파라메트릭 설계 구현을 위한 모델링과 해석 시스템의 결합
Integration of modeling and analyzing systems for implementation of parametric design

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1. Introduction

Structures of a machine tool should have a sufficient strength against the inertial loads from their fast movement. In industry, there has been an increasing demand for high-performance machine tools which can improve machining productivity. The productivity requires a high translation velocity and acceleration of a moving element such as a column or a table. Accordingly, the structures of such a high-performance machine tool should be robust to sustain the inertial forces.

Efforts have been made to identify an optimal design of a structure of a machine tool. The optimal design should meet the technical requirement of strength and then an additional requirement of, for example, mass for fast movement or manufacturability. Design of a light and strong structure made of a cast iron requires lightening holes for mass and stiffeners for strength. These design details produces a lot of design parameters which lead to difficulties with identifying the optimal design.

Many systems have been developed for designing structures of machine tools. Some have a design database such as materials and ball screws. Most systems have the advantage of automating the process of generation and analysis of a structure but the disadvantage of its deterministic configuration. It has only several types of common configurations for a structure such as a column and a bed. Systems of this kind may be used for the conceptual design stage for a general configuration of a machine tool.

Two systems were integrated into a system to adopt a user-defined configuration of its structure. They are the modeling system, CATIA V5 [1], and the analysis system, SimDesigner [2]. The system constructed with the integration can import the geometric model from the modeling system and execute the analysis of the model in the analysis system. The model import also extracts user-defined parameters. The system allows automation of varying the value of the parameters and then of executing the subsequent analysis and, therefore, identification of an optimal design.

2. Systems integration

The systems, CATIA V5 and SimDesigner, used for designing a machine tool in geometric modeling and structural analysis. The analysis system is embedded in the modeling system for the purpose of using a geometric model. Both of them are constructed on the basis of object-oriented programming and therefore, an object-oriented programming (OOP) language can access the objects of the systems to use geometric elements such as a surface and analysis conditions such as load cases. The language used for the system integration was Visual Basic for Application which is embedded in the modeling system.

The system from the integration in this paper can use the geometric model and the analysis model both defined by a user. It extracts the user-defined parameters connected with the geometric and analytical models, varies their value, and subsequently updates the models. It runs the analysis again and extracts the result of the analysis. Using the objects of the systems, the integrated system performs these processes of the extraction, variation, and analysis execution. It also allows the parameters to be evaluated on the basis on the criteria defined to identify an optimal design. Accordingly, it implements parametric design through the processes including the evaluation and therefore, was named a parametric design system (PDS).

2.1 System implementation

The parametric design system was constructed as shown in Fig. 1. The VBA integrated the objects of CATIA V5, EXCEL, and SimDesigner into the system for geometric modeling, for structural analysis, and for data arrangement, respectively.

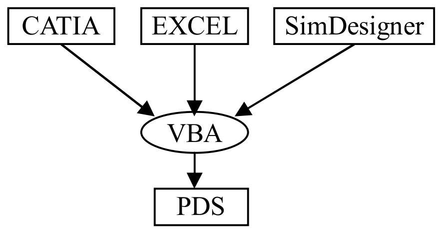


Fig. 1. Integration of the systems into the PDS.

2.2 Structure of the system.

Fig. 2 shows the structure of the PD system. It is composed of the several modules including control engine. It is similar to the structure of a knowledge-based engineering system [3]. The difference is that the PDS does not have design knowledge implemented and thus knowledge database. The database of the PDS accommodates the data generated from the modeling and analysis systems including the user-defined parameters. The modules interacts with each other. For example, the control engine commands the analysis module to run finite element analysis (FEA) with the input data supplied from the database module and the module of data arrangement to display the result of the FEA. Graphic user interfaces (GUIs) are used to allow a user to interact with the system.

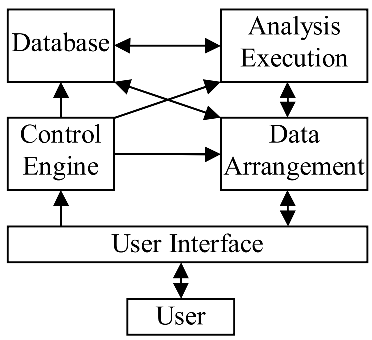


Fig. 2. Structure of the PDS.

2.3. Task flow in the system

The PDS performs the processes successively as shown in Fig. 3. A user defines a geometric model and its analytical model with geometric and analytical parameters. The system retrieves the parameters and arranges them for the user to generate their values. It changes the value of the parameters and then updates the geometric and analytical models. After the FEA of the updated model is carried out, its result is extracted. This task is repeated until all sets of the parameter values. It provides all data available in the types of tables and charts for the user to identify an optimal or robust design. The user can use this PDS until finding out an appropriate design.

