Defect Analysis of Hot Rolled Strip Q345BTube Flat Strip

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Abstract: This article has found out the causes of defects through the tracking and analysis of flat strip defects, the microhardness, mechanical properties and metallurgical structure of the tube, and adopted a series of measures to reduce the occurrence of supercooled microstructure and uneven performance of the steel plate Low manganese Q345B production process system.

1. Introduction

1.1 Overview of Q345B

Tonggang Co. uses thin slab continuous casting and rolling lines to produce Q345B hot-rolled strip steel. The process flow is: blast furnace molten iron → magnesium-based molten iron pretreatment (high molten iron sulfur content) → top-bottom double-blown converter (120t) → LF furnace refining → FTSC Thin slab continuous casting machine → roller hearth furnace → rough rolling (R1-R2) → finishing rolling (F1-F5) → laminar cooling → underground coiling machine. The size of the strip steel ordered by the customer is 4.65 ~ 7.5 × 1500mm.

1.2 Description of Platform Defects

During the manufacturing process, the platform area appears along the length of the steel pipe, which makes the circumferential out-of-roundness severely out of tolerance [1]. In severe cases, it can be directly observed by the naked eye and is called the “pipe plane” defect. The steel pipes are connected by wire buckles, and the out-of-roundness causes the wire buckles to be out of tolerance, and even the entire steel pipe is scrapped. Welded pipe users report irregular platform defects during the coiling process. This defect occurred before welding and was not caused by welding. The welded pipe adopts the high-frequency straight seam welding (ERW) process. The main processing process includes raw material inspection → Kaiping → edge trimming → slitting → looper → welding molding → calibration → heat treatment → weld inspection → final inspection → anti-corrosion treatment → packaging . Cut a section of the defective steel pipe of the platform. This section of steel pipe is not a finished product and has not been heat treated. The specification of the steel pipe is 150 * 5mm, and the macroscopic appearance of the defect is shown in Fig.1.

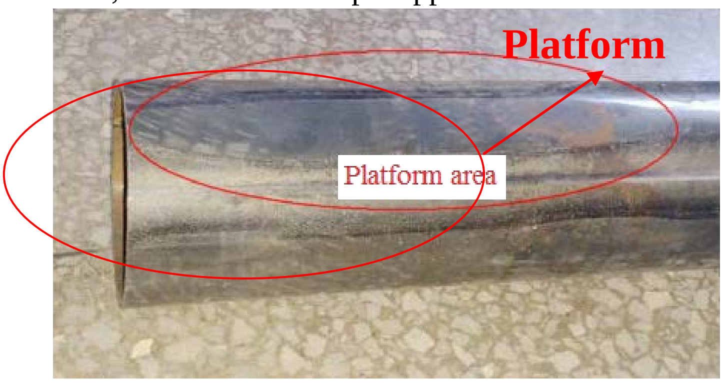


Fig.1 Macroscopic Appearance of the Flat Strip

2. Sample preparation and inspection results

2.1 Sample Preparation

Sampling problematic steel pipes for composition, mechanical properties, hardness, and tissue analysis. The2 and 4 # samples are in the transition zone of the flat belt, the 3, 6, 7 # samples are completely on the flat belt, and the 1 and 5 # are on both sides of the flat belt. The sampling location is shown in Fig. 2.

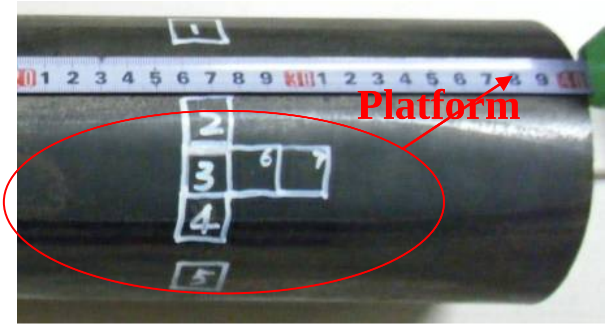


Fig.2 Sketch of Sampling Position

2.2 Test Results

The composition and mechanical properties of the samples were tested. The specific results are shown in Table 1 and Table 2 respectively.

