

Mechanical Properties of 93W-Ni Fe Alloy under Electroplastic Assisted Tensile Testing

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Abstract

The effects of tensile speed, deformation temperature, effective current density and pulse frequency on the electroplastic assisted tensile properties of 93W-Ni-Fe alloy were studied by WDW-50 electronic universal testing machine. The results show that under constant other conditions, the tensile strength of tungsten alloy increases with the increase of tensile speed, and decreases with the increase of deformation temperature, effective current density, and pulse frequency. With the increase of pulse frequency of effective current density, the dislocation slip in tungsten alloy increases and the tensile strength of tungsten alloy decreases.

Keywords

93W-Ni-Fe Alloy; Electroplastic Assisted Tensile; Mechanical Property.

1. Introduction

Tungsten alloy is a two-phase alloy material composed of tungsten as matrix and other materials such as Fe, Ni, Cu, etc. The tungsten content is generally 85%~97%. High specific gravity tungsten alloy has high density, high strength, high melting point, oxidation resistance, corrosion resistance, good ductility, high mechanical strength, low thermal expansion coefficient, strong adiabatic shear ability, strong ray absorption ability and other excellent properties. Because of its excellent properties, tungsten alloy is widely used in aerospace, military, medical and other fields. Such as gyroscope rotor, aircraft counterweight, missile core, X-ray radiation shielding[1,2,3].

Tungsten alloy has excellent properties and is widely used in aerospace, medical, military and other fields. However, tungsten alloy has high density, high strength, high melting point, and brittle and poor plasticity under normal temperature conditions. It is a typical difficult to add material because of its coarse grain, brittle quality and limited bonding ability. In the traditional tungsten alloy cutting process, the cutting force is large and the cutting temperature is high, which is easy to produce brittle removal, grain collapse and granular chips. These problems increase the tool wear and reduce the tool life; At the same time, the surface is rough and the surface integrity is poor. It is difficult to achieve high efficiency and high quality machining of tungsten alloy by traditional cutting methods. The results show that the deformation resistance of metal materials can be reduced by the interaction between drift electrons and dislocations when current is applied to the workpiece during forming. Make it easier to process, improve the formability, improve the forming quality, this phenomenon is called the electroplastic effect of metal. The machining properties of tungsten alloy can be improved effectively by using pulse current to assist tungsten alloy cutting. Hao Shangdong[4] conducted electroplastic assisted milling of tungsten alloy and found that compared with conventional milling, the electroplastic assisted milling can significantly reduce the milling force and can be reduced by up to 46%. Zhao Lixiang[5] carried out electroplastic assisted turning of tungsten alloy, and found that pulse current can improve the surface roughness of tungsten alloy processing and reduce the degree of surface defects. Compared with conventional cutting, pulsed current can effectively alleviate tool

wear, but it will also form chip nodules on the back tool surface. Pulse current can improve the machining properties and plasticity of tungsten alloy, but there are few related studies, and the effect of pulse current on the properties of tungsten alloy is not clear.

In summary, the high energy pulse current can improve the new processing energy of tungsten alloy and improve the plasticity of tungsten alloy. Under the action of pulse current, the tensile speed, deformation temperature, effective current density and pulse frequency will affect the mechanical properties of tungsten alloy. At present, there are few reports about the effect of electric pulse on the properties of tungsten alloy. In this paper, the effects of tensile speed, deformation temperature, effective current density and pulse frequency on the properties of 93W-Ni-Fe alloy were studied by WDW-50 electronic universal testing machine. The research can provide theoretical basis and technical support for tungsten alloy electroplastic assisted machining.

2. Test materials and Methods

The material used in this study is a tungsten alloy plate with a thickness of 1.5mm. Its chemical composition (mass fraction,%) is 4.8 Ni, 2.2 Fe, 0.008 Si, 0.005 Ca, 0.005 C, 0.005 O, 0.003 Mg, 0.003 N, 0.002 Al, 0.001 H, and the rest is W. The sample was processed by EDM, and a layer of high temperature resistant black paint was uniformly painted on the surface of the sample. The size of the sample was shown in Fig. 1.

