Analysis and Research on Dynamic Characteristics of Hydraulic Shock Absorber

Sen ZHANG
Binzhou University, China

ABSTRACT : *Hydraulic support is the important supporting equipment for fully mechanized coal mining. Pro/E and ADAMS were used to establish the three-dimensional model of hydraulic support and complete the dynamic analysis. The introduction, restraint and load definition of the hydraulic support model are all based on the interface software Mech/pro. The dynamic analysis of the model adopts parameterized method and is simulated and simulated in ADAMS. The calculation results show that the fluctuation shape of the lateral and vertical average acceleration of the hydraulic support roof beam is similar in the course of movement, but the numerical difference is large. In the aspect of optimization research, the CAE optimization technology based on ADAMS is used to optimize the size of the four-bar linkage mechanism of the hydraulic support, which reduces the angular displacement of the lateral swing of the roof beam end point, thus greatly improving the support efficiency of the hydraulic support.*

KEYWORDS -*hydraulic support, ADAMS, dynamic characteristics, optimization*

I. INTRODUCTION

With the improvement of coal mine fully mechanized mining level, enhancing the research and development technology of hydraulic support, improving the design level of hydraulic support and enhancing the reliability of hydraulic support have become the basic functional requirements of product competitiveness [1]. With the development and progress of electromechanical technology, the dynamic analysis and optimization of hydraulic support has become a hot research topic. Good design of hydraulic support can greatly increase the moving speed and sliding speed of coal face, strengthen the support strength of roof of coal face, provide better mining conditions for coal miners, and reduce the production cost of enterprises [2]. The research on the structure optimization of hydraulic support can not only improve the support efficiency of the whole equipment, but also ensure the improvement of working environment and production conditions of coal workers, and at the same time reduce and improve production efficiency.

In recent years, CAD and CAE technology have been rapidly developed and widely used. For the design and research of hydraulic support, the most original method, empirical calculation and verification, has been transferred to the direction of dynamic numerical simulation analysis [3]. Therefore, this paper uses the numerical simulation method to analyze and optimize the dynamic characteristics of the hydraulic support, so as to improve the supporting efficiency of the equipment and increase the economic and social benefits brought by the equipment.

II. DYNAMIC SIMULATION OF HYDRAULIC SUPPORT SYSTEM

2.1 Functions of ADAMS

ADAMS is one of the most recognized dynamic analysis software at present. It is developed by MDI Company of the United States. Through many updates of different versions and gradual improvement of functions, ADAMS has now become widely used virtual prototype analysis software. ADAMS has been applied to various fields in various countries, occupying a large part of the global share of use, and has achieved great success in both technical and economic aspects. ADAMS uses a user interactive interface, which aggregates a variety of analysis modules [4].

ADAMS also has a very powerful data processing capability. According to the different needs of users, the corresponding characteristic curve can be obtained. The post-processing module can ensure the clarity and accuracy of the analysis results. In dynamic analysis, Lagrange equation method is the core of multi-rigid-body system

dynamics theory, which can be applied to many complex and changeable rigid systems. With ADAMS software, users can easily conduct comprehensive static, kinematic and dynamic analysis of the virtual system, and carry out secondary analysis, development and optimization of the model based on the algorithm and technology of virtual prototype [5].

2.2. Establishment of parametric model

In this paper, the parametric modeling of hydraulic support is mainly based on three-dimensional software PRO/E. PRO/E is the modeling software developed by PTC Company in the United States. It can not only design three-dimensional parts, but also assemble three-dimensional parts. It can realize the numerical simulation of the whole or local movement process of the assembly. It is one of the most representative three-dimensional CAD software at this stage. Pro/E integrates parametric modeling technology and variable modeling technology into three-dimensional solid modeling system under Windows platform. It has very powerful function of mechanical assembly design and drawing. It can easily convert and link data with ANSYS, FLUENT, MATLAB and other application analysis software. Pro/E has powerful modeling function. It can not only complete complex modeling design and assembly design, but also project all kinds of parts, assemblies and other entities and eventually generate two-dimensional engineering drawings. It conforms to the drawing standards of our country and has high projection accuracy, which greatly simplifies the design process of hydraulic support and its components.