Table 1 Chemical Composition Table

Sample Number	Elements	C	Si	Mn	P	S	Alt
1#	content%	0.19	0.25	0.75	0.012	0.005	0.022
2#		0.20	0.24	0.78	0.014	0.006	0.023
3#		0.19	0.24	0.77	0.010	0.005	0.024
4#		0.193	0.24	0.77	0.012	0.004	0.020
5#		0.195	0.26	0.73	0.011	0.005	0.024

Table 2 Mechanical Properties

Sampling location	Yield strength($Rt_{0.5}$)MPa	Tensile strength MPa	Elongation %
Flat zone 1	535	607	21.8
Flat zone 2	524	589	23.7
Normal zone 1	485	566	25.6
Normal zone 2	492	574	24.1

The test results show that the chemical composition of the flat zone and the normal zone are the same, and there is no change. The yield strength and tensile strength of the pipe are obviously higher and the elongation is lower. Among them, the yield strength is about 30MPa higher than the normal level, the tensile strength is about 20MPa higher than the normal level, and the elongation rate is about 1.5% lower than the normal level.

The Vickers hardness HV10 of samples 1 # and 3 # is shown in Table 3. Microhardness HV0.1 of sample 1-5# is shown in Table 4.

Table 3 Vickers Hardness Hv10

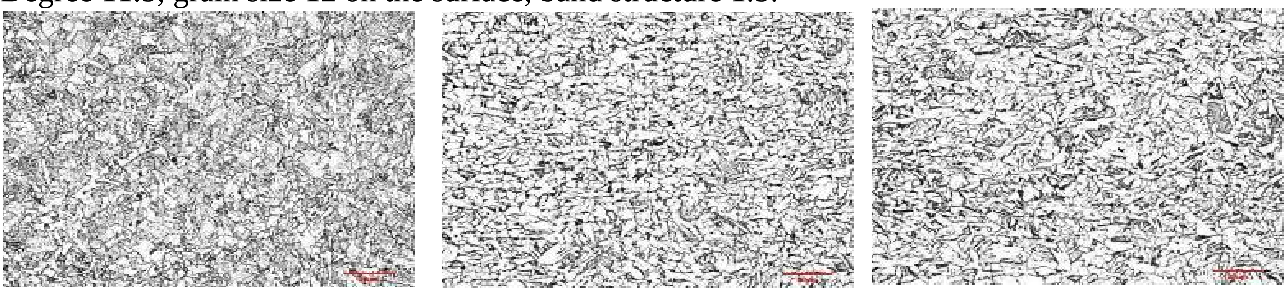
Hardness value	Point 1	Point 2	Point 3	Average
Normal zone sample	192	194	192	192.7
Platform zone sample	240	236	241	239.0

Table 4 1-5 # Microhardness Hv0.1

Sample Number	Point 1	Point 2	Point 3	Average
1# Sample	204	228	213	215
2# Outside arc	217	214	211	214
2# Inside arc	224	228	221	224.3
3# Sample	239	284	256	259. 7
4# Inside arc	239	241	234	238
4# Outside arc	241	187	232	220
5# Sample	214	210	223	215. 7

It can be seen from the table that whether it is Vickers hardness or micro hardness, the hardness of the flat strip sample is significantly higher.

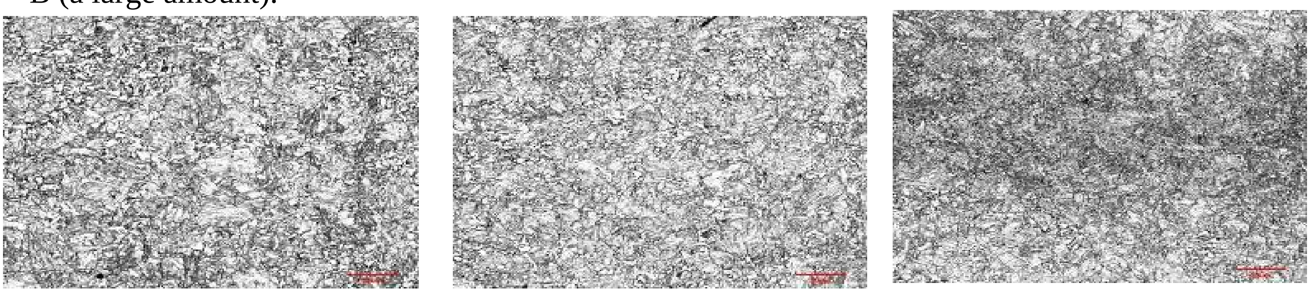
1 # metallographic structure is shown in Fig.3. The normal part, surface part and 1/4 place are F + P, the thickness center is F + P + B (a small amount), and the thickness is 1/4 and the center grain Degree 11.5, grain size 12 on the surface, band structure 1.5.



a.Surface b. 1/4 Thickness c. Thickness center

Fig.3 Metallographic Structure of Normal Parts

The metallographic structure of sample 3 # is shown in Fig.4. The structure of the surface and 1/4 thickness of the defect site is F + P + B, and the structure at the center of the thickness is F + P + B (a large amount).



a.Surface b. 1/4 Thickness c. Thickness center

Fig.4 Metallographic Structure of the Defect

3. Analysis and Discussion

From the inspection results, the chemical composition, grain size and band structure of the flat area and the normal area are basically the same, and there is no difference, indicating that the problem is not related to these items. However, the organization of the flat area is quite different from that of the normal area. The content of bainite in the flat area is significantly higher.

