APPLICATION OF UG PARAMETRIC DESIGN IN MODERN MECHANICAL MANUFACTURE

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ABSTRACT: *To study the application of UG parametric design in modern mechanical manufacture, in this research, the UC design of automotive differential was taken as an example to study the application of UG software in the design development and motion simulation of automotive differential. Combined with UG assembly technology, the general process of mechanical equipment assembly was analyzed, and the general steps of UG motion simulation were analyzed with UG motion simulation technology. The research results included differential modeling based on the relevant parametric model, creation of models for other components of the differential, and motion simulation of the differential in both linear and curved motion states. This research hoped to take UG software as the development platform to design and build a UG system with professional knowledge and complete functions to further promote the standard mechanical parts to be widely used in all aspects of mechanical design and manufacturing.*

KEYWORDS: *UG, Parametric design, Differential, Motion simulation*

1. INTRODUCTION

Computer Aided Design (CAD) technology completes the entire product design process based on computer. It focuses on the use of computers, peripherals, graphics input and output devices and the corresponding software to help people with engineering and product design technology. CAD is an important part of electronic information technology, which is widely used in machinery, construction, automotive, electronics, aerospace and other fields. It is of great significance to accelerate the development of new products, shorten the design and manufacturing cycle, improve product quality, save cost, enhance the market competitiveness and innovation ability of enterprises, and accelerate the development of national economy and modernization of national defence. Nowadays, CAD technology has become a necessary condition for manufacturing enterprises to participate in market competition and a ticket for enterprises to enter the world market.

A large number of auto parts are needed in auto production and auto maintenance. The production of auto parts has entered a period of rapid development with the development of the automobile industry, and the two are closely linked. Automobile differential is an important part of the automotive transmission system. It is of great significance to adopt CAD technology to design and develop automotive differential parts in the production of auto parts.

2. LITERATURE REVIEW

UG is a three-dimensional parameterization software integrating CAD/CAM/CAE provided by Uingraphics Solutions (UGS). Alghazzawi, Seager and Bircan believe that one of the most representative software in the field is UG [1, 2, 3]. Kirkwood, Gao and Kang believe that UG can be used for product design, structural design, parts assembly design, sheet metal design, mold design, numerical control programming, design analysis, etc. through research and data collation. In the field of development, it can provide all solutions for conceptual design, product modeling, structural design, analysis and manufacturing [4, 5, 6]. In addition, Alghazzawi and Gherardini showed that the combination of knowledge engineering and design optimization technologies based on products and processes of UG significantly improved the generation rate of relevant industries [7, 8].

Suhane and Chai pointed out that the differential is a small bearing installed between two driving half-shafts, which can divide the output torque of the engine into two parts, allowing two different speeds to be output when turning. Without it, the two driving shafts were only rigidly connected, and the rotation speed of left and right wheels remained the same, so the car can only run in a straight line and can't turn [9, 10]. Therefore, the differential played an important role in it.

3. METHODOLOGY

3.1 UG Assembly Technology

Assembly sequence design is an important part of equipment assembly. It will not only affect the difficulty of equipment assembly, but also cause the damage of assembly parts and directly affect the assembly results. Accurate and effective assembly process design can greatly improve the assembly efficiency of process personnel and reduce the workload.

Generally speaking, the assembly process design process of mechanical equipment has certain rules. Firstly, the 3d solid model of mechanical equipment is required, then the feasible model assembly mode and method are studied, and finally each method is compared to obtain the optimal result. Among them, a comprehensive consideration should be given to the study of feasible assembly methods, which are directly related to the quality of assembly. Figure 1 shows the general process of its assembly process design.

A large amount of assembly information is involved in the assembly process design of mechanical equipment. The establishment of a complete and sound 3d assembly information model can effectively improve the accuracy of assembly sequence planning, simplify the assembly process, and improve efficiency.

