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Data Collecting and Processing System and Hydraulic Control System of Hydraulic Support Model Test

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Abstract: Hydraulic support is an important equipment of mechanization caving coal in modernization coal mine. Hydraulic support must pass national strength test before it quantity production and use. Hydraulic support model test based on similarity theory is a new effective hydraulic support design and test method. The test information such as displacement, stress, strain and so on can be generalized to hydraulic support prototype, which can prompt hydraulic support design. In order to satisfy the need of hydraulic support model test, the data collecting and processing system of hydraulic support model test was established, relative software was programmed, the tress computation software of practical measurement data of hydraulic support model test was programmed, which provide practical and convenient research method for hydraulic support model test. By the data collecting and processing system software of hydraulic support model test and related software, user can realize the function such as data collecting, real time display, saving, analysis and processing to strain signals. The construction of load equipment and hydraulic control system of hydraulic support model test provides a practical and convenient research way for hydraulic support model test.

Keywords: Hydraulic support, Model test, Data collecting and processing system, Hydraulic control system.

1. Introduction

Three dimensions design software SolidWorks has good three dimensions construction model function. So, this paper constructs the three dimensions solid model of ZT6500/19.5/34 hydraulic support [1, 2]. Its prototype is shown as Fig. 1. Relevant simplified hydraulic support model is shown as Fig. 2. In order to realize hydraulic support model test, data collecting and processing system, load equipment and relative hydraulic control system of hydraulic support model test were constructed.

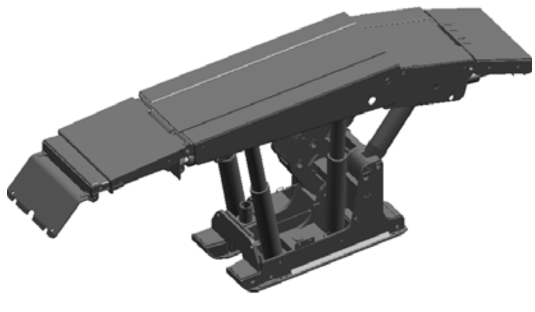

Fig. 1. ZT6500/19.5/34 hydraulic support prototype.

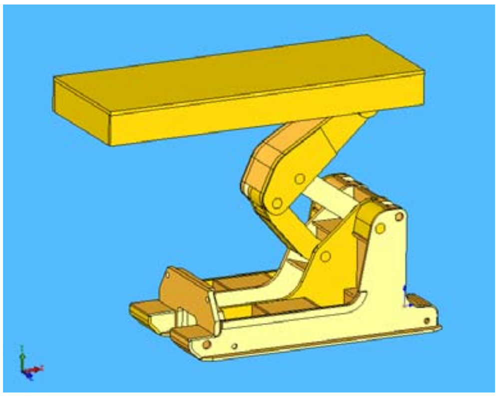

Fig. 2. Relevant simplified hydraulic support model.

In recent years, high performance computer has been applied widely. Test technology has been developed continuously. It has become possible to realize large capacity collecting and processing of test data. Data collecting system is the most universal application system of computer on natural science research and Industrial real time control system [3]. The data need collected and processed in hydraulic support model test mainly is the strain of hydraulic support model structure under load. By hydraulic support, model test, lots of basic test data of different structure hydraulic support model can be collected. The design of hydraulic support can be improved constantly based on these data. The strain and other parameter of hydraulic support structure was mainly tested and noted by some simple test equipments. The tested data was mainly analyzed and processed by handmade drawing, using empirical formula and check curve statistical method. By the above method, not only test speed is slow, work capacity is big, but also will cause primary instrument error and some artificial error during operation. These causes the test result cannot satisfy need. The establishment of hydraulic support model test data collecting and processing system can solve above problem effectively.

