Test Research on Airdrop Shock Vibration of Armored Vehicles

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Abstract. In view of the airdrop adaptability of a lightweight high-mobility wheeled armored vehicle, the shock vibration of the vehicle’s onboard electronic equipment under simulated airdrop was tested and the shock characteristic of the equipment was analyzed. The test results show that the onboard equipment of the airdrop vehicle is mainly subjected to three stages of shock vibration, which includes the crash of the lifting rope, shock of the cushion airbag and the rebound shock. The cushion airbags can effectively reduce the shock acceleration peak of the onboard electronic equipment of the light wheeled armored vehicle, and the shock peak of the onboard computer and power supply is about 9-10 g with the shock duration of 0.15-0.2 s. While compared with the shock of the base, the buffering effect of the isolators to the airdrop shock vibration is not satisfied. Resonances of the isolation system are caused by the airdrop shock and the shock peaks of the tested electronic equipment are higher than that of the base.

1. Introduction
With the development of military science and technology, the ground wheeled armored vehicles are developing towards the direction of lightweight and high-speed, and the high mobility is becoming a key development direction. The rapid delivery of ground vehicles to the battlefield by air transport has become a typical mobility mode of modern warfare, which has attracted much attention from the armies of various countries. Although the airbag cushion system can greatly reduce the shock at air landing, the vehicle body and the onboard equipment will still bear large shock vibration. Therefore, in the development stage of the equipment, shock vibration laboratory test is needed to test the impact resistance of the equipment. In GJB150.18A-2009[1], it is recommended to use the measured shock vibration for bench test, and the shock load will be performed according to the typical shock peak and duration given in the standard if no measured data are available.

Due to the disadvantages of high cost and long test period, the simulated airdrop is often adopted to replace the practical airdrop in the adaptability test of the vehicle equipment, so as to reduce the test cost and shorten the test period. Domestic and foreign scholars have researched on the shock test method and shock spectrum data processing method. The finite element model of airbag and vehicles was studied by Huangjie HONG[2]. Yibing HU[3] studied the filtering method of shock vibration data and verified the application of wavelet analysis in airdrop shock signal processing. Xiaobo LEI[4] analyzed the shock response spectrum of aircraft when landing, and obtained the digital filter coefficient of shock spectrum by using the ramp response invariability method. Shoujun LIU[5] simulated the airbag landing process based on ANSYS and compared with the test results. Xin Xu[6] simulated the dynamic landing process of the airdrop and obtained the changing stress.
Aiming at the airdrop adaptability of a light wheeled armored vehicle, the shock vibration of the main onboard equipment in the vehicle was tested by simulated airdrop experiment, and the shock vibration characteristics of the onboard equipment are analyzed.

2. Airdrop Cushion System
The airdrop cushion system for vehicle equipment and cargo mainly includes parachute, cargo platforms and cushion airbag. The airdrop process is shown in figure 1. During the airdrop of vehicles, the main parachute is drawn out by the traction parachute system, so that the vehicle maintains falling at a constant speed. At the same time, the conformal balance lever keeps the cushion airbag inflated by the air inlet under its own gravity. During landing, the airbag compresses the air under the shock load, and pushes the air outlet to open. The air in the airbag is discharged at a specified flow rate, the falling speed of the vehicle is reduced at the same time. Finally, the airbag lands at a safe speed, which owes to the cushion effect of the airbag.

![Figure 1 Airbag cushion process of vehicles](image)

The structure of the airdrop cushion airbag is shown in figure 2. The overall structure adopts the cushion airbags without cargo platform, and two supporting beams are connected to the bottom of the vehicle body. There are four air bags connected under the supporting beams with volume of about 12m³. Two conformal balance lever are connected with the bottom of the airbags, which can keep the airbags filled with air when landing.

