *et al.*, 2007; Wang *et al*., 2009; Rosenman *et al*., 2006). By using the system, the manager could confirm the general design task and set various sub-design tasks of the conveyer to different designers according to the design requirements; the designers could accomplish the quick design, three-dimensional modeling and dynamics analysis of the belt conveyor by using client design system; the design result will be uploaded to the server to perform assembling and interference examination of the conveyer system, and then the inspection results will feed back to the designers. After the structure adjustment, the designers could achieve the whole design rapidly and accurately.

The platform used the three-dimensional model of the belt conveyor as the vehicle of message exchange. This kind of communication for information was visual and abundant. The rapid and precise design information transmission by means of network transmission protocol have significant reference value to the establishment and management of three-dimensional digitization thermal power plant and the research of the multidisciplinary collaborative design technique.

Integration of Collaborative Design Information about Bell Conveyor

(1) The Requirement of Information about Collaborative Design for Belt Conveyor

The design of coal-fired plants belt conveyor is a complex design process. It involves with customers, managers, designers, also including coal transportation, power, civil engineering, water supply, HVAC, etc. Designers often need cross-department design information communication and feedback to adjust the structure design and complete design task. Thus, the main task of belt conveyor collaborative design platform is to realize the flow of product information between staffs in different branches of science department and coordinate the various designers work. According to the role of the staff and the different demands of collaborative design function, information synergy of the platform can be divided into the following categories:

(1.1) Customer information synergy. Design process is a mapping process from function domain to physical domain, with the customer -the purchaser of the function, so the client's demand information is very important to design system. At the beginning of design, customers directly contact designers and managers through the platform to set functional requirements, and discuss the demands and scheme to make clear design task. In the design process, customers can work on the designing product by browsing, refining functional requirements as well as collaborative notation modification and finally make the designed products properly to meet the practical requirements.
(1.2) Management information synergy. Management includes project management, personnel coordination and information

management. Project management refers to the decomposition of various design tasks and establishes the relationship between tasks and the progress management so as to achieve the purpose of consistent synergy of component design tasks with unified task allocation and progress management. Collaborative design platform is to put the person on the space distribution together through network organization to jointly complete the design of product, because the space distribution and designer change frequently etc. It needs to manage and maintain the role and information frequently. The flow of information constitutes the core problem of collaborative design, given the current network transmission bandwidth limit on the Internet. How to realize the management and maintenance of transmit information is the key to a collaborative design.

(1.3) Design information synergy. The product design process is a multidisciplinary fusion process. The required design information for different disciplines is different, therefore it needs to establish the right information model associated with different disciplines, to extract professional information, to establish their own discipline views and finally complete the professional design. Further, it still needs to build constraint relationships between various disciplines through design information model so that it can predict, inspect and avoid the conflicts caused by concurrent operation. As a result, it may guarantee a smooth design of products and complete product development.

(2) The Information Model of Collaborative Design of Delt Conveyor

Product information model is the digital information of a product. Through the product information model, all collaborative researchers obtain relevant information about their roles from different disciplines and coordinately complete product development. In order to adapt the different requirements of design process for different researcher roles, integrated collaborative design information model for belt conveyor is established, shown in Fig. 1. Information model is divided into: Demand sub-model, design sub-model, management sub-model, Collaborative sub-model, etc. Each model has its different organized form and usage.

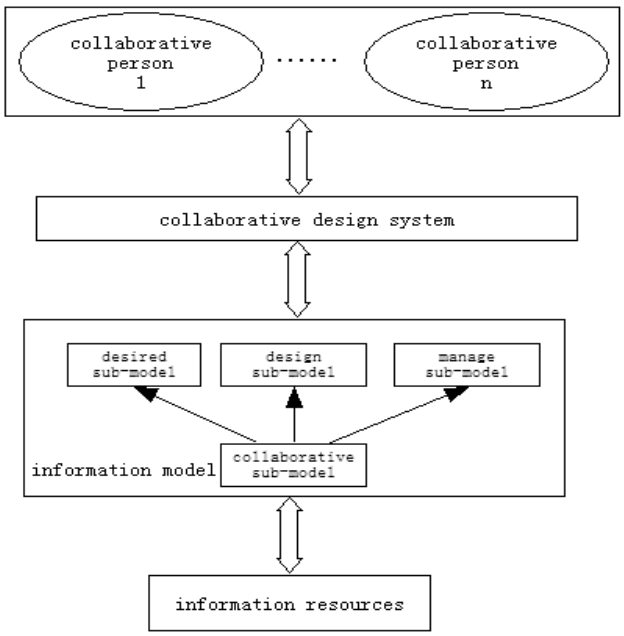

Fig. 1: Collaborative Design Information Model of Belt Conveyor.