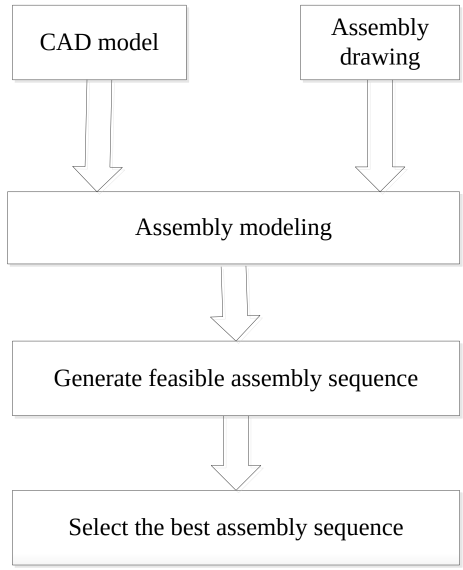

Figure 1. General process of assembly process design

Assembly information model plays a very important role. At present, there are three typical assembly modeling methods: three-dimensional topological assembly model, five-dimensional topological assembly model, and hierarchical semantic web model. The advantages and disadvantages of the three typical assembly modeling methods are shown in Table 1.

Table 1 Advantages and disadvantages of three typical assembly modeling methods

Name	advantages	Disadvantages
Three-dimensional topological assembly model	The model is the simplest to describe Assembly relation is visual and intuitive	Assembly information missing There are many cut sets in assembly process Break down the question of feasibility
Five-dimensional topological assembly model	The model description is simple Assembly information accurate and complete	The way of definition is tedious and unintuitive Product design process integration is difficult
Hierarchical semantic web model	Semantics are defined in predicate form Part attributes Entity relationship attribute The model description is not simple Intuitive assembly relation	Complex definition Product design process integration is difficult

3.2 Differential Assembly

After the 3D solid modeling of the differential straight bevel gear and the gear bracket is completed, the model file is saved under a certain directory, and then it enters the assembly module of the UG. The various components of the differential are added to the differential assembly file with "adding components".

There are three positioning methods to add UG model to the assembly environment: "absolute origin", "selection origin" and "pairing". These three methods define the specific location of the added model in the assembly environment. In general, the main components are positioned in the way of "absolute origin", while other components are positioned in different ways according to the actual situation and needs, or in the way of “selecting origin” or “pairing” to place the target components in an appropriate position. For other components, “pairing” is often adopted to constrain the positioning of the parent component or the shape and position of other parts, so as to ensure the accurate positioning of parts.

In the UG assembly module, the freedom degree of the constraint model is matched by “matching components” to achieve the real assembly effect. Each constraint can restrict one or more degrees of freedom of a model. In fact, the assembly process of UG is to use various “pairing” design functions to limit one or more degrees of freedom of the model, so as to ensure the correct assembly position relationship between parts.

The UG assembly environment provides users with eight “pairing types”, as shown in Table 2 below:

Table 2 UG assembly environment for the user to provide eight types of pairing

Matching type	Matching function
Pairings	used to constrain two homogeneous objects to be in the same position
Alignment	can be used to align planes, axes, etc
Angle	used to constrain the Angle relationship between objects
Parallel	ensures that the object vectors are parallel to each other
Verticality	ensures that the vector directions of the object are perpendicular to each other
Center	used to constrain the geometric center alignment of two objects to coincide
Distance	guarantees the vertical distance between two objects
Tangent	used for assembly between planar and curved objects

4. RESULTS AND DISCUSSION

The motion simulation analysis module of UG is a CAE application software, which is a simulation analysis tool. It is mainly used to predict and verify the motion characteristics of the mechanism with software before the trial production of the prototype. The CAE module can perform interference analysis on the mechanism, track the motion trajectory of parts, motion simulation and strength analysis, etc., and it can optimize the motion mechanism with the displacement, coordinate, acceleration, velocity and force changes of the graphic output parts. The ADA software embeds the ADAMS system solver, which can easily perform motion simulation on the model.

