JFE TECHNICAL REPORT
No. 18 (Mar. 2013)

Weight Reduction of Body Exposed Panels by Applying UNI HITEN™†

1. Introduction

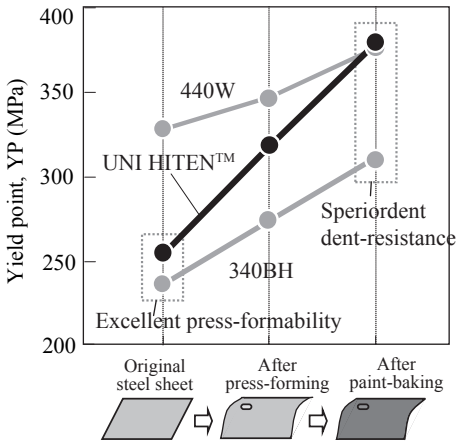
Bake-hardenable steel sheets with 340 MPa grade in tensile strength (hereinafter, 340BH) have been applied to automotive exposed panels such as doors, hoods, etc. to satisfy sufficient dent-resistance. Superior press-formability is also required for the steel sheets to achieve excellent surface accuracy of pressed parts to realize a beautiful body design. In general, however, high strength and superior press-formability are mutually contradicting properties[1], and this makes it difficult to strength the steel sheets and reduce the thickness of these parts.

JFE Steel has developed a new bake-hardenable steel sheet with 440 MPa grade, "UNI HITEN™," which realizes strengthening of steel sheets in exposed panels. This steel sheet is a dual-phase steel (hereinafter, DP steel). This steel sheet has a superior dent-resistance, which is 20% higher than that of 340BH, performing the same surface accuracy after press-forming as conventional 340BH. To apply 440 MPa grade steel for exposed panels, a new method to quantify the surface distortion has been also established. Application of UNI HITEN™ is expected to contribute to further weight reduction in exposed panels.

2. Concept of UNI HITEN™

To improve surface accuracy after press-forming into the conventional 340BH's level, yield point (YP) of the material should be as low as conventional 340BH. On the other hand, yield point after press-forming and paint-baking (YP') should be increased by 50 MPa compared with 340BH to realize a 0.05 mm thickness reduction of an exposed panel, because the dent-resistance of pressed parts depends on sheet thickness and YP'[2].

In UNI HITEN™, YP is reduced to the same level as 340BH and YP' is drastically increased to a level which enables a 0.05 mm thickness reduction by controlling a microstructure of a ferrite + martensite DP steel(**Fig. 1**). The new steel sheet was also performed various other properties required in exposed panels, i.e., high stretch-formability, anti-aging property, chemical conversion property, corrosion resistance, and beautiful coating appearance quality.



440W: Conventional 440 MPa grade steel sheet
340BH: Conventional 340 MPa grade bake-hardenable steel sheet

Fig. 1 Change in yield point (YP) during car-making process

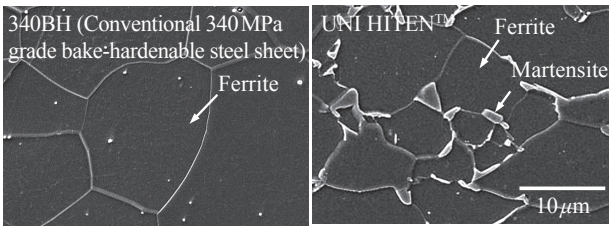


Photo 1 Micrographs of 340BH and UNI HITEN™ by scanning electron microscopy [3]

