

The Research and Development of Acid Resistant Steel Q315NS

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Abstract: In this paper the main use of acid resistant steel Q315NS is introduced ,and the actual working conditions of the steel is detected. Based on the effect of Cu, Cr and Sb alloy elements in steel materials,the composition design of medium and thick plates is completed .And also the corresponding production process is formulated . The microstructure of the steel plate was analyzed and the acid resistance test is carried out.

1. Background

In metallurgy, electric power, petrochemical and other industrial fields, the flue gas treatment system of heavy oil or coal as the main fuel, such as air preheater, chimney and desulfurization device, the sulfur content of fuel is overproof. The sulphuric acid dew point can be generated in low temperature condition. The equipment corrosion can be happened. This phenomenon is called “Sulfuric Acid Dew Point Corrosion”^[1]. With this working environment, the corresponding sulphuric acid dew point corrosion steel has been developed successively. Shougang produce the steel plate in the medium plate plant. The test results showed that the acid resistance is good.

2. The effect of element alloy Cu Cr Sb

Copper plays an important role in improving the corrosion resistance of the steel^[2]. Copper plays the role of active cathode, in certain conditions can make the steel produced anodic passivation to reduce the corrosion rate of steel^[3]. Also the copper and steel combined together as Cu₂S passivation on the surface of the steel, electrochemical reaction to inhibit the anodic reaction and cathodic, alleviate the sulfuric acid dew point corrosion. The copper content is generally at 0.20%~0.50%, avoiding the excessive adding generate the cracks on the surface of the plate. The element of Ni, the proportion of Ni/Cu is 1/2~1/3, can produce copper and Ni compounds, in order to reducing the effect of copper brittleness.

The Chromium element can refine the grain size, improve heat resistance and high temperature oxidation resistance of steel, and reasonably match with copper and sulfur in steel, which can significantly improve the corrosion resistance of steel^[4]. Research data show that in the third stage of corrosion, the optimal content of Chromium is about 1%, because of the effect of passivation tendency, so as to improve the corrosion resistance ability.



The causes of Antimony can improve the corrosion resistance is complex. It has been reported that Antimony can form thin films of Cu_2S or Sb_2S_5 on the steel surface. These thin films prevent the electron transfer, and increase the corrosion resistance^[5].

3. Working condition of Q315NS

The slag temperature is above $1000\text{ }^\circ\text{C}$, and the slag is quenched by water. During this process a lot of steam will be produced. The environment of slag treatment workshop is a weak acid Chloride, The concentration of Chloride ion is 0.14% in the pool. Q315NS is used in the position of the condensing tower of the slag workshop. With the decrease of steam temperature, the steam will condense. The chemical composition of water is as Table1.

Table1. The chemical composition of water

Items	Pool water	Condensate water
pH	6.13	6.32
Electric conductivity (uS/cm)	5150	2900
Hardness of water (mg/L)	2029.8	2185.9
Alkalinity (mg/L)	40	40
Chloride ion (mg/L)	1420	213

And Figure1-Figure3 show actual working environment of the Q315NS.



Figure 1. Working environment



Figure 2. Working environment



Figure 3. Working environment

4. The composition design and process control of Q315NS

The main alloys for Acid resistant steel are Cu, Cr, Ni, Sb and other alloy. Reasonably addition of these alloy can effectively reduce the corrosion rate of steel. The addition of different alloying elements will bring difficulties to the manufacturing process at the same time, for example, the addition of copper elements will easily cause the surface quality of steel plate, so we must design a reasonable process route to ensure the performance of the steel plate to meet the standard requirements.

4.1 The composition design

The Q315NS composition is designed as low carbon series alloy steel due to various factors such as comprehensive performance and acid resistance. The main alloy elements are C, Mn, Ni, Cr, Cu and Sb elements. The specific components are designed as following Table2:

Table2: The alloy elements design

C	Si	Mn	P	S	Ni	Cr	Cu	Ti	Sb
0.03%~0.1%	0.3%	0.8%	0.01%	0.004%	0.1%~0.3%	0.5%-1%	0.1%~0.3%	0.01%~0.03%	0.1%~0.2%

4.2 Heating process

Acid resistant steel Q315NS contained Ni, Cu, Cr alloy. It is easily to generate iron oxide skin, probably make serious oxidation during the heating process. The heating temperature of the slab should be guaranteed to be as low as possible under the condition of sufficient heating, and the setting temperature is 1180 °C.

