Research on similar test device of deep roadway impact

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Abstract. With the continuous increase of coal mining depth, the impact of ground pressure disaster is showing more and more serious development trend, which poses a great threat to the safety production of coal mine and the life safety of miners. The design and construction of similar test bench for deep tunnel excavation has become one of the difficult problems of scholars at home and abroad. When the impact of high altitude falling hammer on the tunnel is tested, the drop hammer hits the pressure column and will be bounced, causing two shocks and affecting the experimental results. Based on the disaster mechanism of roadway rock burst, and simulating the damage caused by the immediate release of rock burst, we designed a test system that can fall smoothly when the falling hammer falls, and it will be held when the falling hammer starts to fall again. The device prevents the second impact of the falling hammer in the impact test of the roadway, and realizes the dynamic loading of the roadway.

1. Introduction
Rock burst, also known as rock burst, refers to the dynamic phenomenon of sudden and severe damage of rock mass around the roadway or working face due to the instantaneous release of elastic deformation energy [1-3]. Rock burst has the characteristics of sudden, instantaneous and huge destruction. The occurrence of rock burst is rapid and short-lived. In mining engineering, the loading of roadway surrounding rock is mainly static loading, which can not simulate the damage of roadway caused by "rapid and short" instantaneous release of rock burst. Therefore, the design and construction of dynamic simulation experimental device of roadway surrounding rock failure has become an urgent problem to be solved in rock burst research [4-5].

Many simulated impact ground pressure test devices have been designed and studied by domestic experts and scholars [6-10]. He Manchao used the self-designed experimental system of deep rockburst process to study the process of granite rockburst under the condition of deep high stress [11]. Therefore, this paper introduces a test device designed by the author to simulate the destruction of the upper part of the roadway caused by the instantaneous release of rock burst, which realizes the one-time dynamic loading of the roadway.

2. Description of the device
The author designed a mechanical experimental system to test the impact of high-altitude drop hammer on roadway and simulate rock burst. The device can prevent the impact of the second impact of drop
hammer on the experimental results. The experimental device includes drop hammer, spring, two connecting rods, drop hammer guide rail, tapered pin, pressure column and roadway. The utility model is characterized in that a two link mechanism is arranged in the guide rail, and the spring is tensioned. The hinged part of the two connecting rods and the spring are fixed on one side wall of the guide rail by the pin shaft, and the upper end of the pin shaft is conical. Figure 1 is the schematic diagram of the device, and the left view is shown in Figure 2.

![Figure 1](image.png)

**Figure 1.** Device schematic diagram

![Figure 2](image.png)

**Figure 2.** Device left view

The innovation of this device is that in order to solve the problem that the existing drop hammer impact test will cause secondary impact and inaccurate test data, a device is provided to prevent the secondary impact of the falling hammer. The effect of the device is that when the falling hammer falls, the tapered pin shaft will be squeezed into the guide rail and fall smoothly. When the hammer is hit, the tapered pin will be pushed into the guide rail, and the tapered pin will be pushed when it hits the pressure column. When the shaft is pulled up, the spring will pull the hinge to straighten the crank slider mechanism, and the two connecting rod will extend out inside the two guide rails. When the falling hammer falls again, it will hold the drop hammer, thus realizing the one-time dynamic loading of the roadway and preventing the secondary impact of the falling hammer.

In order to make the falling hammer pass through the pin shaft smoothly, the spring-up type can push the pin shaft open and trigger the tension spring. The pin shaft is designed as a cone shape. The spring is in the state of tension, so that the trigger pin of the drop hammer provides power for the two connecting rods (crank slider mechanism).
3. **Operation steps**

The device is a kind of test device to test the impact of high-altitude drop hammer on the roadway, to prevent the second impact of drop hammer, to simulate the deep roadway excavation similar test, and the instantaneous release of drop hammer causes damage to the roadway, which can better realize the one-time dynamic loading of the roadway.

