Sensor Position Design and Data Acquisition System of Track Model Soil Tank Test Bench Based on Labview

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Abstract: To study the influence of different grouser structures and soil parameters on the adhesion and resistance characteristics of tracked vehicles, we must accurately obtain the adhesion and resistance of tracked vehicles under different slip rates. Aiming at the difficulty in and low accuracy of measuring slip rate, adhesion and resistance of tracked vehicles, the installation position of the sensor of the track model soil tank bench was designed, and the data acquisition system of the soil tank bench was written based on Labview. The experimental results show that the sensor system can collect the adhesion and resistance of the track model under different slip rates, and has high engineering application value for studying the adhesion and resistance characteristics of the track model.

Keywords: soil tank test bench; data acquisition; Labview; unilateral track model

1. Introduction

Off-road maneuverability of military tracked vehicles is a complex performance concept, which mainly includes traction adhesion, geometric off-road performance and vehicle navigation performance. When tracked vehicles travel on flat soft dirt roads, their maneuverability is largely affected by adhesion and resistance. It is of great significance to study and analyze the adhesion and resistance characteristics of different structure sizes for improving the maneuverability of military tracked vehicles [1,2].

The tension and pressure sensor used in the existing soil tank test bench has the disadvantage that it can't be lifted and lowered, which leads to great interference and inaccurate measurement results. The purpose of this paper is to design a follow-up lifting tension and pressure testing device for soil tank test bench, which can be used to measure the stress state of various track models with different structural sizes, simulate the actual driving environment more truly, and improve the measurement accuracy of stress state. The sensor testing device and data acquisition system designed in this paper can measure the adhesion and resistance of single-side track model in various soil media with different slip rates. Compared with the soil tank test bed used in the past, it is more accurate to measure the adhesion of tracked vehicles, which solves the problems of difficulty in measuring track slip rate and resistance in the past. It can be applied to study the adhesion and resistance characteristics of different structure sizes in the soil tank test bed, which has a certain reference for optimizing the design of the track structure and improving the maneuverability of tracked vehicles.

2. Overall Design of Data Acquisition for Soil Tank Bench

The soil tank test bench should be able to measure the speed, displacement, slip rate, adhesion and resistance value of the single-side track model. The American NI cDAQ modular data acquisition system composed of chassis, modules and LabVIEW software, is adopted [3]. The connection of the sensor and its test acquisition system is shown in Figure 1.

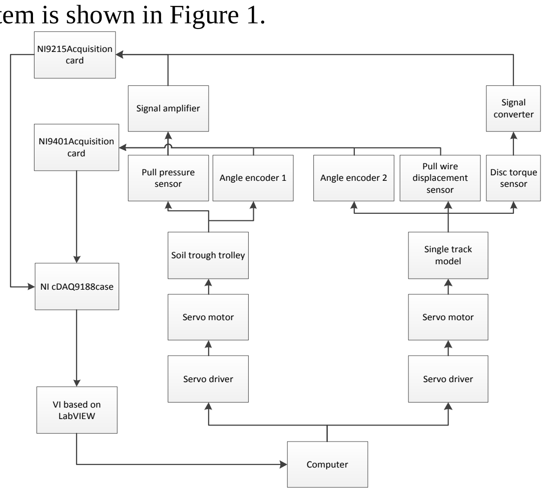

Figure 1. Schematic diagram of sensor and test acquisition system of soil tank test bench.

3. Test Equipment and Sensors of Soil Tank Test Bench

The soil tank experiment platform is mainly divided into three parts: soil tank, experimental trolley and track model. The soil tank is 14 meters long and 2 meters wide. Guide rails are installed on both sides of the soil tank. Test trolleys are installed on the guide rails, and their power comes from stepless variable speed motors in drive boxes on both sides of the soil tank. Chain clamping plates on both sides of the bench are fastened with bolts to realize the fixed connection with the surrounding chains on both sides of the soil tank, which is used to transmit force and prevent the trolley from slipping on the track. The bench is supported by four steel wheels with rims on the rails on both sides of the soil tank. The outer edges of the rims are just in contact with the inner edges of the rails, thus realizing the movement and guidance of the whole experimental trolley and preventing it from being separated from the rails. The track model is installed on the trolley, and its power is transmitted to the track model by the motor on the rear side of the trolley through the speed reducer and then through the chain on the side of the parallelogram linkage mechanism, so that it is able to travel actively. The trolley is connected with the single-side track through a bridge-type tension and pressure sensor, as shown in Figure 2 and Figure 3.

