Boron-Added Steel

by

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Synopsis

Recently, material cost reduction is needed from serious industrial depression. It is also needed in the field of steel wire rod for bolts. As the response for such demand, application of boron-added steel has been popular. It makes the wire production process free from spheroidized annealing and drawing. That is caused by high cold -forgeability of boron-added steel because the steel's carbon and some alloy elements contents are less than conventional carbon steel's and low-alloyed steel's.

1. Introduction

Recently, because of the economical stagnation, cost reduction of material has been strongly required. In the field of bolts for cars, the replacement of carbon steel and low-alloyed steel with boron-added steel has been attempted for cost reduction.

Table 1 illustrates some production conditions of bolts. The carbon steel and the low-alloyed steel have mainly been used for JIS-specified, frequently used 7T～10T class bolts.

Using the boron-added steel, it is possible for bolts to be produced by the simple wire manufacturing process compared with the conventional carbon and low-alloyed steel. For example, we can obtain boron-added steel wire for 10T class bolts by one spheroidized annealing and one drawing (1SA-1D) or by just one drawing. On the other hand, we have to manufacture the conventional low-alloyed steel into wire by one spheroidized annealing and two drawings (1SA-2D).

In this paper, we introduce the boron-added steel for Cold Heading Quality (CHQ).

Table 1 Production condition of bolts

Steel grade / Strength	Mild steel	Carbon steel	Microalloyed steel	Boron-added steel	Low-alloyed steel
4T 5T 6T					
7T 8T					
9T 10T 11T over 12T					
Wire production process	R→D	R→D R—SA↑ (Quench-tempered)	R→D	R→D or R→SA→D └D┘ Quench-tempered	R—D—SA→D R—SA Quench-tempered

R : Rolling
SA : Spheroidized annealing
D : Drawing

2. Features of Boron-Added Steel

It is noted that addition of boron into low-carbon steel makes its hardenability improve. **Figure 1** shows the comparison of cost for improving hardenability. It is shown that a very small quantity of boron can dramatically improve the steel's hardenability. Therefore, the cost to improve hardenability is lower for boron than with addition of any other element. It is also noted that the boron-added steel can be worked easily because the boron-added steel has a smaller amount of other elements (ex. Cr, Mo, Ni), and hardenability can be obtained from boron itself. Therefore, we can simplify the wire production process to reduce its strength.

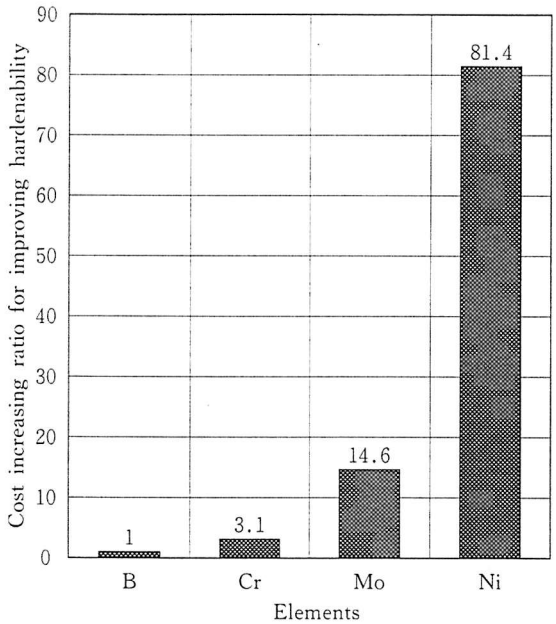

Fig. 1 Comparison of cost for improving hardenability

Figure 2 shows a detail of application of boron-added steel. The case where conventional Cr-Mo steel was replaced by the boron-added steel is shown. In such a case, it is possible to reduce the amounts of C, Cr and Mo because of the ensuring hardenability by boron. The tensile strength of as-rolled boron-added steel falls due to the reduction of the amounts of such elements. Therefore, the wire production process can be simplified.

Ductility and toughness also improve by reduction of the amount of C and other elements. **Figure 3** shows impact value transition curves of boron-added steel and conventional steel (Mn steel). It is noted that the boron-added steel's toughness is higher than conventional steel's in the whole temperature range.

