

# Study on the process control of AH36 high strength ship plate

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**Abstract.** There are amounts of surplus in the performance of A 36 high strength ship plate at present. The optimal control of smelting process and method of controlled rolling and controlled cooling parameters was used to in order to higher the efficiency on the basis of statistical analysis of production data of A36 high strength ship plate. The influence of the content of Nb reduced and the content of C and Mn controlled on the performance of A36 high strength ship plate was investigated. The result show that the content of Nb can reduced by the optimization of the composition A36 using the lower plate finishing rolling temperature and rolling red temperature limited which is stability controlled at process parameters. The cost of A36 high strength ship plate is reduced and the performance can meet the requirements.

## 1. Introduction

Energy saving, green production has become a trend, in the nine elements of high strength ship plate index meets the ship regulation under the condition of statistical analysis of AH36 plate of high strength ship plate performance, reduce the amount of the substitute alloy, precious alloy, and through smelting and rolling process optimization [1-4], to ensure good mechanical properties of the plate at the same time, but also can to reduce the production cost of ship. Therefore, this study through the control of smelting of AH36 high strength ship plate steel Gao Jie, clarity, shape and size of inclusions, the metallurgical quality of continuous casting billet; optimization of high strength ship plate cold rolling rolling process, obtained the good ship type, performance and surface quality.

## 2. Comparative analysis of the statistical properties of AH32 steel and the requirements of high strength ship agency

Now AH36 high strength ship steel performance and the requirements of classification performance comparison and analysis are shown in Table 1, the thickness of plate is less than or equal to 25mm AH36 yield strength margin of more than 40MPa accounted for 91.94% of the amount of surplus, the tensile strength above 40MPa accounted for 59.05%, the elongation amount of surplus more than 4% accounted for 91.82% of the impact energy, the proportion of rich margin of more than 40J 98.08%. Plate thickness more than 25-38mm A36 yield strength 40MPa above the amount of surplus accounted for 94.23%, the tensile strength margin above 40MPa accounted for 36.69%, the elongation amount of surplus more than 4% accounted for 95.72% of the impact energy rich margin of more than 40J accounted for 99.81%. As shown in Table 2, statistics on AH36 actual components according to the yield strength margin, yield strength of the surplus is less than 40MPa, 40-80MPa, 80MPa, the composition of control, average [C] = 0.14 - 0.15 %, [Si] = 0.30 %, [Mn] = 1.26 % - 1.30 %, [Als] =



0.020 % - 0.021 %, [Nb] = 0.023 %- 0.024 %. A large amount of surplus, you can optimize the performance of AH36.

**Table 1** The performance analysis of AH36 rolling ship

standard(mm) (Total batch)	Surplus yield (MPa)	Tensile surplus(MPa)	lot number	proportion	Extend surplus (%)	lot number	proportion	Impact surplus(J)	lot number	proportion
	≤40	≤40	2134	40.95%	≤4	426	8.18%	≤40	100	1.92%
8-25 (5211)	>40- 80	>40-80	2981	57.21%	>4-8	3011	57.78%	>40-80	341	6.54%
	>80	>80	96	1.84%	>8	1774	34.04%	>80	4770	91.54%
	≤40	≤40	340	63.31%	≤4	23	4.28%	≤40	1	0.19%
25.5-35 (537)	>40- 80	>40-80	192	35.76%	>4-8	216	40.23%	>40-80	11	2.05%
	>80	>80	5	0.93%	>8	298	55.49%	>80	525	97.76%

**Table 2** The component analysis of AH36 rolling ship

specifications	Surplus yield(MPa)	chemical composition %													
		C			Si			Mn			Als			Nb	
		Min	Max	Av	Min	Max	Av	Min	Max	Av	Min	Max	Av	Min	Max
AH36	≤40	0.12	0.18	0.14	0.2	0.40	0.30	1.18	1.41	1.26	0.009	0.039	0.020	0.020	0.029
8-25mm	>40-80	0.12	0.18	0.14	0.2	0.40	0.30	1.15	1.50	1.27	0.008	0.071	0.020	0.017	0.035
5211	>80	0.12	0.18	0.15	0.2	0.40	0.30	1.15	1.53	1.29	0.008	0.045	0.020	0.017	0.035
AH36 26-	≤40	0.13	0.16	0.14	0.2	0.30	0.30	1.18	1.40	1.26	0.014	0.034	0.021	0.020	0.027
36mm	>40-80	0.12	0.18	0.14	0.2	0.40	0.30	1.15	1.53	1.28	0.009	0.069	0.021	0.020	0.033
537	>80	0.12	0.18	0.14	0.2	0.40	0.30	1.21	1.53	1.30	0.009	0.069	0.021	0.020	0.033

### 3. Experimental results and analysis

#### 3.1. Control of production process and related technical parameters

Through the performance analysis and optimization of composition, formulate the corresponding optimization test scheme, the specific parameters are as follows: AH36 high strength ship steel smelting, composition, Mn from 1.28% to 1.35%, Nb from 0.025% to 0.015%, the target of smelting cost can be reduced by 29.5 yuan / ton; In the rolling process, the final rolling temperature was reduced by 10 ~30 / C, according to the thickness of the steel plate, and the upper limit of the return temperature was reduced by about 20 DEG C. The first batch of smelting process control strictly according to the Nb component smelting, the average Mn content of 1.28%, the average Nb content of 0.015%, in line with the smelting target, the specific composition of Table 3 shows.

**Table 3** The control composition of AH36 down cost performance optimization test smelting

batch number	C%	Si%	Mn%	P%	S%	Als%	Nb%
20907416	0.15	0.24	1.24	0.026	0.013	0.014	0.016
20408887	0.14	0.25	1.27	0.017	0.012	0.02	0.016
20408888	0.14	0.26	1.28	0.007	0.005	0.028	0.015
20907435	0.15	0.26	1.27	0.015	0.008	0.019	0.017
20907436	0.15	0.26	1.35	0.017	0.014	0.029	0.018
20907438	0.13	0.23	1.32	0.021	0.007	0.021	0.013
20408910	0.14	0.24	1.26	0.027	0.014	0.021	0.015
20408911	0.14	0.26	1.27	0.021	0.008	0.025	0.015
20805508	0.13	0.22	1.29	0.022	0.006	0.013	0.015
20703723	0.15	0.24	1.3	0.019	0.014	0.022	0.014
20408981	0.13	0.23	1.27	0.021	0.012	0.024	0.014
20409026	0.16	0.25	1.19	0.018	0.011	0.012	0.016
20907604	0.14	0.27	1.29	0.016	0.006	0.036	0.016
20907605	0.15	0.28	1.27	0.024	0.006	0.024	0.015
20805614	0.13	0.08	1.37	0.044	0.023	0.002	0.013
20409100	0.15	0.28	1.29	0.022	0.007	0.023	0.018
20409101	0.15	0.26	1.28	0.022	0.009	0.023	0.017
20409157	0.14	0.24	1.30	0.021	0.006	0.023	0.015
20907662	0.16	0.26	1.30	0.019	0.01	0.020	0.015

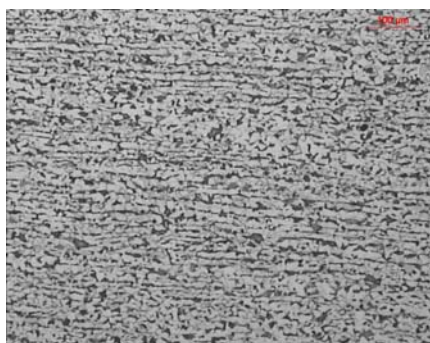
### 3.2. The performance of AH36 high strength ship after optimization

The first test in rolling plate mill in wire plate, rolling down Nb AH36 ship a total of 9 batches of 73 pieces of 222.487 tons, the rolling thickness is 8mm, 10mm, 20mm, performance inspection of finished products have reached the requirements. The average yield of 8mm steel plate is 57Mpa, the average amount of tensile strength is 58Mpa, the average amount of elongation is 8%, the average amount of impact energy is 48J; 10mm steel plate yield strength average surplus amount of 46.5Mpa, the average tensile strength of surplus 63.5Mpa, the average rate of elongation of 7.5%, the average amount of impact energy surplus 68J; 20mm steel plate yield strength average surplus amount of 50.5Mpa, the average tensile strength of surplus 46Mpa, the average rate of elongation of 6%, the average amount of impact energy surplus 194J. The specific performance is shown in Table 4.

**Table 4** The performance of AH36 test plate for reducing cost performance optimization

batch number	thickness (mm)	Yield strength (Mpa)	Tensile strength (Mpa)	Extensibility (%)	0°C impact of collision (J)			cold bending
2YA03886	8	406	542	29.5	75.9	74.5	72.4	qualified
2YA03887	8	430	551	32	72.8	64.5	66.6	qualified
2YA03888	8	401	551	26	67.6	73.8	67.9	qualified
2YA03889	10	400	552	29	97.6	75.5	104	qualified
2YA03890	10	403	555	28	98.4	95	110	qualified
2LB04437	20	405	536	26.5	205	250	200	qualified
2LB04438	20	405	538	29.5	233	218	229	qualified
2LB04439	20	413	541	25.5	246	232	244	qualified
2LB04440	20	399	530	26.5	206	225	253	qualified

The AH36 plate is optimized by sampling, 4% nital etching after the optical microscope observation of microstructure, as shown in Figure 1 (1/4) by tissue. The matrix microstructure is ferrite and pearlite, microstructure, grain is fine, and the grain size is 10.



**Fig. 1** The microstructure of AH36 drop cost performance optimization test steel plate

After the optimization of AH36 drop Nb, the pilot scheme was converted to the product process specification, and the following adjustment was made on the basis of the original A36 process specification: Reduction of Nb (-0.010%), Mn (0.07%), lower trim plate finishing temperature (-10~30 DEG C) and red temperature limit (-20 C). A36 ship parameters and stability control of subsequent production, the performance of all qualified, the total production of A36 reduced Nb ship a total of 3839 tons, the cumulative drop of 113 thousand and 300 yuan.

#### 4. Conclusion

In the plate by composition in smelting fine C, Mn, down Nb, rolling on the lower plate finishing temperature and red temperature limit, process parameter control stable performance can meet the requirements, to achieve high strength ship plate AH36 performance optimization to reduce costs. According to the degree of improvement of the performance of different alloy plate, to increase the cheap alloy addition amount, reduce the precious alloy, and optimizing smelting and rolling process, which can ensure the good mechanical properties of the plate, but also can reduce the production cost of shipbuilding, improve the level of production technology and resource utilization, has an important significance for the development of circular economy the iron and steel enterprises and sustainable development.

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