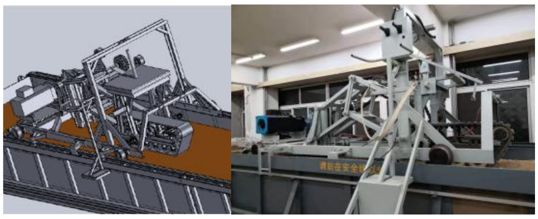

Figure 2. Design drawing and physical drawing of soil tank and test trolley.

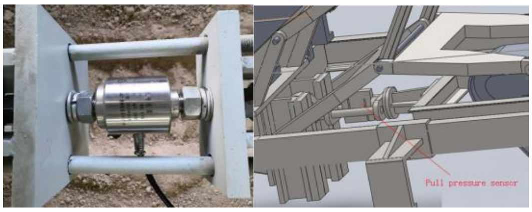

Figure 3. Follow-up lifting tension and pressure testing device.

The unilateral track model is the main research object of the track adhesion test system, which is installed on the trolley through the follow-up lifting tension and pressure sensor. Among it, the disc torque sensor for measuring the torque of single track is installed on the intermediate shaft assembly, which can measure the driving torque, as shown in Figure 4.

Figure 4. Physical drawing and layout of disc torque sensor.

Two angle encoders are used to measure the moving speed and displacement of trolley and single track respectively. The angle encoder for measuring the moving speed and displacement of the test trolley is installed on the right side of the tail end of the bench and connected with the small wheel with hard rubber, as shown in Figure 5. The angle encoder for measuring the moving speed and displacement of the single-side track is installed on the driving wheel of the track model, as shown in Figure 6.

Figure 5. Trolley angle encoder.

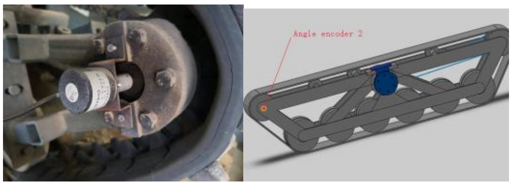

Figure 6. Physical drawing and installation position of track model angle encoder.

There are 4 sensors of 3 types in the test system of the tank test bench, namely GB-YQ angle encoder, RC-5T tension force sensor and 5-GB-DTS torque sensor. Among it, the output signal of angle encoder is 0-5K-15K digital pulse signal; the output signal of tension force sensor is 0-10V analog signal; the output signal of torque sensor is 0-5-10V analog signal.

As for the speed of the trolley and the single-side track, the required speed difference is formed between them, so that the single-side track model can slip in the soil tank, and the required slip rate and continuously changing slip rate can be obtained.

4. Data Acquisition System of Soil Tank Bench

4.1. Hardware System of Data Acquisition System

Hardware system mainly includes chassis, acquisition board, sensor, signal conditioning board, etc. Sensors are used to acquire signals, and signal conditioning boards are used to amplify and convert signals. As shown in Figure 8, acquisition boards mainly realize data transmission and other functions.

NI cDAQ-9188 chassis which can realize long-distance stable data transmission is adopted, and NI9215 module and NI9401 module are adopted, as shown in Figure 7.

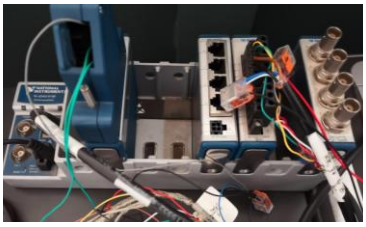

Figure 7. Chassis and acquisition module.

