THE DEVELOPMENT OF NB-V MICROALLOYED STEEL PLATE

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ABSTRACTS

In order to manufacture the large construction machine, mine hydraulic pressure bracket a type of heavy plate with 450MPa higher yield strength has been investigated and developed in Jinan Steel, which is delivered after TMCP rolling. The plate is designed as microalloyed containing Nb , V and Al. The steel is refined by ladle furnace, which has higher strength, excellent low temperature toughness and good weldability. More than 60 thousand tons of this high strength steel plates have been successfully produced and used in the manufacture for construction machine, mine hydraulic pressure bracket etc.

KEY WORDS

NbV microalloing, TMCP, heavy plate, LF , control rolling, strength, toughness

INTRODUCTION

Recently the more and more widely application of high strength steel brings about actively research and development on high strength steel. The steel plate with yield strength above 450MPa is widely welcomed by many machine customers and is becoming main trend high strength steel for manufacture in construction, heavy and mine machine industry[1] etc. After technology and equipment reconstruction in Jinan Iron and Steel Co. Ltd., process for production of high strength steel was optimized and the steel grade with 590MPa tension strength, named as JG590, was developed. The steel was refined and the chemical composition were adjusted at LF. The lower temperature impact toughness of steel plate can be combined well with its higher strength and good weldability at the same time. The high strength steel plate JG590 microalloyed with Nb and V was introduced in this article.

1. EXPERIMENTAL MATERIAL AND EXPERIMENTAL

The main chemical compositions of JG590 are (%):C0.12~0.19,Si0.15~0.65,Mn1.10~1.80. Microalloy elements Nb, V and Al were added in steel. The procedure of production are KR BOF CAS LF CCM reheating 20Mpa high press water descaling 4H rough mill rolling 4H finish mill rolling and fine descaling rectification cooling sampling cutting collecting. Heat simulation test, analyzing of stress with strain and CCT drawing were obtained from Gleeble1500 simulator at

University of Science and Technology Beijing. The micro structure and impact rupture were observed through SEM XL30 that made by Netherlands PHILLIP.

2.EXPERIMENTAL RESULTS AND DISCUSSION

2.1 CONTINUOUS COOLING TRANSFORMATION OF NBV STEEL

It is very important to study the CCT curve of steel[2]. The CCT curve of steel can be used to direct research and control for development of new products. Fig 1 indicates the CCT curve of high strength steel contained Nb-V. According to the CCT curve, it is clear that the microstructure can be transform from austenite to ferrite, pearlite and some bainite at 880 finish rolling temperature and 0.5 2.0/S cooling rate. The quantity of bainite will be increased with increasing of the cooling rate of steel plate. The CCT curve of high strength steel contained Nb-V can be applied for establish the reasonable process regulations.

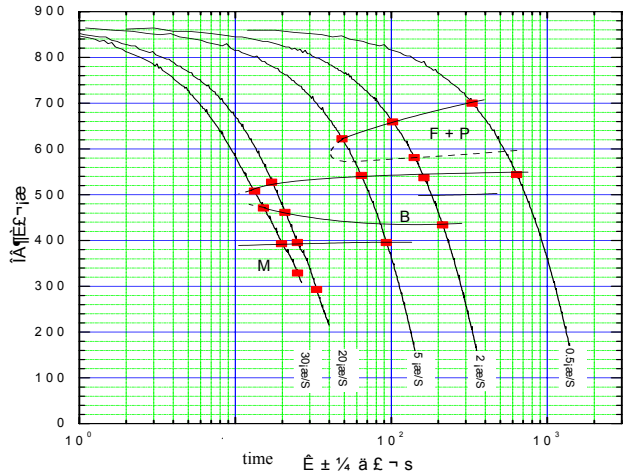

Fig.1 the CCT curve at 880 finish rolling temperature

2.2 TRUE STRESS-TRUE STRAIN CURVE

To study and use the true stress-true strain curve of steel is helpful to design the production process. Fig 2 shows the true stress-true strain curve of NbV steel plate. Compare to Q235 plain carbon steel, the deform stress of high strength steel JG590 is closed to the Q235's under the high temperature deforming condition. The rolling force and torsion is not distinctly increased in fact as shows in Fig3 measured at 880.

