DEVELOPMENT OF 500 MPa HIGH STRENGTH STEEL BAR

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Abstract: The paper introduces the research process, technical plan of developing the 500MPa high strength steel bar and application effect of alloy addition of vanadium nitride.

Key Words: 500MPa high strength steel bar; alloy addition of vanadium nitride; precipitation strengthening, controlled rolling

1 Introduction

The building industry is one of the pillar industries in national economy and the steel products for building is one of the fundamental materials which plays a key role in the development of building industry. Presently, domestic building industry consumes more than 20 millions tons of steel bars each year, among which over 90% are steel bars of II grade while III grade of 400 MPa becomes popular and grade of 500 MPa are being promoted in foreign countries. With the fast progress of domestic building industry, the safety of structures are upgrading for which the grade of 400MPa steel bar could not meet the requirements of building dams of hydropower stations. The national new standard 1499 - 98 for hot-rolling ribbed steel bar stipulates that the chemical analysis of 5 basic elements of 500 MPa grade should be basically same as that of 400 MPa grade and 335 MPa grade, but the content of C should not be higher than 0.25%. However, additions of V, Nb, Ti can be made when necessary.

Researches have been making by Metallurgists from home and abroad on how to improve the ductility, toughness and weldability while upgrading the strength of steel bars. For the time being, high strength low – alloyed steel bar can be produced either by way of waste heat treatment after rolling (penetrated water cooling) or by way of micro – alloyment.

The Ministry of Metallurgy and the Ministry of Construction have jointly made promotion of applications of over 400 MPa grades for benefit to post generations. The newly published norms for engineering have already required the use of micro – alloyed steel bars of over 400 MPa grades, which is surely favorable to promoting the applications, especially the application of 500 MPa grade in key projects. PZH Steel is one of the producers for V – contained steel bar of 400 MPa in China, and has made achievements in promoting application of 400 MPa grade in southwestern region. Therefore, it is important for PZH Steel to develop 500 MPa grade in order for wider applications of high strength steel bars and effective use of rich V and Ti resources in Panzhihua area.

2 The Process of Test Production

2.1 Technical highlights

The smelting process adopts addition of VN16 ( VN16 is self produced by PZH Steel with con-
tainment of 78.3% V and 15.3% N) and chemical analysis is controlled, con – casting is used for casting process and con – rolling for steel rods used for rolling process, the tapping temperature and finishing temperature are controlled. The product is Ø25 ribbed steel bar.

2.2 Process flow

25t BOF → VN16 addition → argon flow at bottom of ladle → con – casting into billet of 150 mm x 150 mm → walking beam furnace → 18 stands no – twist continuous rolling → walking cooling bed → cut – to – length packing

2.3 Result

(1) Chemical analysis

Two heats of industrial test have been made, which shows the chemical analysis meets the requirement of the standard. During the tests, Si, Mn, V is controlled to the upper limit or lower limit while C is always 0.21 %, see table 1.

(2) Mechanical and technological properties

The tests have shown qualified mechanical and technological properties with the yield strength being over 520 MPa, tensile strength over 695 MPa, elongation rate over 20% and elongation rate under max. tension δe over 10%. The cold bending and negative bending has been tested qualified, see table 2.

(3) The metallographic structure of the test steel is of mixture of ferrite and pearlite, the ferrite grain size is 19 ~ 24μm on average.

(4) The strain aging inspection of the test pieces have shown no change in the strength and ductility, which demonstrates a property of strain aging resistance.

(5) The yield rate of V is more than 97% .

3 Analysis and Discussions

For steels with same amount of V content, VN precipitation phase has more power in strengthening. It has been demonstrated from the tests of V – contained grade of 400 MPa that VN12 alloyed rebar has more precipitated N phases, finer ferrite grains and higher strength than FeV 80 added rebar. Moreover, due to the effect of grain refinement, unfavorable impact by precipitation strengthening to the ductility and toughness of the steel has been partially offset, which results in minor change or improvement in the plasticity and toughness.

After the VN addition in steel, the combina-
tion of N with V is very strong due to good combining action between V and N, thus making it easy for free N to become effective alloying agent, which leads a high V yield. By calculation[2], it can be known that the ideal V/N ratio is 3.64 which is difficult to reach. In fact, a V/N ratio of 6, which is bigger than 3.64, is actually used, for an effect of dismissing free N in steel and formation of VN compound, therefore aging effect won’t happen in VN12 alloyed rebar.

In order to reduce the V/N ratio, VN12 for substitution of VN16 has been used in this experiment, which shows an outstanding increase in N content and big improvement in strength.

The research group will continue with the tests in performances of impacted toughness, weldability and earthquake resistance.

4 Conclusion

(1) The performance data of the trial 500 MPa grade rebar produced by VN16 addition technology has reached the stipulations in GB1499-98.

(2) The trial 500 MPa rebar has a property of resisting stain-aging effect.

(3) The V yield of VN16 alloyed 500 MPa rebar is bigger than 97%.

References:
