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Analysis and Test on Dynamic Loads of Chassis of the Hydraulic Drill

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Abstract: It is proved that this kind of device of crawler frame can be designed according to the static design through test and analysis. The static analysis design of the crawler frame is also proved to be the final design. The dynamic loads of the crawler frame of D55 hydraulic drill have been tested and analyzed during work in the study. The stress and strain of the crawler frame are obtained from the data measured in different working environments and the spectrum analysis is conducted. The main vibration frequency and its impact are analyzed. The improved measures are put forward to reduce the impact of the dynamic loads.It is proved that the dynamic loads have little effect on the chassis in walking and drilling. According to structure characteristics and mechanical characteristics of track frame of D55 hydraulic drill on the different loads and constraints of the different conditions, hydraulic drill arm in the process of stress state has been studied. The design method is simplified very much. Meanwhile it provides the necessary basis for engineering practice. It provided theoretical support for selection for engineering design.

Key words: Hydraulic drill, crawler frame, dynamic stress, load analysis

INTRODUCTION

The deep-hole hydraulic drill is a mining crawler construction machinery and equipment, which is newly developed and produced in recent years. It is mainly used in rock, soil drilling and mining operations of the mine. Working conditions is poor. The rig is widely designed and analyzed in many papers. Speed control system of hydraulic drive (Lu *et al*., 2011; Meng and Bo, 2008; Yao and Zou, 2007) , the positioning system of the drilling (Yu and Zhang, 2010) and suspension system of host and drilling (Fan and Pang, 2006) are analyzed and designed more perfectly. The chassis and track frame which play a supporting role were referred to other issues such as bulldozer analogy use. The track frame is an important support component of the hydraulic drill. The whole weight and external load by concentrated load are passed to the crawler frame through the frame junction. It is passed by uniform load to the ground through bearing wheel. Therefore, the crawler frame should have sufficient strength and stiffness. When walking, the crawler withstands the dynamic load (Wang *et al*., 2012; Fan and Yang, 2011) called tensile stress. In addition, the crawler also bear a strong wear of the sand, mud, stone and other media. Materials and structures of the crawler should have good abrasion resistance and mechanical properties. Static analysis and design are used for track frame. The finite element techniques (Hu and Wang, 2009; Cheng and Wang, 2009; Wang and Zhou, 2005) are used to optimize currently.

Static stress distribution of track frame is obtained by ANSYS software in the study. The dynamic loads of the crawler frame of hydraulic drill have been tested and analyzed during work. The spectrum analysis is conducted. It is proved that the dynamic loads have little effect on the chassis in walking and drilling.

METHOD TO DETERMINE THE TEST POINTS

Test point is two ways to combine. Firstly, the finite element analysis is used to obtain the stress field. The dynamic impact is tested at large parts of the track frame stress. Secondly, the dynamic effect is observed according to the structural characteristics to determine the larger source of the possible deformation. In the test the D55 hydraulic drill is used. As shown in Fig. 1.

Operating parameters:

- The main technical parameters of the ROC D55 hydraulic drill
- Overall weight: 22 tons
- Engine speed: Low-speed 1200 rpm, high-speed 1800 rpm
- Displacement of the Walking pump: The displacement of the Walking motor 86/43 mL r^{-1}
- The maximum pressure: 250 bar
- Requirements of walking speed: Walking high-speed 3.7 km h^{-1}, walking high-speed 1.8 km h^{-1}

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Fig. 1: Hydraulic drill working

- Walking traction (Or the maximum output torque of the reducer): Maximum torque 22000/11000 N.m

Static stress of the track: Based on the structural characteristics of the track frame and the mechanical characteristics, low strength material Q345B is used and the total length of the track frame is 3192 mm. Supporting wheels is set along the track vertically to effectively transfer load to the crawler board. The loads and constraints of the track frame are different in different operating conditions. In order to compare to the dynamic stress analysis of comparative experiments part, the stress condition in the process of hydraulic drill is only studied. The load and the constraints imposed as shown in Fig. 2. Stress distribution as shown in Fig. 2.

