Study on The Process of Hydrogen Steel 12Cr2Mo1VR Rolling and Heat Treatment

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Abstract: In order to research the heat treatment process of hydrogen 12Cr2Mo1VR steel, the small furnace of 50 kg was smelted and rolled. The influence of cooling rate on the microstructure of steel was studied, and the quenching and tempering process of heat treatment was explored. It is found that the austenitizing temperature of heat treatment should be above 875℃ in order to obtain better solid solution strengthening effect and avoid two coarsening caused by undissolved phase after quenching. In order to avoid serious M6C phase with coarse coarsening in tempering, the tempering temperature should be higher than 706℃. After comparing the impact properties and tensile properties of different heat treatments, two heat treatment systems were further contrasted, and 970℃ WQ + 710℃ AC was selected as the best heat treatment system.

1. Introduction

Hydrogen equipment refers to the equipment containing hydrogen in the medium, such as the hydrogenation reactor in the refining and chemical equipment, the hydrogenation heat exchanger, the hydrogenation separator and so on. With the production of high quality fuel and ethylene cracking, there are more and more equipment construction in the hydrogen plant, and the demand for the steel for the hydrogen equipment is huge. The products are mainly for large scale equipment manufacturing steel for Sinopec and other enterprises. Hydrogen equipment is widely used in oil refining and ethylene production, as well as in the coal oil industry. Equipment usually works in high temperature, high pressure and hydrogen environment. In hydrogenation unit, usually there are hydrogen sulfide corrosion medium, the corrosion rate will increase with the increasing of temperature; stress corrosion cracking is caused by the interaction of cracking tensile stress and corrosion medium chromium - molybdenum steel; temper brittleness is steel will keep for a long time at high temperature, the fracture toughness of the material it caused the deterioration and damage phenomenon, the hydrogen steel has put forward higher requirements.

2. Experimental research

2.1 Small furnace smelting

The 50kg vacuum induction furnace is selected for small furnace smelting. The composition is referred to the ASME SA-832 and SA-542 standard. The actual composition is shown in Table 1.

Table 1 smelting component wt.% in small furnace

C%	Si%	Mn%	P%	S%	Cr%	Mo%	Al%	V%
0.1	0.035	0.27	0.007	0.003	2.35	1.0	0.002	0.25

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2.2 Billet rolling
The heating temperature is 1250℃, the heat preservation time is 6h (including heating time), the target thickness is 30mm, the rolling temperature is 900, the final rolling temperature is 850℃, and the cold or slow cooling after rolling.

3. Results analysis

3.1 Rolling process
The rate of path reduction is shown in Figure 1, and the rate of 1 and 2 passes is 20%, 3 and 4 in 25%, 5, and 6 times respectively in 22.22% and 14.29%.

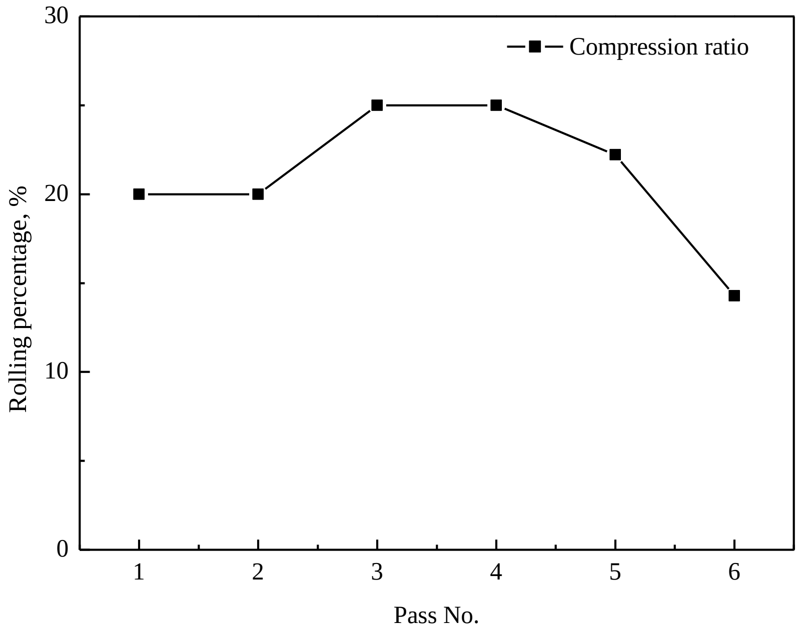

Figure 1 Rolling process of Cr Mo steel hydrogenation

3.2 effect of cooling rate on the hydrogenation of Cr Mo steel organization
Figure 2 shows the austenite transformation curve of hydrogen chromium molybdenum steel. It can be seen that the Ac1 of the steel is 810 ℃, Ac3 is 937 ℃, Ar1 is 728 ℃, and Ar3 is 844 ℃. Therefore, in order to obtain complete austenite, the quenching temperature should be above 937℃, and the tempering temperature should be guaranteed to be below 810 ℃.

