

## **Introduction to WEDM and Constant Tension Control**

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**ABSTRACT:** *Based on the introduction of WEDM and its development trend, narrates the requirements and development of tension control and all kinds of constant tension control device of a simple classification summary, finally indicating the direction of wire cutting technology in China need to develop.*

**Keywords:** *WEDM, the Development Trend, Tension Control, Classification Summary, Direction*

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### **I. INTRODUCTION**

In 1943 year, a former Soviet scholar Lazarenko and his wife invented the EDM (Electrical Discharge Machining referred to as EDM), The working principle is to use the tool electrode and workpiece between constant pulse discharge is produced by high temperature Make the metal melt oxidation and corrosion processing method, it is also called electrical discharge machining or electric erosion machining. Due to the spark was visible in the discharge process, so it is called EDM<sup>[1]</sup>. Wire cut Electrical Discharge Machining referred to as EDM is often used in non-traditional ways, it belong to Electric processing category. The world's first wire-cutting machine was invented in 1960 by the former Soviet Union, as countries on pulsed power supply and control system for continuous improvement and quickly prospered. The world actually use the EDM wire cutting machine for industrial production of the country is our country.

According to Wire speed, WEDM machine can be divided into<sup>[2]</sup>: Reciprocating type high speed wire cut electrical discharge machining and Low speed one-way walk wire cut electrical discharge machining and Vertical wire electrical discharge machining machine tool with rotation wire. In recent years, China has successfully developed a medium speed wire cut electrical discharge machining, commonly known as “medium speed wire”. In the so-called “medium speed wire” is also a class belongs to one of the reciprocating wire high speed wire-cut EDM machine, namely adopt the strategy of high speed wire when rough machining and finish machining with the low speed strategy. Existing on the market of silk machine is essentially a kind of can realize no stripes reciprocating type high speed cutting namely reciprocating type high speed wire cut electrical discharge machining<sup>[3]</sup>. MS-WEDM is better than reciprocating type high speed wire cut electrical discharge machining and it is worse than Low speed one-way walk wire cut electrical discharge machining in machining quality. Divided according to the workbench, and can be divided into single column cross table and double column type<sup>[4]</sup>.

### **II. The development trend of WEDM technology**

After decades of rapid development, wire cutting technology has been mature, technological level has reached a quite high level: High speed walking wire edm wire cutting machine can cut 1000 mm thick workpiece<sup>[5]</sup>. The low-speed unidirectional wire cut EDM machining precision can reach 0.001mm, the surface roughness of Ra<0.2μm and its quality is close to the level of grinding. Domestic and foreign scientific research institutions and producers in adopting modern technology and means of knowledge and in-depth research and innovation of WEDM in order to create a high level of processing technology of wire cutting machine, so In order to meet the needs of the market we should make the WEDM processing automation.

### **III. Raise the smooth movement electrode method**

Tension control of wire is an important control of wire cut EDM machining constituent parts. The electrode wire in the machining process due to the continuous change of the tensioning force lead to constant fluctuation of wire electrode, this is the source of machining precision and surface quality caused by. Ensure the stability of wire electrode movement there are two main possible solutions: using constant tension control, which is a great means of producing wire-cutting machine tool manufacturers often takes; The other is a relatively little use is to increased rigidity of the wire electrode.

#### **IV. The requirement of constant tension control**

The requirement of constant tension control system<sup>[6]</sup>: (1) Higher sensitivity. When the electrode wire tension is greater than or less than optimal tension, should immediately be adjusted response. (2) Better stability. Less during the cutting process is not subject to or affected by other disturbances in addition to the tension change, wire electrode can be maintained at optimum tension range. (3) the structure should be simple, easy to use and maintain.

