JFE TECHNICAL REPORT
No. 18 (Mar. 2013)

540–780 MPa Grade Hot-rolled Steel with Excellent Formability†

1. Introduction

In recent years, weight reduction by application of high strength steel sheets has become an urgent issue from the viewpoint of improving automobile fuel economy. High strength steel sheets are widely used in a variety of body structural parts. Although the main stream in automobile chassis and truck frame parts is currently 440 and 540 MPa grade steel sheets, full-scale efforts to reduce weight by applying high strength steel sheets have begun recently[1].

Chassis are important safety parts. High punchability, stretch-flangeability, fatigue properties, etc. are particularly demanded in this application, but it is difficult to realize these properties and high strength simultaneously. Moreover, in many cases, toughness is also required in application for thick parts. A chemical conversion property and weldability are also essential.

As a result of research and development to improve formability and fatigue properties, mainly from the viewpoint of microstructure control, JFE Steel succeeded in developing a series of 540, 590, and 780 MPa grade high strength hot-rolled steel sheets with high formability, which provide formability exceeding the conventional steel sheet with excellent stretch-flange formability B (JFS: The Japan Iron and Steel Federation Standard). This report introduces the developed steel sheets, focusing on their outstanding performance and examples of application.

2. Performance of Developed Steel Sheets

2.1 Basic Properties

Figure 1 shows the balance of elongation and the hole-expansion property of the developed 540, 590 and 780 MPa grade steel sheets, together with those of the conventional steel sheets. As a distinctive feature, the developed sheets possess a hole expanding property and elongation far exceeding the property balance of the conventional JSH540B, JSH590B, and JSH780R of the same strength grades, respectively. Examples of the typical mechanical properties of the developed steel sheets

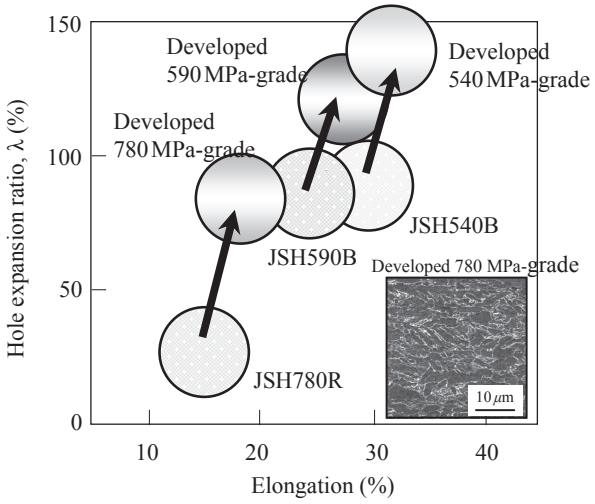

Fig. 1 Balance of elongation and hole-expansion ratio

Table 1 Mechanical properties of developed steels

Grade	Thickness (mm)	YP (MPa)	TS (MPa)	El (%)	λ (%)
540	2.9	410	550	30	130
590	2.9	540	635	26	120
780	3.2	722	824	19	80
780	6.0	733	825	21	—

YP: Yield point TS: Tensile strength
El: Elongation λ: Hole expansion ratio

are shown in **Table 1**. Because the developed 540 and 590 MPa grades both guarantee a lower limit value of elongation exceeding those of JSH540B and JSH590B by 2%, and a hole expanding ratio ($\lambda \geqq 100\%$) exceeding those of JSH540B and JSH590B by 20% and 25%, respectively, higher strength and weight reduction can be expected in parts to which JSH440B ($\lambda \geqq 100\%$) was conventionally applied. In the 780 MPa grade in Table 1, the thin material (3.2 mm) is a pickled sheet and the thick material (6.0 mm) is a non-pickled sheet. In addition to an elongation value equal or superior to that of JSH780R, a hole expanding ratio of 60% or more is guaranteed in thin material applications. The inset in Fig. 1 shows the typical microstructure of the developed 780 MPa grade, which has a microstructural morphology consisting mainly of bainite.