The vertical beam hydraulic support is taken as the research object for modeling and analysis. This type of hydraulic support is composed of insert board, guide rod, shield beam, roof beam, base, column and other components. In order to simplify the analysis process of the hydraulic support, the components are divided into two categories, one is welded parts, and the other is assembled parts. Among them, the elements are connected by the welding process of steel plate or circular pipe, forming a rigid connection, so the relative position between the parts is fixed, and can be assembled directly according to the assembly or connection relationship. The assemblies need to consider the degree of freedom of motion, and assemble according to the characteristics of rotating pairs and moving pairs, so as to realize dynamic analysis of hydraulic supports under different states.

Firstly, the assembly drawing model of hydraulic support is established by Pro/E three-dimensional software, and then the parametric transformation of virtual prototype is completed by Mech/pro interface software and imported into ADAMS. In the dynamic analysis of hydraulic support, it is necessary to set different types of constraints and connection forms according to the actual working conditions, so as to realize the virtual assembly and motion simulation of hydraulic support. In order to operate conveniently, we can add constraints in Mech/pro as much as possible. The dynamic analysis software ADAMS can directly identify the document as CMD file. By importing the document, the parameterized virtual prototype model of hydraulic support can be obtained, as shown in Fig.1.

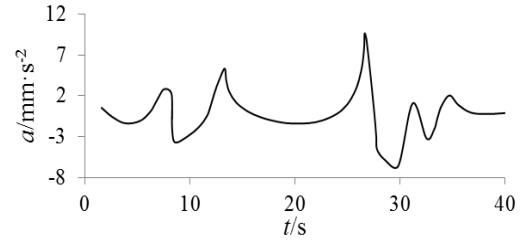
Fig.1 The model and constraints of hydraulic suppor

2.3 Result analysis

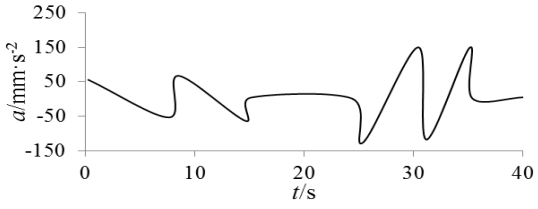
In order to better simulate the kinematic characteristics of hydraulic support, the definition of boundary conditions is needed. According to the working condition, the vertical speed of the roof beam driving motor is defined as 6mm/s, and the bracket is set to start running from 3000mm. According to the results of support analysis, load is added to the roof beam and the base. In the load condition of the virtual prototype of hydraulic support, the support force at both ends of the base is simplified by the support force in the actual working condition of the base. Therefore, in order to be closer to the actual working condition, the pressure load of the roof beam is distributed according to the structure. In ADAMS, the lifting motion of the hydraulic support is set up as a uniform motion, and the relationship between the dynamic load of the support and time is established, so that the corresponding dynamic characteristics of the hydraulic support at different heights can be

calculated, and the relationship between the bearing capacity of the hydraulic support and the height of the support can be studied. After the system is set up, the dynamic simulation analysis can be carried out. Finally, the curves of the roof beam movement in space (horizontal and vertical) are obtained as shown in Fig. 2, respectively.

According to the analysis results in Fig.2, it can be seen that the lateral movement of the roof beam of the hydraulic support is relatively stable and the acceleration change is relatively gentle. In the process of moving support, the horizontal inertia additional force is relatively small and the inertia frequency is relatively low. In the vertical direction, the movement characteristics of the hydraulic support are similar to that in the lateral direction, but the average acceleration is more than 10 times of that in the lateral direction. The inertia force is larger relative to the horizontal direction. In order to adapt to the support direction of the hydraulic support, it is necessary to further optimize the analysis and design of the four-bar structure of the hydraulic support.