2. The Component of Hydraulic Support Model Test Data Collecting and Processing System

In hydraulic support model test, the strain of hydraulic support model structure was measured firstly, and then the stress can be obtained by conversion based on stress-strain theory. Now, the strain measurement method in hydraulic support model test was resistance strain method mainly. In hydraulic support model test, the strain signal need to be collected real time accurately, saved, analyzed and processed. Hydraulic support model test data collecting and processing system is mainly composed of resistance strain foil, electric bridge, dynamic resistance strain instrument, A/D conversion card, computer and its periphery equipment and corresponding software. Firstly, strain signal can be measured by resistance strain foil, electric bridge and CS-1A dynamic resistance strain instrument. Then, the measured data can be imported in computer by PCI2300A/D conversion card and self-contained complete PCI2600 terminal block. Finally, through the hydraulic support model test data collecting and processing system software programmed by LabVIEW programming language, the signal can be collected, real time display, saving, analysis and processing. The makeup frame figure and practical object figure of hydraulic support model test data collecting and processing system are shown as Fig. 3 and Fig. 4 separately.

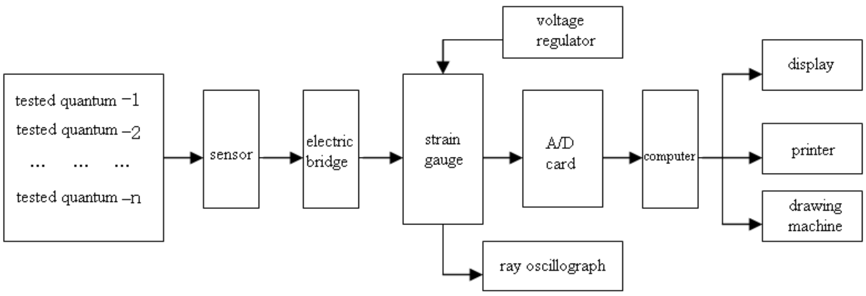

Fig. 3. Makeup frame figure of data collection and disposal system.

3. The Conversion Course of Hydraulic Support Model Test Measured Data

Firstly, hydraulic support model structure strain can be obtained by measurement electric bridge voltage ΔU and the relations between electric bridge voltage and strain. Then, the stress can be obtained by material dynamic theory. For the characteristic of non electrical quantity electrometric method, the strain under plane stress was measured generally. In hydraulic support model test strain measurement, the load form on hydraulic support model structure mainly was the combination of draw, press and bend. So, the load situation of measured point is shown as Fig. 5. Paste right angle strain flower method can be adopted on every measured point. The strain foil on

0°, 45° and 90° aspect may adopt temperature compensation measure and compose half bridge circuit by connecting temperature compensation foil respectively. The relevant circuit bridge structure form is shown as Fig. 6.

Fig. 4. Practical object figure of data collection and disposal system.

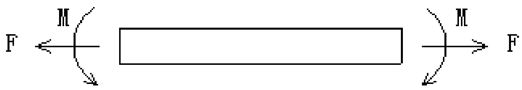

Fig. 5. Load status of measurement point.

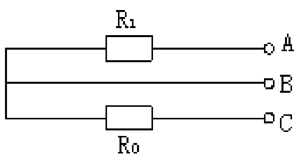

Fig. 6. Circuit bridge structure form.

Now, the relatively accordant viewpoint on processing stress computation result is that when material bring yield, hydraulic support was considered breakage. So, the yield condition of hydraulic support material need researched. Hydraulic support is large structure welded by steel plate. Adopting aberrance energy theory to research steel yield condition is considered adapted relatively. Now, the fourth strength theory namely aberrance energy theory was applied on engineering widely. The theory shows that the main factor caused material yield is aberrance energy density v_d. When v_d achieves material unidirectional draw yield aberrance energy density v_{ds}, material will arises yield. According to this theory, the material yield condition is shown as equation (1):

$$v_d = v_{ds}, \tag{1}$$

The equation of aberrance energy density v_d is shown as equation (2):

$$v_d = \frac{(1+\mu)}{6E}\left[(\sigma_1-\sigma_2)^2+(\sigma_2-\sigma_3)^2+(\sigma_3-\sigma_1)^2\right], \tag{2}$$

The equation of aberrance energy density v_{ds} is shown as equation (3):

$$v_{ds} = \frac{(1+\mu)\sigma_s^2}{3E}, \tag{3}$$

When equation (2) and equation (3) was substituted in equation (1), the material yield strength is shown as equation (4):

$$\sigma_s = \frac{1}{\sqrt{2}}\sqrt{(\sigma_1-\sigma_2)^2+(\sigma_2-\sigma_3)^2+(\sigma_3-\sigma_1)^2}, \tag{4}$$

