Research and Implementation of a Novel Elevator Speed Limiter Test Device

Yang He [1, 2, *], Xiao Lv [1, 2], Nima Zaxi [3], Zhonggeng Chen [1, 2], Haijun Jia [1, 2], Jun Su [4]

[1] Chongqing Special Equipment Inspection and Research Institute,Chongqing,China

[2] Key Laboratory of Electromechanical Equipment Security in Western Complex Environment for State Market Regulation, Chongqing, China

[3] Tibet Special Equipment Inspection Institute, Lhasa,China

[4] Aba Special Equipment Supervision and Inspection Institute,Aba prefecture,China

* Corresponding Author Email: heyang@cqtj.org

Abstract. According to the requirements of GB/T 7588.1—2020[1],the operating speed and tensile force of the elevator speed limiter need to be measured.Under the actual operating conditions,the operating speed and tensile force of the speed limiter are generated simultaneously,and the process is generally completed within 2 seconds.The traditional test method is to measure these two parameters separately,which is time-consuming and inefficient.In particular,it cannot fully reflect the force condition of the speed limiter rope under the actual operation condition.Aiming at above problems,in this paper,a new type of elevator speed limiter test device is designed.By constructing a torque dynamic compensation model,the action process of the speed limiter is amplified and the torque compensation is carried out,which accurately reproduces the real working conditions and greatly improves the test efficiency and reliability of the results.

Keywords: Elevator speed limiter, test device, torque dynamic compensation model, tensile force.

1. Introduction

The elevator speed limiter is an indispensable safety protection device in elevator safety system. The linkage mechanism composed of elevator speed limiter and safety gear is an important guarantee for the safe operation of elevator. According to the requirements of table 11 of GB/T 7588.1-2020, in case of car falling and car descending overspeed of traction lift and positive drive lift, the safety gear as the elevator safety protection device shall be triggered by the speed limiter, so as to realize the protection function of slowing down or stopping the car. Before the elevator speed limiter is delivered for use, the operating speed and lifting force of the speed limiter will be tested and set to make it reach the allowable range of the standard. This test method has a great amount of engineering application.

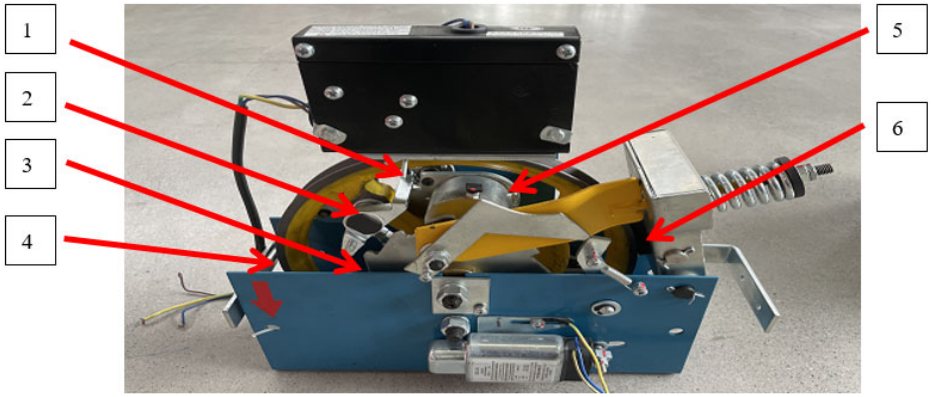
The traditional test method is to use the test device to load the speed limiter to make it act, and test its speed and tensile force twice. These two parameters are measured separately, which leads to a large deviation of the test sample itself. The test results cannot truly reflect the actual operation of the speed limiter, and the efficiency is low.

2. Action principle and force analysis of speed limiter

2.1. The action principle of speed limiter

When the elevator runs within the action speed of the speed limiter, the connecting rod mechanism of the safety gear always remains unchanged. When the running speed of the elevator exceeds the action speed of the speed limiter, the centrifugal mechanism on the speed limiter first triggers the action of the electrical safety switch to cut off the safety circuit or control circuit of the elevator and make the electromagnetic brake lose power for braking; If the elevator continues to operate without

control and the speed continues to increase, the ratchet and pawl on the speed limiter will produce mechanical action, so as to operate the clamping mechanism to clamp the wire rope. The wire rope is subjected to unbalanced tension to produce the tensile force on the safety clamp, forcing the safety clamp to act to force the elevator car to decelerate or stop on the rail. The speed limiter structure is shown in Fig.1.



1: Electrical safety switch; 2: Pawl; 3: Ratchet; 4: Speed limiter pulley;
5: Centrifugal mechanism; 6: Clamping mechanism

Figure 1. Structure of speed limiter.