(a) Demand sub-model: this model consists of customer demand for design functions. It is the basis for project managers to allocate task and designer to initiate design. The updating and refining of demand promotes in-depth and perfection of design work.

(b) Design module: the model is the expression of designed products in computer. According to requirements of designers in different application, there are different models including CAD model, VRML model, dynamic model, etc. It is the core of the collaborative design system.

(c) Management module: the model includes management and maintenance of different roles in design activities as well as the management of component tasks progress between various designs. Through the coordination between component tasks of the design, it can smoothly finish the design.

(d) Collaborative sub-model: the model includes concurrent operation's description and conflict's resolution in the design process; it is the fundamental guarantee to ensure collaborative design smoothly.

Collaborative design information sub-model is an information collection to make the disordered product information to order. The collaborative persons gain related information from different information models to complete the design functions of their respective roles. The establishment and completeness of information model is the foundation of proceeding system design.

Framework Structure of the System

Each belt conveyor design includes the design of belt conveyor itself and the design of auxiliary equipments. And all the belt conveyors constitute the coal transportation system for the thermal power plant, therefore, according to the characteristics and requirements of the belt conveyor of the thermal power plant, the framework structure of multidisciplinary collaborative design platform is proposed in this paper, shown in Fig. 2.

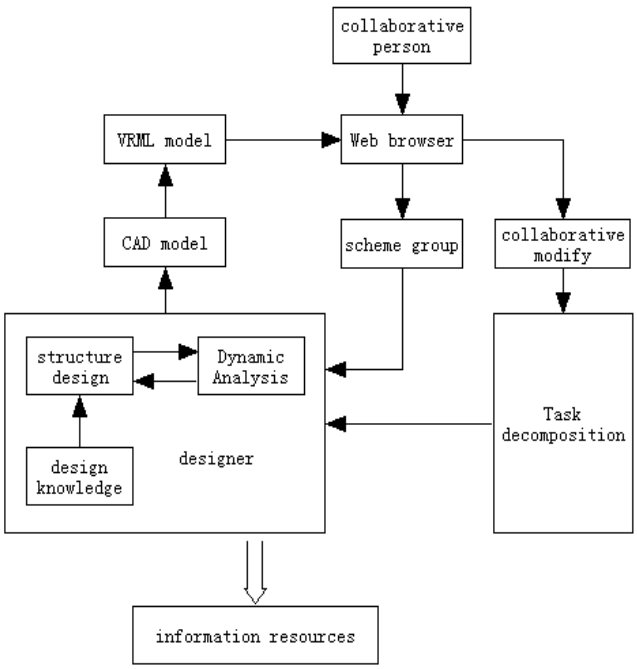

Fig. 2: The Framework Structure of Multidisciplinary Collaborative Design Platform.

System uses distributed - centralized structural framework. In the design process of each belt conveyor, a small network consists of the coal handling professionals, civil engineers, electrical engineers, HVAC and water professionals and other professionals (Rosenman and Wang, 2001). They communicate with each other, coordinate with each other and complete their own design of the network. In the mean time, through the interconnected server, the design tasks and the progress between the belt conveyors are coordinated.

Collaborative personnel, according to their different roles, are divided into collaborators and developers. Collaborators include customers and managers. Their main tasks are to gain the macro information through internet web surfing, collaborative revising and communication between collaborators. Developers of the belt conveyor design process are relevant professional members, including the coal handling professionals, civil engineers, electrical engineers, HVAC and water professionals and other professionals. Their works are mainly targeted at CAD model. Through the direct operation of three-dimensional model or information extracting from the three-dimensional model required by each professional, they create their own discipline views, complete their own professional designs. Then they can upload the design information to the server and complete the design of belt conveyor together.

(1) The Framework Structure of Collaborators

Collaborators include the authors of requirements and project managers. The main tasks of authors of requirements are to input the demand information, consult the product features, implement program decision-makers, browse together with inspect the product design and feedback for the developer to modify the design and model. Project Managers are responsible for the authentication of designer, roles distribution, program design. According to the demand of a product, they should cut the design into relatively independent sub-design tasks and coordinate the design of the progress between the sub-tasks. According to the functional requirements of collaborators, the framework is established and shown in Fig. 3. Frame functions

include authentication, role management, project interfaces, communication interfaces, file transfer interface, model shows and other collaborative mark.