The internal stress distribution of the crawler frame and the stress distribution of rib are reflected from track stress distribution Fig. 2. The stress of track is distributed near the main bearing and auxiliary bearing. The Stress of the ribs under the sleeve in the middle of the main support is larger and the maximum reaches 198 Mpa. Track frame model and boundary conditions.

Test equipment: A strain gauge and the dynamic strain gauge are used in the dynamic load stress test of track structure using. Computer is used to record and store data.

Designs of test conditions: In order to study the payload data of the acquisition mining machinery crawler chassis frame in the actual conditions, combined with the data of finite element analysis, load spectrum acquisition experiment of the crawler chassis is conducted. Rock is for design of working conditions. The type of work is divided into walking, machine rotation, arm swing and drill positioning and drilling.

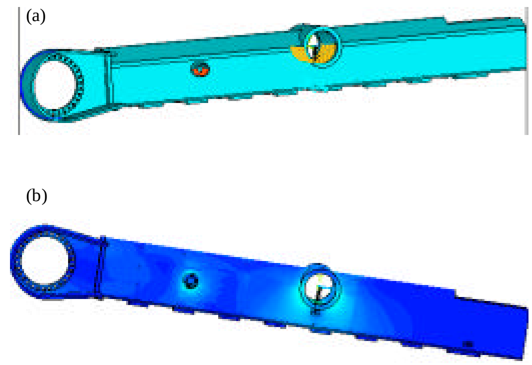

Fig. 2(a-b): Boundary conditions and stress distribution of track frame model

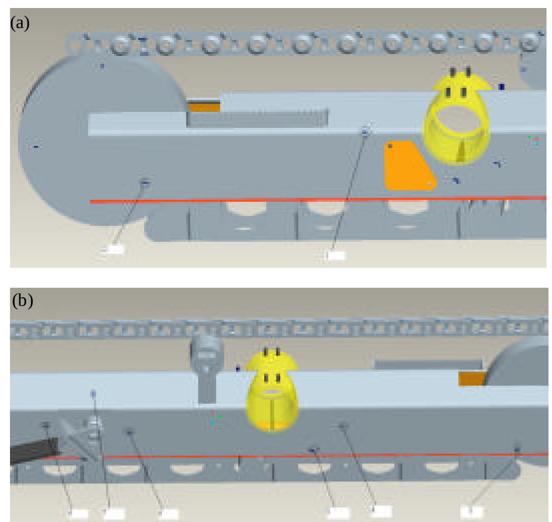

Fig. 3(a-b): Location of the strain gauge of rigs drilling for positioning

The design of test point: Collecting test of the process of arm before the punch positioning of hydraulic drill: Spectrum analyzer with eight channels, that is, the surface stress of eight positions is collected. The test point is set shown in Fig. 3.

ANALYSIS OF TEST DATA

Test stress strain analysis: Stress acquisition of actions of a walk test, forward, back, vehicle rotation, arm and drill

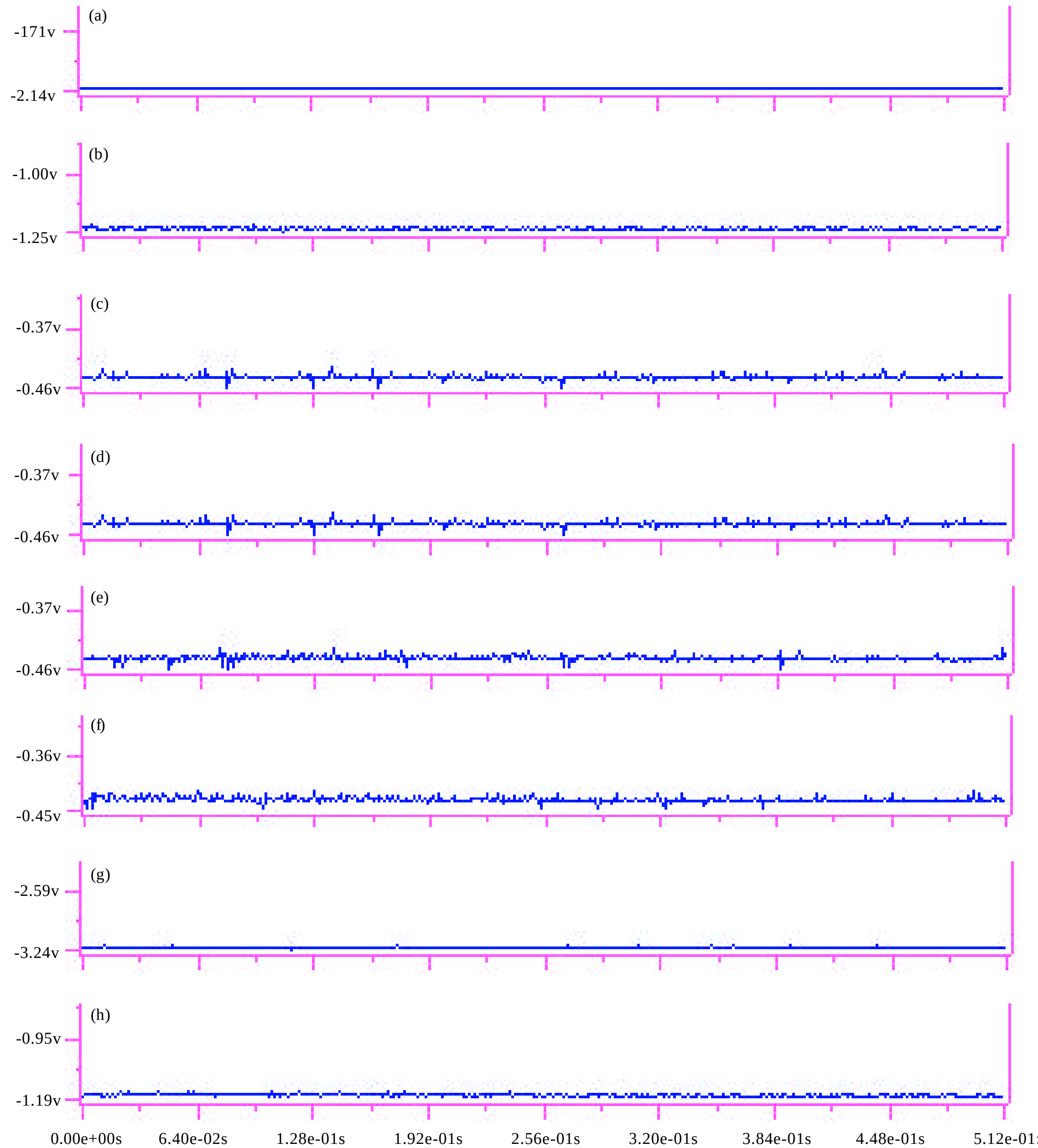

Fig. 4(a-h): Time domain diagram of output signals of strain gauge

positioning and drilling is conducted. Arm status is researched in this study. Hydraulic drilling rig before work, take the arm placed in the appropriate location for the accurate positioning of the drill bit in order to drilling. In this process, the crawler system will be subject to changes in load.

Third-order headings: The following is a collection point time domain shown in Fig. 4. According to the time domain diagram of output signals of strain gauge, the data recorded by strain gauge can be transformed into the strain of the strain gauge, that is, Strain of the track frame. According to the formula $\Delta R/R = K \bullet \varepsilon$, where K is the strain gauge sensitivity coefficient, the measured strain gauge resistance value change ΔR will be entitled to the strain ε of the object under test:

- According to Hooke's law, Stress [σ]

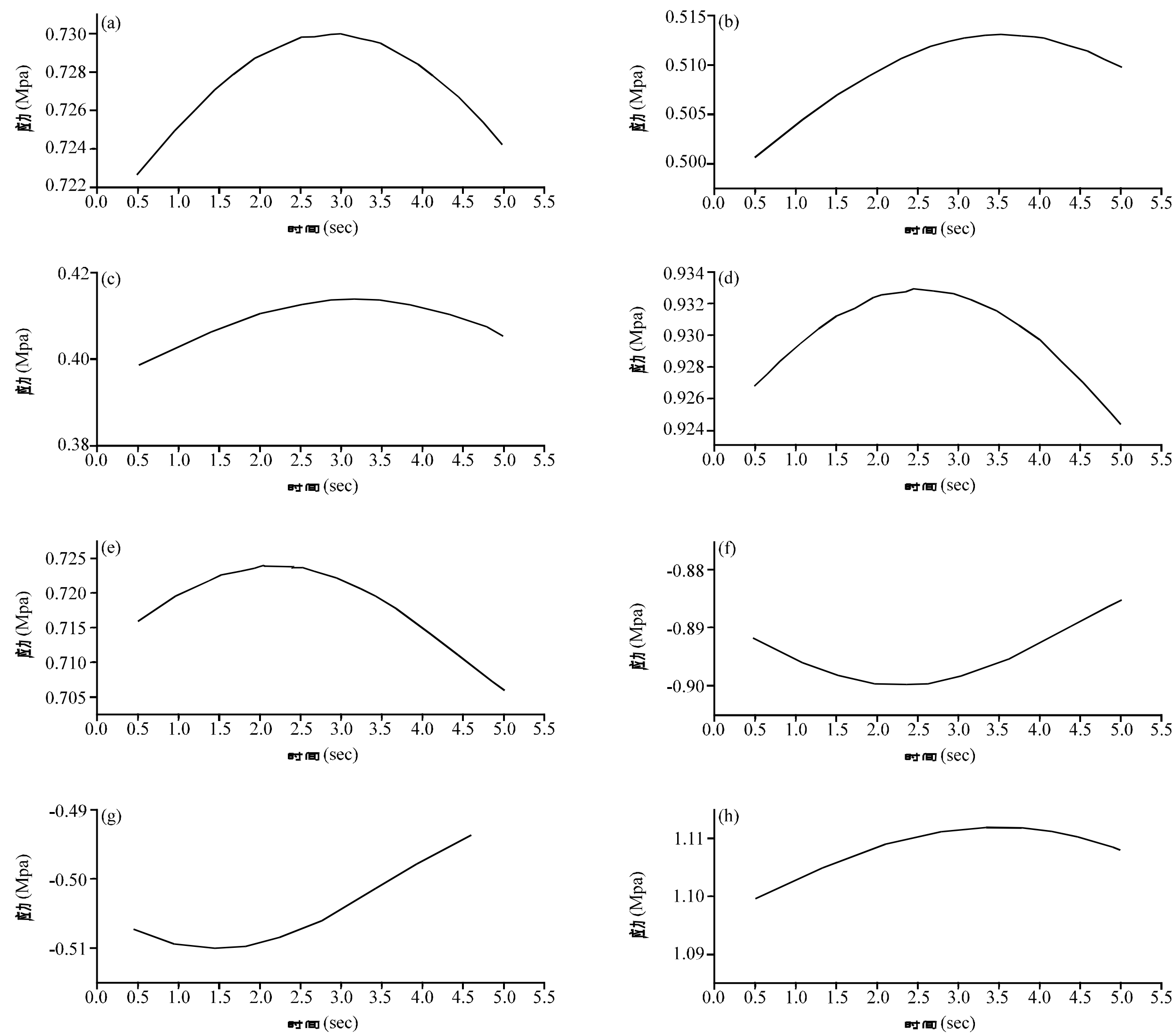

Fig. 5(a-h): The stress diagram of all test points

- σ = E•ε

where, σ is the stress of the crawler collection point, ε is the strain, E is the elastic modulus of the crawler.