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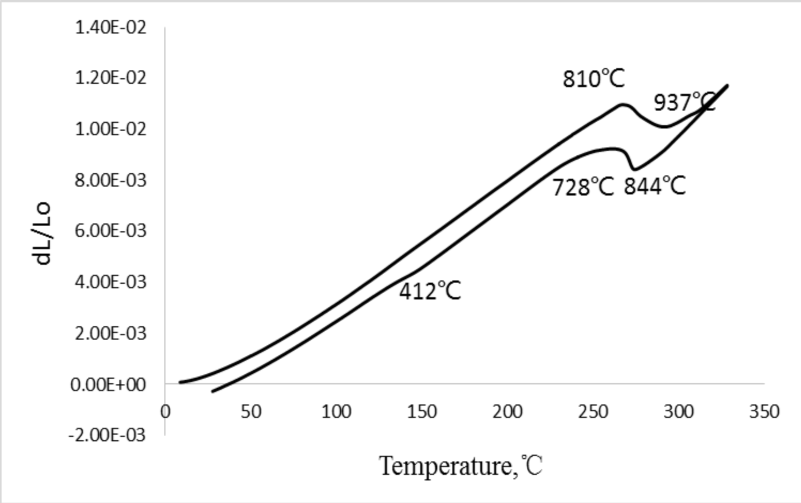

Figure 2 Determination of austenite hydrogen chromium molybdenum steel

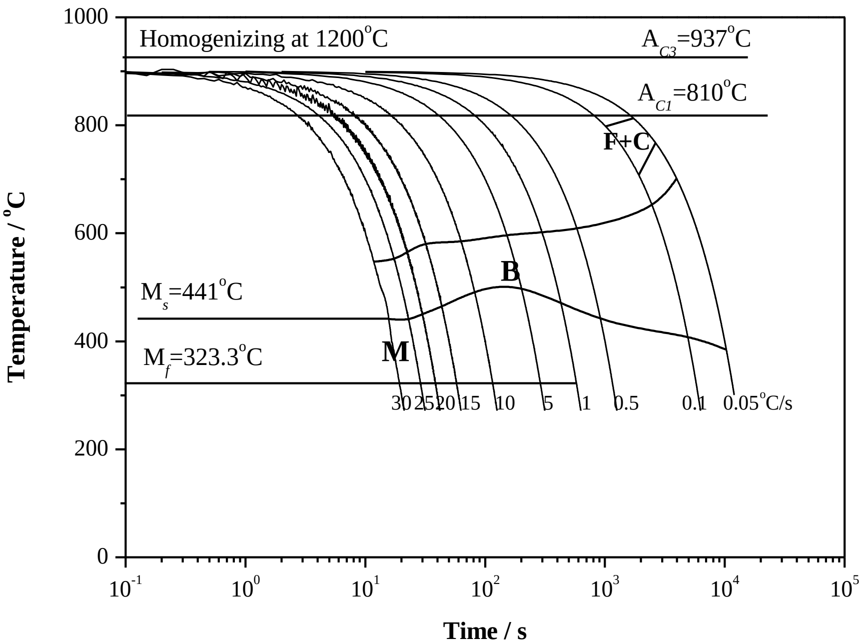

Figure 3 The static CCT curve of hydrogen chromium molybdenum steel

Figure 3 shows the static CCT curve of hydrogen chrome molybdenum steel, figure 4 shows the different cooling rate of the organization. We can see that in the cold at the low speed (0.05 and 0.1 ℃ /s-1) for mixed organization of polygonal ferrite and granular bainite; cooling rate is (0.5~10 ℃ /s-1), upper bainite, lath bainite and martensite gradually appears in the microstructure, and polygonal ferrite content gradually reduced to disappear; high cooling rate (15~30 ℃ /s-1), organization for the mixed microstructure of lath bainite and lath martensite.