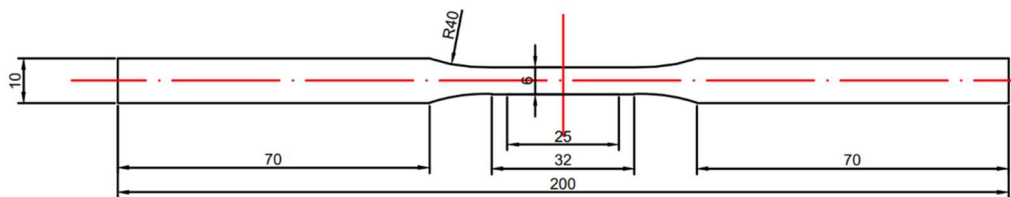


Fig. 1 Size diagram of the tensile specimen

The test was carried out on WDW-50 electronic universal test machine, and the high energy pulse current was provided by TJMC-1 pulse power supply. The electroplastic assisted unidirectional tensile test was carried out on tungsten alloy samples by controlling effective current density (J_{eff}), pulse frequency (f), tensile speed (V) and test temperature (T). The current density were 6 A/mm², 8 A/mm², 10 A/mm². The pulse frequency were 200 Hz, 250 Hz, 300 Hz, The stretching speed were 1.5mm/min, 6 mm/min, 10 mm/min, The test temperature were 100°C, 150°C, 200°C. During the experiment, an infrared thermal imager was used to detect the test temperature, and a cooling vortex tube was used to control the test temperature. The experiment ended after the sample was pulled apart. Record the tensile strength of tungsten alloy.

Remove the black paint from the contact part of the tungsten alloy sample and the fixture to ensure the electrical conductivity of the tungsten alloy sample during the test. The unidirectional tensile test with the same parameters was repeated three times, and the average value of the three tests was taken to ensure the accuracy of the test results.

3. Test Results and Discussion

3.1 Influence of Tensile Speed on Tensile Strength of Tungsten Alloy

Fig. 2 shows the tensile strength of tungsten alloy at different tensile speeds under the conditions of $J_{eff}=10$ A/mm², $f=200$ Hz, and $T=180$ °C. As can be seen from the figure, when the tensile speed $V=1.5$ mm/min, the tensile strength of tungsten alloy material is the smallest, which is 794.13Mpa. When the tensile speed $V=10$ mm/min, the tensile strength of tungsten alloy material is the largest, 805.36Mpa. The difference between the two is 11.23 Mpa. The tensile strength of tungsten alloy material increases with the increase of tensile speed.

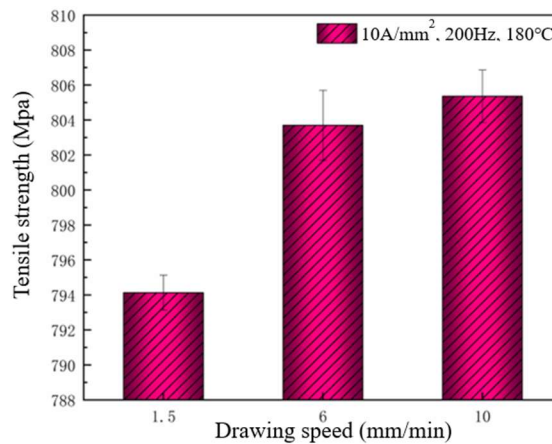


Fig. 2 Tensile strength of tungsten alloy at different tensile speeds

As can be seen from Fig. 2, the tensile strength of tungsten alloy increases with the increase of tensile speed, which is consistent with the conventional tensile law. This phenomenon can be explained by the strain rate strengthening effect. Under the same test conditions, the higher the strain rate, the greater the tensile strength of the material. The strain rate of tungsten alloy is related to the tensile speed. If other conditions remain unchanged, the faster the tensile speed of the material, the higher the strain rate will be. The high strain rate will strengthen the tungsten alloy material and increase the tensile strength of tungsten alloy.

3.2 Influence of Pulse Frequency on Tensile Strength of Tungsten Alloy

Fig. 3 shows the tensile strength of tungsten alloy at different pulse frequencies under the condition of $J_{eff}=10 \text{ A/mm}^2$, $V=1.5\text{mm/min}$, and $T=180^\circ\text{C}$. It can be seen from the figure that when the pulse frequency $f=200\text{Hz}$, the tensile strength of tungsten alloy is the highest, which is 794.13Mpa. When the pulse frequency $f=300\text{Hz}$, the tensile strength of tungsten alloy is the smallest, 740.83Mpa. The tensile strength of tungsten alloy decreases with the increase of pulse frequency.