In the production of Q345B, in order to ensure high-strength finish rolling, non-recrystallization control is adopted, and the front-end strong cooling mode is used for cooling. According to the composition design and cooling process of Q345B, the coiling temperature is set to be slightly higher than the bainite transformation start temperature, the laminar cooling rate v_c is greater than the bainite transformation critical velocity v_p, making the normal coil structure F + P. Under ideal conditions, the CCT curve of Q345B hot rolled coil is shown in Fig 5. During the actual laminar cooling process, the plate has a temperature gradient along the thickness direction. From laminar cooling to coiling temperature measurement point, there is a dynamic equilibrium process in the thickness direction of the sheet. In this case, the actual cooling rate v_c of the surface of the plate will be greater than the ideal state, and the cooling end temperature is also lower than the coiling temperature, so the surface area of the plate will likely produce bainite structure [2]. Impact is shown in Fig 6.

The cooling rate is too fast [3] easy to form low-temperature product bainite or martensite, so that the steel plate is too strengthened. The uneven content of bainite or martensite results in the coexistence of soft and hard tissues, and it is easy to form flat, flat areas during the tube rolling process[4,5]. In addition, the strong cooling at the front end causes the cooling water to concentrate on the steel plate. After the cooling, the cooling air will not blow it off completely. The cooling water on the transmission side of the steel plate is significantly more than the working side. The flat band of the coil tube coincides with a high probability of appearing on the side of the width of the steel coil.

Through the analysis of the defects of the flat belt, three improvement measures have been taken:

1) While stabilizing the Mn content at 0.75%, increase the Ti content between 0.03-0.05% to ensure the strength and plasticity of the steel plate.

2) Reduce the final rolling temperature to 850 ℃ and adopt the uniform cooling mode. The speed of 5.0mm plate is reduced from 5.0m / s to 4.18m / s, the cooling time is extended by 1.7s, and the cooling water is increased by 2 ℃to prevent the plate from cooling. The speed is too fast to avoid hard phase organization.

3) Strengthen the wind blowing device to eliminate the residual cooling water on the surface of the steel strip and reduce the performance fluctuation caused by the accumulated water.

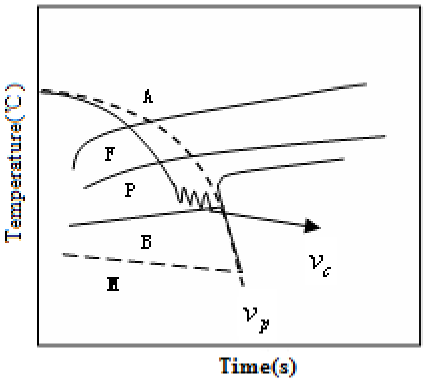


Fig.5 Normal Production

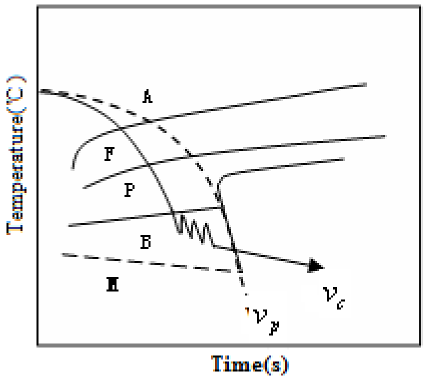


Fig.6 Effect of Large Cooling Rate on the Surface

4. Conclusion

Through the analysis of the Q345B hot rolled strip samples produced by the thin slab continuous casting and rolling line, the following conclusions are drawn:

(1) The flat area of the steel pipe is 30-40 MPa higher in yield strength than the normal area, and the Vickers hardness HV10 is 40 greater than the normal area, which is the direct cause of the flat band of the pipe body.

(2) The bainite structure in the flat zone is obviously more than the normal zone, which is related to the uneven cooling strength of the strip during the cooling process.

(3) The coiling process uses a uniform cooling mode to reduce the cooling strength of the steel strip, increase the plasticity, and improve the cold forming performance.

(4) Strengthen the wind blowing device, rationally design the blowing angle, reduce the retention of residual water on the surface of the steel strip, stabilize the coiling temperature, and make the coil performance more uniform.

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