On the other hand, as a fault of boron-added steel, it is pointed out that the tempering temperature of boron-added steel is lower than conventional steel's because of a little amount of C and other elements. **Figure 4** shows tempering curves of boron-added steel and conventional steel. It illustrates that

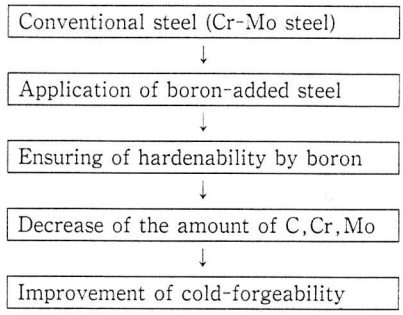

Fig. 2 Detail of application of boron-added steel

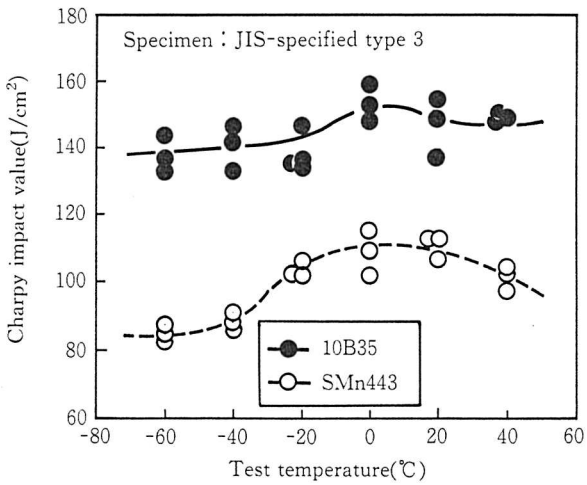

Fig. 3 Impact value transition curve (TS=1 200N/mm²)

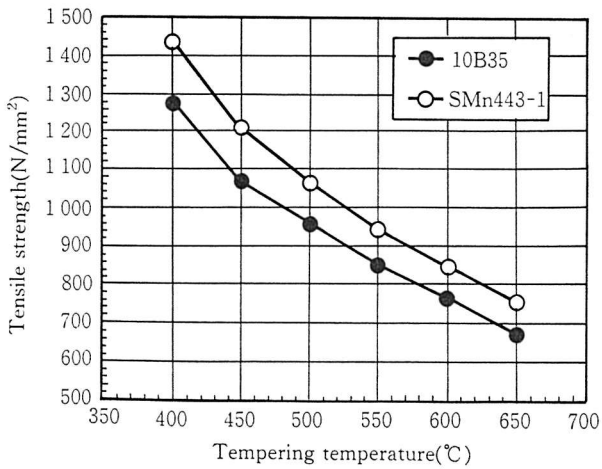

Fig. 4 Tempering curve of boron added steel and conventional steel

tempering temperature of the boron-added steel should be about 50 degrees lower than the conventional steel's to coordinate both steels' strength. Above the 10T strength level, it should be noted that low tempering temperature would cause delayed-fracture.

3. Types and Uses of Boron-Added Steel

Table 1 shows that boron-added steel has been applied to 7T~10T class bolts. 8T and 10T class bolts are mainly produced and the steels in **Table 2** are applied.

4. Wire Production Process of Boron-Added Steel

Table 3 shows comparison of the wire production process between boron-added and conventional steels. According to the cases of both 8T and 10T classes in **Table 3**, it is possible to simplify the wire production process, and this can be expected to reduce the production cost. Sometimes the tensile strength of wire rod from boron-added steel, depending on its size, reaches 600 N/mm^2 in the case of 5.5mmϕ. It is necessary to lower wire rod tensile strength by controlled rolling, etc. because the strength would increase after drawing.

5. Application

On the Jominy test curve, boron can improve steel's hardenability near the water-quenched end of the test piece rather than the opposite end. Therefore, thick material could not be quenched well. From this point of view, the largest size of products made by boron-added steel would be about maximum M14 bolt as shown in **Table 4**.

As examples of application, 10B22 is applied as 8T wide-use bolt and 15B25 as 10T engine bolt.

Table 4 Application size

Steel grade	Size	Example of application
10B22	M6~M14	For a wide use
15B25	M6~M14	For engine, etc.

6. Conclusion

Sumitomo's boron-added steel, for mainly car parts use, was reported. Using the boron-added steel, it is possible to reduce the production cost because of simplifying its wire production process. The output of boron-added steel, for example, is about 700t per month as 10B22.

Cost reduction by simplification of its production process is a general trend not only for boron-added steel, but also for many kinds of steels.

In the future, many kinds of steels and parts would be considered for production by such a method. As a subject for the future, it is necessary to lower the wire rod's strength for improvement of die life. Therefore, it is necessary to establish the production condition using controlled rolling and controlled cooling technology.

Table 2 Types and uses of boron added steel

Classification	Steel grade	Chemical composition (mass%) C	Si	Mn	B	Use
8T	10B22	.20 / .25	.10 / .35	.80 / 1.10	.0010 / .0030	Upset bolt Flange bolt etc.
10T	15B25	.22 / .28	/ .35	.90 / 1.20	.0005 / .0030	Upset bolt Flange bolt etc.

Table 3 Comparison of production process

Classification	Steel grade		Production process
8T	Conventional steel	S45C	Rolling→Drawing→SA→Drawing→Cold heading
	Boron added steel	10B22	Rolling →Drawing→Cold heading
10T	Conventional steel	SMn443	Rolling→Drawing→SA→Drawing→Cold heading
	Boron added steel	15B25	Rolling →(SA)→Drawing→Cold heading

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