

PRODUCTION AND APPLICATION OF HIGH STRENGTH STEEL

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ABSTRACTS

The rapidly development of modern metallurgy and manufacturing industry break the spacious outlook for manufacturing technique and application of high efficiency materials. The application of high efficiency materials can save lots of materials and create benefits on economy, society and environment. It can promote sustainable development and civilization of all society .

KEYWORDS

high strength steel control rolling application benefits

INTRODUCTION

Human beings has been pursuing the improvement of the social civilization and standards of living and making the manufacturing industry to pursue higher efficiency and the products be made with more functions. Therefore it stimulates more and more higher efficiency materials be produced. The rapidly development of machine manufacturing and steel further treatment industries extremely push the development and application of higher efficiency materials-high strength structure steels. That can make each machine be manufactured lighter and flexible. The works the machine finished can be better and fast. The technique advancement on steel manufacturing, especially the development of microalloy theories combining with control rolling practices, have provided the firm foundation for production of higher efficiency materials-high strength structure steels. The production and application of high efficiency materials can be supplement each other and accelerate the favorable circulation to mankind materials civilization. This paper introduces manufacturing key process and application of JG590 high strength steel.

1. PRODUCTION PROCESS AND TECHNICAL PRACTICE

1.1 TECHNOLOGY PRINCIPLE

The progresses of metallurgy process support the development of higher efficiency materials that combine strength with toughness and weldability. Today, the TMCP process can produce the high strength and toughness steel which could be gotten only by heat treatment in the past. The TMCP process is enough mature to control the better and more uniform properties of steels, the more

friendly with environment and less cost of manufacturing. The high strength structure steel of JG590 can be manufactured with the microalloyed of Nb and V under the reasonable control rolling process in Jinan Steel. The particles of Nb(C, N) can control the coarsening of austenite grains and retard recrystallization of austenite in procedure of rolling and refine the phase transformation structure[1]. Therefore the strength and toughness of steel JG590 can be improved at the same time. The metallurgy objectives of the adaptation between strength and toughness can be achieved with this process.

1.2 CHEMICAL COMPOSITION DESIGN

Table 1 indicates the basic chemical composition of high strength steel of JG590. Nb+V in steel is less than 0.15%. Deoxygenation and fixing nitrogen can be implemented by Al adding.

Table 1 Chemical composition (%)

MARK	C	Si	Mn	P	S	Alt
JG590	0.10~0.18	0.15~0.55	1.20~1.70	≤0.030	≤0.030	≥0.02

1.3 TECHNOLOGY ROUTE

molten iron pretreatment→BOF→LF/VD refine→continuous casting with protection→steel slab finishing→reheating→descale→rough rolling→finish control rolling→rectification→cooling→shearing→checking→storage

The key process is purity of steel, stable composition and reasonable control rolling. The purity and composition of steel are depended on the processes of molten iron pretreatment and steel refinement in ladle. Rolling process is implemented by rough and finish mills separately. The rolling force of finish mill is 70,000KN with the advanced controlling model software. This control rolling process can meet the requirement of heavy deformation under lower temperature. The grain size of microstructure can be controlled finer.

1.4 CONTROL ROLLING PROCESS

When the chemical composition of steel is determined, the microstructure and the properties of steel are determined mainly by the control rolling process. The thickness of slab is 200 and 270mm. There are three control rolling instruction as follow:

Process A. The thickness of finished products is 20mm. The temperature of begin rolling is 1080-1140°C. The thickness of middle slab is 45mm. After cooling, the temperature of begin rolling in finish stage is 900-960°C. The temperature of finish rolling is 800-850°C.

Process B. The thickness of finished products is 30mm. The temperature of begin rolling is

1080-1140°C. The finish rolling temperature is 920-980°C without cooling delay.

Process C. The thickness of finished products are 30 and 20mm. The temperature of begin rolling is 1050-1100°C. The thickness of middle slabs are 70 and 60mm respectively. After slabs cooling, the temperature of begin rolling in finish stage is 930-960°C. The temperature of finish rolling is 840-890°C. The deformation rate is more than 55% in finish stage.

1.5 COMPARISON ON PROCESSES

As show in table 2, we can see ,obviously, the process C is the best process. This process can balance well the strength with toughness of the steel plates.

Table 2 Mechanical properties with different process

Process	Spec./mm	Tensile Test			Impact Test			Bending
		YS/MPa	TS/MPa	$\delta_5/\%$	T°C	Ave	Energy /J	b=2a 180°
A	20	470	600	18	-5	22	21 22 23	d=3a
B	30	450	620	16	-5	8	8 8 7	d=3a
C	20	460	600	20	-5	105	101 107 118	d=3a
	30	455	595	22	-5	140	134 139 148	d=3a
Objective	20/30	430	570	16	-5	27		d=3a

1.6 SELECTED PROCESS

When the chemical composition are given, the Process C is reliable and practicable.

2. APPLICATIONS CASES

2.1 CONSTRUCTION AND MINE MACHINES

The working structures or devices of bulldozers, loader-dozers, fork-lift , ditching machines and crane ,hydraulic bracket are made of high strength structure steel of JG590.