When measured point is under unidirectional draw stress condition, there is $\sigma_2 = \sigma_3 = 0$, corresponding material yield strength is shown as equation (5):

$$\sigma_s = \sigma_1, \tag{5}$$

When measured point is under plane stress condition, there is $\sigma_3 = 0$, corresponding material yield strength is shown as equation (6):

$$\sigma_s = \frac{1}{\sqrt{2}}\sqrt{(\sigma_1-\sigma_2)^2+\sigma_1^2+\sigma_2^2} = \sqrt{\sigma_1^2-\sigma_1\sigma_2+\sigma_2^2}, \tag{6}$$

4. The Selection of Data Collecting Card

The high-speed, high-accuracy and stability performance requirements of real time signal data processing on data acquisition card were considered [4]. After market investigation, PCI2300A/D conversion card and self-contained complete PCI2600 terminal block based on PCI bus were adopted in test. They are shown as Fig. 7 and Fig. 8 respectively.

Fig. 7. PCI2300A/D conversion card.

PCI2300A/D conversion card may insert on discretionary PCI slot to form data collecting system and industry manufacture course monitor system in laboratory test center and production test center [5]. 12 Bit resolution ratio converter was fixed on PCI2300A/D conversion card [6]. The corresponding input signal range may be ±5 V, ±10 V and 0~10 V. The card can also provide 32 ways single-terminal simulation input passage or 16 ways double-terminal simulation input passage.

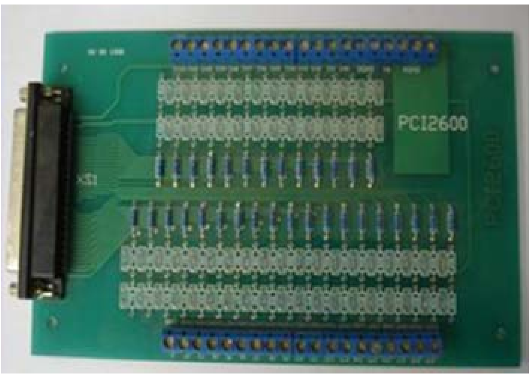

Fig. 8. PCI2600 terminal block.

5. The Design of Hydraulic Support Model Test Data Collecting and Processing System Software

Through the hydraulic support model test data collecting and processing system software programmed by LabVIEW programming language based on Windows XP computer operating system platform. The software can realize follow functions conveniently such as data collecting, real time display collected data with figure form, write data into file and save file, read data from file, reproduce locale collecting condition, design collecting parameter according to collecting need.

In LabVIEW, flow figure provides VI graphical original program [7]. Every program front panel corresponds to a flow diagram program. Program flow figure of data collecting and processing system software is shown as Fig. 9.

Graphical programming mode was adopted by LabVIEW based on flow figure. It is different from conventional code programming. So, its programming is easy. It is easy to be understood. Its application is flexible. Parallel task processing can be realized expediently [8]. The order structure program of hydraulic support model test data collecting and processing system software contains three sub flow diagrams. Every flow diagram was named as frame. Sub flow diagram number start from 0. The order structure program start performs from 0 sub flow diagram, then perform every sub flow diagram in order. Frame 0 was performed to create device. Frame 1 is program main part that was performed to read batch data on A/D equipment, switch data as corresponding voltage, show data on display front panel by display equipment and save data. Frame 2 was used to release device after performing program.

The three sub flow diagrams are shown as Fig. 10, Fig. 11 and Fig. 12.

In Frame 0, CreateDevice function was used to create PCI equipment object. Device ID is equipment identifier.

In frame 1 namely program main part sub flow diagram, ReadDevBulkAD function was used to read batch data on A/D equipment, then, switch data as corresponding voltage, show data on front panel by display equipment and save data. When press  icon in toolbar, program start perform. The wave form figure of collected data was shown on front panel simultaneity. When press save icon on front panel, program will switch array of collected data into binary system text character string and write it into a new document by Write To Spreadsheet File. VI function.