UG motion simulation module is the main component of UG simulation analysis and an important tool for mechanical mechanism simulation. It can be used to simulate the movement principle of the mechanism, analyze the assembly interference of the mechanism, and carry out kinematic analysis of the mechanism such as displacement, speed and force, and output the analysis results. Through the analysis and research of the output results, the structure design and function design of the machine can be optimized.

The general process of motion simulation of mechanical mechanism by UG is shown in figure 2.

4.1 Differential Motion Simulation When Driving in a Straight Line

When the car is traveling in a straight line, there is no relative motion between the two wheels of the differential, so there is no gear transmission between the planetary bevel gear and the half-axle bevel gear, just rotation. The simulation process is as follows:

Enter the UG motion simulation environment by [Start] \ [Motion Simulation], right-click the name of the simulation model, create a new motion simulation, and select the “Kinematics” analysis type. The simulation name is named motion_1.

The rigid connecting link is defined by the “link” command, the bracket is defined as the link L001, the two planetary bevel gears are defined as the link L002, and the two half-axle gears are defined as the link L003.

The motion constraint between connecting links is defined by the “kinematic pair”, and the bracket connecting link L001 is defined as the rotating pair. The center of the end face is selected as the origin, and the vector direction is the negative direction of the Y axis, which is named as J001; the planetary bevel gear connecting link

L002 is defined as the rotary pair, and the origin of coordinates is selected as the origin, and the vector direction is the negative direction of the Y axis, named as J002; the semi-axle bevel gear link L003 is defined as the rotary pair, the origin of the coordinate is selected as the origin, and the vector direction is the negative direction of the Y-axis, which is named J003.