†Originally published in *JFE GIHO* No. 30 (Aug. 2012), p. 51–52

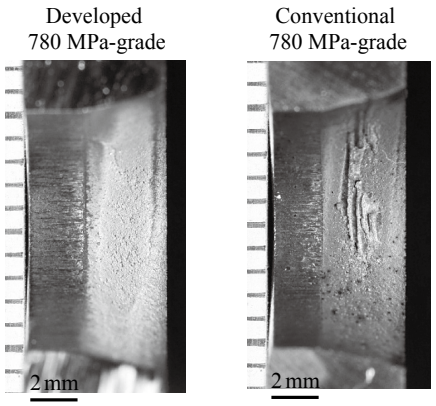

Photo 1 Appearances of punched surface

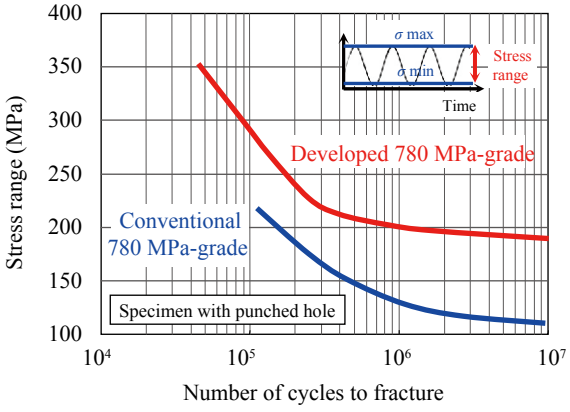

Fig. 2 Fatigue properties

Fig. 3 Application of developed 780 MPa-grade steel to lower-arm

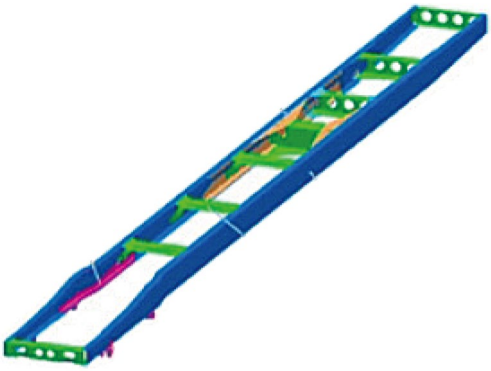

Fig. 4 Application of developed 780 MPa-grade steel to truck frame

2.2 Other Properties

One key point in application to both chassis and truck frame parts is punchability. **Photo 1** shows the quality of the punched surface after punching with a diameter of 10 mm punch using the developed 780 MPa class steel sheet and a conventional 780 MPa sheet. With a wide range of punching clearances, the developed 780 MPa grade steel sheet displays excellent punchability with satisfactory punched surface quality.

Figure 2 shows an example of the fatigue properties of the developed 780 MPa steel sheets. The figure shows the results of a fatigue test of a fatigue test specimen with a punched hole for axial tension (tensile-tensile mode). The fatigue properties of the punched hole part are considered to be related to the quality of the punched surface[2]. The developed steel, which has excellent punched surface quality, also displays high fatigue properties in comparison with the conventional steel.

Among other properties, the developed sheet also provides arc weldability and the chemical conversion performance equal or superior to those of the existing materials of the same strength grade.

3. Examples of Recommended Applications

3.1 Chassis

The trend toward weight reduction by applying high strength steel sheets to automotive chassis is continuing to become a full-scale practice. Accompanying severe stretch-flange forming and burring forming, punchability before burring forming is also essential. The developed steel sheets series is ideal for providing these properties. Application of the developed 780 MPa grade steel sheet to lower-arm parts, as shown in **Fig. 3**, is beginning. Various benefits can also be expected, for example, improved yield, cost reduction, and the like by omission of edge trimming after press-forming.

3.2 Truck Frame Parts

From the viewpoints of improved fuel economy and increased load-carrying capacity, weight reduction by applying high strength hot-rolled steel sheets to truck frame parts is desired. In addition to high fatigue properties and formability (punchability, bendability, stretch-flangeability), toughness is also important in application for thick parts. Application of the developed 780 MPa grade steel sheet to truck frame cross members, as

shown in **Fig. 4**, is progressing.

4. Conclusion

JFE Steel developed a series of high strength hot-rolled steel sheets with excellent formability using the company's unique material design technology and high accuracy manufacturing technology. These steel sheets provide an excellent balance of stretch-flangeability and elongation, and have various other outstanding properties, such as punchability, fatigue properties, toughness, etc. Weldability and chemical conversion performance are also equal or superior to those of the existing materials. Application to automobile chassis has begun. The developed steel sheets are also suitable for truck frame parts, construction equipment, and similar applications.

JFE Steel intends to create a mass production system for these steel sheets and promote further expansion of their applications in order to contribute to automobile weight reduction.

References

1) Tatsumi, Taro et al. Transactions of the Society of Automative Engineers of Japan. 1998, no. 92-98, p. 1–4.
2) Tomita, Kunikazu et al. Tetsu-to-Hagane. vol. 87, no. 8, 2001, p. 37–43.

For Further Information, Please Contact:

Sheet Business Planning Dept., JFE Steel
Phone : (81) 3-3597-3735 Fax : (81) 3-3597-3035