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ISSN 0543-5846
METABK 64(1-2) 31-34 (2025)
UDC: 669.15:786.9:621.785:620.18:620.17=111

EFFECT OF QUENCHING TEMPERATURE ON MICROSTRUCTURE AND PROPERTIES OF 0Cr13Ni8Mo2Al STAINLESS STEEL FOR PIANO STRINGER

Received – Primljeno: 2024-06-20
Accepted – Prihvaćeno: 2024-08-20
Original Scientific Paper – Izvorni znanstveni rad

T Stainless steel, as a common material for piano stringer, has the advantages of high strength and good toughness. 0Cr13Ni8Mo2Al stainless steel meets the strength and enhances the toughness of the piano string machine, so it is a relatively successful golf club material. A new type of 0Cr13Ni8Mo2Al stainless steel was studied. The microstructure, hardness and tensile properties of the stainless steel after quenching treatment were studied. The effects of quenching treatment on the microstructure, hardness, strength, plasticity and toughness of the alloy were clarified. The experimental results show that the best quenching process of stainless steel is 515 °C, the hardness is the highest 45.7 HRC, the tensile strength is the highest 145 MPa and the elongation is 13.8 %. This study has a certain guiding role in the development of piano stringing machine materials.

Keywords: 0Cr13Ni8Mo2Al stainless steel, piano stringer, quenching temperature, microstructure, mechanical properties

INTRODUCTION

The string striking machine is the main part of the piano, and it is a kind of precise structure of pure physical braking without power supply. The piano string striking machine is composed of iron frame, main beam, pillow beam, regulator and starter, impactor, sound maker and other parts. The string striking machine is the main component of the vibration of the string, which can also be said to be the heart of the piano. The piano string machine is like the engine of the car, is the heart of the piano.

0Cr13Ni8Mo2Al stainless steel, as the main material of piano stringer, not only has high strength and hardness, good toughness and ductility, but also has good weldability and corrosion resistance. It has become an important candidate material in many application fields. It has been widely used in aerospace, marine engineering, nuclear power equipment and musical instrument production. In this paper, the quenching treatment of 0Cr13Ni8Mo2Al stainless steel at different temperatures is carried out, and the microstructure, tensile properties, hardness and impact properties of the alloy under different heat treatment conditions are studied, which provides a reference for the formulation of heat treatment process of 0Cr13Ni8Mo2Al stainless steel in the production project of piano string striking machine.

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MATERIALS AND METHODS

The experimental material is 0Cr13Ni8Mo2Al stainless steel. The chemical composition (mass fraction) of the stainless steel is C : 0.035 %, Si : 0.05 %, Mn : 0.01 %, Cr : 12.545, Ni : 8.15, Mo : 2.22 %, Al : 1.05 %, N : 0.001 %, Fe : Bal. The experimental steel was quenched by box-type resistance furnace. The quenching holding temperature was 480,510,540,570,590 and 620 °C respectively, and the annealing time was 2 h. The microstructure of the experimental steel was observed by metallographic microscope. The corrosive agent was 3 % nitric acid alcohol solution. The mechanical properties of experimental steels in different states were tested on 5105 microcomputer controlled electronic universal testing machine.

EXPERIMENTAL RESULTS AND DISCUSSION

Figure 1 shows the SEM microstructure after quenching in the range of 485 to 625 degrees. Under the scanning electron microscope, the microstructure morphology of the original austenite grain boundary and martensite plate can be clearly seen. The aging samples at 480-540 °C show a typical aging martensite matrix. It can be seen that the grain orientation of martensite is different, but the grain boundary of martensite is difficult to distinguish. After 570 °C, the banded structure in the lath martensite matrix gradually becomes extremely fine until it completely disappears, while the growth of martensite subgrains causes the connection between martensite lath bundles and the recovery phenomenon occurs. When the quenching temperature is 590 °C and 620 °C, the recovery rate is the highest.