As shown in Fig. 1 and Fig. 2, the function of connecting and dropping hammer is realized by two connecting rods (crank slider mechanism), one end of the two connecting rod is fixed on the guide rail wall, one end can extend from the guide rail to realize the function of catching the falling hammer. The groove hole is designed inside the guide rail to make the two connecting rod extend smoothly. The spring is in tension state before triggering. One side of spring is fixed on the guide rail wall, the other side is connected with the middle hinge of the two connecting rods, and two tapered pin shafts are respectively pierced through the pin shaft (see Fig. 3), and fixed at the hollow part inside the guide rail wall. Since the spring before triggering is in tension state, when the falling hammer falls, it compresses the smooth surface of the tapered pin shaft to squeeze the pin shaft into the guide rail. The drop hammer can fall smoothly. When it is ejected after hitting the pressure bearing column, the pin shaft will be pulled out of the pin shaft perforation, thus triggering the spring tension. The spring pulls the two connecting rod (crank slider mechanism) to extend the two connecting rod from the inside of the guide rail to connect the falling hammer again, and the actual situation is realized The second impact of the drop hammer is prevented.

4. **Technical background and principle**

4.1. **Technical Background**

In the similar test of deep tunnel excavation, the roof of the roadway needs to apply dynamic load. The dynamic load is realized by the impact of falling hammer. The impact of the falling hammer after falling will affect the test results once again, and affect the accuracy of the test results of the first impact test. At present, the research on secondary impact prevention at home and abroad mainly includes mechanical, pneumatic, electromagnetic and hydraulic. For example, semi-automatic pneumatic clamping device, automatic control of falling height and drop hammer lifting: electromagnet can automatically capture to prevent the sample from being impacted by secondary impact. Moreover, most of the existing secondary impact devices are designed for the secondary impact devices on small impact testing machines, and there is no large impact test device.

![Figure 3. Crank slider mechanism diagram](image)

Crank slider mechanism (two link mechanism) is an evolutionary form of hinge four-bar mechanism, which is composed of several rigid components connected by low pairs (rotary pair and moving pair). It is composed of crank (or crankshaft, eccentric wheel) and connecting rod slider through moving pair and rotating pair.

Crank slider mechanism is often used to convert the rotary motion of crank into the reciprocating linear motion of slider, or convert the reciprocating linear motion of slider into the rotary motion of
crank. To analyze the motion characteristics of crank slider mechanism is to study the trajectory, displacement, velocity and acceleration of other parts of the mechanism when the dimension parameters, position parameters and motion law of the original moving parts are known, so as to evaluate whether the mechanism meets the requirements of working performance and whether the mechanism has motion interference. The slider crank mechanism has the advantages of low pair motion, surface contact between the components, simple geometry, convenient processing, easy to obtain high manufacturing accuracy and so on. Therefore, it has been widely used in all kinds of machinery including coal mine machinery, such as automatic feeding mechanism, punch, internal combustion engine air compressor and so on. As shown in Figure 3 is the specific form of crank slider mechanism in this design.

4.2. Principle

![Figure 4. Schematic diagram of local structure](image)

This paper introduces a device to prevent the second impact of falling weight in the similar test of deep roadway excavation, which specifically relates to the field of roadway falling weight control technology. It solves the shortage of the existing technology of lacking large-scale impact test device to prevent falling weight. The device comprises a drop hammer, a first drop hammer guide rail and a second drop hammer guide rail, the inner walls of the first drop hammer guide rail and the second drop hammer guide rail are respectively provided with an extension groove, the drop hammer is clamped between the first drop hammer guide rail and the second drop hammer guide rail to form a sliding connection, a pressure column is arranged between the inner walls of the first drop hammer guide rail and the second drop hammer guide rail, and the inner walls of the first drop hammer guide rail and the second drop hammer guide rail are respectively provided with a pressure column. The horizontal plane of the crank slider mechanism is higher than the top of the pressure column. The crank slider mechanism comprises a first connecting rod and a second connecting rod connected with each other. One end of the crank slider mechanism is respectively fixed on the outer wall of the first and the second drop weight guide rails, and the other end is located at the extending groove. Tapered pin, two connecting rods and spring connection, as shown in Figure 4.

5. Conclusion

(1) This paper introduces a test system designed by the author to simulate the destruction of the upper part of the roadway caused by the instantaneous release of rock burst. The device can prevent the secondary impact of the drop hammer in the roadway impact test, and better realize the dynamic loading of the roadway.

(2) The device can achieve the effect that when the falling hammer falls, it will squeeze the conical pin into the guide rail and fall smoothly. When it touches the pressure column, it will pull up the conical pin. The tension spring is touched to straighten the crank slider mechanism, and the two connecting rods
will extend out from the inside of the two guide rails. When the falling hammer falls again, it will hold the falling hammer, so as to prevent the second impact of the falling hammer.

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