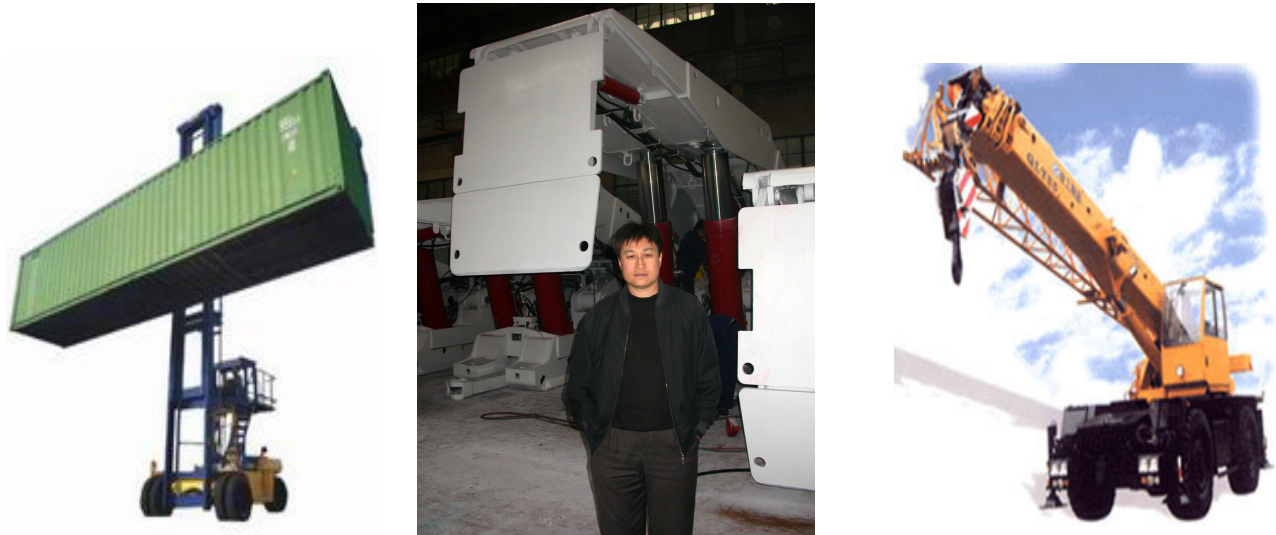


Fig1 Machine Structures made of JG590 high strength steel

2.2 STEEL STRUCTURES

JG590 high strength structure steel can be applied in production and manufacturing of mine machines, industrial buildings and higher layers buildings etc. Fig 1 shows some application cases.

2.3 ECONOMIC EFFECTS

Table 3 shows the material saving results of one high strength steel substituted the other lower strength steel. The benefits is quite a lot.

Table 3 Comparison of cost using different strength welding structure steel

Steel Grade	S335M	S460M (as JG590)
Quantity	1000t	700t
Materials cost , US\$	660, 000	610, 000
Manufacturing fee , US\$	1, 100, 000	875, 000
Anticorrosion fee , US\$	260, 000	260, 000
Construction fee , US\$	175, 000	175, 000
Total cost , US\$	219,500,000	192,000,000
Saving of materials quantity : 30%		
Saving of total cost: 14%		

JG590 is a type of new material for outstanding structure design. The technology security and construction cost must be considered for one outstanding structure design. The size of structure can be calculated according to the transform type and volume of stress. The higher of the materials' yield strength, the less the consumption of the materials. The substitution of carbon steel with JG590 can save materials above 40%. Table 3 shows that it can save materials 30% with yield strength increase from 335MPa to 460MPa (as JG590). The saving of total cost reached 14%.

2.4 SOCIAL AND ENVIRONMENT BENEFITS

The thickness and weight of steel structure can be reduced with the increasing of steel strength. Therefore welding materials can be reduced in terms of exponential rule [2]. The weight of construction and swing can be reduced and the manufacturing fees and the construction time can be saved greatly. The social benefit is enormous.

High strength steel is higher efficiency steel. It can produce enormous environment benefits by substituting the plain carbon steel. Every year, the production of carbon steel plates is about 20 million tons [3]. If it can be substituted by 20%, therefore there are 4 million tons saving for rough steel production. So it can reduce resource wasting about 30.78 million tons, including fresh water 20 million tons and reduce energy consumption 7200GJ. It can reduce the CO₂ emission about 9.2 million tons, liquid waste 12 million tons, waste residue 2.4 million tons. It can not only cut down the consumption of resource, improve living environment, but also reduce consumption of energy, human powers, materials and financial capacity in the procedure of resource developing and transportation. It even can facilitate the utmost improvement of economy and society and the sustainable development.

3. PROSPECTS

3.1 The combining of application of microalloy technology with higher rigidity mill can bring control rolling process sufficiently into play. It is advantageous to manufacture grade 590MPa high strength structure steel of JG590. The deformation must be more than 55% in finish stage and the finish rolling temperature will be between 840-890°C;

3.2 The substitution of the low-grade materials by high-level materials and the improvement of quality and the upgrade of products have become the important way to strengthen the market competition of enterprises. The steel JG590 can be widely used in manufacture of heavy machine, equipment and large steel structures. It can save 23.3-40% materials to take place of low alloy steels and carbon steels. It can reduce the manufacturing cost and create distinct benefits for enterprises;

3.3 The extending and application of higher efficiency materials has the considerable benefits to economy, society and environment. It can meet the requirement of historic trend of sustainable development for whole society.

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