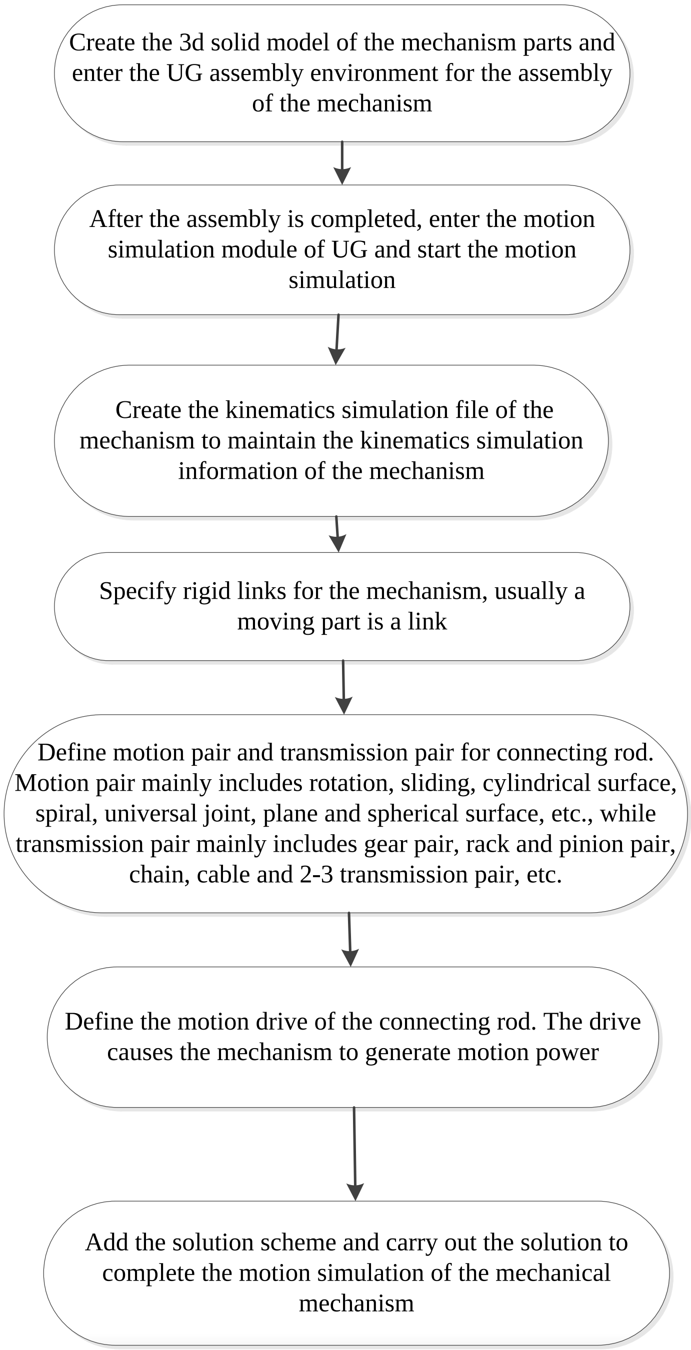

Figure 2. General flow of motion simulation of mechanical mechanism by UG

Add the driver by editing the rotation pair, right-click J001, click edit, enter the “motion pair” dialog box, and click “drive”. In the dialog box, the initial displacement and acceleration are set to zero, and the initial velocity is 20, which is an angular velocity. Click “OK” to complete the setting of motion drive.

Enter the solution dialog through the “Solution Scheme” command. In the solution option, select solution type is conventional drive, analysis type as kinematics/dynamics, time is 100, number of steps is 100, other options can be selected as default, and click “OK” to generate the name solution_1. The specific information is shown in Figure 3 below:

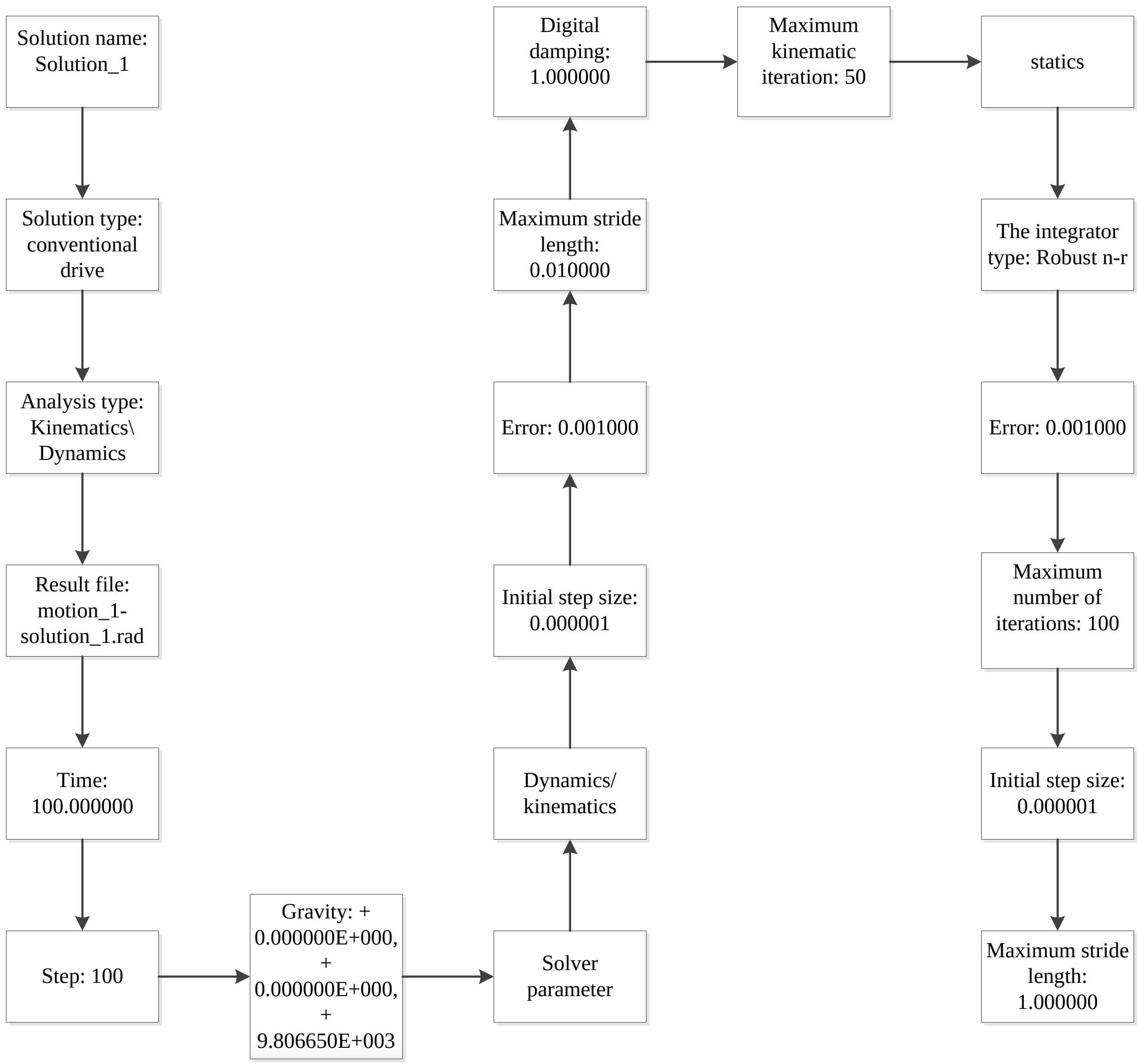

Figure 3. Details on generating solution 1

Through the "Solve" command, enter the solution phase of the motion system and solve the solution scheme. The solution method of the UG system will send changes according to the solution scheme. For the general solution, the system will directly solve the problem. For other solutions, such as motion driven or spreadsheet driven, the user needs to complete the corresponding settings to solve the problem. In this research, the solution is a conventional driver, and the solution can be directly solved to obtain the result.

After the solution is completed, if no error is reported, the system can automatically generate the simulation animation of the differential. It can be viewed through the corresponding function button.

4.2 Motion Simulation of Differential During Cornering

When the car is turning, there is relative motion between the two wheels of the differential, so there is relative motion between the differential planetary bevel gear and the semi-axle bevel gear, and it is gear transmission. The simulation process is as follows:

Enter the UG motion simulation environment by [Start] \ [Motion Simulation], right-click the name of the simulation model, create a new motion simulation, and select the "Kinematics" analysis type. The simulation name is named motion1.

The rigid connecting link is defined by the "link" command, the bracket is defined as the link L001, the two planetary bevel gears are defined as the link L002 and L003, and the two half-axle gears are defined as the link L004 and L005.

The motion constraint between connecting links is defined by the "kinematic pair", and the bracket connecting link L001 is defined as the rotating pair. The center of the end face is selected as the origin, and the vector direction is the negative direction of the Y axis, which is named as J001; two rotary pairs are defined on the planetary bevel gear connecting rod L002, and the coordinate origin and end face center are selected as the designated origin respectively. The vector directions are the negative direction of Y axis and the positive direction of X axis, and they are named J002 and J003 respectively. Similarly, the vector directions are the negative direction of the Y-axis and the positive direction of the X-axis, and they are named J002 and J003 respectively; two rotation pairs are defined on another planet bevel gear link L003, and the coordinate origin and end face center are selected as the designated origin respectively. The vector directions are negative direction of the Y-axis and negative direction of X-axis, and they were named J004 and J005 respectively. The semi-axle bevel gear link L004 is defined as the rotating pair, the center of the end face is selected as the designated origin, and the vector direction is the negative direction of the Y-axis, which is named J006; the other half-axle gear link L005 is defined as the rotary pair, the center of the end face is selected as the designated origin, and the vector direction is the negative direction of the Y-axis, which is named J007. Then, the gear pair is added by the "Gear Pair" command between the rotary pair J003 and J006, J005 and J006, J005 and J007, respectively.

