Containing Vanadium and Titanium Steel Research Status and Prospects

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ABSTRACT

Ti, V are very important alloying elements which give full play to the role of grain refinement and precipitation strengthening in the steel. Performance of steel materials can be improved by adding steel. At present, vanadium-containing steel and titanium-containing steel are widely used in various fields. In combination with the characteristics and development of vanadium-containing steel, titanium-bearing steel and Vanadium-titanium microalloyed steel, pointed out that the preparation of vanadium-titanium composite steel material is the direction of future research.

KEYWORDS

Containing Titanium Steel, Containing Vanadium Steel, Vanadium and Titanium Microalloyed Steel

Vanadium and titanium are extremely important strategic resources, in industrial production occupies a considerable proportion. Vanadium has many excellent physical properties and mechanical properties, in the modern industrial technology is widely used, up to 80% to 85% of vanadium used in metallurgical industry additives, with alloying elements to prepare special steel. It is because of the various characteristics of vanadium, making it as an indispensable alloying element for the development of new steel grades. Iron and steel production, most of the vanadium are alloyed to join the steel, can increase the toughness and strength of steel, while improving the corrosion resistance of steel. China has 139 kinds of

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vanadium-containing alloy steel; they are used in automobile, aviation, aerospace, ships, railways, bridges, high-rise buildings, construction machinery and other fields. Titanium can effectively enhance the structural properties of materials, reduce the weight of the material, while increasing the heat resistance and corrosion resistance of the material, but also can improve the toughness and elasticity of the material[1]. Titanium can also be added to aluminum, iron, molybdenum and other elements into the alloy, to create a higher strength of light alloy[2]. There is a wide range of applications in many aspects, especially in aviation, aerospace and other high-tech fields. Titanium in the oil, electricity, chemicals, construction, daily necessities, etc. has been gradually recognized. It is essential to the strategic materials on improving the level of national defense equipment. This text reviews the research status of vanadium steel, titanium steel and vanadium titanium microalloy steel, and prospects its future development.

CONTAINING TITANIUM STEEL

The general argument that: There are two kinds of effects that the titanium added to the steel: Precipitation hardening and grain refinement [3]. The two acts are produced by the precipitation of carbonitrides, nitrides, microalloyed carbides[4]. Because the chemical properties of titanium is more lively, it is easy to react with O, C, N, S and other elements to form compounds[5]. O and Ti have a very strong affinity, only with aluminum fully deoxidized Ti can be added to steel[6]. N and Ti in a higher temperature environment to generate a stable TiN[7], due to the low solubility of titanium, to achieve all aspects of the criteria, it requires titanium content in the steel reach 0.01% to 0.02%[8]. If the titanium content is low, a sufficient volume of TiN can not be used to effectively prevent grain coarsening[9]. If the titanium content higher, will result in the coarse liquid TiN production, meanwhile can not prevent the grain grow, but beyond the Ti / N ideal chemical ratio of Ti, the solid solution in the molten steel or in small TiC particle form Precipitation, then can play a precipitation strengthening effect [10].

Yan Fengyi[11] through the use of transmission electron microscopy, scanning electron microscopy, metallographic analysis. And the role of Ti in steel is analyzed and studied. The result shows that Ti can not only produce Precipitation hardening and grain refinement, but also can produce Ti₄C₂S₂ inclusions in S of molten steel. At the same time, titanium can change the morphology of inclusions in steel, MnS from the strip into a spherical compound inclusions, so that steel processing and molding performance can be improved, solve the high sulfur content of the adverse effects of steel. Liu Qingyou[12] and so on through the metallographic analysis and inclusions analysis found that when the titanium content is greater or equal to 0.11%, Ti and sulfur in the steel completely combined to produce Ti₄C₂S₂, and did not form long strip MnS; but when the titanium content is 0.026 %, there will be part of the Ti₄C₂S₂ production, sulfide morphology has gradually improved. Adding 0.05% to 0.11% Ti in steel can not only precipitation hardening and grain
refinement, but also improve the morphology of inclusions in steel and increase the fatigue and forming properties of the steel.