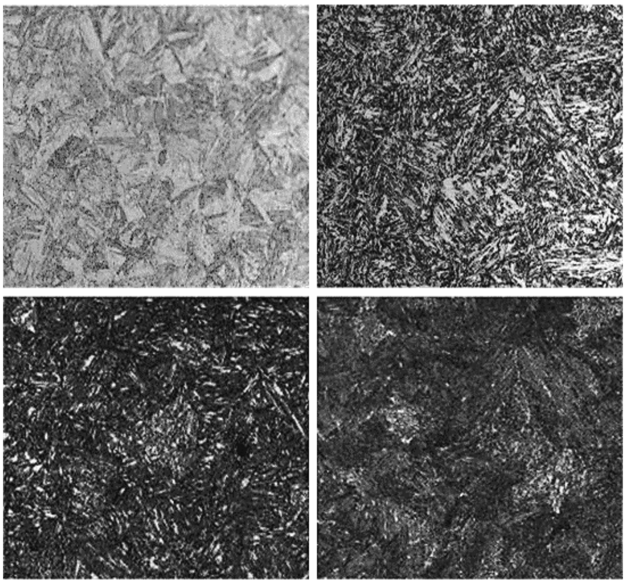

Figure 1 Microstructure of the sample at quenching temperature

Table 1 **The mechanical properties of experimental stainless steel after different quenching temperatures were studied**

Number	Tempering temperature	Hardness/ HRC	Rv/ MPa	Rm/ MPa	Elongation/%	impact work/J
1	485	42.8	1489	1274	16.4	73
2	515	45.7	1503	1336	13.8	68
3	545	43.4	1405	1331	14.9	101
4	575	41.2	1251	1154	16.8	145
5	595	36.8	1141	1042	18.7	169
6	625	30.4	1106	641	19.9	177

During the quenching process, the quenching time and temperature affect the properties of the material. In general, the best ratio can be obtained by controlling the parameters. The mechanical properties of 0Cr13Ni-8Mo2Al stainless steel at different quenching temperatures are shown in Table 1.

Figure 2 shows the effect of quenching temperature on the hardness of experimental stainless steel. The hardness values range from 30.4 HRC to 45.7 HRC. The change of hardness value is consistent with the change of strength value, both of which show a trend of increasing first and then decreasing. When the single aging temperature is 515 °C, the hardness is the highest, reaching 45.7 HRC. At 625 °C, the hardness value is the smallest. Due to the increase of quenching temperature, the content of reversed austenite in the sample increases and the growth and dissolution of NiAl phase lead to the gradual softening of the matrix and the decrease of hardness. It can be seen from Figure 2 that the strength shows a trend of increasing first and then decreasing. That is, from 485 °C to 515 °C, the hardness increases from 42.8HRC to 45.7HRC. When the aging temperature is about 515 °C, the hardness value is the largest. It can be concluded that the best quenching temperature of hardness is 515 °C..

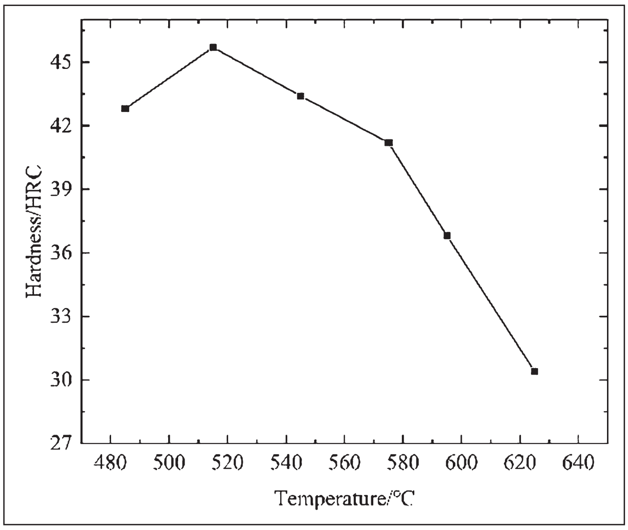

Figure 2 Effect of quenching temperature on hardness of experimental stainless steel