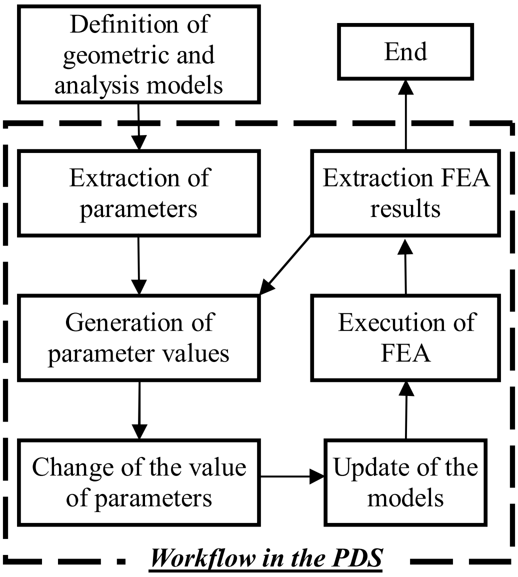
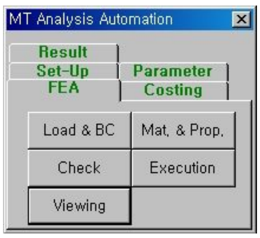


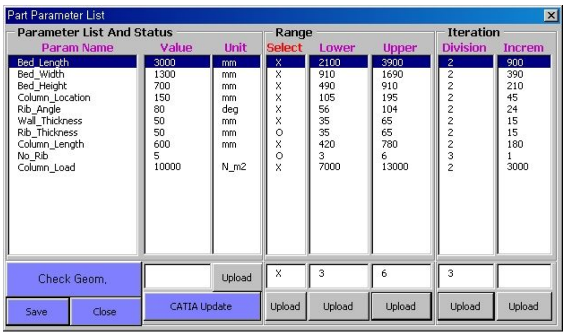
Fig. 3. Work flow using the PDS

2.4. Graphic user interface (GUI)

Graphic user interfaces were developed for a user to interact with the PDS. They also connect its modules with each other. The GUI in Fig. 4 (a) can bring the user the GUI required to perform the corresponding task and the GUI in Fig. 4 (b) allows him/her to define the sets of parameters to confirm the integrality of the geometric model.



(a) Main GUI

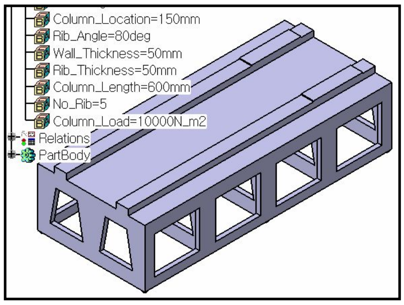


(b) GUI for generation of parameter values

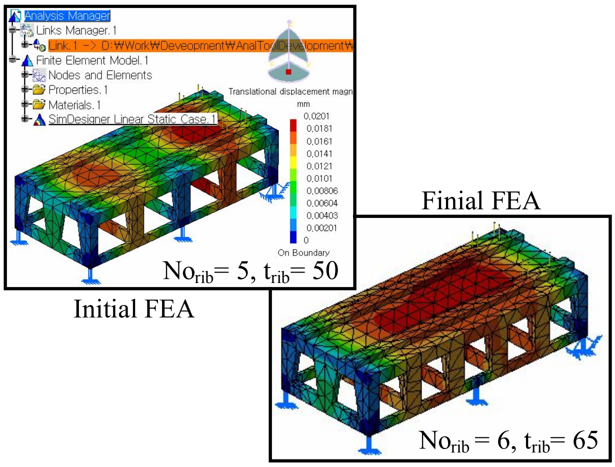
Fig. 4. Graphic user interfaces of the PDS

3. Application of the system to design

The system for parametric design was applied to the design of a simplified bed of a machine tool. The geometric model of the simplified bed shown in Fig. 5 (a) was built with the parameters and the FEA for the structure was once performed. The PDS extracted the parameters and changed their value defined as shown in Fig. 4 (b). After updating the geometric and FE models, it executed the analysis of the model. It ran all sets of the parameters selected in Fig. 4 (b). It extracted the output of the FEAs such as displacement and display it in a chart or a table for the user to determine a best design of the bed.



(a) Initial geometric model with parameters



(b) FEA for the initial geometric model and the final one

Fig. 5. Application of the PDS to bed design.

4. Conclusion

Modeling and analysis systems were integrated into a system to implement parametric design. It is constructed to have several modules to perform the tasks for the implementation. GUIs were developed to allow a user to interact with the system. It was applied to design of a simplified bed.

Acknowledgements

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