Titanium is most likely to be precipitated in the molten steel, titanium precipitation will also be affected by the thermodynamic and dynamic role[13]. The solid solubility and free energy formed by the titanium-related compounds yielded the precipitation order of the titanium compound TiN- Ti₄C₂S₂-TiC [14-15]. When the titanium content is low, titanium mostly produces TiN particles. According to the increasing titanium content, Ti has generated Ti₄C₂S₂ and TiC particles. When the content of titanium in the steel is 0.025%, only generated the TiN particles and the strengthening effect is not significant. When the titanium content rises to 0.04%, the TiC particles or Ti₄C₂S₂ are formed in the steel, and the strength of the steel is obviously enhanced. When the titanium levels are increasing, Because of the particles are TiC and Ti₄C₂S₂ that the tendency to increase the strength of steel is slowing[16].

Jiao Lan[17] studied the microstructure and properties of the heat affected zone of the micro Ti pipeline steel, and the addition of a little Ti to low alloy high strength steel and increase the strength of the steel, and the welding performance and cold performance of the steel get a big improvement. Tong Tingting[18] obtained by analysis, when the steel content of titanium is very small, when less than 900 ℃ normalizing, can increase the yield ratio and yield point of steel, steel toughness is not affected. It can be seen that when the ideal ratio of titanium and nitrogen is higher than 4, then the toughness and strength of steel are rapidly declining. Han Xiaoyong analyzed the role of niobium, vanadium and titanium in microalloyed steels. When the heating temperature is higher than 1100 ℃, the carbide having a large specific gravity is incorporated into the austenite. After quenching or normalizing, the strength of steel will be greatly enhanced. Mao Xinping[20] and so on in the thin slab continuous casting and rolling Ti microalloyed steel physical metallurgy characteristics of the study that when the titanium content is 0.04 ~ 0.10%, titanium content increased yield ratio strength, When the titanium is higher than 0.10% or less than 0.04%, has little effect with the yield strength. Master the titanium alloy to join the time and the amount of added O, S, N and other elements of pure steel.

CONTAINING VANADIUM STEEL

There are a lot of alloys on vanadium, and the compounds are made of steel. Vanadium in the steel can play the role of additive effects, it can increase the wear resistance of steel, ductility, strength, heat resistance, toughness and so on. So far its use accounted for 85% of the total amount of vanadium[22]. Vanadium in the superconducting material, cemented carbide, magnetic materials, etc. are widely used[23]. Vanadium added to the alloy, not only can strengthen the alloy steel, but also can be used as deoxidizer. If the steel V is 0.010% ~ 0.025%, the use of molten
iron direct alloying technology, not only can improve the steel production, but also can make the steel required vanadium elements improve, the best economic benefits. If V is 0.025%~0.05%, then only the use of vanadium-containing molten iron directly alloying will not be able to meet the requirements of molten steel; it should be used iron alloying process and vanadium slag alloying can achieve the requirements[24]. Ren Xueyou[25] through the experimental study of a small amount of vanadium into low-alloy steel, the use of grain refinement, phase change and other strengthening methods to increase the strength of steel. Increasing the V by 0.01% V, the yield strength will increase by 12.5 MPa relative to the hot rolled bars. In order to improve the hardenability of steel can be added to the austenite vanadium, vanadium can also improve the tempering stability of hardened steel, so as to achieve secondary hardening.

Vanadium can be added into the steel form the alloy steel, tool steel, carbon steel, structural steel[26]. Liu Xinggan[27] by studying the application of vanadium in steel, in terms of structural steel, due to the addition of vanadium fixed free nitrogen in steel, vanadium combined with nitrogen eliminate the steel of the aging tendency, so that the presence of nitrogen in steel More favorable. Kang Zhuo[28] through the hard-line steel vanadium nitrogen micro-alloying and controlled rolling and cooling technology research, the result shows that when the vanadium dissolved temperature is low, vanadium in the normal heating temperature in the solid solution in the steel. Yin Yunyang[29]studied the effect of isothermal treatment on the microstructure of VN steel after a large number of experiments. The results show that the vanadium carbonitride is easy to precipitate and not only in the high temperature austenite precipitated, To prevent the growth of austenite grains to accelerate the position of ferrite nuclei, and in the low temperature conditions can be precipitated ferrite, the intra-crystal ferrite nuclei increased, so that the ferrite grain refinement.