Figure 8. Signal amplifier and signal converter.

Output signals of two angle encoders are ABZ phase pulse signals, which can be collected by using NI9401 board. Connect the terminals of the sensor with the terminals of NI9401 module respectively, then count and record the frequency through the program written by Labview. And the displacement and speed values of trolley and single track can be collected and recorded. Output signals of disc torque sensor and tension/compression sensor are voltage signals, which can be collected directly by using the program written by NI9215 module based on Labview.

4.2. Data Acquisition System Software System

LabVIEW graphical software is the most representative graphical programming language in virtual instruments. As the standard of data acquisition and instrument control software, it is widely used in industrial, academic and research laboratories. Virtual instrument VI consists of front panel, program chart and icons. Based on LabVIEW graphical software of NI Company in the United States, a 6-channel virtual instrument VI is written, which can realize the synchronous acquisition, storage and processing of the signals of four sensors in the soil tank bench system, and can realize the measurement test of the track model car's speed, displacement, slip rate, adhesion, resistance and hook traction force. The front panel and program chart of 6-channel virtual instrument VI are shown in Figure 9 and Figure 10.

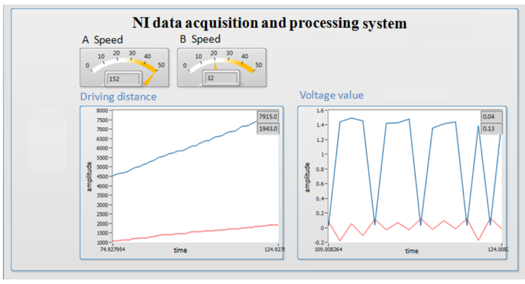

Figure 9. VI front panel.

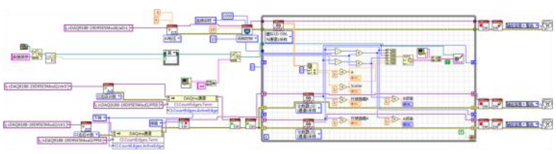

Figure 10. VI Program chart.

5. Test and Result Analysis

During the test, the track model and trolley speed are set to the same value, and the track model advances and sinks into the soil. During the running process, the sliding is gradually increased by increasing the model speed while keeping the trolley speed constant. The curves of hook traction and motion resistance obtained by controlling different slip rates are shown in Figure 11 and Figure 12.

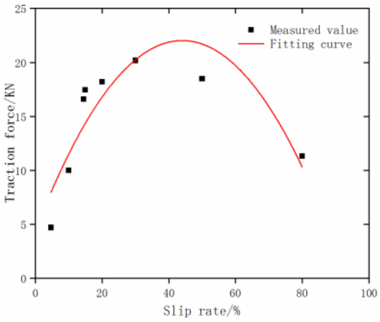

Figure 11. Curve of hook traction force changing with slip rate.

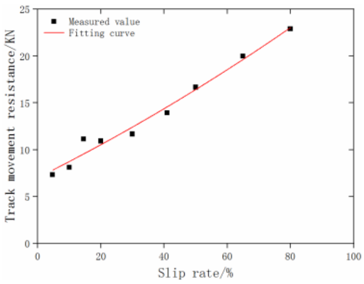

Figure 12. Curve of motion resistance changing with slip rate.

It can be concluded from the analysis in Figure 11 that when the tracked vehicle runs on the soil, there will be the maximum hitch traction at a certain slip rate. According to the measured results, the slip rate at this time is about 40%. It can be seen from the analysis in Figure 12 that the motion resistance of tracked vehicles is affected by the slip rate. The greater the slip rate is, the greater the motion resistance is.

6. Conclusion

The sensor installation position and test acquisition system based on the soil tank bench can conveniently and accurately collect the data of adhesion characteristics and resistance characteristics of the single-side track model. The measured data are consistent with the theoretical values, and can be used to measure and analyze the stress state of different track structures on different soils, improving the accuracy and convenience of measurement. The obtained experimental data can provide reference for the optimal design of track vehicles.

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