Method on parametric design technology of spacecraft assembly MGSE

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Abstract: MGSE [1] (Mechanical Ground Support Equipment) is necessary equipment for spacecraft research and development. The traditional MGSE design method requires repeated modeling, analysis and drawing, so the traditional design method is inefficient for the design of stereotyped MGSE. This paper introduces a new parameter-based fast design MGSE method. This method extracts the key parameters to drive the establishment of the model. Parametric analysis can be carried out in the system. Compared with traditional design methods, the efficiency can be at least double.

1. Introduction
MGSE (abbreviation process equipment) is a necessary equipment for spacecraft research and development. At present, some types of process equipment such as satellite assembly bracket equipment have been finalized. The structure of bracket equipment used in different models is basically the same, but there are changes in the bearing capacity and size. The traditional design method has some disadvantages for universal process equipment design; 1) repeated modeling, analysis and drawing affect the design efficiency; 2) lack of unified standards for process equipment design and analysis; 3) there is no effective way to inherit process equipment design experience; 4) the calculation of stereotyped formula lacks fast calculation methods, and non-automatic calculation methods affect the efficiency.

Parametric design [2] is an important branch of computer-aided design, the design method can reduce the repetitive work of designers, improve work efficiency, and greatly shorten the design and development cycle of products. Aiming at the problems of traditional process equipment design methods, this paper deeply explores the capability of parametric design and rapid design of analytical methods, and studies the realization method of parametric rapid design of process equipment. The key factors of the module are controlled by parameters. Process equipment model can be established quickly by changing parameters, the mechanical analysis model and specific calculation formula of the equipment have also been solidified in the program, only the key parameters of the design are passed to the equipment software for quick analysis. Finally, the drawing has been finalized in the system. When the model changes, the corresponding factors of the drawing can be quickly responded to achieve the effect of rapid design, analysis and drawing.

2. Parametric design techniques

2.1. General idea
As for the parameterized rapid design of tooling, the overall idea of rapid design and specific solutions
are shown in figure 1 in combination with existing technical means and specific features of equipment.

![Diagram](image-url)

Figure 1. The overall process

2.1.1. Design ideas and processes The top-down design method is used to realize the flow of equipment from conceptual design to detailed design, from the overall to the subsystem and then to the structural design. Top-down design is in the initial stage of product design, according to the basic function of the product and requirements, in the design of the top-level construct a basic frame, define the general layout, spatial location and the constraint relations, then the design of the process are basically on the basis of the basic skeleton of modified, perfect and complete the final design process.

2.1.2. Rapid design Through the construction of parameterized and normalized standard parts library and template library, and effective management, the design of components can be re-invoked and quickly extracted. Classify existing parts and components, and extract important parameters as the basis for change and retrieval, and through the standardized modeling and database integration, it is convenient for designers to call, and at the same time ensure the standardization of the design model. Through the establishment of the template library of complex structural parts (blank), it is convenient to adjust the template library for detailed design and reduce the modeling time.

Through the establishment of knowledge base, save the design experience, reasoning design, shorten the design cycle, record the design parameters and configuration selection of mature models to facilitate the rapid variation of equipment. At the same time, the knowledge base judges the parameters or design requirements, automatically retrieves the model corresponding to the model base, and reduces the manual operation.

Through the quick design wizard, the design process is encapsulated, and parameters and design requirements are transferred step by step according to the corresponding equipment design process in the form of similar software installation wizard, meanwhile, 3d modeling tools are driven to automatically create model features to reduce the tedious manual creation of features. Parameter correlation technology is used to associate parameters with skeleton and model library, realize the following of the whole structure, convenient to modify and change equipment quickly. It can be achieved through the secondary development means of ProE.

2.1.3. Rapid analysis By associating the analysis calculation program with the design wizard, the model can be quickly analyzed. Using the secondary development technology and the background
startup mechanism of the analysis tool software, the equipment model is automatically divided into grids, and the background solver is used for calculation, and the analysis results are transmitted to the front interface.

2.2. Implementation method

To achieve the rapid design of equipment, the implementation method is shown in figure 2.

2.2.1. Object analysis Before the standard parts library and design wizard, it is necessary to analyze the design process and classification of equipment to determine the overall basic framework of the design system. The design system takes parameters as the driving means and has strict requirements on parameters, therefore, it is necessary to conduct strict classification and parameter extraction of equipment objects, and define the association mode of each part of the system (including assembly constraint relationship, component design correlation, etc.) as well as input and output information, request and the realization of each function design experience, to formulate the models of design scheme. It includes dividing each component of equipment, establishing the design focus of each module, establishing the design basis of parametric modeling of each module, determining the overall design requirements, and completing the assembly constraints and parameter relationship control definition of each module.

2.2.2. Parameter extraction According to the characteristics of equipment, the design parameters are extracted, and the main component of the design parameters is the structure control parameters. Structural control parameters refer to the related information between the structural modules of the equipment, including constraint relation of position, assembly constraint relation and dimension constraint relation, etc. This part of information needs to be transmitted in the rapid design process of the equipment. The structure of each part establishes a dependency relation, so the correctness of parameter extraction is very important.