Add the driver by editing the rotation pair, right-click J001, click edit, enter the "motion pair" dialog box, and click "drive". In the dialog box, the initial displacement and acceleration are set to zero, and the initial velocity is 20, which is an angular velocity. Click "OK" to complete the setting of motion drive; right-click J007, click edit, enter the "motion pair" dialog box, and click "drive". In the dialog box, the initial displacement and acceleration are set to 0, and the initial velocity is 5. Click "OK" to complete the setting of motion drive.

Enter the solution dialog through the "Solution Scheme" command. In the solution option, select solution type is conventional drive, analysis type is kinematics/dynamics, time is 100, number of steps is 100, other options can be selected as default, and click "OK" to generate the name Solution_1. The specific information is shown in Figure 3 below:

Through the "Solve" command, enter the solution phase of the motion system and solve the solution scheme. The solution method of the UG system will send changes according to the solution scheme. For the general solution, the system will directly solve the problem. For other solutions, such as motion driven or spreadsheet driven, the user needs to complete the corresponding settings to solve the problem. In this research, the solution is a conventional driver, and the solution can be directly solved to obtain the result.

After the solution is completed, if no error is reported, the system can automatically generate the simulation animation of the differential. It can be viewed through the corresponding function button.

5. CONCLUSION

The differential is an important part of the automotive transmission system. In this study, the research on differential modeling and motion simulation under the UG system platform was completed, which provided important support for the modeling and design of the automotive differential. Firstly, the UG assembly technology was studied, the general flow of mechanical equipment assembly was analyzed, and the assembly of the differential three-dimensional model was completed. Then, the motion simulation technology of UG was studied, the general steps of UG motion simulation were analysed, and the motion simulations of the differential under the two motion states of straight line and turning were completed. Through the parametric modeling and simulation analysis of the automotive differential, the research and development functions of similar products were also realized, which saved production costs and improved efficiency goals.

Acknowledgements:

The authors acknowledge the National Natural Science Foundation of China (Grant: 111578109), the National Natural Science Foundation of China (Grant: 11111121005).

6. REFERENCES

►Alghazzawi T F. Advancements in CAD/CAM technology: Options for practical implementation. Journal of Prosthodontic Research, 2016, 60(2): 72-84.

►Seager C. CAD/CAM with PCBs. Electronics Education, 2017, 2004(3): 21-24.

►Bircan D A, Dede D, EkåI A K. Development of the customised implant system using CAD/CAM/CAE tools. Advances in Materials & Processing Technologies, 2016, 2(1): 57-65.

►Kirkwood R, Sherwood J A. Sustained CAD/CAE integration: integrating with successive versions of step or IGES files. Engineering with Computers, 2017, 34(3): 1-13.

►Gao S, Zhang S, Xiang C, et al. A framework for collaborative top-down assembly design. Computers in Industry, 2013, 64(8): 967-983.

►Kang X, Peng Q. Integration of CAD models with product assembly planning in a Web-based 3D visualized environment. International Journal on Interactive Design & Manufacturing, 2014, 8(2): 121-131.
►Alghazzawi T F. Advancements in CAD/CAM technology: Options for practical implementation. Journal of Prosthodontic Research, 2016, 60(2): 72-84.
►Gherardini F, Zardin B, Leali F. A parametric CAD-based method for modelling and simulation of positive displacement machines. Journal of Mechanical Science & Technology, 2016, 30(7): 3253-3263.
►Suhane A, Rana R S, Purohit R. Prospects of Torsen Differential in Four Wheel Drive Automobile Transmission System. Materials Today Proceedings, 2018, 5(2): 4036-4045.
►Chai R, Savvaris A, Tsourdos A, et al. Multi-objective trajectory optimization of Space Manoeuvre Vehicle using adaptive differential evolution and modified game theory. Acta Astronautica, 2017, 13(6): 273-280.