Non-Strain-Hardening Steel Wire for Cold-Forging

by

Ryuji Koyama / Staff Engineer, Bars & Wire Rods Technology Planning & Service Sec., Kokura Steel Works
Takashi Tsukamoto / Staff Manager, Bars & Wire Rods Technology Planning & Service Sec., Kokura Steel Works
Toshiaki Hagiwara / Staff Manager, Bars & Wire Rods Technology Planning & Service Sec., Kokura Steel Works (Nagoya Branch Office)
Hyoji Hagita / Staff Manager, Bars & Wire Rods Technology Planning & Service Sec., Kokura Steel Works (Chugoku Branch Office)

Synopsis

Recently, the rate of cold-forge has been increasing in automobile parts manufacturing. However, during the cold-forging, it is a problem that the die-life decreases because of the material's strain aging. In this paper, we explain about the non-strain-hardening steel for cold-forging. The steel can reduce the strain aging because of the control of Al/N ratio and overaging treatment.

1. Introduction

Recently, many kinds of parts can be manufactured by cold-forging because of the development of the parts former. These parts tend to be cold-forged at higher compression ratio and strain rate. The material's temperature, in such case, increases to 100～200°C during cold-forging. Therefore, the material is hardened by aging during cold-forging and this decreases the die life.

Strain aging occurs by the formation of dislocations during plastic-working movement of solid-solved C and N in temperature-increased material. Namely, strain aging is caused by fixing of dislocation by C and N. Therefore, to restrain the strain aging, it is effective to decrease the amount of solid-solved C and N.

In this paper, we will report on the development of non-strain-hardening steel wire for cold-forging.

2. Concept for Development

In this section, we introduce the concept of developed new steel. According to the last section, reduction of solid-solved C and N are effective to keep strain aging down.

To reduce the amount of solid-solved C, low-temperature annealing (overaging) is conducted on the new steel. **Figure 1** shows the relationship between overaging temperature and tensile strength of 0.05% carbon steel. The overaging time is 1 hour. **Figure 1** illustrates that the tensile strength has a local minimum value when the overaging temperature is 300～350°C. As a result, we applied the low-temperature overaging to the new steel.

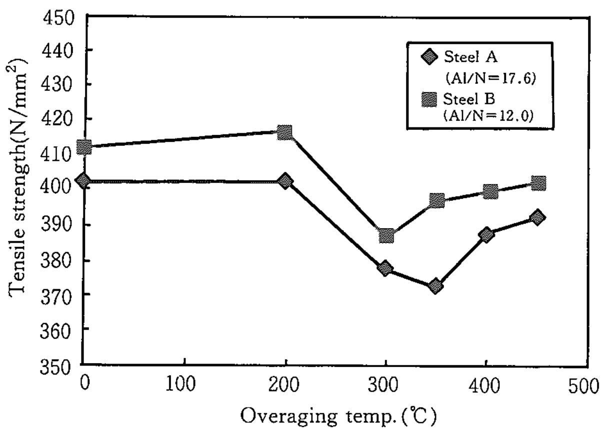

Fig. 1 Relationship between tensile strength after heat treatment and overaging temperature

As a method to reduce solid-solved N, Al/N ratio is controlled. **Figure 2** shows the relationship between Al/N ratio and strain aging ratio. The strain aging ratio is calculated as the rate of increase in tensile strength by accelerated aging test (80°C×2hr). The figure shows that the strain aging ratio becomes lower when Al/N ratio becomes higher. Al/N ratio of the developed steel is controlled at over 20 to reduce the aging caused by N.

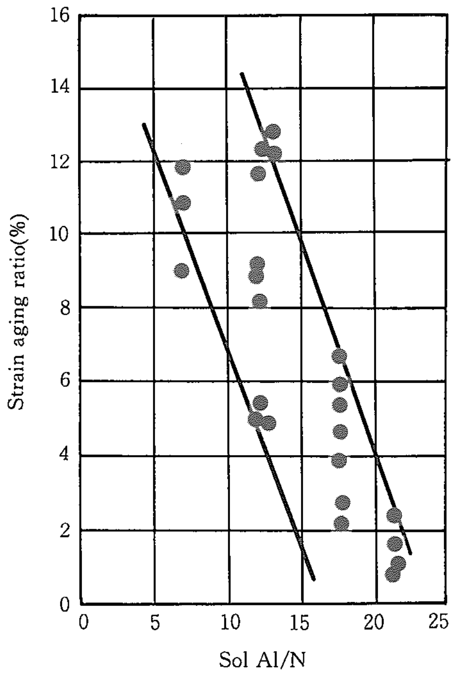

Fig. 2 Relationship between strain aging ratio and Al/N

3. Introduction of the Developed Steel

3.1 Chemical Composition

We designed the chemical composition of the new steel, according to these concepts. **Table 1** shows the chemical composition of the developed steel, SNH08.

3.2 Production Process

Figure 3 illustrates the conventional and developed steels' production processes.

According to the result shown in section 2, overaging is conducted on the developed steel (SNH08A). However, there is a case where the new steel is produced without overaging (SNH08B) when the required strength of developed steel is higher.

