Innovative and optimized design of automatic adjustment system for beaded rope of new diamond wire sawing machine

Bangju Wei1, Huiping Liang2, JiaHao Feng1, JianWei Liu1,3,4, Shenyan Xie1

1 College of Mechanical and Electrical Engineering, Guilin University of Electronic Technology, Guilin, Guangxi 541004, China;
2 School of Art & Design, Guilin University of Electronic Technology, Guilin, Guangxi 541004, China;
3 National Experimental Teaching Demonstration Center of Mechanical and Electrical Engineering Comprehensive Training, Guilin University of Electronic Technology, Guilin, Guangxi 541004, China
4 Email: 147709105@qq.com

Abstract. Compared with traditional stone cutting technology, the diamond wire saw cutting technology is more efficient, safer and less polluting. Therefore, wire saw technology is more and more widely used in stone mining and other fields. However, the existing wire sawing machine must ensure the tension of the string bead wire at all time during the cutting process. Therefore, after cutting for a period of time, the wire breaking work must be performed, which greatly reduces the engineering efficiency, so this paper introduces a new automatic adjustment device of a diamond wire saw. Firstly, the overall structural design of the diamond wire saw is introduced. Secondly, the mechanical structure and sensing control of the automatic adjusting device of the diamond wire saw are introduced in detail. On the basis of the original wire saw, an adjustable wheel that can be automatically moved is added, and the working pressure of the string bead wire is measured in real time by a pressure sensor, the back and forth movement of the adjusting wheel can be controlled to drive the stretching of the string bead wire, thereby realizing the automatic tensioning of the string bead wire; Finally, working parameters of the wire saw are transmitted by Bluetooth or other wireless communications to achieve remote control operation of the wire saw. Through the innovative and optimized design of the automatic adjustment system for string bead wires of the wire saw, it provides a good reference for the high-efficiency, low-cost and environmentally-friendly quarrying technology.

1. Introduction
Stone is one of the earliest resources for human exploitation. Due to its excellent performance and adaptability, stone has been favored in all periods of human history. Nowadays, with the popularization of stone products, the social demand for stone is increasing day by day. For the mass sawing processing of mountain stone, the traditional sawing methods are mainly diamond circular saw, granite sand saw and diamond rope saw machine [1-2]. Compared with the sawing technology of diamond circular saw and granite sand saw, the diamond wire sawing machine has the advantages of strong adaptability, high efficiency, high yield, low cost, safety and environmental protection, etc. It has been widely used in mining, processing of mountain rocks and other industries [3]. However, due to the shortage of stone in today's society, it is extremely urgent to develop a new type of diamond
wire saw machine that improves the efficiency of mining machinery and reduces the maintenance cost of mining machinery. Because the diamond string bead rope saw machine needs to maintain the tension of string bead rope in the working process, it is necessary to perform the work of broken rope disconnection. However, the operation of disconnection is complex, and frequent disconnection increases the workload of operators, seriously affects the engineering efficiency and increases the engineering cost [4]. In this paper, the structure of the wire saw machine is innovated, and a new wire saw machine with automatic beading rope adjusting device and automatic tension measuring device is designed. The tensioning force is automatically measured and externally transmitted, and then uses the automatic adjustment device for tension. This greatly reduces the number of rope breaking and splicing in the working process of rope sawing machine, and improves the working efficiency. Hope for providing a useful reference for the research of wire sawing technology in China.

2. Overall structural design of the wire saw

2.1. Overall design principle
The diamond wire sawing machine is composed of a main motion mechanism, a feed motion mechanism, a driving wheel position adjustment mechanism and a control system [5]. Different from the general wire sawing machine, the wire sawing machine designed in this paper has innovated a beaded rope automatic adjusting device mechanism. By adding the adjusting wheel, it can move according to the tension of the beaded rope, and the wire sawing machine does not move as a whole. In the case of tensioning the bead rope until the adjustment wheel moves into position and can no longer move, as shown in Figure 1.