(a) Authentication: It can register, verify and monitor the operation of users through the database, and provide records for the latest modification and discussion of design.

(b) Role management: As collaborators may take different tasks in the same project, this paper adopts the management mechanism based on the role which has been discussed in reference (Yu, 2008). Access control system authorizes role directly and links the collaborator with the role. So it can avoid the task switch to other designers because of the changes in progress

(c) Project Interface: Project interface provides descriptions of the design requirements, the design programs and the progress between the sub-tasks. So collaborators can understand the project through project interface as a whole.

(d) Communication interface and file transfer interface: It provides communication services between collaborators for designers. Communications can be a form of chat rooms or a point to point communication. Through the interface, collaborators can easily communicate with the developers to exchange design information.

(e) Model display and collaborative annotation: Through this interface, the products can be browsed. The server will change the CAD models into VRML models which are suitable for network transmission and show them in the collaborator's interface. By browsing the 3D models and collaborative annotation, cooperative information will be feedback to the designers and work as references for design modification.

Developer is the main operator of product design, modeling and main actor of changing the user's needs into real product from concept. Cooperation between developers is the most important part of collaborative design system. Collaborative design developers include various professional members involving in the process of design belt conveyer. The professions include coal conveying engineering, civil engineering, drainage, HVAC and electrical engineering. In the design process, different design information is useful for different professionals, therefore extracting the required professional information from the shared design model and establishing constraint relationships between different professionals, becomes the core work of developer's framework, shown in Fig. 4. The collaborative framework of developers is developed.

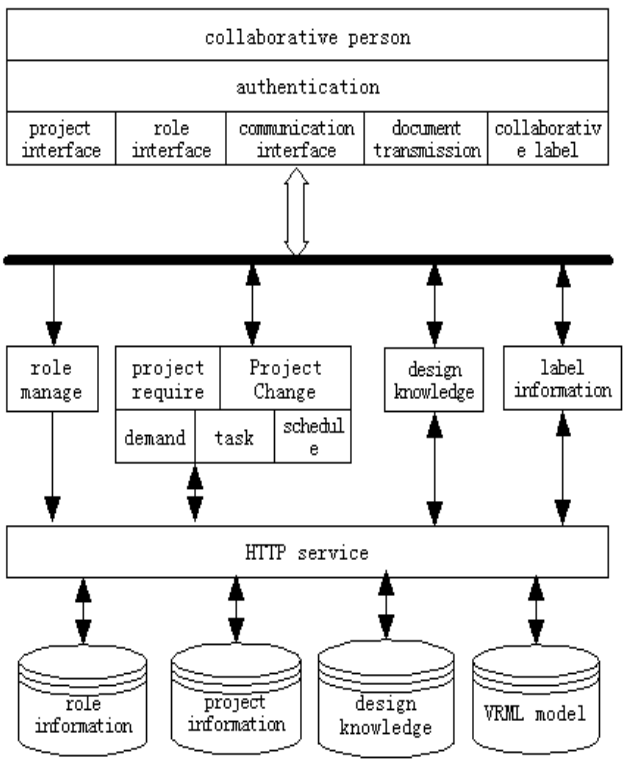

Fig. 3: The System Framework of Collaborator.

Discipline members obtain design requirements and tasks from resource database. Inherit components from the existing component libraries, form view model of the discipline through this subject processing and visual processing of data, and design the subject model by CAD, and add design attributes of the discipline, thus finish this subject design. Finally it should upload design information to server and jointly complete the design of the product through coordination between disciplines.

Design is based on certain design knowledge, rules and experience. The designing knowledge and rules of all disciplines are stored in design knowledge base. Knowledge can be organized by XML Language (eXtensible Markup Language). A mapping can be created between the event of

design knowledge and design operation. Design knowledge can be obtained through the driving mechanism based on events. Knowledge is integrated into the form that can be studied by each subject in the design process through knowledge converter.

Data processor and conflict resolution contain the definition and processing of conflict caused by the concurrent operation of the designers. This paper adopts time locking algorithm which is introduced in literature (Chen, 2005), and the data processor upload the operation of the model by the subject designer to the message queue of the conflict resolution, and add "read" or "writing" state to the sharing model and the component model in servers according to the order of the operation of the designer, also update component model of interdisciplinary designers. Interdisciplinary designer do the discipline design according to the current state of components of model, waiting for the release of operating of the model by other disciplines. Or complete the design by operating the discipline model directly, then upload the design result to server, and complete update of corresponding models.