2.2.3. Building model library The 3 dimensional standard model template library of equipment can be divided into the overall skeleton model template library, the stereotyped model template library, the standard parts and the general parts library, etc, the design process is divided into the following two parts:

By defining the assembly constraint of the skeleton model, the assembly constraint definition of the
overall assembly model and its sub-models is realized. In accordance with the mechanical connection mode and structural characteristics of the parts of the skeleton model, fixed constraint assembly method was adopted to establish a dependency relationship between the assembly reference features of the sub-model and the geometric features of the superior model through the "geometric copy/release" function of Pro/E, the parameter values between the upper and lower models are transferred by the method of uniform parameter definition.

By setting parameter names, parameter relations, Pro/E internal assembly labeling and so on in all model files of the model template library, the Pro/Toolkit program[3] can identify and modify models, model parameters, model assembly relations and other operations under the Pro/E design environment.

2.2.4. Establish a skeleton

The assembly model of equipment is gradually established in the top-down[4] design process of equipment, and its hierarchical structure is shown in figure 3.

![Figure 3. Equipment model hierarchy definition](image)

The overall skeleton[5] model of the product includes the geometric features such as the reference coordinate system, contour line and contour surface in the product model, as well as the design parameters contained in these geometric features, the binding constraint relationship between them and the formulation of the overall assembly relationship. The framework design of the first-level subsystem is based on the overall design parameters and assembly interface information, and the overall layout of the module design. The design stage of the detailed model of the secondary submodule is the stage of detailed design of the product. After inheriting the superior design information and the interface information between the submodule and other modules, the designer completes the design of the detailed model of the secondary submodule by adding model features. Considering the actual design complexity of the product, the detailed design process of the second-level sub-module can be completed at this level, even if the assembly relationship exists. From the overall skeleton model design stage to the first level sub-module skeleton design stage, and then to the second level sub-module model detailed design stage, the overall design information of the product is fully expressed from top to bottom through the skeleton model at all levels. After the detailed design stage of the second-level sub-module model is completed, the low-level detailed model of the product has been constructed. The detailed model of the product model is assembled from the bottom up step by step, and the overall model of the product is finally completed.

Based on the definition of the top-down model framework solves the model dependence complex problems, before the tooling 3 d design of two stage, the main top-down design information transmission, the superior skeleton model model of each module design benchmark (geometric feature) and overall design parameter data variables (parameters) is passed to the child module, and in order to control the model, makes use of the same design datum in different models, avoid repetitive modeling design reference. The transfer mode of this process is mainly realized through the "geometric copy/release" and "relationship" of Pro/E system. In the third stage of design, after the detailed design of related geometric features of the second-level sub-module model is completed, the first-level
sub-model and the overall model are assembled from the bottom up of the detailed sub-model to feedback the design information to the overall design. The transmission mode of this process will completely rely on the assembly function of the Pro/E system.

2.2.5. Association with analysis The equipment rapid design system is implemented by secondary development of Pro/E, and the static analysis of the tool needs to be carried out in the ANSYS environment. Therefore, it is necessary to call ANSYS under Pro/E conditions and call the batch file of ANSYS (.dat file)\(^6_7\) on Pro/E, so as to call ANSYS in the background. Starting with this method requires no complex programming, just writing a.dat file. In order to realize automatic analysis, the input and output information of analysis should be determined, and the analysis method should be encapsulated and integrated.

3. Application and effect

3.1. The application case

Taking the design of the satellite support vehicle for satellite assembly as an example, the parameterized rapid design is illustrated.

The system is divided into several sub-subsystems according to the structure of the satellite support vehicle, and the whole satellite support vehicle can be designed from top to bottom parts according to the sequence of sub-systems. Click the subsystem to input the key parameter value of the corresponding item, and the required model can be established according to the parameter value in the system. The demonstration of parametric modeling is shown in figure 4. In the modeling design, there is an expert system to guide the design, which prompts the input parameters to consider the working conditions and other factors, so as to avoid design errors. For the established model in the stereotyped module system, only the mature modules needed can be selected in the design. In the system, the checking formula of typical structure has been solidified, only mechanical parameters need to be input to automatically carry out a series of checking. Since the drawing has been finalized, the corresponding analysis has been completed, for the scheme passed through the analysis, click the corresponding subsystem to generate the drawing and the drawing will be drawn automatically, as shown in figure 5.

![Parameterized drive modeling patterns](image1)

![Drawing module](image2)

Figure 4. Parameterized drive modeling patterns  
Figure 5. Drawing module

3.2. Application effect

When adopting parametric design technology to design the whole star bracket vehicle, the design period is greatly shortened. According to the traditional design, the time required is about 5 days (modeling + analysis + 2 days + modification + drawing + 2 days), while according to this method, the design takes only 1 day (modeling + analysis + modification = 0.5 days + drawing + 0.5 days). It is verified that the parametric modeling method greatly improves the design efficiency.
4. Conclusion
In this paper, a fast design method based on parameterized drive is presented and verified by practical application. Based on the control of key parameters, the establishment of stereotyped modules and general parts modules, the equipment design can be carried out quickly, which can be widely used in stereotyped equipment design.

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