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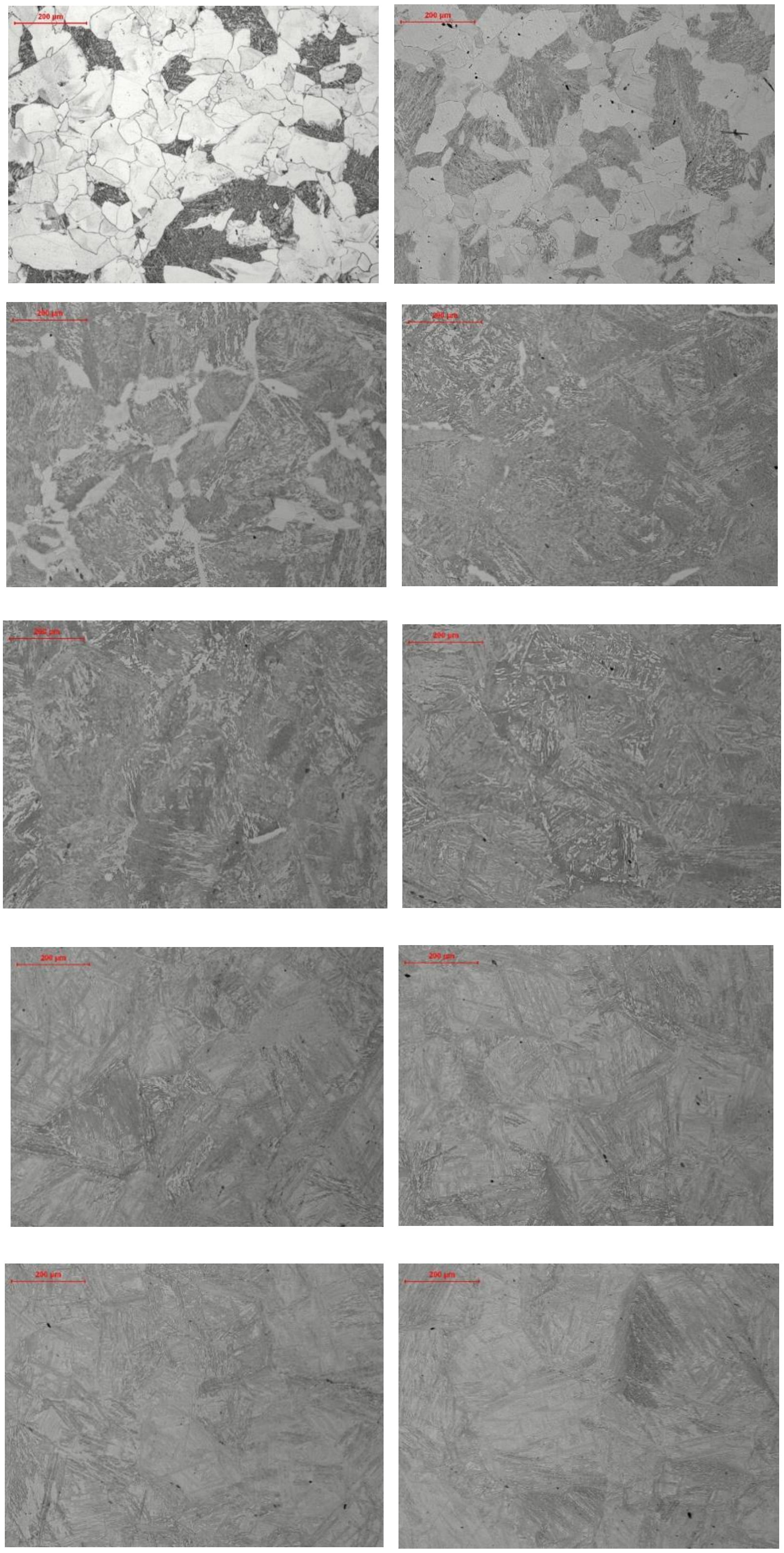

Fig. 4 Tissue images(a) 0.05ºC/s；(b) 0.1ºC/s；(c) 0.5ºC/s；(d) 1ºC/s；(e) 5ºC/s；(f) 10ºC/s；(g) 15ºC/s；(h) 20ºC/s；(i) 25ºC/s；(j) 30ºC/s

3.3 Analysis of heat treatment test

3.3.1 thermodynamic simulation calculation:

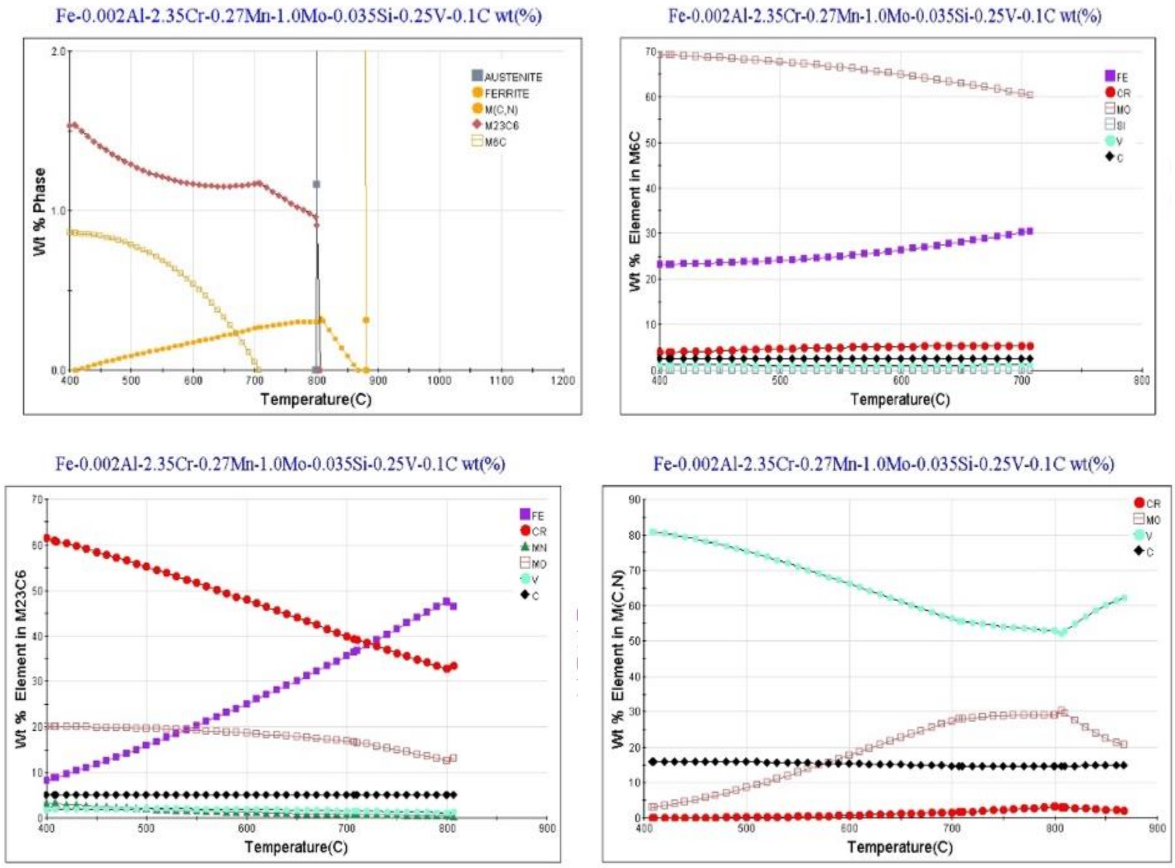

Figure 5 The thermodynamic calculation results of hydrogen chromium molybdenum (a) properties of graphs; (b) M6C elements; (c) M23C6 elements; (d) M (C, N) phase elements

The calculation of hydrogen chromium molybdenum thermodynamic, the results are shown in figure 5. We know. With the decrease of temperature, M (C, N), M23C6 and M6C were precipitated successively. M (C, N) is a precipitated phase rich in V and Mo from the temperature range of the two phase region. Its initial precipitation temperature is 875 degrees. M23C6 is the precipitation phase of Cr rich and Mo, and the initial precipitation temperature is 810 degrees. M6C is the rich Mo precipitation phase, and the precipitation temperature begins at 706 ℃. Therefore, in order to obtain the solid solution strengthening effect better, and avoid the presence of undissolved precipitates caused by tempering two coarsening after quenching, austenitic temperature during heat treatment can be more than 875 ℃; tempering in order to avoid the serious tendency of coarse M6C phase appears in the microstructure, the tempering temperature should be higher than 706 ℃. The thermodynamic simulation calculation is based on the equilibrium precipitation of the phase, which is different from the actual heat treatment, so it can only be used as a reference.

3.3.2 Study on mechanical properties

The tensile properties of different heat treatments are shown in Figure 6. It can be seen that after 680℃ tempering at different quenching temperatures, high temperature quenching is conducive to the increase of strength. After high temperature tempering, the strength caused by different quenching temperature is not very different. With the increase of tempering temperature, the strength gradually decreases, and the plasticity fluctuates greatly. Compared with the standard, the 920℃ WQ 710℃ AC, 970℃ + WQ + 710℃ + AC, 970℃ WQ 740℃ AC can meet the performance requirements, and the heat treatment, the plastic sample is low, did not reach 18% elongation requirements.