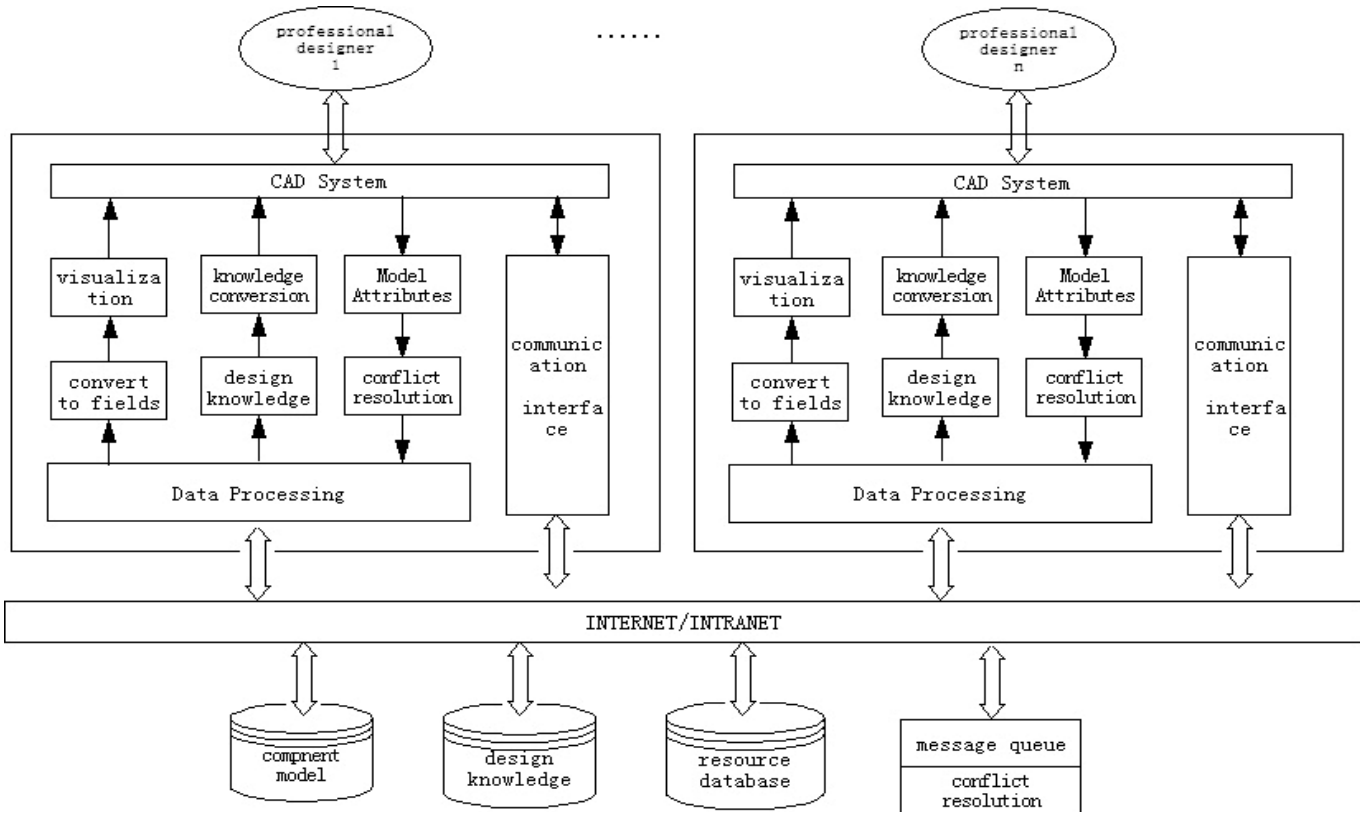

Fig. 4. The Collaborative Framework of Developers.

Results and discussion

The design of belt conveyor is a process of multidisciplinary collaboration. To build thermal power plant conveyor multidisciplinary collaborative design platform can effectively organize the flow of information through the professional integration of enterprise resources, improve the design efficiency and enhance the competitiveness of enterprises. By using the multidisciplinary collaborative design platform, managers can effectively manage the design process to control design results. Customers who involve with the design activities, propose and refine their various needs so that the results can satisfy the design requirements. It makes the design process easier, more intuitive, more convenient and accurate.

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