New Products & Technologies

"CHLY980", a TS980MPa Grade Cold-Rolled Steel Sheet with Excellent Formability*

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1 Introduction

Demand for high-tensile-strength steels is increasing because of improvement of crashworthiness and weight lightening of car body in white. Elongation generally tends to decrease with increasing tensile strength and steel grades of high formability are required when high-tensile-strength steels are used in complicated automobile parts, etc.

In fractures which occur during actual forming of steel sheets, various types of deformation occur in materials which depend on the stress paths of fracture portions, because individual automobile parts have different shapes. Therefore, the mechanical properties required of steel sheets differ depending on the type of deformation of the materials, so it is very important to select steel sheets with mechanical properties suitable for the shapes of parts.

This report presents the features of "CHLY980," a TS980MPa grade cold-rolled steel sheet with excellent formability. Its crashworthiness makes it ideal for use in parts such as bumper reinforcements, door guard bars, impact beams, and other reinforcing members.

2 Concept of Material Design of CHLY980

A metallurgical mechanism for increasing elongation of the developed steel sheet is described. A dual-phase steel having a primary phase of ferrite with a hardened low-temperature transformation phase is obtained by optimizing the chemical composition of steel, hot rolling conditions and annealing conditions. This metallurgical control enables a steel which combines tensile strength and high elongation to be manufactured.

A metallurgical mechanism for raising the hole expansion ratio is now described. When high-tensile-strength steels of TS590MPa grade and higher are used in pressed parts, it may sometimes be important to ensure stretch flanging formability in addition to stretch formability, etc. in some shapes of parts. The hole expansion ratio is widely used as an index for evaluating stretch flanging formability and it is known that the hole expansion ratio is improved by reducing the causes of cracking at the flange parts during hole expansion[1].

One cause of cracking is the interface between a hardened phase and a softened phase, in which the hole expansion ratio decreases when the difference in tensile strength between the two phases is large. For this reason, a structure composed mainly of the bainite phase can be ensured by optimizing manufacturing conditions.

The higher the volume fraction of carbides and sulfides, the more fracture strains decrease. Moreover, fracture strains tend to decrease when inclusions are shaped like plates rather particles. In addition, the higher the content of sulfur in steel, the more elongated inclusions (A-type inclusions) increase[1]. Therefore, it is possible to raise the hole expansion ratio by lowering the content of sulfur in steel in order to reduce the causes of cracking thereby reducing sulfides.

The hole expansion ratio is substantially improved by controlling microstructures as mentioned above, with the result that the obtained steel displays excellent stretch flanging formability.

3 Mechanical Properties

A typical chemical composition of CHLY980 is shown in **Table 1**.

The relationship between elongation and yield strength and tensile strength of actually produced TS980MPa grade cold-rolled steel sheets is shown in **Fig. 1** and the relationship between elongation and hole

Table 1 Typical chemical composition of TS980 MPa grade cold-rolled steel sheet

(mass%)

	C	Si	Mn	P	S	Al
CHLY980	0.08	0.2	3.1	0.02	≦0.010	0.04

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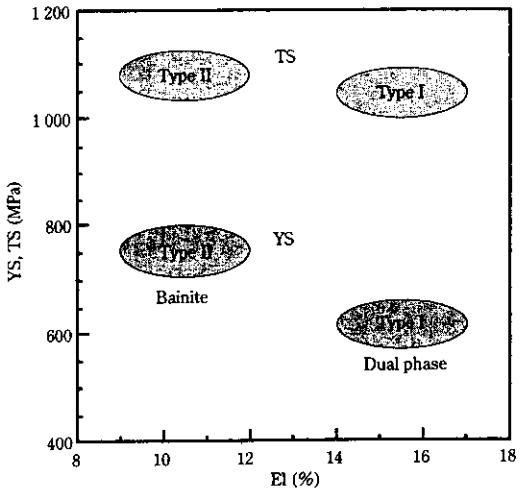

Fig. 1 Relationship between elongation and yield strength and tensile strength of cold rolled steel sheet

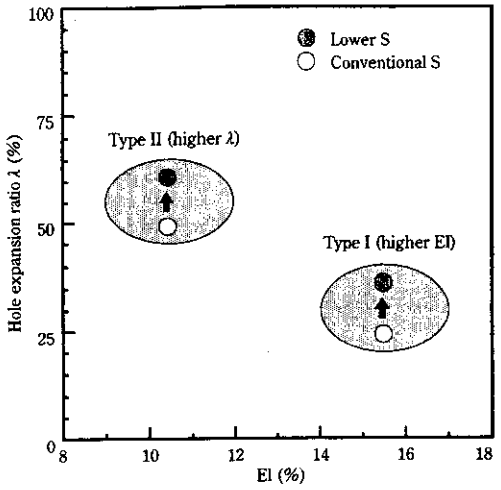

Fig. 2 Relationship between elongation and hole expansion ratio λ of cold rolled steel sheet

expansion ratio of actually produced TS980MPa grade cold-rolled steel sheets is shown in **Fig. 2**. It is possible to produce two types of steel sheets, i.e., a steel sheet which is designed to be elongated while keeping the same tensile strength level (Type I: dual-phase steel) and a steel sheet of high hole expansion ratio (Type II: steel of bainite structure).

For example, the Type I steel sheet is suitable for preventing α-fractures during press forming. In addition, such steel sheets are also expected to be effective in improving poor automobile panel shapes caused by lower yield strength (wrinkles, suppressing twists, etc.), and reducing low dimensional accuracy, such as shape freezing[1]. This steel sheet displays very excellent press formability.

Steel sheets of high hole expansion ratio are suitable for parts which are mainly subjected to stretch flanging deformation in which flange parts are most elongated and a high ultimate deformation ability is required, such as punch hole expansion forming.

In both Type I and Type II steel sheets, it is possible to significantly improve only the hole expansion ratio without changing tensile strength and ductility levels by lowering the content of sulfur in steel. Lowering the sulfur content to very low levels enables steel sheets of Type I to be formed by complicated forming, which involves stretch flanging in addition to stretch forming. In Type II steel sheets where a hole expansion ratio of 64% maximum is obtained and the sheets can be used in specialized applications in stretch flanging. Moreover, steel sheets of high hole expansion ratio are expected to be effective in reducing defects caused by wrinkles during the butt welding of edges of steel sheets in roll forming in the pipe manufacturing process. This is due not only to an improvement in press formability, but also to a reduction in the occurrence of wrinkles on the edge of steel sheets resulting from higher yield strength during the production process[2,3].

4 Concluding Remarks

Kawasaki Steel has developed a technology for producing "CHLY980" a cold-rolled steel sheet with excellent formability, by optimizing microstructures by the control of chemical compositions and manufacturing conditions. This steel sheet is available in two types with a different balance of mechanical properties, i.e., a type which is designed especially for elongation and a type of high hole expansion ratio.

This steel grade is used in automobile parts and reinforcements that must have crashworthiness. In addition, this steel can be applied to strengthen machine parts and building members.

References

1) The Japan Sheet Metal Forming Research Group: "Handbook of Ease of Difficulty in Press Forming", (1997), [Nikkan Kogyo Shinbun Sha]
2) Y. Hayashi and M. Takaya: *Sosei-to-Kako*, **259**(1982)23, 779
3) T. Hira, H. Abe, K. Nakagawa, Y. Koizumi, and S. Saeki: *Sosei-to-Kako*, **225**(1979)20, 933

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