2.2. The difference between the working principle of the new wire saw machine and the conventional wire saw machine
The main motor of the conventional wire saw machine realizes the grinding of the stone by the rotation of the diamond bead rope by the driving wheel; at the same time, the feeding motor drives the wire sawing machine to move on the track through the feeding device, and provides the feeding force when sawing the stone. And the tension of the beaded rope, complete the cutting of the stone [6-7]. The new wire saw machine adds an adjustment length to the original technology, thus reducing the frequency of the bead cord disconnection. When the adjustment length is equal to the running rail, the bead cord disconnection frequency is doubled. Compared with the previous wire sawing machine, the workload of the operator is reduced and the engineering efficiency is improved.

![Figure 1. The overall structure of the new wire saw machine.](image_url)
of the regulating wheel on the slide track to timely adjust the tension degree of rope sawing and reduce the disconnection frequency of rope sawing machine, thus effectively improving the working efficiency of wire sawing machine.

3.1. Composition of beaded rope automatic adjustment device
The beaded rope automatic adjustment device mainly includes: shore, adjusting device frame, adjusting wheel, support frame, stepping motor, screw rod, adjusting block, adjusting block bearing, screw bearing, coupling, adjusting block connecting rod, support frame, the front mounting plate and the rear mounting plate of the support frame.

3.2. Working principle of automatic adjusting device for string bead rope
Under the driving of the stepping motor, the ball screw acts as the active body, and the nut will be converted into a linear motion according to the lead angle of the screw according to the rotation angle of the screw. The bead rope guide wheel can be connected through the nut seat and the nut, thereby realizing The corresponding linear motion is shown in Figure 2. Its main function is to make the guide wheel move forward and backward, so as to adjust the length of the bead rope, the stroke can reach one meter, and it has the characteristics of reversibility, high precision and high efficiency.

![Figure 2. Internal structure of the beaded rope automatic adjustment device.](image)

1. Thrust bearing, 2. trapezoidal screw, 3. driven wheel, 4. connecting straight rod, 5. mounting frame, 6. coupling, 7. stepper motor

4. Pressure measuring device
In order to understand the magnitude of the tension force more intuitively, so as to adjust the length of string by using the automatic adjustment device, this paper designs a pressure automatic adjustment device. Since the pressure measured by the device is the tension force, the pressure sensor is used to detect the pressure in real time to obtain the value of the tension force.

4.1. Composition of pressure measuring device
The pressure measuring device mainly consists of mounting bracket, sliding track, sliding block, movable part, movable part bearing, spring, button under the spring, button on the spring, pressure sensor mounting block, pressure sensor, front axle of movable part, connecting plate of slider at the back end of movable part.

4.2. Working principle of pressure measuring device
Firstly, the slide track 502 of the pressure measuring device is fixed in the installation bracket 501, and the slide block 503 is installed together with the slide track 502, and then the slider connection plate 512 at the back end of the moving piece is connected with the slide block 503, so as to realize the sliding of the movable piece on the slide track. Secondly, the pressure sensor 510 is installed in the pressure sensor mounting block 509 and connected with the spring. The spring 506 is located between the movable piece 504 and the pressure sensor 510. With the tensioning of the string of beads, upward pressure will be applied to the guide wheel. After the transfer of the bottom guide wheel 102 movable
piece 504, the pressure works on the spring 506, and then the spring 506 transmits the pressure to the pressure sensor 510, and the measured pressure is the tension force, the pressure automatic measuring mechanism is shown in Figure 3.

Figure 3. Structure drawing of automatic pressure measuring device.

5. Automatic pressure measuring system
Since the conventional rope saw machine must be displayed through the data of the upper computer, only human-machine interface LCD display can be carried out to observe and adjust the system parameters [8]. In order to observe the tension force data more easily and intuitively, and then automatically adjust the tension force, this paper designs an automatic pressure measurement system on the basis of the pressure measurement device. The whole measurement system can realize the automatic collection, processing and transmission of pressure, as well as the real-time display and storage of pressure information.

5.1. Composition of automatic pressure measuring system
The automatic pressure measurement system is mainly composed of the pressure sensor signal conditioning module data acquisition and processing module bluetooth wireless communication module and the external display interface. The system structure frame is shown in Figure 4.