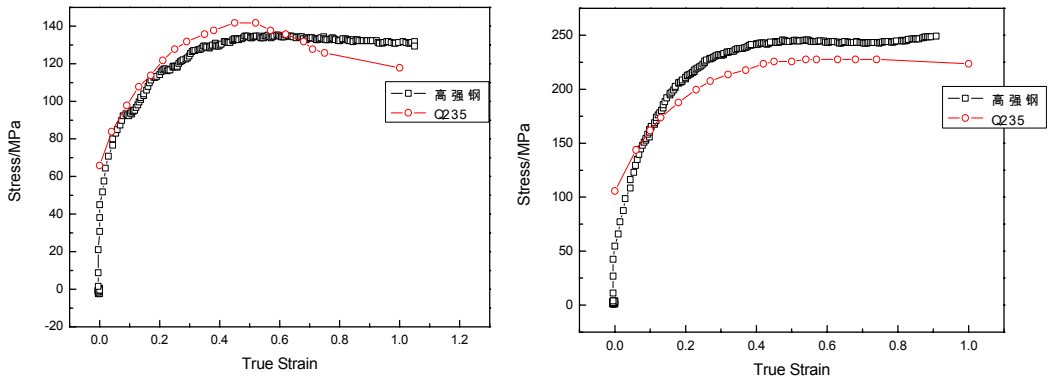

Fig.2 stress-strain curves of JG590 & Q235 at 1100(left)/900 right

These studies and practices have demonstrated that the technology and equipments in Jinan Iron and Steel Co. Ltd. are capable of developing and producing the NbV high strength steel plate.

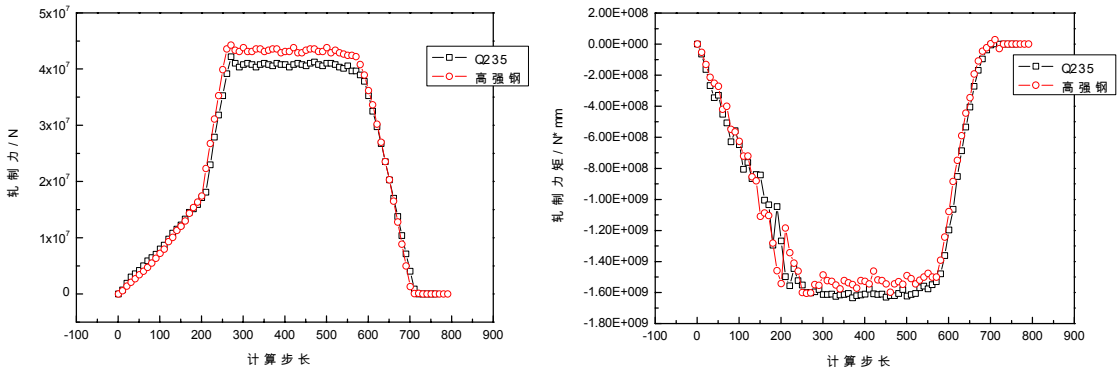

Fig.3 rolling force(L) and torsion(R) of JG590 & Q235 at finish mill

2.3 MECHANICAL PROPERTIES

2.3.1 NORMAL MECHANICAL PROPERTIES

The normal mechanical properties of JG590 and Welten590REB/C[1] are listed in table 1. The lower temperature impact energy of 25~30mm steel plates of JG590 is better than that of 23~25mm steel plates of Welten590REB.

Table 1 compareration of JG590 with Welten590REB/C

grade	specs. mm	Y.S. σs/MPa	T.S. σb/MPa	EL δ5/%	Akv J -5℃ L	bending b=2a 180°
JG590	30	450~530	580~635	17~23	62~148	d=3a
	25	460~535	595~640	17~26	81~182	d=3a
	20	455~550	600~655	18~25	67~145	d=3a
	14	475~540	610~645	18~26	70~118	d=2a
	10	480~565	615~650	18~27	51~78	d=2a
	8	480~540	615~660	18~28	56~81	d=2a
Welten590REB	23-25	≥450	590~710	≥16	0℃≥27	d=1.5a
Welten590REC	6-20	≥450	590~710	≥20	-5℃≥47	d=1.5a