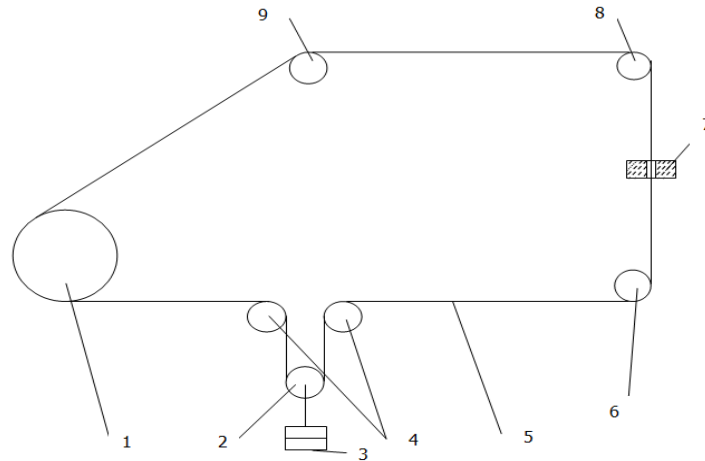
Tension value of the size of precision control is the main direction of WEDM research. The value of tension in the cutting process is too large to cause wire fracture, The value of tension is too small and will make the wire electrode tension relaxation and become bent, These will affect the processing efficiency and workpiece quality. And in the machining process of the appropriate tension value can reduce the electrode wire fluctuation, therefore, we must in the electrode wire strength limit range to maintain high and stable tension as possible, due to the skill and equipment limitations, uses a simple wire plus a heavy punch or spring to solve the problem of the cutting wire bending and fluctuation in the process of production, this can create a simple constant tension control. Although all of them play a certain role, but its response was too slow, tension is not always constant, and wire breaking often occur<sup>[7]</sup>. With the rise of simple control, most of the tension control system adopted a simple open loop control. And usually divided into two types<sup>[8]</sup>: directly open-loop tension control system and indirect tension control system. This control system since there is no feedback loop, can only control the output signal. Also known as the no feedback control system. Open-loop control system is relatively simple, work is relatively stable, convenient for users to master, but to improve the precision and speed are subject to certain restrictions. So it is usually only used for outside influences can be neglected or does not require very high precision wire cutting machine. With the continuous development of control technology and mature, the tension of wire cutting machine control system using closed loop control. In the closed-loop control of controller according to the feedback information timely discover and correct quickly the wire electrode tension of runtime value size deviation, for its strong anti-jamming ability, can carry out effective control, but also ensures the accuracy of control, so now most of the manufacturers began to use this system. In addition, with the development of control theory, some new ideas and control have been brought in the tension control system. Such as optimal control, adaptive control, robust control, neural networks control, which makes control system more and more high precision control mode is also more flexible<sup>[9]</sup>.

#### **4.1 The existing tension control device and its characteristics**

##### **4.1.1 High speed WEDM wire electrode typical tension control devices**

(1) Artificial tensioning device: Although our country's high-speed WEDM after 30 years of development and innovation, there are quite a few not installed tensioner. Because the molybdenum wire generate heat in the process of machining so it will get long and due to the molybdenum wire discharge loss make the wire diameter became fine, these will lead to wire electrode loose. Due to the lack of the tensioner makes the molybdenum wire tension degree is not timely adjustment, in the machining process often adopt the way of manual setting to adjust tightness of molybdenum wire so the machining efficiency and quality can not get effective guarantee. when the wire tension drops, when machining the workpiece does not meet the requirements, you should stop the machine and use your hand to tensioning wire, this is the manual setting<sup>[10]</sup>. Due to the low efficiency, low control precision, it is facing a phased out now.