The domain diagram can be transformed into the corresponding stress diagram. Shown in Fig. 5.

Third-order headings: The time-domain diagram of Collection point and stress curve can be transformed into Table 1.

Maximum stress of collection point shown in Table 1 is about 1 Mpa. In the process of Hydraulic drill arm, range of track stress is very small, Dynamic loads on the strength of the crawler frame stiffness has little effect.

Table 1: Maximum strain and stress of arm collected point

		Swing arm			
Channel member	Zero point	Maximum	Difference	Strain	Stress (Mpa)
1	-2.141	-2.129	0.012	7	0.7
2	-1.252	-1.245	0.007	5	0.5
3	-0.461	-0.445	0.016	9	1.0
4	-0.439	-0.433	0.006	4	0.4
5	-0.464	-0.451	0.013	7	0.8
6	-0.452	-0.469	-0.017	-9	-1.0
7	-3.237	-3.246	-0.009	-5	-0.5
8	-1.189	-1.176	0.013	10	1.1

Table 2 lists dynamic stress of various operation conditions.

Spectrum analysis: Spectrum analysis determine provider of the dynamic loads, analysis of the main vibration

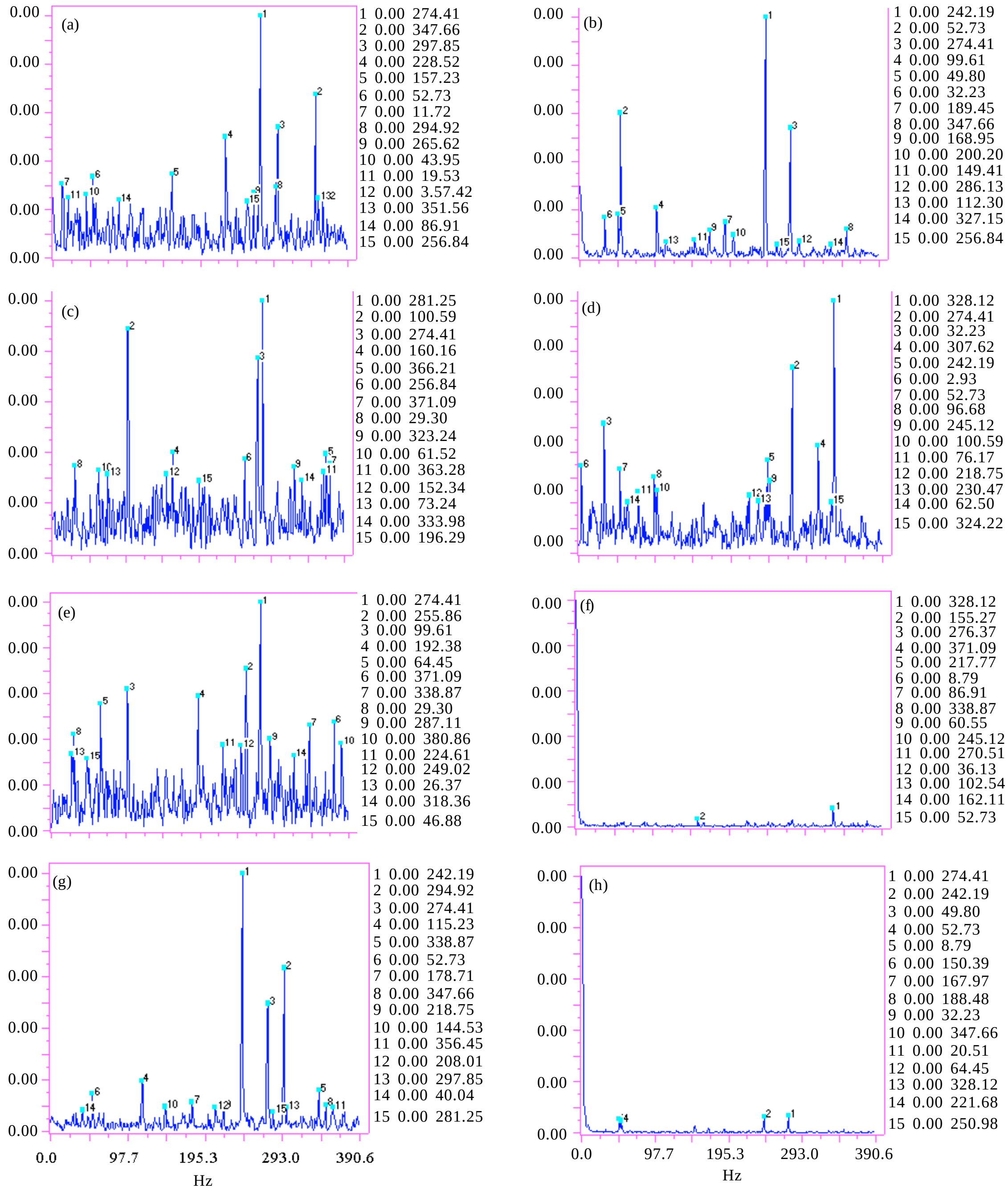

Fig. 6(a-h): Frequency domain figure of all test points

frequency and its impact and analysis of improved measures to reduce the impact of dynamic load. Working status of the arm, according to the auto power spectrum analysis, the spectrum of the analysis is obtained in Fig. 6 shown.

In Fig. 6 the energy contribution of the various frequencies is reflected and the vibration of the collection point is reflected. Level of power spectrum under the various frequencies from the graph is almost zero, that is, the value of the coordinates is almost zero. Contribution of various frequencies of vibration load is almost zero, that is, effects of vibration can be ignored in the design. It may be calculated in static state.

Table 2: Dynamic strain and stress data of all operating conditions

