

High Strength Steel Sheets with Excellent Formability Series, JEFORMA™

1. Introduction

In order to improve automobile fuel consumption and safety, application of high strength steel sheets to automotive body structural parts has increased remarkably in recent years. As a top maker of automotive steel sheets, JFE Steel has continued to develop easy-to-use automotive high strength steel sheets over many years up to the present so as to respond to social needs.

Because high strength steel sheets generally have poor formability, such as elongation, stretch-flangeability, etc. in comparison with mild steel sheets, the applicable parts had been limited. Therefore, JFE Steel systematically developed high formability, high strength steel sheets with distinctive features in cold-rolled steel sheets and galvanized steel sheets (GA) in order to supply the optimum steel sheets matching the forming elements demanded in parts, such as elongation, stretch-flangeability, etc., and commercialized those products in the JEFORMA™ Series.

2. Concept of JEFORMA™

2.1 Concept

To satisfy the needs of diverse parts in which high strength steel sheets are applied, JFE Steel's JEFORMA Series of high strength steel sheets with excellent formability comprise three types, as shown in **Fig. 1**. These are a High El type (Type 1) with higher elongation than conventional high strength steel sheets, a High El and high λ type (Type 2) with high elongation and high stretch-flangeability and a Super high El type (Type 3) with even higher elongation. The line-up is based on a uniform concept in the strength grades 590, 780, 980 and 1180 MPa class for both cold-rolled steel sheets and galvanized steel sheets (GA). Needless to say, the material design of all of these steel sheets considers the weldability and delayed fracture resistance demanded in automotive body structural parts. In addition, JFE Steel can also supply a wide range of product sheet thickness variations to respond to the need for high strength thin-thickness parts for

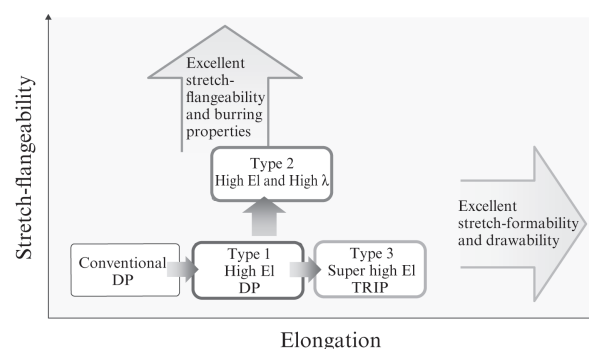


Fig. 1 Types and their features of JEFORMA™, high strength steel with excellent formability series

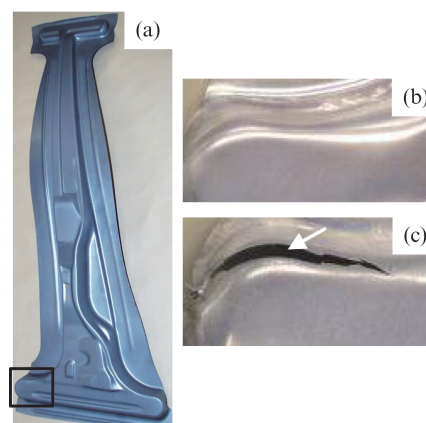


Photo 1 Press forming results of B-pillar
(a) Whole image of press formed part (Closing lined part is magnified)
(b) JEFORMA™ 980GA Type 1 (High El type)
(c) Conventional 980GA (for comparison)

auto body weight reduction. The origin of the name JEFORMA is JFE Excellent FORMAbility.

2.2 Examples of Applicable Parts

Next, the superiority of JEFORMA in press-forming of an actual part model will be shown. **Photo 1(a)** is a model of a B-pillar. Because the bottom part is box-shaped, high stretchability is required in the steel sheet material. A crack occurred in the conventional 980 MPa class GA steel sheet shown in Photo 1(c), but in contrast, with the JEFORMA 980GA Type 1 (High El type) in Photo 1(b), satisfactory press-forming with no cracks was possible.

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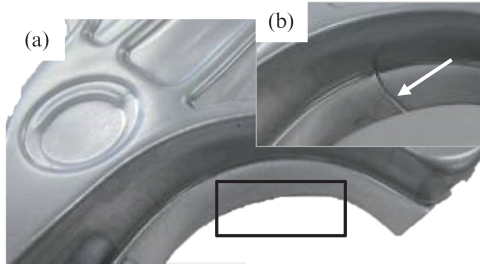


Photo 2 Press forming results of B-pillar upper
(a) JEFORMA™ 590GA Type2 (High El and high λ type)
(Closing lined part is compared)
(b) Conventional 590GA (for comparison)