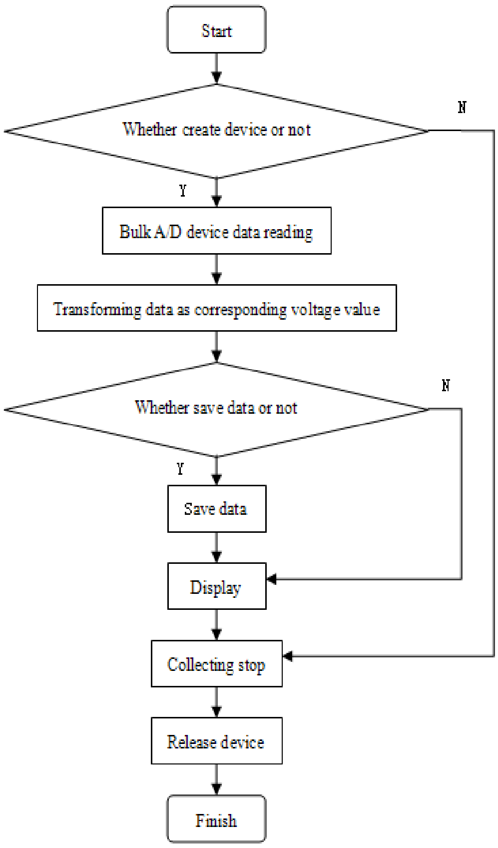

Fig. 9. Program flow figure of data collecting and processing system software.

In frame 2 namely releasing device sub flow diagram, when press  icon in toolbar, then, all data display and data save will be stopped. Program performing is stop. Simultaneity, ReleaseDevice function was used to release occupied system resources by device object and device object self. After double-click LabVIEW shortcut icon, LabVIEW was performed. The strain collecting program and file read program of hydraulic support model test data collecting and processing system software was performed.

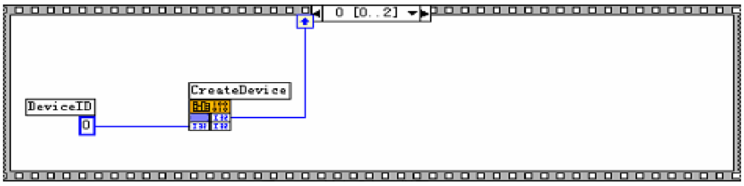

Fig. 10. Frame of creating device.