	Swing arm		Drill location		Vehicle rotation		Drilling	
Channel	Strain	Stress (Mpa)	Strain	Stress (Mpa)	Strain	Stress (Mpa)	Strain	Stress (Mpa)
1	7.0	0.7	24.000	2.7	8	0.8	6	0.6
2	5.0	0.5	-7.000	-0.8	6	0.7	4	0.5
3	9.0	1.0	-75.000	-8.3	10	1.1	8	0.8
4	4.0	0.4	2.400	0.3	4	0.5	2	0.2
5	7.0	0.8	83.600	9.2	8	0.8	6	0.7
6	-9.0	-1.0	-587.400	-64.6	-10	-1.1	-8	-0.8
7	-5.0	-0.5	-21.450	-2.4	-7	-0.7	-4	-0.4
8	10.0	1.1	742.400	81.7	12	1.3	10	1.1

TEST DATA OF MODE

The dynamic stress data of all operating conditions is shown for the track frame in Table 2.

Except the drill positioning, other stresses are smaller and can be ignored. The drill positioning is the three orientations, that is, three-point force.

In the positioning process, the whole front end tilt and the force of backend of the track will increase sharply. Dynamic stress of the collection point reflected by channel 6 and 8 changes greatly and the data also shows this. It also requires auxiliary support parts of the crawler frame to withstand greater dynamic stress. In the course of their work, the action is slow and a gradual process, that is, the slow loading. Therefore it can be used as static analysis uses.

CONCLUSION

According to research and analysis of test results, the following conclusions:

- The dynamic response of each test point can be ignored for strength and stiffness
- The main frequency of frequency spectrum is frequency division and variable frequency which is generated by the rotation of the system
- For large-scale low-speed rig chassis it is designed in the static loads state and dynamic loading stress can be ignored
- The key points of the design are analysis and research of static load
- It is proved that this kind of device of crawler frame can be designed according to the static design through test and analysis

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