2.2. Force analysis of speed limiter

The speed limiter wire rope forms a closed loop through the speed limiter pulley and the pulley of the tension device, and moves up and down with the car. In order to achieve the simulation of the speed limiter tensile force consistent with the actual working condition, the test device needs to be designed as the speed limiter wire rope to do the upper and lower circulation movement around the speed limiter pulley and the tension device pulley, and the wire rope can form a closed loop. Through the speed sensor and force sensor, the data is collected in real time. After the test, the collected data are analyzed, and the conclusion that conforms to the actual working condition is obtained. The force acting on the speed limiter is shown in Fig.2.

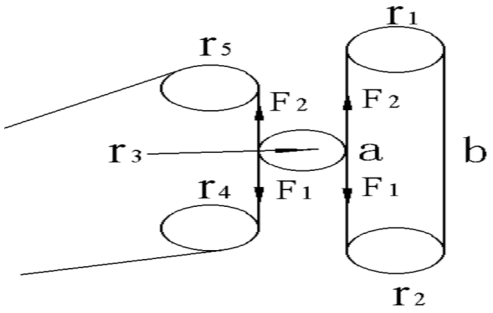


Figure 2. Diagram of force analysis for speed limiter.

The guide frame of the tension wheel **r2** on the tension device is installed on the base of the speed limiter **r1**.The installation base can move around and adjust the position to ensure the synchronous movement of **r1** and **r2**, and the radius of **r1** and **r2** is the same to ensure that the wire ropes a and b on both sides are parallel. Moving **r1** and r2 make it tangent to the force sensor pulley **r3**, moving guide wheels **r4** and **r5** ensure that the right end of the wire rope is in a straight line and tangent to **r3**, so as to ensure that the wire rope on both sides of the force sensor pulley **r3** is parallel to each other.

During the test, the sensor pulley **r3** receives two upward tension F_2 and two downward tension F_1.The force P of the pulley seat can be measured by the force sensor on the pulley seat, that is:

$$P=2F_2-2F_1 \quad (1)$$

The speed limiter wire rope tension F is:

$$F=F_2-F_1 \quad (2)$$

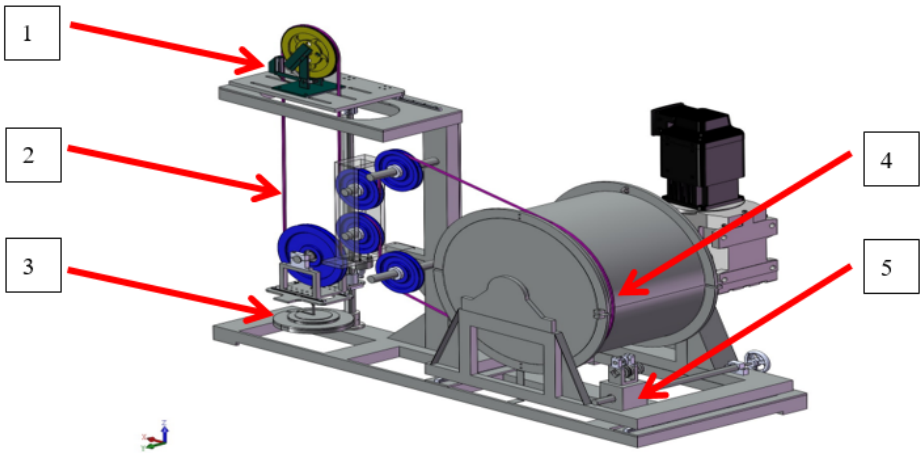
Therefore, through Formula (1) and Formula (2), it can be obtained that the tensile force F of the speed limiter wire rope is:

$F=P/2$

3. Design model

In order to accurately measure the speed and tensile force of the speed limiter, and ensure that the test process and results are consistent with the actual working conditions, it is necessary to systematically analyze the components and components involved in the detection device.

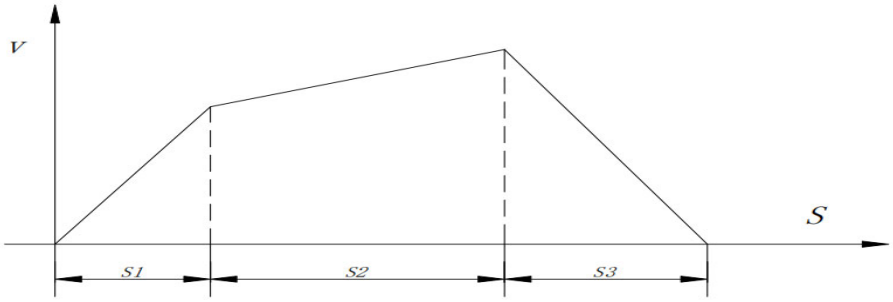
The main indexes of the speed limiter include:(1)the pitch diameter of the speed limiter pulley;(2)speed limiter wire rope diameter;(3)Operating speed of speed limiter;(4)speed limiter pulling force. When the mechanical action of the speed limiter is triggered, the resultant force (i.e., unbalanced force) of the tension generated by the two ends of the speed limiter wire rope on the lift arm of the safety gear linkage mechanism during the sliding process of the speed limiter wire rope on the speed limiter pulley must exceed the lift force required to trigger the safety clamp action. Otherwise, the safety gear cannot be reliably triggered, but this force should not be too large. Otherwise, it is easy to damage the speed limiter, the speed limiter wire rope and the safety gear linkage mechanism [2].The test device structure is shown in Fig.3.