3.3 Features of the Developed Steel

(1) Reduction of upsetting load

Figure 4 shows relationships between mechanical properties and strain for the conventional and developed steels. Without drawing (ln d1/d0 =0), the tensile strength and the reduction of area are almost the same level between the steels. However, a remarkable difference occurs when the strain increases. Tensile strength of SNH08A (with overaging) and SNH08B (without overaging) are lower than that of SHA08 (conventional steel). Therefore, the developed steel's upsettability is better than the conventional one's. At the higher strain range (ln d1/d0 = 1.5~2.0), the reduction of area of the developed steels is about 55%. On the other hand, that of

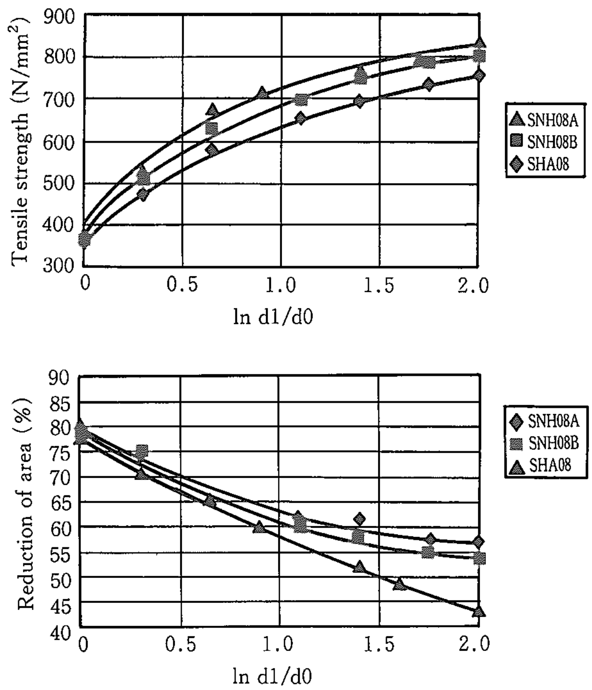

Fig. 4 Relationship between mechanical properties and strain for non-strain-hardening steel

Table 1 Chemical composition of materials (mass%)

Steel grade		C	Si	Mn	P	S	Al/N
SNH08	Developed	≦0.10	≦0.10	0.30/0.50	≦0.025	≦0.035	≧20
SHA08	Conventional	≦0.10	≦0.10	0.30/0.50	≦0.025	≦0.035	–

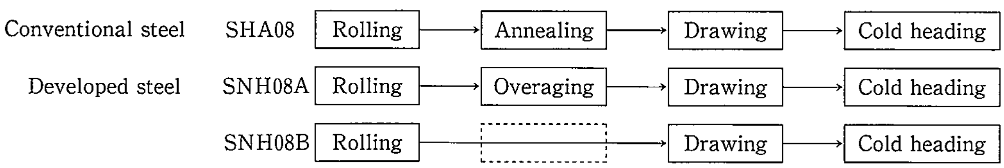

Fig. 3 Production process

the conventional steel is under 50%.

(2) Improvement of die life

Next, we introduce an example of improvement of the developed steel's die life upsetting by the cold parts former. **Table 2** shows the die lives of the conventional and the developed steels. The die which formed the conventional steel broke after upsetting about 40 000 parts. On the other hand, the die for the developed steel broke after upsetting about 60 000 parts. Therefore, it is noted that the developed steel can improve die life dramatically.

Table 2 Comparison of die life (Parts former)

	SHA08 (Conventional)		SNH08A (Developed)
Die life (Pieces/die)	42 000	→	58 000

4. Applications for Cold-Forged Parts

Figure 5 shows applications of the developed steel. The steel can be applied in a large range of cold-worked parts, for example, plate yoke and bolt manufactured from 24.0mmϕ and 5.5mmϕ materials.

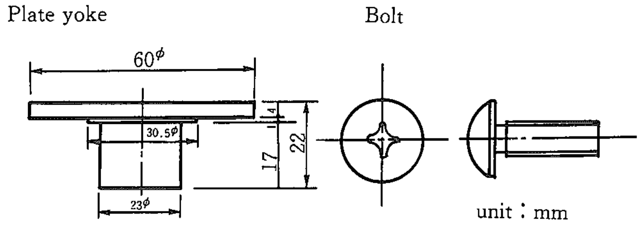

Fig. 5 Examples of application

5. Conclusion

We reported on Sumitomo's non-strain-hardening steel wire for cold-forging. Non-strain-hardening steel wire can improve die life during cold-forging, because it suppresses the strain aging by the reduction of the amounts of solved C and N. Solved C is reduced by overaging and solved N is reduced by controlling the Al/N ratio.

At present, the developed steel, whose C content is from 0.06 to 0.20 mass%, which is mainly SNH08 (0.08%C) reported in this paper, is being used in various applications.

Ryuji Koyama

Staff Engineer, Bars & Wire Rods Technology Planning & Service Sec., Kokura Steel Works

Phone: 093(561)8096