Figure 4. Pressure automatic measurement system block diagram.
5.2. Working principle of automatic pressure measurement system
The pressure measurement system is mainly controlled by the STM32 microprocessor. The specific working process is as follows: Pressure data is measured by installing a pressure sensor. The pressure value of the sensor output is amplified by the signal conditioning module, and the conditioned signal is converted into a digital quantity by the A/D conversion module of the microprocessor, and the microprocessor sends the converted data to the transmission module, and the transmission module converts the converted data. The signal is transmitted to the external display module through wireless communication, realizing the real-time display of the data and the change curve, realizing the real-time monitoring, data recording and analysis of the pressure on the ground upper computer [9-10].

5.3. Signal Conditioning and Amplifying Circuit
Since the output signal of the pressure sensor is small, data acquisition and output cannot be directly performed, and signal conditioning and amplification are generally performed. In order to realize the signal output function, this paper adopts signal processing and amplifying circuit the output signal characteristics of the pressure sensor are adjusted to improve the accuracy and sensitivity of the output signal. Since the output signal is an analog signal, it is needed. After converting to a digital signal using a digital-to-analog conversion module, an external output is made [11].

6. Conclusion
In order to improve the working efficiency of the wire sawing machine, on the basis of summarizing and analyzing the existing mine wire sawing machine technology, a new mine wire sawing machine that automatically adjusts the tension of the diamond bead rope and detects the tension is proposed. The overall structure of the wire saw machine, the bead rope automatic adjusting device, the pressure measuring device and the pressure measuring system are explained and analyzed. The new wire sawing machine proposed in this paper reduces the number of broken ropes that must be passed during the working process of the wire sawing machine, and can use the app to detect the tensioning force in real time, which greatly improves the working efficiency of the new wire sawing machine, and is a rope for the future. The innovative development of sawing machines provides a certain value.

Acknowledgements
This study was financially supported by the National Natural Science Foundation of China (Grant No. 51765013 and No. 51564007), Guangxi Science and Technology Base and Talent Special Project (Grant No. AD19110055) and Guangxi Natural Science Foundation (Grant No. 2016GXNSFAA380135). The authors would like to take this opportunity to express their sincere appreciation to these funding organizations.

References
[1] Yao Ling T. 2008 Development trend of international stone sawing machinery, tools and processes [J] Stone 07 15-18
[2] Liao Yuan S. 2009 Application technology of diamond bead saw in the production of facing stone [M] Metallurgical Industry Press
[3] Xiao Shuang L, Jiu Li L, Zhen Chang L 1996 Overview of the application and development of diamond bead saws [J] China Building Materials Equipment 08 30-32-42
[4] Feng Shun L. 2016 Research and design of key technologies for super power wire sawing machine [D] Huaqiao University
[5] Qiu Ping C. A diamond wire saw machine [P]. Chinese patent, 20100512084.4, 2011-05-18.
[6] Jin Sheng Z, Zheng Mei Z, Zhi W. 2005 Research and development of new diamond bead saw for mining stone [J] Stone 11 5-8
[7] Jin Sheng Z, Zheng Mei Z, Zhi W. 2006 Research and innovative design of new stone back-
harvest diamond bead saw[J] *Diamond and Abrasives Engineering* **04** 17~20

[8] Li Wen C, Qing Xin M, Hai Tao T, Hua W. 2006 Tension Detection System of Underwater Diamond Wire Saw Machine[J] *Sensors and Microsystems* (02) 67-69

[9] Yan Qing G, Lie Gang M, Lu L. 2015 Foot pressure measurement system based on STM32[J] *Metrology & Testing Technology* **42**(07) 9-11

[10] Chun Hui L, Wen Chao H, Yang W, Teng Fei L. 2015 Based on STM32 wireless pressure monitoring system[J] *Coal Mine Machinery* **36**(08) 214-217

[11] Ping Ping C. 2019 Design of Pressure Transmitter Detection System in Hydraulic Support[J] *Mechanical Research & Application* **32**(03) 148-150