3. Features of UNI HITEN™

3.1 Microstructure

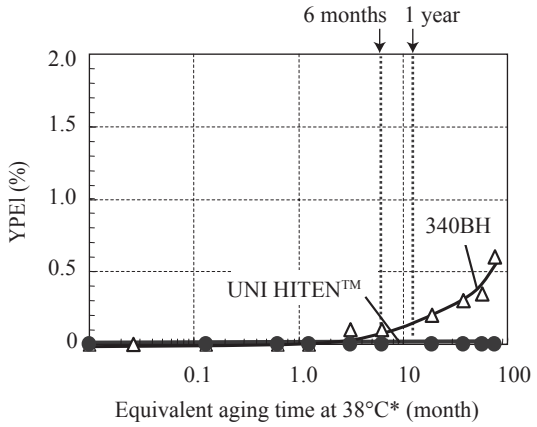
Photo 1 shows the microstructures of 340BH and UNI HITEN™. The conventional 340BH is a ferritic single phase steel containing small amount of solute C to ensure a bake-hardenability. In contrast, in UNI HITEN™, a small amount of martensite is dispersed uniformly in the ferrite phase by increasing C content. As a result, YP was greatly reduced, and a large bake-hardenability and a superior anti-aging property were successfully imparted[3].

† Rearranged from *Materia Japan* Vol. 51 (2012), p. 22–24

Table 1 Typical mechanical properties of steel sheets[3)]

Steel	YP (MPa)	TS (MPa)	El (%)	n_{6-12}	WH (MPa)	BH (MPa)	YP' (MPa)
340BH	242	354	41	0.21	33	35	310
440W	322	457	36	0.20	10	36	368
UNI HITEN™	257	455	37	0.23	62	57	376

JIS Z 2201(2011) No. 5 specimen t: 0.75 mm Pre-strain: 2% BH Condition: 170°C×20 min
340BH: Conventional 340 MPa grade bake-hardenable steel sheet 440W: Conventional 440 MPa grade steel sheet
YP: Yield point TS: Tensile strength El: Elongation
n_{6-12}: n-Value between 6% and 12% in tensile strain
WH: Amount of work-hardening BH: Amount of bake-hardening YP'=YP+WH+BH



340BH: Conventional 340MPa grade bake-hardenable steel
YPEl: Yield point elongation
*Aging temperature: 70°C

Fig. 2 Aging behavior of 340BH and UNI HITEN™ 3)

3.2 Mechanical Properties

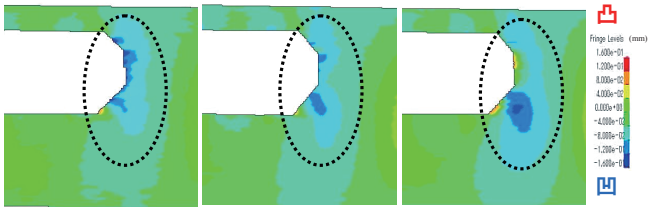
Table 1 shows the typical mechanical properties of 340BH, 440 MPa grade conventional steel (hereinafter, 440W) and UNI HITEN™. UNI HITEN™ is featured to have a low YP in 440 MPa grade close to that of the conventional 340BH. And it exhibits higher elongation (El) and a higher work-hardening rate (n-value), compared with 440 W.

Furthermore, the amount of work-hardening during 2% pre-straining and the amount of bake-hardening (BH) are high, and YP', which is an index of the dent-resistance of pressed parts, is substantially improved compared to 340BH.

Figure 2 shows the aging behaviors of UNI HITEN™ and 340BH. Here, the aging test was performed at 70°C, the aging time was converted to the equivalent aging time at 38°C[4)]. UNI HITEN™, which contains small amount of martensite, has an excellent anti-aging property.

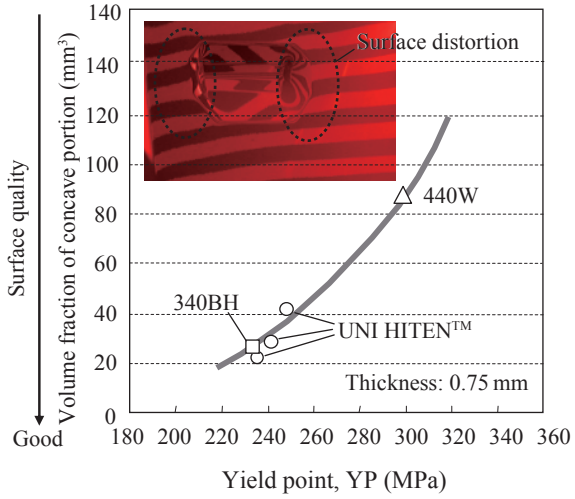
3.3 Press-Formability

A press-forming test was performed with 340BH and UNI HITEN™ using a door outer die. As a result, UNI HITEN™, which has high El and n-value, was formed