(a) horizontal acceleration



(b) vertical acceleration

Fig.2 Acceleration variation characteristics of roof beam

III. OPTIMIZATION OF CONNECTING ROD SYSTEM OF HYDRAULIC SUPPORT

3.1. Optimization principle

In this paper, the optimization method of hydraulic support connecting mechanism is mainly based on ADAMS. In ADAMS, the optimization variable is one of the most widely used parametric analysis methods. It can not only define the user's own parameter variables, but also correlate simulation objects to analyze the results. In ADAMS/View, a reliable design method is provided for the selection of design variables, which can clearly show the parameters, so that the values of each parameter variable can be easily observed and modified. After the initial parameters are given, the design variables can be selected continuously in a certain range of changes through the selection of parameterization, and the corresponding analysis can be carried out to complete the optimization of the parameters. ADAMS mainly provides the research methods of three parameters: design research, experimental design and optimization analysis.

Generally, variables that need to be optimized are interrelated with other variables in the whole analysis, and there are different functional relationships among different variables. In the calculation of optimization results, it is necessary to keep the optimization variables consistent with the objective function. For this reason, it is necessary to transform the parameter variables. Without the conversion of the parameter variables, the optimization results not only make the user unable to select the parameters clearly, but also the optimization results are not ideal, and cannot effectively analyze the structural performance of the hydraulic support. In this paper, the four-bar mechanism of hydraulic support is taken as the optimal structure, and there are many optimization objectives. Therefore, different numerical values will appear in the calculation results. The results of each optimization calculation are independent, and the relationship between them cannot be obtained. Based on this result, the numerical value of the calculation results must be unique through some method.

3.2. Establishment of optimization model

Aiming at the four-bar structure of hydraulic support, this paper establishes a mechanical analysis model (the structural parameters are shown in Fig.3). The main optimization objective of parameterization of genetic algorithm is to minimize the lateral swing of the roof beam.

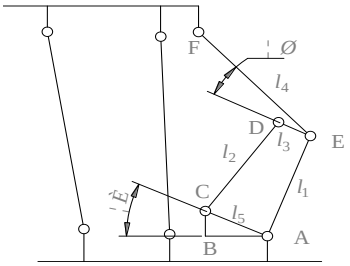


Fig.3 Structural parameters of optimization model

The optimized parameters are simulated in ADAMS to verify whether the parameters meet the requirements. The genetic method selected in this paper not only achieves the accuracy of the results, but also ensures the rapidity of the calculation. Aiming at the optimization objective, the l_1, l_2, l_3, l_4 and l_5 of four-bar linkage are optimized.

3.3. Result analysis

In ADAMS/View, design variables can be used not only to store data but also to design parameters. The main method to realize parameter variables is Create Design Variable. The selection of variable types and values is carried out by using variable generation dialog box [6].

In ADAMS/View, three combinations of optimization schemes are obtained through repeated iterations. Through repeated comparative analysis, this paper adopts the better optimization scheme 1. As shown in Tab.1, the lateral swing value of the optimized top beam end trajectory decreases significantly, this is of great significance for improving the working efficiency of the hydraulic support.

Tab.1 Goal optimization results

No	l_1 /mm	l_2 /mm	l_3 /mm	l_4 /mm	l_5 /mm	ω /°
1	1606	1511	635	2043	1242	1.2
2	1622	1503	644	2203	1252	2.2
3	1602	1505	645	2255	1244	1.8

IV. CONCLUSION

In this paper, a three-dimensional model of hydraulic support is established by Pro/E software, and introduced into ADAMS by Mech/pro. A rigid parameterized model is established to simulate the dynamic characteristics. The results show that the lateral and vertical acceleration of the hydraulic support roof beam are quite different in numerical value, and its inertia force is larger than the horizontal direction. Based on ADAMS, the size of the main four-bar structure of the hydraulic support is optimized. Through continuous iteration calculation, three optimal combination schemes are obtained. Finally, the trajectory efficiency of the front end of the top beam of the hydraulic support is improved by adopting the better optimization scheme, which makes the angular displacement of the lateral swing drop to 1.2 degrees, and achieves good optimization effect.

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