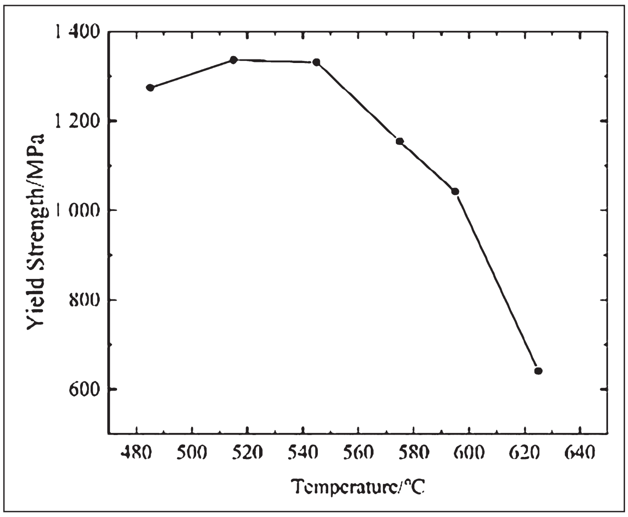

Figure 3 Effect of quenching temperature on tensile strength of experimental stainless steel

Figure 3 is the effect of quenching temperature on the yield strength of experimental stainless steel. The yield strength of the experimental stainless steel after heat treatment at different quenching temperatures ranges from 641 MPa to 1724 MPa.When aged at 485 °C to 595 °C, the yield strength does not change much. When aged at 625 °C, the yield strength decreases sharply. The reason may be that the increase of reversed austenite causes obvious softening phenomenon, which makes the yield strength decrease sharply. At 485 °C to 515 °C, the yield strength increases from 1274 MPa to 1336 MPa, and at 515 °C to 620 °C, with the increase of quenching temperature, the yield strength decreases to 641 MPa. When the quenching temperature is about 515 °C, the yield strength value is the largest. It can be considered that the optimum quenching temperature of yield strength is 515 °C.

Figure 4 is the effect of quenching temperature on the tensile strength of experimental stainless steel. The tensile strength of the experimental stainless steel after heat treatment at different quenching temperatures ranged

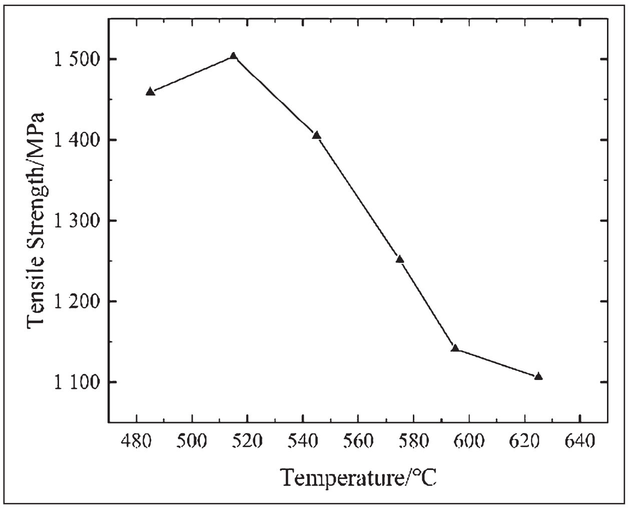

Figure 4 Effect of quenching temperature on tensile strength of experimental stainless steel

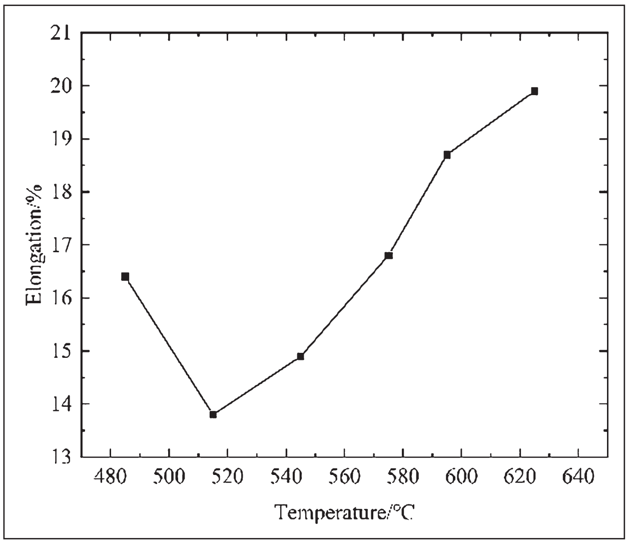

Figure 5 Effect of quenching temperature on the elongation of experimental stainless steel