2.3.2DUCTILE –BRITTLE TRANSITION CURVE

The ductile –brittle transition curve is different with different process condition. The ductile –brittle transition curves of 20mm and 30mm thickness steel plates produced with No.1 steel works slabs are showed in Fig.4. The toughness of 20mm steel plate rolled by fine rolling mill is less than 72J

due to lacking of LF or RH refining equipments in No.1 steel works and the slabs contained more sulfur range from 0.017 to 0.032%. When rolling with rough mill only, the transition of steel plates from ductile to brittleness are reduced quickly than that rolled by rough plus fine mills. There are more inclusion in steel. On the one hand, the steel plates are not enough clean is the main cause of their bad toughness. See Fig. 6 SEM photograph. On the other hand, the small deformation or reduction and higher deformation temperature in rough mill only are also harm to the improvement of steel plates' toughness. To the contrary, the toughness of steel plates using the clean slabs of No.3 steel works can be improved greatly. See Fig. 7 SEM photograph .

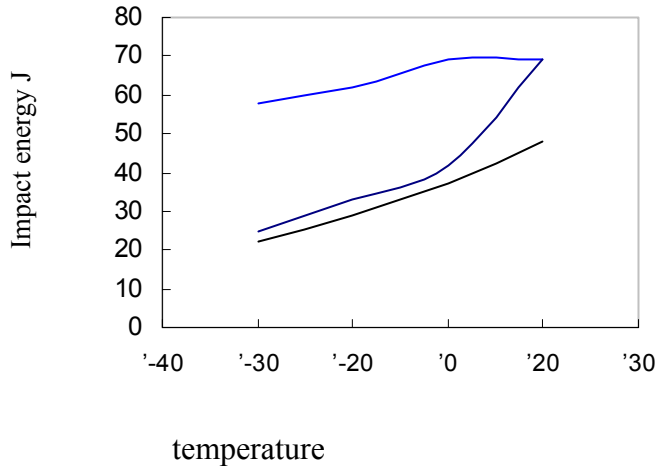

Fig. 4 results of fine rolled(20mm uper)and rough rolled(20/30mm down)

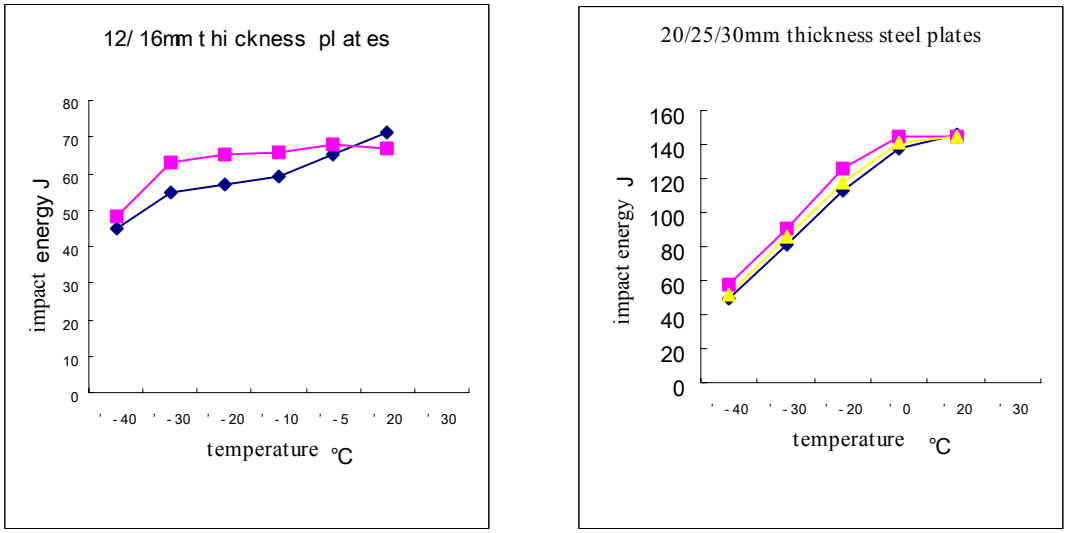

Fig.5 controlled rolling plates toughness used slabs of No.3 steel works

2.4 OBSERVATION OF MICRO STRUCTURE

Fig.6 and Fig.7 show the microstructures investigated by scanning electron microscopy(SEM). There are lots of nonmetal inclusions in the impact ruptureside produced in No.1 steel works which has not refining furnace. The ruptureside of impact samples is brittle structure as showed in Fig.6.