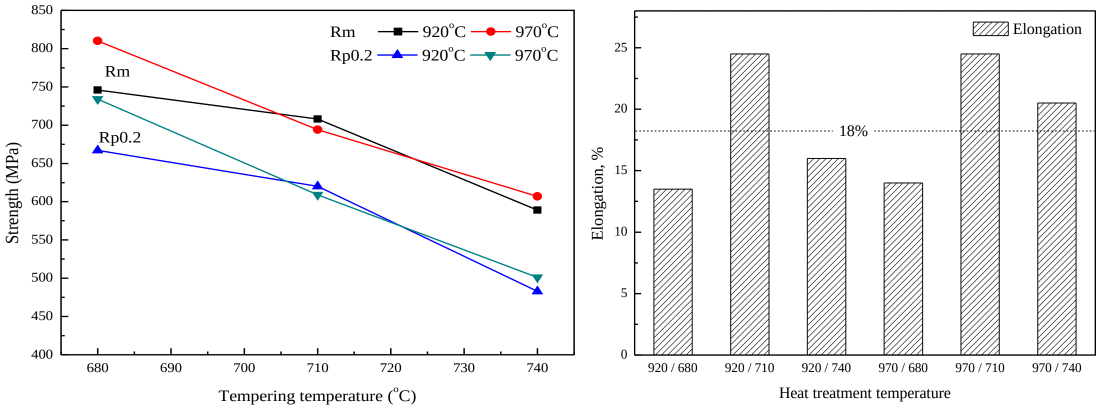

Figure 6 The tensile properties of 6 different heat treatments (a) (b) elongation strength

The impact performance of different heat treatment is shown in Table 5. The test temperature of the notch impact toughness required by the ASME standard is -18℃, so this test focuses on the impact results of -20℃, as shown in Figure 7. It can be seen that except for 920℃ WQ + 710℃ AC, the impact performance of other heat treatment can meet the requirements. The impact property of 970℃ after quenching is higher than that of 920℃ quenching, and the impact property increases with the increase of tempering temperature. In addition, it can be seen from table 5 that, when the test temperature is lower than -20 ℃, the impact performance fluctuates greatly up to 100J.

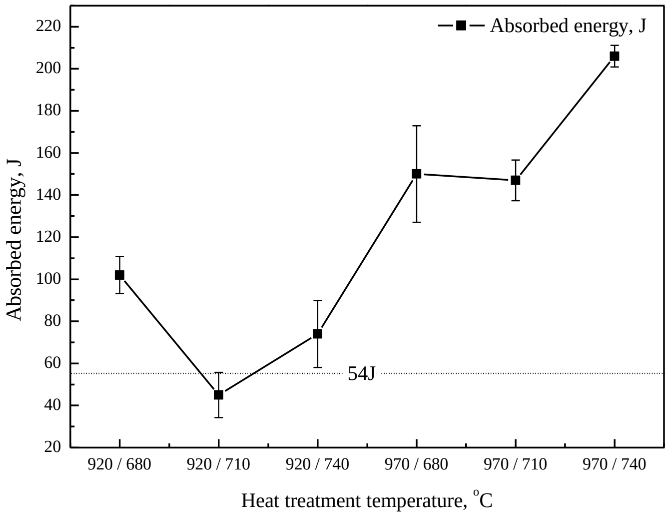

Figure 7 shock absorption energy at -20℃ after different heat treatment

4. Research conclusions

1) The Ac1 of the steel is 810℃, Ac3 is 937℃, Ar1 is 728℃, and Ar3 is 844℃. The austenite should be heated completely. The quenching temperature should be above 937℃, and the tempering temperature should be below 810℃.

2) At low cooling rate is obtained when the polygonal ferrite mixed body and granular bainite; upper bainite, lath bainite and martensite microstructure in gradually cooling rate, while the polygonal ferrite content decreased gradually to disappear; high cooling rate is mixed microstructure of lath bainite and

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lath martensite.

3) Obtained the solid solution strengthening effect is good, and avoid the presence of undissolved precipitates caused by tempering two coarsening after quenching, austenitic temperature during heat treatment can be more than 875 ℃ ; tempering in order to avoid the serious tendency of coarse M6C phase appears in the microstructure, the tempering temperature should be higher than 706 ℃.

4) Comprehensively compare the impact properties and tensile properties of different heat treatments, further compare the two heat treatment systems, and select 970℃ WQ + 710℃ AC as the best heat treatment system.

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