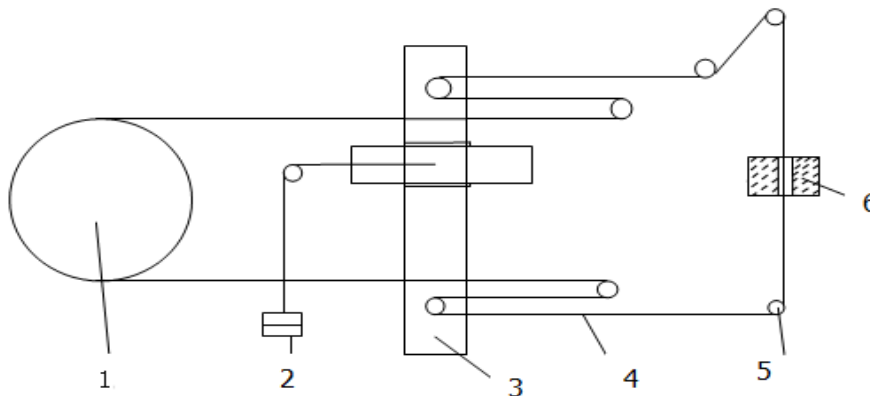
(2) Automatic takeup: Now the constant tensioner of fast walking wire WEDM often uses simple a heavy punch or spring structures<sup>[11]</sup>. Through a lot of actual machining verification elastic tension control can't meet the constant tension control and it has been eliminated. The simple gravity constant tensioner consists of two fixed pulleys and a free activity pulley, wire electrode around the three pulleys, freely moving pulley attached to a weight of hammer, to a certain extent, can keep the wire electrode constant tension stability. As shown in Fig 1. The device has the following advantages<sup>[12]</sup>: ①Simple structure, easy implementation and low cost; ②Can achieve constant tension control of wire electrode; ③Saves the manual process of tight wire. Therefore, it Once widely used in WEDM. But the tension control agencies also exist deficiencies: ① Sometimes heavy hammer hanging down above a certain limit makes resistance increase at this time it requires downtime and need someone to participate in the closed silk operations, Which affect the processing efficiency; ②when the filament tube change direction it will affecting the processing quality more obviously; ③ the tension agencies tensions wire electrode in the workspace, due to long time work will raise the temperature of wire electrode so the wire electrode easy to cause the elongated and necked, the life expectancy will be decline and is not suitable for large current cutting, So the agency is also began to gradually become obsolete.



1—Filament tube; 2—Activities on guide; 3—heavy punch; 4—Fixed carrier; 5—Electrode wire; 6—lower tumbler; 7—workpiece; 8—top tumbler; 9—After the idler pulley

Fig 1 Gravity tensioning device

(3) Bilateral tight wire device: This tensioning device often used in high-speed WEDM machine tool. Its working principle as shown in Fig 2, take the form of bilateral simultaneous tight wire, its sliding part move in the linear rolling guide and can improve the stability of motion. It has a number of advantages: ①Simple structure, easy to implement; ②Low cost, requirements for the precision of rolling guide is not high, Good scrolling performance; ③Adopt bilateral tight wire device and rolling guide, the work is more stable and reliable.



1-Filament tube; 2-heavy punch; 3-cam block; 4-wire electrode; 5-guide wheel; 6-workpiece

Fig 2 Bilateral tight wire tension device

(4) Intelligent tensioning device: With the development of science and technology, a new intelligent control device of tension emerges at the right moment, such as with the magnetic powder brake as the element of wire electrode constant tension control system, it is made up of tension detector, tension sensor, tension controller and magnetic powder brake. The basic control principle is shown in Fig3.