But after the treatment or refined in ladle furnace(LF), steel plates can obtain good lower temperature impact Charp-V-notch energy and there is less nonmetal inclusions as showed in Fig.7 which slabs made in No.3 steel works in Jinan Iron and Steel Co. Ltd. Therefore, it is important and essential to refining molten steel to improve the toughness property of steel plates[1][3].

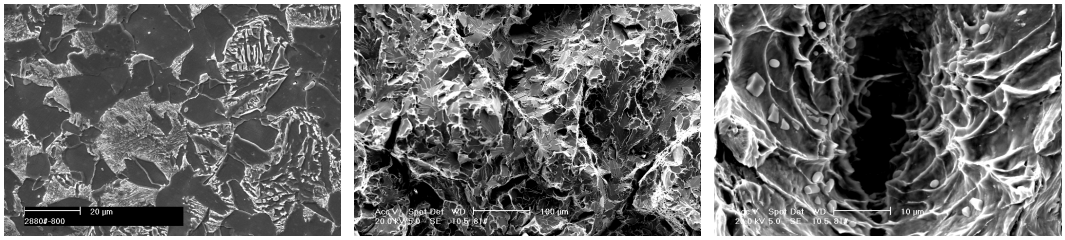

Fig. 6 microstructure and impact rupture inclusions without LF refining (SEM)

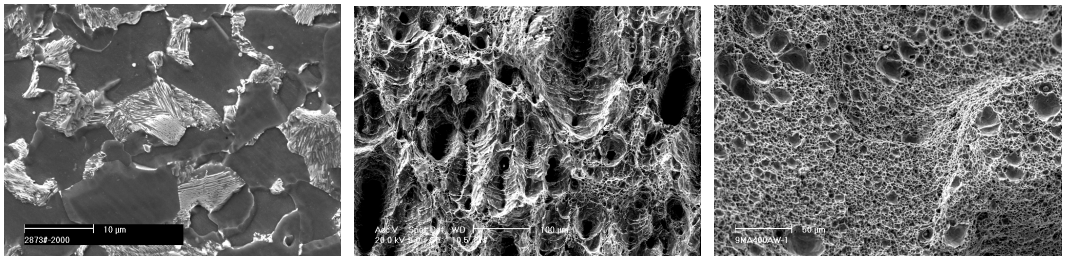

Fig. 7 microstructure and impact rupture after LF refining (SEM)

3. APPLICATION

JG590 high strength steel plates have been applied widely for manufacture of construction machine and mine machine. Fig 8 shows the application case of mine machine and the fork –lift vehicle

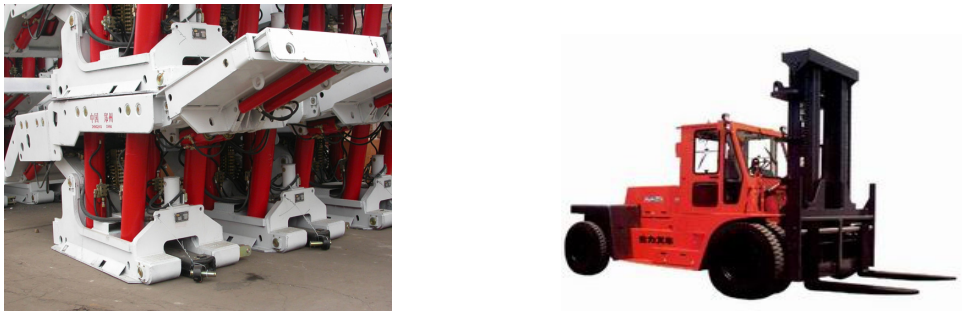

Fig.8 application cases of JG590 high strength steel

4. CONCLUSION

4.1 Treated and refined with LF and controlled rolling ,cooling in air, the fine ferrite-pearlite micro structure can be gained in NbV microalloyed steel plates. The thickness of plate is up to 30mm. The yield strength can be got more than 450MPa with good lower temperature impact toughness. The steel plates can be adapted to mass production.

4.2 The NbV microalloyed steel platesJG590 can be widely used in manufacturing for construction machine and mine machine. The application of this type high strength steel can create a great of economy and social profits.

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