340BH: Conventional 340 MPa grade bake-hardenable steel
440W: Conventional 440 MPa grade steel sheet
YP: Yield point

Fig. 3 Quantitative mapping of surface distortion around doorknob[3)]



340BH: Conventional 340 MPa grade bake-hardenable steel
440W: Conventional 440 MPa grade steel sheet

Fig. 4 Effect of yield point (YP) on the surface quality around doorknob[3)]

without cracks and wrinkles.

Next, surface accuracy after press-forming was evaluated using a press die simulating the area around a doorknob. The surface shape of the pressed part was measured, and the volume of concave portion was compared as the amount of surface distortion. The results are shown in **Figs. 3** and **4**. The amount of surface distortion is correlated with YP. Surface distortion of UNI

Photo 2 Application of UNI HITEN™ to door panel

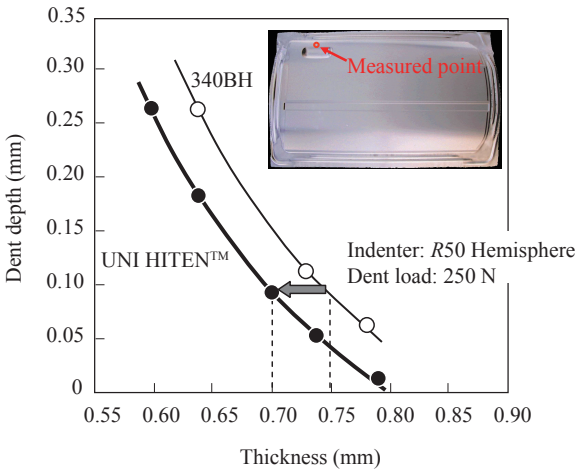
Photo 3 Application of UNI HITEN™ to hood panel

HITEN™ is greatly reduced compared with that of 440W, and is close to a level of 340BH.

In addition to the material development, JFE Steel also established a new method which enables to measure and to map the amount of surface distortion quantitatively[5], as well as a method to predict a surface distortion using computer aided engineering (CAE). These techniques contribute to the application of high strength steel by providing proper die-shape to reduce surface distortion.

3.4 Dent-Resistance

Figure 5 shows the dent-resistance of 340BH and UNI HITEN™ in an actual door panel. The dent depth of UNI HITEN™ with high YP' is much reduced compared with that of 340BH. Therefore it is possible to reduce sheet thickness by 0.05 mm (weight reduction of approximately 7%) while maintaining the same dent-resistance as the conventional steel.



340BH: Conventional 340 MPa grade bake-hardenable steel

Fig. 5 Relationship between thickness and dent depth of pressed parts[3]

4. Examples of Application of UNI HITEN™

UNI HITEN™ was adopted in the door outer panels (**Photo 2**) of a lightweight automobile marketed in January 2011 and in the hood outer panel (**Photo 3**) of a pickup truck marketed in October 2011. In the case of the door outer panels, a weight reduction of approximately 1.1 kg/vehicle was achieved by reducing the thickness of the steel sheets.

5. Conclusion

Although the application of high strength steels to exposed panels has been limited so far, it might be accelerated in future from the increasing demands for CO_2 reduction because of the great potential of weight reduction. UNI HITEN™ is expected to be one of the important break-through materials to realize it.

JFE Steel continues to develop both materials with high performance and forming technologies which realize application of high strength steels.

References

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