4.3 Rolling process

The TMCP process is used in the rolling. Because of the melting point of copper is 1080 °C, the copper in the rough rolling stage is melted. Therefore, it is necessary to avoid the excessive pressing of the rough rolling stage to avoid the crack. The maximum press amount of the rolling process is no more than 10%. With water cooling after the rolling process, the grain refinement is realized, and the strength is raised properly. The final cooling temperature is set as 580°C.

5. Microstructure and properties of steel

5.1 The Microstructure of Q315NS

The microstructure of Q315NS is mainly composed of Ferrite and a few Pearlite. The Metallographic structure basically accord with the setting organization because of the good performance for corrosion resistance of Ferrite. The Metallographic structure show as Figure4-Figure8. The precipitate analysis of grain boundary position showed that no Sb element precipitates were found, indicating that Sb elements can be dissolved in grains well without enrichment, and it can improve the corrosion resistance ability of the steel. The precipitate detected result show as Table3.

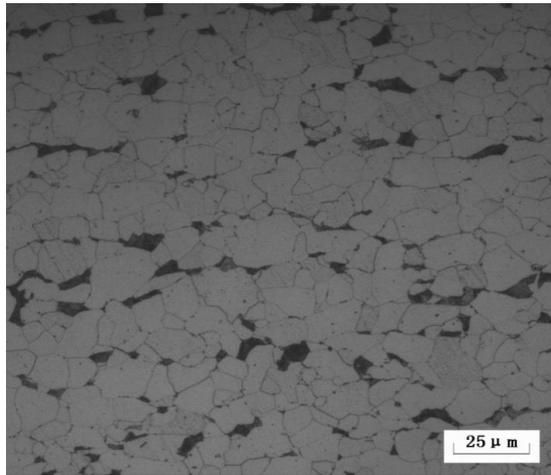


Figure 4. Metallographic structure of Q315NS.

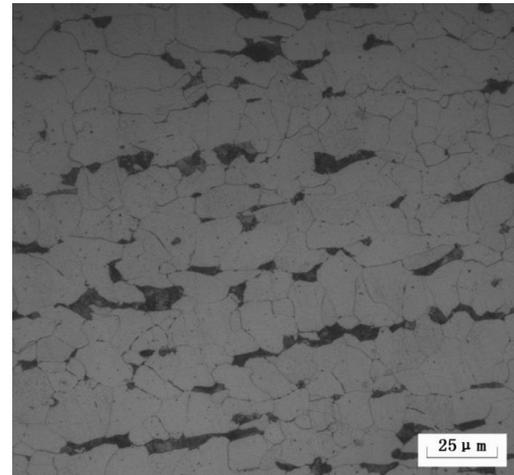


Figure 5. Metallographic structure of Q315NS.

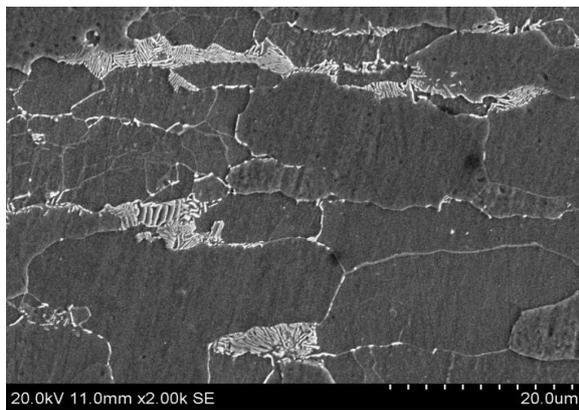


Figure 6. Metallographic structure of Q315NS.