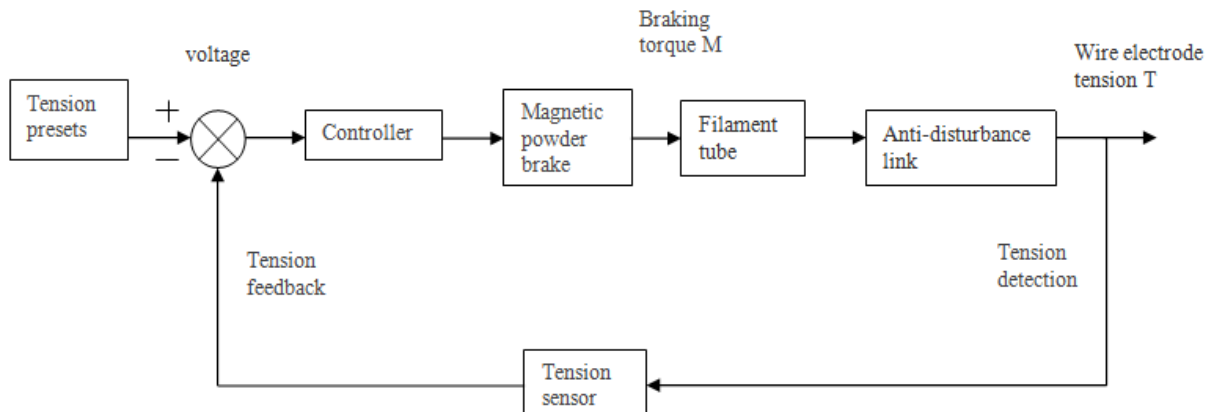


Fig 3 Constant tension control principle diagram

This device of tension intelligent control has the following advantages; ① A high degree of intelligence, The realization of the constant tension control is both convenient and quick; ② A feedback can quickly response to tension of system change; ③ Avoid people participation cause control error, control more precise.

#### 4.1.2 Low-speed WEDM wire electrode tension control devices

(1) Mechanical type: Mainly includes spring type, heavy hammer type and spring-heavy hammer type categories. This type of structure is the most simple, price is cheap, but the tension control is not precise and constancy is poor, also Each has many deficiencies.

(2) Electromagnetic type: Magnetic powder clutch and magnetic powder brake are two main types. According to the principle of electromagnetic and magnetic powder is used to transfer torque, its basic conforms to the linear relationship between torque and excitation current<sup>[13]</sup>. Therefore, we can only need to adjust the size of the exciting current according to the tension requirement. Its advantages are buffer start, overload protection, instant Reaction, the noise is small, no impact vibration and Save energy etc. Now most of the low speed WEDM are in use this device.

(3) Motor speed differential: we can create tension take advantage of small speed difference between wire drawing machine and release molybdenum wire machine<sup>[14]</sup>. Its working process is composed of tension sensor detect molybdenum wire tension values and tension signal feedback to the controller through the feedback loop to adjust the two servo motor speed difference reached moderate tension. We can use it to achieve constant tension closed-loop control. Its characteristics are quick response and high control accuracy.

#### 4.1.3 Medium speed WEDM wire electrode tension control devices

Medium Speed WEDM through constant innovation and development, it has become an irreplaceable and has great development potential of mechanical processing equipment<sup>[15]</sup>. In recent years some wire cutting production factory have produced some machine tools which they can realize multiple cutting, due to the limitation of the space structure of machine tool so they use a tension mechanism between in line arm of the machine tool body and filament tube. But the agency also cannot meet the demand of reciprocating silking and the size of the tension is not automatic control, in times of multiplicity cutting can only rely on the experience of skilled workers to adjust the tension value. we have a lot of difficulties, but also made some progress in the aspect of intelligent control of tension. such as: Suzhou baoma CNC equipment co., LTD has developed a silking institutions which can realize closed-loop dynamic control, the agency can automatic silking and pulled thread. Characteristics of Mechanical agencies are: 1) Molybdenum wire tension adjustment speed reach micron level through sensors and servo loop electrical control<sup>[16]</sup>. 2) The realization of the basic constant size of the wire electrode tension values mainly through symmetrical mechanical tension adjusting agencies. 3) To improve processing efficiency to improve the quality of machining surface the user cost of processing has been further decline.

## V. Conclusion

In recent decades researchers and companies at home and abroad carried out extensive research and innovation about WEDM and wire electrode constant tension control, to a certain extent, shows their development prospects. At present, there is a great gap between wire-cutting technology in our country and advanced foreign technology, we need to make unremitting efforts to keep up with The Times the pace of

development promote the rapid development of the WEDM technology. The main development direction of wire cutting technology in the future: 1) To the high speed, high accuracy direction; 2) Machine tool processing information direction of development; 3) To develop in the direction of intelligent, green; 4) To develop in the direction of high reliability.

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