![Figure 2 Structure of the cushion airbag](image)

3. Test System
The schematic diagram of the shock vibration test system is shown in figure 3. The test system for shock vibration of simulating airdrop is composed of multi-channel data collector, shock acceleration sensors and the acquisition software. The single channel sampling frequency of LMS multi-channel data collector can reach 200kHz, which can meet the requirements of shock acceleration test with high response frequency. The frequency response range of shock acceleration sensor is 0.2Hz-25khz and the measuring range is ±5kg, which can meet the peak test requirements of shock vibration.
4. Test Results and Data Analysis

4.1 Simulating Airdrop Test
The landing speed of vehicle equipment during airdrop is generally 7-9m/s, and the drop height of the simulating airdrop can be calculated according to the landing speed of 9m/s, which is 4.1 meters. Firstly, the shock acceleration sensor was installed on the base and body of the onboard electronic equipment, as shown in figure 4. The data cable is connected to the data collector outside the vehicle, and the sampling frequency is set to be 100kHz. The airdrop cushion system was fixed at the bottom of the tested vehicle, and then the tested vehicle was lifted by a crane with airdrop ropes by 4.1 meters above the ground. Then the rope was suddenly released, allowing the tested vehicle to fall freely to the ground, and the shock acceleration signal during the landing was tested and recorded.

4.2 Data Processing and Analysis
Literature [7] pointed out that filter should be avoided to apply in the shock acceleration measurement due to the continuous spectrum with unlimited bandwidth of the shock vibration in the frequency domain, however, the shock vibration of the actual movement is often characterized by complex time domain waveform, which requires low-pass filter to eliminate the mechanical and electrical interference, and to filter the resonance and high frequency noise of the accelerometer. These noise signal superimposed on the shock acceleration waveform, affected accurate interpretation of the peak acceleration. In the shock acceleration measurement, low-pass filtering is usually required, and the cut-off frequency of the low-pass filter is generally not less than 10/T Hz, where T is the pulse duration of shock acceleration.

According to the preliminary analysis of the measured shock acceleration signal, the duration of the main pulse is about 0.15-0.2s, so the cut-off frequency of low-pass filtering should not be less than 70Hz. In this paper, the time-domain signal of impulse acceleration tested was processed by a fourth-order Butterworth low-pass filter, and the cut-off frequency of the filter was set to be 200Hz. Figure 5 shows the original shock vibration signal and filtered signal of the communication device and control terminal.

It can be seen from the shock signal of the communication device and control terminal that the shock signal mainly includes three shock periods. According to the recorded video in the simulating airdrop, it can be analyzed that the first impact is caused by hitting of the lifting rope to the top deck of the vehicle after release due to elastic force. Its time range is short, and the devices connected to the
The second shock signal is the main shock signal, which lasts for a long time and has a large peak value. It is the sudden shock generated from the airdrop cushion airbag touching the ground to the first landing of the vehicle’s bottom until the air in the bag fully exhausted. Due to the buffering effect of the cushion airbag, the duration of the shock is prolonged and the peak acceleration is effectively reduced. The third shock signal has a small peak value and a short duration, and there are several small peaks in the base position of the onboard equipment, where the peak value is caused by multiple bounces after hitting the ground.

5. Summary
Through the test and analysis of the impact vibration of the electronic onboard equipment of a wheeled armored vehicle during airdrop, the test results show that the onboard equipment of the airdrop vehicle is mainly subjected to three stages of shock vibration during the simulating airdrop, which includes the impact of the lifting rope, the shock of the cushion airbag and the rebound landing shock. Cushion
airbag can effectively reduce the shock acceleration peak of the onboard electronic equipment of light wheeled armored vehicles. The peak impact of the equipment is about 10-15g, and the impact duration is about 0.15-0.2s. However, the buffer effect of isolators of the electronic equipment is not obvious, and the shock peak value of the equipment is higher than the impact of the installation base, which is attributed to resonance of the isolation system induced by the shock vibration. Compared with the rear peak sawtooth wave of the ground equipment recommended in GJB150.18A-2009, the peak value of airdrop shock vibration of the measured equipment is relatively low with prolonged duration.

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