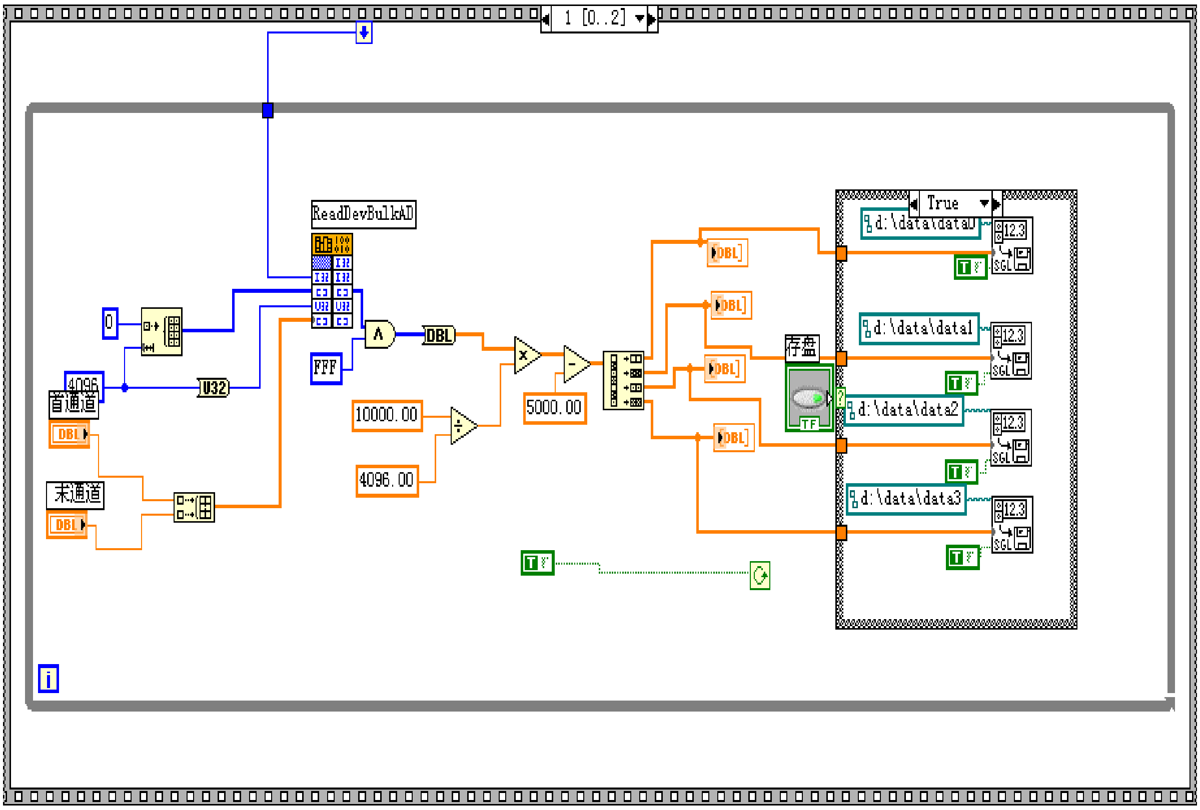

Fig. 11. Frame of program main part.

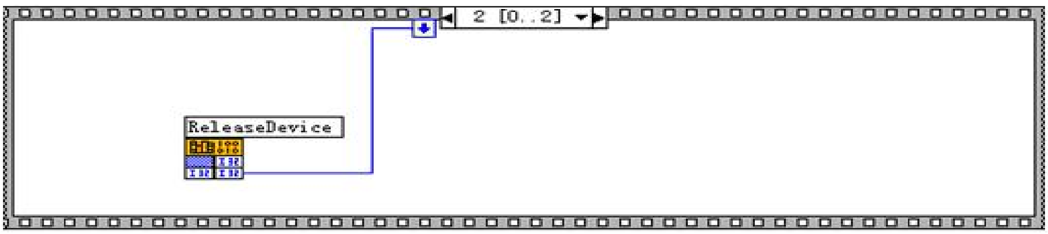

Fig. 12. Frame of releasing device.

6. The Design of Stress Computation Software of Practical Measurement Data of Hydraulic Support Model Test

In order to convert strain value of collected data to corresponding stress value, VC++ language was adopted on programming the stress computation software of practical measurement data of hydraulic support model test.

LabVIEW data-base can be visited by the software. Stress computation software program frame figure of practical measurement data of hydraulic support model test is shown as Fig. 13.

After clicking and performing the tress computation software of practical measurement data of hydraulic support model test, corresponding interface will appear. The interface contains four icons. They are parameter input icon, tress computation and lead-in Excel icon, open Excel file icon and help icon.

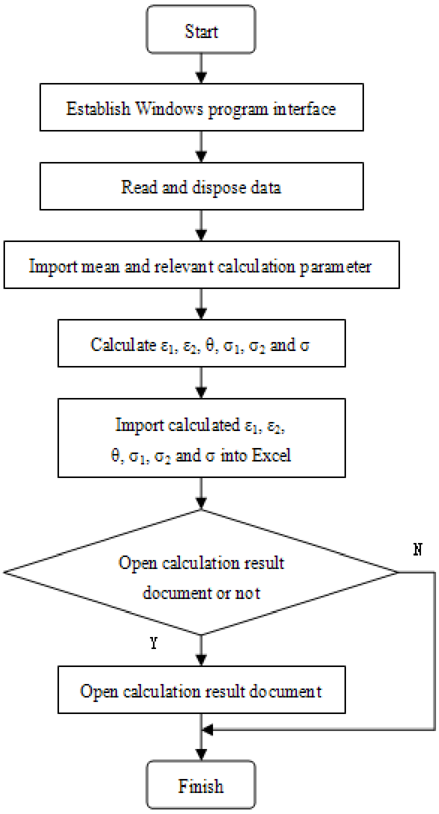

Fig. 13. Stress computation software program frame figure of practical measurement data of hydraulic support model test.

