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High Formability 780–980 MPa Class Hot-Rolled Steel for Automobile Suspensions

1. Introduction

Among automotive parts, the requirements for so-called "suspension parts" such as the suspension, chassis, etc. include durability in the forms of fatigue strength, corrosion resistance, etc. in addition to strength and rigidity. For this reason, mainly hot-rolled steel sheets which have a larger thickness than cold rolled steel sheets are used in these parts. Although the materials mainly used at present are 440–590 MPa steel sheets, application of higher strength hot-rolled steel sheets is being studied in order to realize weight reduction in suspension parts.

JFE Steel developed 780–980 MPa class high formability high strength hot-rolled steel sheets by fully utilizing technology for precise microstructure control of steel sheets. This article introduces the outstanding performance of the developed steel sheets.

2. Performance of Developed Steel

2.1 Basic Performance

Table 1 shows the mechanical properties of 780–980 MPa class hot-rolled steel sheets developed by JFE Steel and a conventional 780 MPa class hot-rolled steel sheet. As a distinctive feature, the developed 780 MPa class steel sheet has a hole expansion ratio, λ, of more than 60%, which is higher than that of the conventional steel. The 980 MPa class steel sheet also has a high λ exceeding that of the conventional 780 MPa class steel sheet.

In the hole expansion test, a punched hole is made in a steel sheet before hole expansion. However, if the microstructure of the steel is not homogeneous, voids will be generated at the interface between the soft phase and hard phase during this punching process[1]. In addition, micro cracks are also generated, originating from nonmetallic inclusions[2]. It is thought that coalescence of these voids and generation of cracks originating from micro cracks occur easily during hole expansion following punching, and this reduces the hole expansion ratio. The developed steel sheets were designed so as to obtain a higher hole expansion ratio than that of the conventional steel sheet by suppressing generation of voids and micro cracks during punching (**Photo 1**), which was achieved by producing a fine, uniform microstructure and reducing nonmetallic inclusions.

Table 1 Mechanical properties of developed steels

Tensile test: JIS no. 5, transverse direction

Steel	Thickness (mm)	YP (MPa)	TS (MPa)	El (%)	λ(%)
Developed 980	2.6	900	1 020	13	60
Developed 780	2.6	730	800	18	80
Conventional 780	2.6	710	810	17	40

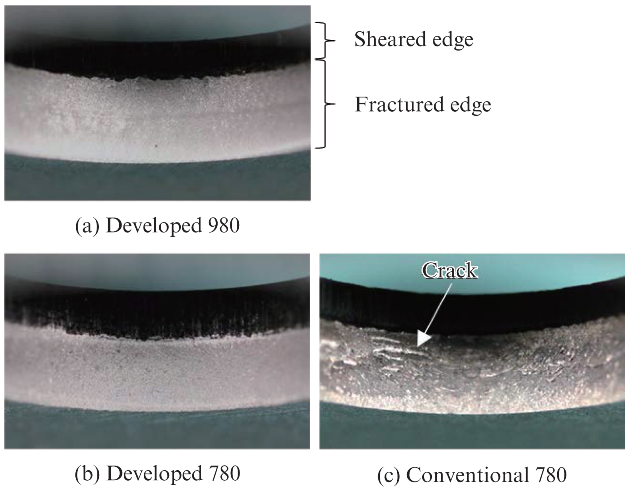

Photo 1 Appearances of punched edge

2.2 Fatigue Characteristics

While an automobile is travelling, its suspension parts are subjected to repeated stress, and the punched edges of parts may also be subjected to repeated stress, depending on the part shape. Therefore, high fatigue strength is required in the base metal and punched edges of the steel sheets. **Figure 1** shows the fatigue limit of the base metal of the developed steel sheets (thickness: 2.9 mm) and the conventional steel sheet (thickness: 2.6 mm) in a plane bending fatigue test, and the fatigue strength of the punched edges of the materials when punched with a 10 mm ϕ punch (clearance:

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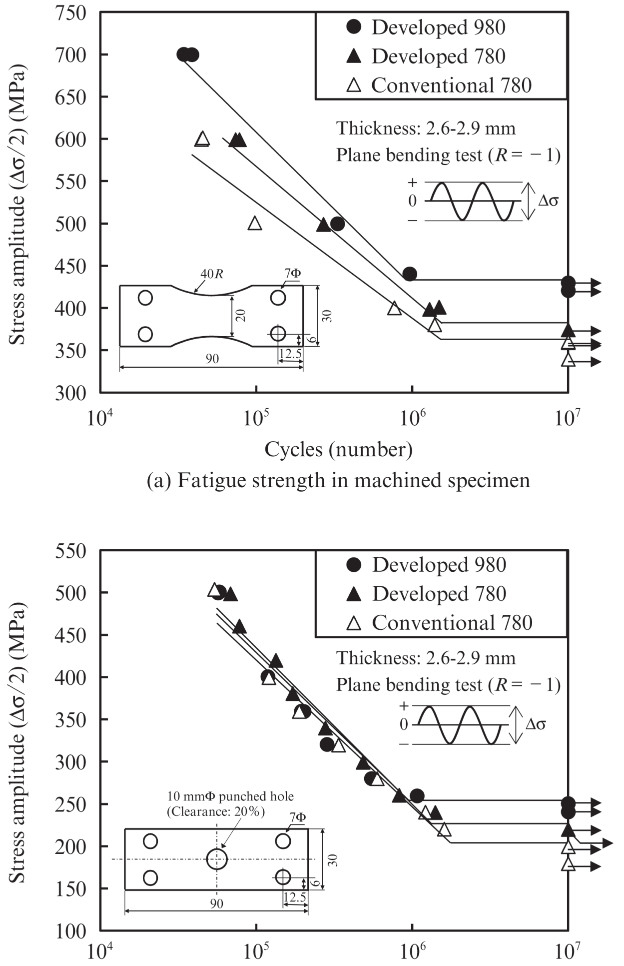
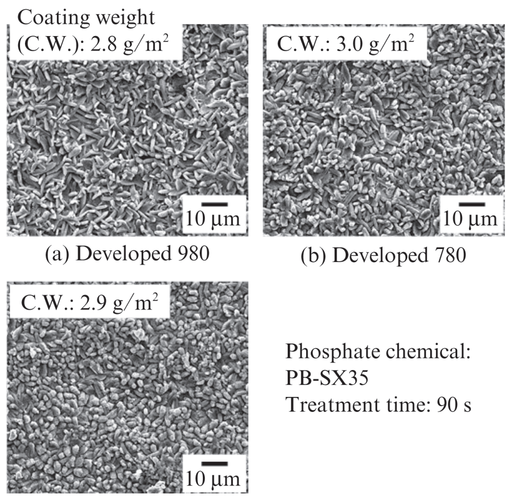


(a) Fatigue strength in machined specimen

(b) Fatigue strength in punched specimen

Fig. 1 Fatigue strength of developed steels



(a) Developed 980 (b) Developed 780

(c) Mild steel

Photo 2 Surface SEM micrograph after phosphate treatment

20%). In comparison with the conventional steel sheet, the developed 780 MPa steel sheet has high fatigue strength in both the flat sheet and at the punched edge. If the surface roughness of a steel sheet is high, local stress concentrations will occur at the surface, fatigue cracks will be generated easily, and fatigue strength will decrease[3)]. The surface roughness of the developed steel sheet was reduced by optimizing descaling conditions in hot rolling, and as a result, it is thought that the fatigue strength of the base metal increased. In addition, if the roughness of the punched edge is large, local stress concentration will occur, fatigue cracks will be generated easily from the punched edge, and the fatigue strength of the punched edge will decrease[3)]. With the developed steel sheet, it is thought that the fatigue strength of the punched edge increased because generation of cracks at the punched edge is suppressed and the developed sheet has a smooth punched edge in comparison with the conventional sheet, as shown in Photo 1.

2.3 Phosphatability

In suspension parts, electrodeposition coating is generally performed to improve corrosion resistance, in which phosphate treatment is performed to form a zinc phosphate coating in the previous processes. If formation of this zinc phosphate coating is inadequate, defects may occur in the electrodeposited coating, and as a result, corrosion resistance will decrease. Therefore, it is necessary to form a dense layer of zinc phosphate crystals. **Photo 2** shows SEM images of the surfaces of the developed steel sheets and a mild steel sheet after phosphate treatment for 90 s in a commercial phosphate treatment solution (Nihon Parkerizing Co., Ltd., Palbond SX35) and the results of measurement of the coating weight by the fluorescence X-ray technique. It can be understood that the developed steel sheets have phosphatability comparable to that of the mild steel sheet.

3. Conclusion

High formability high strength hot-rolled steel sheets of 780–980 MPa class were developed by a unique precise microstructure design and utilizing highly accurate production technology. The developed steel sheets have an excellent balance of stretch-flange formability and elongation, together with a variety of other outstanding properties, including fatigue characteristics, punchability, phosphatability, etc. Because the developed steel sheets also possess toughness and weldability performance equal or superior to that of the conventional steel, applications are not limited to automotive suspension parts, but also extend to truck frame parts, construction machinery, etc.

JFE Steel will contribute to weight reduction in automobiles by creating a mass production system for the steel sheets and promoting a further expansion of their applications.

References

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For Further Information, Please Contact(Nov.2021-):

Sheet Business Planning Dept., JFE Steel

Phone: (81)3-3597-3061 Fax: (81)3-3597-3943
http://www.jfe-steel.co.jp/en/products/sheets/f00.html
Email:t-usuitasec@jfe-steel.co.jp