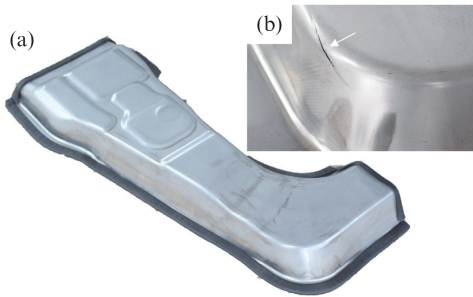


Photo 3 Press forming results of A-pillar lower
(a) JEFORMA™ 1180GA Type3 (Super high El type)
(b) Conventional 1180GA (for comparison)

Photo 2 is an example of a part in which particularly high stretch-flangeability is required. The flange part of the B-pillar upper receives severe stretch-flange forming. With the conventional 590 MPa GA steel sheet shown in Photo 2(b), a stretch-flange crack occurred from the edge, but with the JEFORMA 590GA Type 2 (High El and high λ type) shown in Photo 2(a), it can be understood that forming was possible without cracking.

Photo 3 is an example of an A-pillar lower, which has a deep drawing structure. A crack occurred in the vertical wall part of the conventional 1180MPa class GA steel sheet in Photo 3(b), but satisfactory forming was possible with the JEFORMA 1180GA Type 3 (Super high El type) in Photo 3(a).

Thus, if the optimum steel sheet for the forming method and shape is selected from the JEFORMA Series, it is possible to apply a sheet of a strength level that had been difficult until now, and there is considered to be a possibility achieving a further weight reduction of the part.

3. Features of JEFORMA™

Table 1 shows examples of the mechanical properties of the high formability, high strength cold-rolled sheet series and high formability galvanized (GA) steel sheet series (typical values for sheet thickness of

Table 1 Typical mechanical properties of JEFORMA™ series

Strength Grades	Type	YS (MPa)	TS (MPa)	Elongation El (%)	HER* λ (%)	Development Stage
590CR	Conventional	390	650	29	65	Commercial
	Type1	385	635	32	65	Commercial
	Type3	400	620	37	70	Commercial
780CR	Conventional	560	810	19	30	Commercial
	Type1	505	820	20	50	Commercial
	Type2	520	830	26	45	Developed
	Type3	500	810	29	35	Commercial
980CR	Conventional	690	1 060	14	35	Commercial
	Type1	750	1 030	15	45	Commercial
	Type2	820	1 020	16	55	Developed
	Type3	640	1 030	23	30	Commercial
1 180CR	Conventional	890	1 230	10	30	Commercial
	Type1	910	1 260	12	40	Commercial
	Type2	1 060	1 215	15	55	Developed
	Type3	950	1 240	16	40	Commercial
590GA	Conventional	365	610	29	45	Commercial
	Type1	410	605	31	60	Commercial
	Type2	410	600	33	80	Developed
780GA	Conventional	510	830	18	30	Commercial
	Type1	435	830	21	25	Commercial
	Type2	590	810	22	70	Developed
	Type3	450	800	26	25	Commercial
980GA	Conventional	630	1 030	14	25	Commercial
	Type1	650	1 020	18	30	Commercial
	Type2	800	1 020	16	60	Commercial
1 180GA	Conventional	830	1 230	11	20	Commercial
	Type1	800	1 220	13	20	Developed

*HER: Hole Expanding Ratio, the index of stretch-flangeability

1.4 mm). All three types of JEFORMA are available in strengths from 590 to 1 180 MPa. Type 1 (High El type) is a so-called Dual Phase (DP) steel with a ferrite and martensite microstructure, and high elongation is achieved by optimization of the chemical composition and microstructure. In Type 2 (High El and high λ type), a combination of not only high elongation but also high stretch-flangeability (λ) was provided by control of the difference in hardness between the component phases of the microstructure. Type 3 is a so-called TRIP steel that utilizes transformation induced plasticity by retained austenite.

In addition to the above-mentioned high formability JEFORMA Series for automotive body structural parts, JFE Steel also has a line-up of 1 320 and 1 470 MPa class cold-rolled and GA steel sheets as ultra-high strength steel sheets.

4. Conclusion

JFE Steel developed a line-up of the optimum steel sheets for automotive body structural parts by utilizing its state-of-the-art production equipment for high strength thin steel sheets and manufacturing know-

how. As a result, the company has completed a series of high strength steel sheets with excellent formability under the tradename JEFORMA.

JFE Steel not only develops and supplies outstanding steel sheets, but is also grappling with the development of original forming technologies and welding technologies for those products, and supplies the technologies together with steel sheets. By combining these

material technologies and application technologies, we believe that we can contribute to more stable manufacture of automotive body structural parts.

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