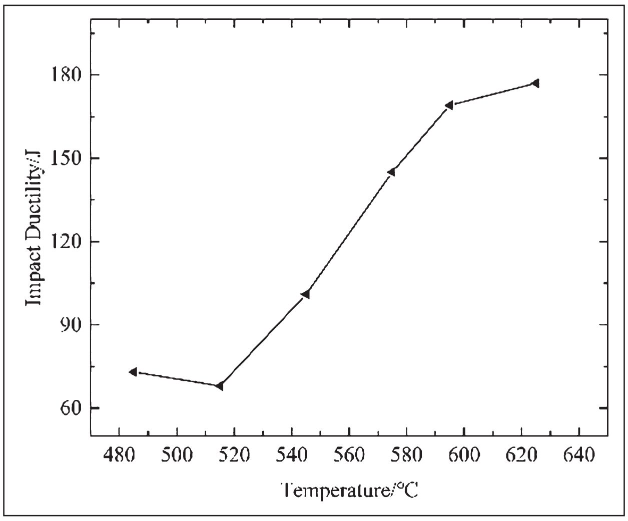

Figure 6 Effect of quenching temperature on impact toughness of experimental stainless steel

from 1106 Mpa to 1503 MPa. It can be seen from the curve that the tensile strength increased from 1459 to 1503 MPa at 485 °C to 515 °C. From 515 °C to 625 °C, the tensile strength decreased to 1106 MPa with the increase of quenching temperature. When the quenching temperature is about 515 °C, the tensile strength is the largest. It can be concluded that the best quenching temperature of tensile strength is 515 °C.

Figure 5 is the effect of quenching temperature on the elongation of experimental stainless steel. The elongation of the experimental stainless steel after heat treatment at different quenching temperatures ranges from 13.8 % to 19.9 %. At 485 °C to 515 °C, the elongation decreases from 16.4 % to 13.8 %. At 515 °C to 625 °C, with the increase of quenching temperature, the elongation increases to 19.9 %. When the quenching temperature is about 625 °C, the elongation is the largest. It can be considered that the optimum quenching temperature of elongation is 515 °C.

The impact energy reflects the ability of the material to resist deformation and failure under impact load, and its size reflects the impact toughness of the material. Figure 6 is the effect of tempering temperature on the impact toughness of experimental stainless steel. Figure 6 shows the effect of quenching temperature on the impact toughness of the experimental stainless steel. With the increase of single aging temperature, the impact energy at room temperature decreases slightly and then increases gradually. When the quenching temperature is 515 °C, the room temperature impact energy is the lowest, and the lowest impact energy is 68J. When the single aging temperature rises to 625 °C, the impact energy at room temperature reaches the maximum. The maximum is 177J. The reason for the increase of impact energy at room temperature is that with the increase of aging temperature, more film-like reversed austenite is formed from the martensite lath boundary or the original austenite grain boundary. When impacted, the crack propagation will pass through the martensite phase boundary, the reversed austenite phase boundary and the large angle phase boundary between the two. The crack may deflect at the reversed austenite and martensite phase boundary, which increases the propagation energy, increases the impact energy, and then the impact toughness becomes better..

It can be seen from the test results that the Rockwell hardness, tensile strength, impact toughness and elongation of the experimental 0Cr13Ni8Mo2Al stainless steel after quenching do not increase or decrease monotonously with the increase of quenching temperature. With the increase of quenching temperature, the strength and hardness of 0Cr13Ni8Mo2Al stainless steel increase first and then decrease, and the plasticity and toughness decrease first and then increase. When quenched at 515 °C, the experimental stainless steel has good comprehensive mechanical properties.

CONCLUSION

The quenching temperature has a significant effect on the mechanical properties of the test stainless steel.

In the quenching temperature range of 485 ~ 625 °C, the hardness, yield strength and tensile strength of the test stainless steel remain high. The change trend of mechanical properties of the test steel is mainly divided into two stages. With the increase of quenching temperature, it increases first and then decreases slowly. The best annealing treatment process of the alloy is 515 °C. The hardness is the highest 45.7 HRC, the tensile strength is the highest 145 MPa and the elongation is 13.8 %. This study has a certain guiding role in the development of piano stringing machine materials.

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Note: The responsible translator for English language is J.J. Wang – Heilongjiang Taiqi Tertiary Education Training Institute Co. Ltd, China.