1: Speed limiter; 2: Drive wire rope; 3: Tension device; 4: Drive winch;
5: Drum synchronization mechanism

Figure 3. Structure diagram of test device.

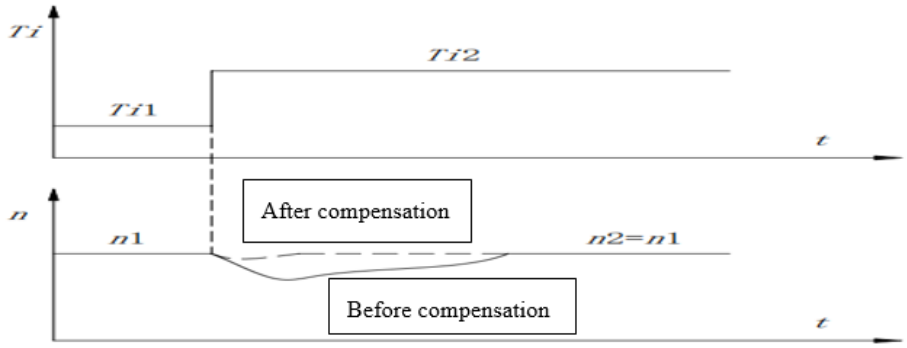
According to the characteristics of the speed limiter, the design of the drive winch can meet the requirements of Fig.4 at least.



v:Speed;S:Travel of the winch;***s1***:Fast acceleration stage;
s2:Slow acceleration stage(data test stage);***s3***:Deceleration stop stage

Figure 4. Chart of speed characteristic curve of winch.

During the test, the driving stage of the speed limiter is divided into three stages. In ***s1*** stage, the speed limiter does not reach the action speed. In order to improve the efficiency, the device can be driven with a large acceleration; In ***s2*** stage, the speed limiter is about to reach the expected action point, and the device reduces the driving acceleration, so as to realize the effect of amplifying the action process of the speed limiter. The speed and force sensors of the test device dynamically analyze and record the measurement results at the same time; in ***s3*** stage, the action of the speed limiter is completed, and the device uses a large deceleration to stop the rotation of the driving device. So far, the whole test process is over. However, in the practical application of the project, it is found that when the driving power of the winch is reduced, the speed of the ordinary winch is unstable. Therefore, a constant torque driving equipment is needed to make the winch output a stable speed. The device considers using PMSM compensation system to compensate the output of the winch, so as to achieve the purpose of stabilizing the output torque and speed. The comparison curve of speed compensation change is shown in Fig.5.



Ti: Torque; n: Revolution speed; t: Time.

Figure 5. Torque-speed compensation curve of driving device.

4. Verified by testing

According to the above analysis and assumption, the prototype machine of the device was actually manufactured, and the prototype of the speed limiter test device is shown in Fig.6.At the same time, in order to achieve the simultaneous test of operating speed and tensile force, the control software built-in in the test device can accurately set the acceleration of the drive device at different stages.

Figure 6. Prototype of speed limiter test device.

The device is used to test a set qualified speed limiter. The rated speed of the speed limiter is 2.5 m/s. According to GB/T 7588.1-2020 and product design regulations, the operating speed range of the speed limiter is 2.875 m/s~3.225 m/s, and the tensile force range is 300 N~1800 N. The test results are shown in Fig.7.

Figure 7. Test result curve.

The test analysis software accurately records the changes of speed, force, time, distance and other parameters of the speed limiter in the same time domain, and provides the oscilloscope software analysis function. According to the analysis of the test software, the final test results of the speed limiter are as follows: action speed: 3.10 m/s, tensile force: 1660 N, meets the standard requirements and is within the design range of the manufacturing unit [1].

5. Summary

The test results show that the device can realize the simultaneous measurement of the operating speed and tensile force of the elevator speed limiter. The test method is feasible. The test results are accurate and reliable, and the dynamic change process of the tensile force can be accurately reflected. The speed limiter test device made by this design idea can provide test help for test engineers.

Acknowledgements

This work was supported by the scientific research planning project of Chongqing Municipal Bureau of Market Supervision and Administration (No.:CQSJKY2019017&CQSJKY2021030).

References

[1] GB/T 7588.1-2020 Safety rules for the construction and installation of lifts–Part 1: Passenger and goods passenger lifts[S].

[2] Changming Zhu, Zhiyu Hong, Huiqiao Zhang. Elevator and escalator: principle, structure, installation, test [M] Shanghai: Shanghai Jiaotong University Press, 1995.