7. The Load Equipment of Hydraulic Support Model Test

The load equipment of hydraulic support model test was designed and made by inside and outside load pattern with artificial simulation the load status of hydraulic support under well. The load equipment and hydraulic control system are connected with high pressure entrance oil piles and return oil piles. The test board can realized the functions of vertical load, level and transverse level load, turn a certain angle from 0 degree to 45 degree and the combination of above functions, etc. The test board can accomplish the strength test for support model according to the national standard. Three dimensions picture of hydraulic support model test load equipment drawn by SolidEdge software is shown as Fig. 14. The load equipment and hydraulic control system technology parameter is shown as Table 1.

8. The Hydraulic Control System of Hydraulic Support Model Test

The hydraulic control system of hydraulic support model test is composed of model pillar adding pressure branch route, vertical load branch route, level load branch route and roll-over load branch route. It can accomplish the control on adding pressure on hydraulic support sustaining post, vertical load, level load and roll-over load of hydraulic support model. The practical object figure of hydraulic control system is shown as Fig. 15. The whole principle figure of hydraulic control system of hydraulic support model test is shown as Fig. 16.

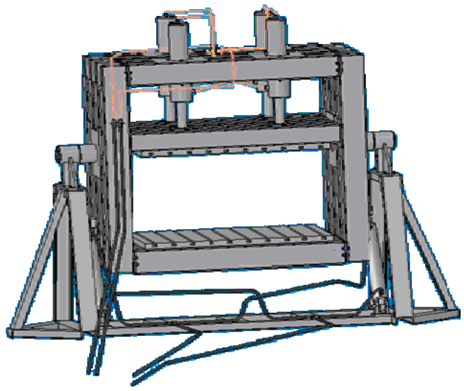

Fig. 14. Load equipment.

Table 1. The actual output of mean torques and maximum torques.

Item	Parameter	Value	Unit
Load ability	Maximum load ability	320	kN
	Vertical travel	800	mm
	Work size	1500×1000	mm×mm
	Horizontal load ability	80	kN
	Inclination Range	0~45	degree
Pumping station	Rated work pressure	7.84	kPa
	Capacity	12	L
Motor	Rated revolution	1500	r/min
	Power	4	kW

Fig. 15. Practical object figure of hydraulic control system.

In Fig. 16, 1 is oil box, 2 is filter, 3 is three-phase asynchronous motor, 4 is gear pump, 5 is overflow valve, 6 is pressure meter switch, 7 is pointer type pressure meter, 8 is three position four pass operating valve, 9 is hydraulic pressure lock, 10 is overflow valve, 11 is one-way valve, 12 is three position four pass operating valve, 13 is supercharger, 14 is hydraulic control one-way valve, 15 is hydraulic control one-way valve, 16 is safety valve, 17 is hydraulic support model sustaining post, 18 is vertical load hydraulic cylinder, 19 is level load hydraulic cylinder and 20 is roll-over load hydraulic cylinder.

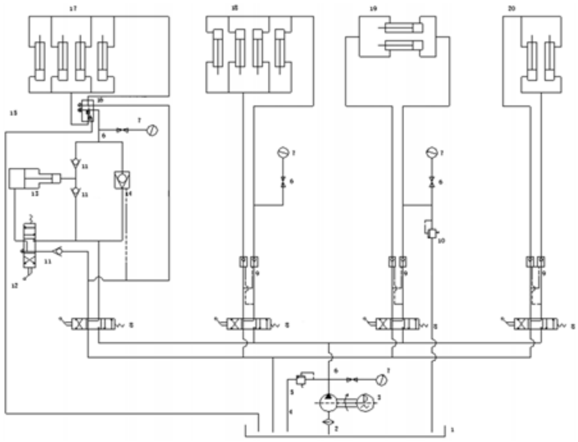

Fig. 16. The whole principle figure of hydraulic control system.

9. Conclusions

The establishment of the data collecting and processing system of hydraulic support model test, the programming of the data collecting and processing system software of hydraulic support model test and the programming of the tress computation software of practical measurement data of hydraulic support model test, which provide practical and convenient research method for hydraulic support model test. It has important significance on designing eligible hydraulic support.

The construction of load equipment and hydraulic control system of hydraulic support model test provides a practical and convenient research way of hydraulic support model test. It also provides an advanced way of research and design eligible hydraulic support.

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