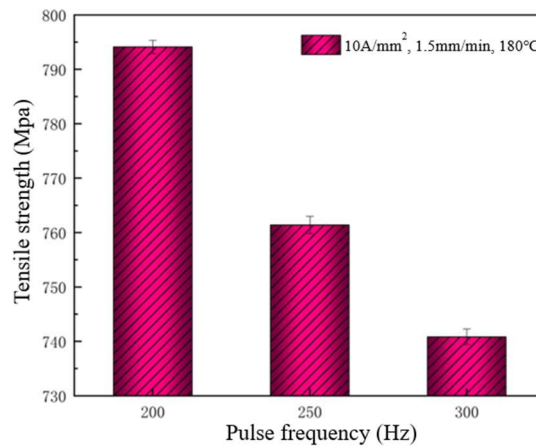


Fig. 3 Tensile strength of tungsten alloy at different pulse frequencies

It can be seen from Fig. 4 that during the unidirectional tensile test of tungsten alloy under the action of electric pulse, the tensile strength of tungsten alloy material decreases with the increase of pulse frequency. The tensile strength represents the resistance to the maximum uniform plastic deformation of the material, and the pulse frequency is related to the speed of electron movement. With the increase of pulse frequency, the movement rate of directional moving electrons in the pulse current increases, the collision between electrons and dislocations increases, and the frequency of dislocation

action increases, which promotes the occurrence of dislocation slip. The plasticity of the material is improved and the tensile strength of the material is reduced.

3.3 Effect of Effective Current Density on Tensile Strength of Tungsten Alloy

Fig. 4 shows the tensile strength of tungsten alloy material under different effective current densities at $f=200\text{Hz}$, $V=1.5\text{mm/min}$, and $T=180^\circ\text{C}$. It can be seen from the figure that when the effective current density $J_{eff}=6\text{ A/mm}^2$, the tensile strength of tungsten alloy is the highest, which is 857.81Mpa. When the effective current density $J_{eff}=10\text{ A/mm}^2$, the tensile strength of tungsten alloy is the smallest, which is 794.13 Mpa. The tensile strength of tungsten alloy decreases with the increase of effective current density.

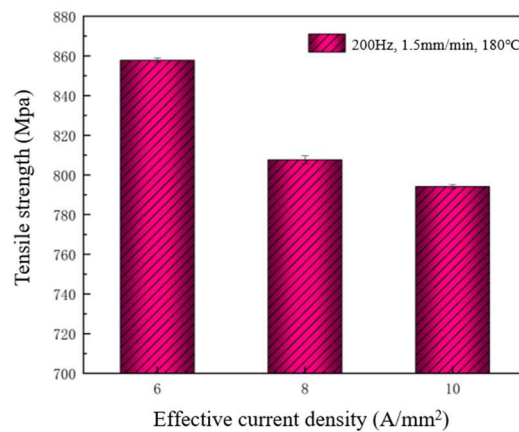


Fig. 4 Tensile strength of tungsten alloy at different effective current densities

3.4 Influence of Test Temperature on Tensile Strength of Tungsten Alloy

Fig. 5 shows the tensile strength of tungsten alloy at different test temperatures under the conditions $f=200\text{Hz}$, $V=1.5\text{mm/min}$, and $J_{eff}=10\text{A/mm}^2$. It can be seen from the figure that when the test temperature $T=100^\circ\text{C}$, the tensile strength of tungsten alloy is the highest, which is 835.22Mpa. When the test temperature $T=200^\circ\text{C}$, the tensile strength of tungsten alloy is the smallest, which is 771.88Mpa. The tensile strength of tungsten alloy decreases with the increase of test temperature.

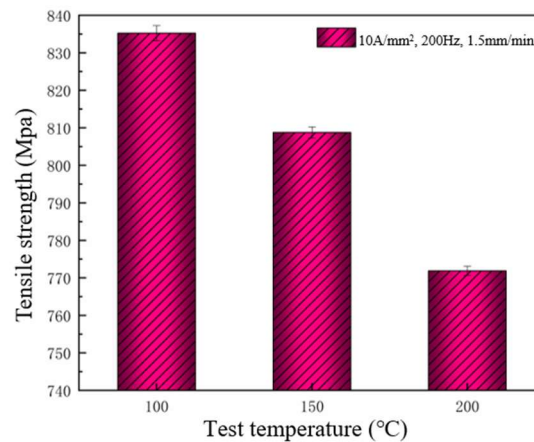


Fig. 5 Tensile strength of tungsten alloy at different test temperatures

As can be seen from Fig. 5, the tensile strength of tungsten alloy decreases with the increase of test temperature. This phenomenon can be explained by the thermal softening effect, the material under

the action of high temperature, softening, its strength and hardness will be reduced. Therefore, the tensile strength of tungsten alloy material increases with the increase of temperature.

4. Conclusion

This article investigates the effect of high-energy pulse current on the mechanical properties of tungsten alloys. The effect of pulse current on tensile properties of tungsten alloy was analyzed. Under the same conditions of other tests. The effect of pulse current on tensile properties of tungsten alloy is analyzed. Under the same conditions as the other tests.

Acknowledgments

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