Vanadium is the most inexpensive microalloying element. During the microalloying process, nitrogen does not have to be removed from the steel. Nitrogen is more economical than alloying elements. Nitrogen not only forms vanadium nitride in steel, but also precipitates with vanadium to achieve the best. The presence of a large amount of nitrogen can enhance the supersaturation of the ferrite so that the V (C, N) particles can be nuclei faster, the distance between the particles becomes shorter and the precipitation effect is enhanced. because vanadium makes nitrogen is known as the most harmful impurities, and now become a useful economic benefits of good alloying elements, which is unique to vanadium characteristics[30]. In recent years, he characteristics of vanadium microalloying have been extensively studied, and the vanadium microalloying of high temperature recrystallization controlled rolling has been gradually recognized and applied. Especially in the steel industry, now is also vigorously developing vanadium microalloyed steel, and in this regard has achieved very good economic benefits.
VANADIUM AND TITANIUM MICROALLOYED STEEL

Because vanadium and titanium elements alone in the role of steel is relatively limited, is now beginning to increase the interaction of vanadium and titanium research. In the steel through the composite interaction of vanadium and titanium, can enhance the grain coarsening temperature of steel, The rate of coarsening of the grains after deformation is reduced, recrystallization temperature decreased, so that the austenite recrystallization temperature range, Can be used as high-temperature austenite area of recrystallization control rolling, in the economic aspects have the advantages[31]. The total amount of alloying elements is less than 0.1% is microalloyed steels, and now widely used microalloying elements are vanadium, titanium, niobium, etc.[32] These microalloying elements can be combined with nitrogen, carbon and carbon oxides in the steel to achieve precipitation enhancement and inhibition of grain growth by low temperature precipitation and high temperature dissolution in various environments[33]. Hirosh Tamihiro [34] and others began to study vanadium, titanium, niobium and other micro-alloying elements in the role of steel mechanism. The results are as follows: precipitation can be produced at lower temperatures, which can hinder grain growth after recrystallization and recrystallization, and can inhibit the growth of the original austenite during heating [35].

Du Shekui[36] analyzed the microstructure and properties of high strength plastic low carbon vanadium titanium microalloyed steels by using experimental studies. Obtain the vanadium-titanium alloying can be used to improve the thermostability of precipitated particles and overcome the difficulties in the performance fluctuation .It provides a theoretical reference for industrial production. Li Jian [37] and so on put the vanadium and titanium micro-alloying elements into the steel, the use of controlled rolling and cooling process, so that it can make precipitation and refinement of grain action to play more obvious, which can improve the strength of steel to reach the best overall mechanical properties. Liu Gang made use of vanadium, titanium, niobium and other alloy elements of the physical characteristics of advanced production technology, play the potential of steel, according to market demand has developed a variety of low, microalloyed steel.

RESEARCH PROSPECTS OF V - TI ALLOY / STEEL COMPOSITES

With the development of industrial modernization, a single steel material has been difficult to meet the real needs of production, on the one hand caused a large number of low-end steel products surplus, on the other hand caused high supply of high quality steel, therefore, research high-performance composite Materials gradually become a development trend. The addition of V and Ti to the steel can act as a grain refinement and precipitation strengthening, and a variety of vanadium-titanium microalloyed steels have been developed according to their properties [39-
However, the price of vanadium and titanium is still expensive, and the overall addition to the steel material will greatly increase the preparation cost. At the same time, China still has a lot of vanadium and titanium production equipment and technology on the technical problems to be resolved, vanadium and titanium alloy steel industry chain has been hovering at the low level.

Therefore, the preparation of V-Ti alloy / steel composite materials, will be the main direction of the development of steel composite materials, use high temperature heat treatment process gold layer. The V and Ti were diffused in the steel by high temperature heat treatment, and the concentration gradient of V and Ti was formed in the matrix of steel. Finally, Ti alloy / steel composite. The composite material not only can effectively and rationally use the steel material, reduce the amount of V and Ti, reduce the production cost, and V-Ti alloy and steel material concentration gradient connection, not just improve the wear resistance of composite materials, while retaining the steel Its own good processing performance, and its surface with high hardness, good toughness, corrosion resistance and other characteristics. The use of this technology can produce high-quality steel and gradually extended to the military, aviation, automotive, high-speed rail and other machinery manufacturing, while accelerating the production of V / Ti steel with low cost and high yield, and ultimately the application of popular, V / Ti steel get more widely used.

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