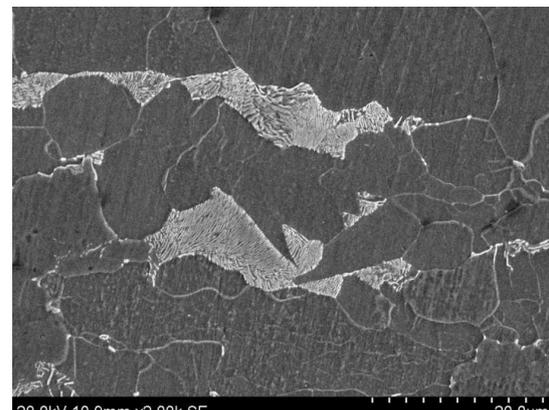


Figure 7. Metallographic structure of Q315NS.

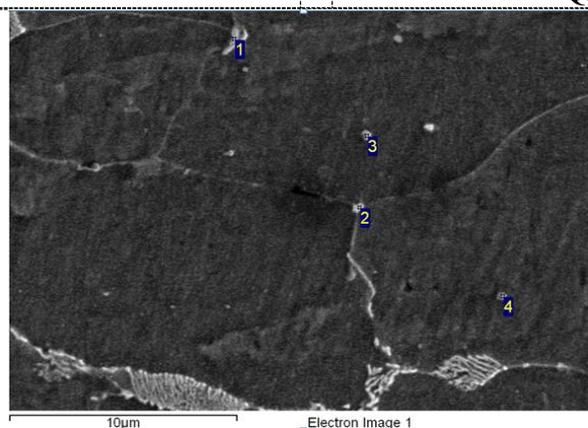


Figure 8. Metallographic structure of Q315NS.

Processing option: All elements analysed (Normalised)

Table3: The precipitates of alloy elemnet

Spectrum	In stats.	C	Si	Cr	Fe	Total
1	Yes	6.68	0.75	0.84	91.74	100.00
2	Yes	5.74		1.05	93.21	100.00

3	Yes	4.76		95.24	100.00
4	Yes	4.13	1.15	94.71	100.00
Max.		6.68	0.75	1.15	95.24
Min.		4.13	0.75	0.84	91.74

All results in weight%

5.2 The properties of Q315NS

The property of 21 plate steel is detected, and the Strength and Elongation of all the plate is qualified. The property show as Table4

Table4: The property of the strength

	Yield Stress/Mpa	Tensile Strength/Mpa	Elongation %
Min	340	443	24.5
Max	434	503	36.5
Ave	382.1	467.9	31.2
Standard	315	440	22

The tensile strength of the tensile strength is low. In the following production, the cooling stop temperature should be set lower. And the content of C should be higher.

6. Test results of acid resistance

The acid resistance test was carried out after the steel plate is produced. The sample size is: Thickness * Width * Length = 40mm * 25mm * 50mm. The condition of the test is 70 °C, 50% of sulfuric acid solution. The setting eroded time is 6 hours, then weightlessness is measured. The experimental results show that the relative weight loss rate of Q315NS is 14.27% of the common carbon steel Q235B. The test result shows as Table5.

Table5: The result of acid resistance test

Steel grade	Sample	Time(h)	Weight (g)	Weight lost (g)	Corrosion rate(g/m ² .h)	Relative corrosion rate(%)
Q295NS	1	6	34.8930	2.6700	145.3317	17.29
Q315NS	2	6	36.8450	2.2210	119.9080	14.27
Q235B	3	6	11.4660	14.5070	840.3820	100

7. Conclusion

- The effect of common adding elements in corrosion resistant steel is analyzed. The elements in acid resistant steel is designed as Ni, Cr, Cu, Sb and so on.
- The rolling and cooling process was designed, and 21 steel plate is produced, and the physical properties is qualified.
- The Metallographic structure of steel plate is analyzed and the element segregation was detected, and the segregation of elements such as Sb and Cu is not detected.
- The acid resistance of the sample was tested. Compared with the conventional steel plate, the corrosion loss was 14.27% of Q235.

References

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