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Zn-Ni Precoated Steel Sheets with Cr(VI)-Free Self-Lubricating Film*

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1 Introduction

At the beginning in the second half of the 1980s, self-lubricating steel sheets which can be press-formed without oil coating were developed[1–4] and are now widely used by electrical makers and auto parts makers. Kawasaki Steel produces River Zinc® FS series, which are self-lubricating steel sheets based on a pure zinc coating, with high reputation. Since the Zn-Ni alloy coating offers excellent corrosion resistance and an attractive appearance there is strong demand for self-lubricating steel sheet based on Zn-Ni alloy coated sheets.

A chromate treatment, which is used on conventional coated steel sheets, provides a self-healing effect of corrosion from scratched and other damaged areas. However, the chromate film contains Cr(VI), hexavalent chromium which is an environmentally unfriendly substance. For this reason, in Europe, "The Final Draft of a Directive on the Recycling of Waste Electrical and Electronic Equipment (WEEE)" has officially announced, that the use of Cr(VI) would be completely prohibited by the year 2007. Thus, development of a Cr(VI) free type coating is highly required.

In response to this requirement, Kawasaki Steel developed a chromate free type coating with better self-lubricating character than the conventional River Z® FS. This report describes the properties of the newly developed self-lubricating film.

2 Properties of Developed Material

2.1 Coating Structure

The coating structure of the developed steel is shown in **Fig. 1**. It features the following three points.

(1) The coating contains absolutely no chromate.

(2) Newly developed 4 μm thickness self-lubricating film secure improved press formability, good appearance and corrosion resistance after forming.

(3) Press forming without oil coating is possible in the same manner as with River Zinc® FS.

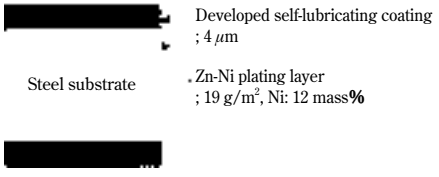

Fig. 1 Cross sectional view of developed self-lubricating steel sheet

Table 1 Specimens used in this study

Symbol	Type	Coating
Specimen A	Cr(VI)-free	Developed self-lubricating coating (4 μm)
Specimen B	Chromate	Chromate coating (Cr; 15 mg/m²) + Conventional self-lubricating coating (4 μm)

Table 1 shows the specimens used in the following evaluation. The developed material (hereinafter called specimen A) is a Zn-Ni alloy coated steel sheet (coating weight, 19 g/m^2; Ni, 12 mass%), with the newly developed lubricating film. As a comparison material (hereinafter called material B), the same Zn-Ni alloy coated steel sheet with the River Zinc® FS lubricating film (film thickness, 4 μm) with a conventional chromate (Cr, 15 mg/m^2) is used.

2.2 Lubricity

Figure 2 shows the coefficient of friction in a flat sliding test using various holding pressures between 20~80 MPa. The coefficient tended to decrease with the increase in the holding pressure. At all holding pressures, the coefficient of friction of specimen A was lower than that of specimen B. In particular, when a

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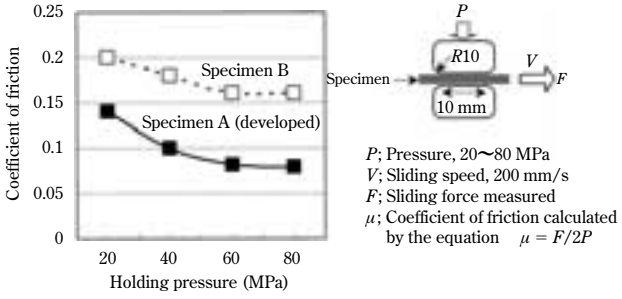

Fig. 2 Relationship between coefficient of friction and holding pressure

holding pressure of above 60 MPa was applied, specimen A displayed an excellent lubricity, with a coefficient of friction approximately a half of specimen B.

2.3 Press Formability

Figure 3 shows the test results of the limiting drawing force in a square cylinder drawing test. Specimen A showed a limiting drawing force 80 kN higher than that of specimen B. Furthermore, the new material showed no influence in limiting drawing force when the die temperature was increased to 90°C, at which temperature actual press forming is performed.

Figure 4 shows the results of SEM observation of the film condition after forming. With specimen B, fine

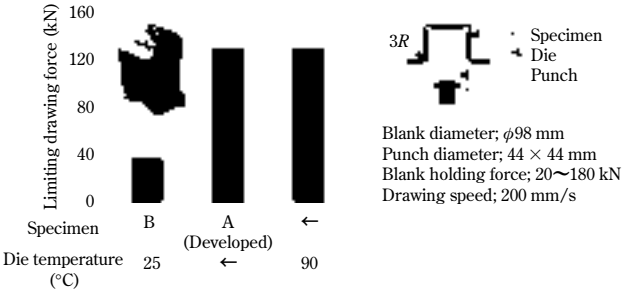

Fig. 3 Limiting drawing force of specimens by square cylinder drawing test

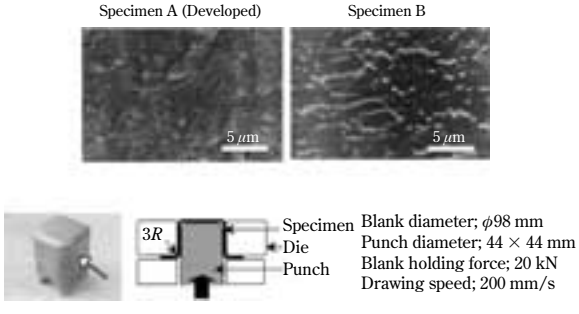

Fig. 4 SEM images of coating surfaces after square cylinder drawing test

Table 2 Corrosion resistance of specimens A and B

	Time to 5% white rust occurrence at salt spray test (JIS Z 2371)	
	Specimen A (Developed)	Specimen B
7 mm-Erichsen	200 h	200 h
Cylindrical cup drawing*	120 h	120 h

*Black diameter; φ74 mm
Punch diameter; φ50 mm
Blank holding force; 20 kN
Drawing speed; 200 mm/s

cracks were observed in the formed part of the film. But with specimen A, virtually no cracks were found, indicating that film damage due to forming is extremely slight.

The high limiting drawing force of specimen A is considered to be due to the fact that newly developed self-lubricating has excellent lubricity and strength sufficient to resist film damage due to forming.

2.4 Corrosion Resistance

Table 2 summarizes the results of a salt spray test (JIS Z 2371) of 7 mm-Erichsen test samples and cylindrical-drawing test samples. The time to 5% white rust occurrence in the salt spray test was 200 h, for all Erichsen samples and 120 h for cylindrical-drawing samples. Thus, even though specimen A is a chromate free material, it showed the same level of corrosion resistance as the conventional chromated product (specimen B).

3 Conclusion

The newly developed chromate free lubricating film has excellent lubricity and strength. When this film is applied to Zn-Ni alloy coated steel sheets, it enables good press formability even without oil coating.

4 Examples of Application

The new material is suitable for applications which require deep drawing. Motor covers and cases, kerosene containers are some of the samples of prospective market.

References

1) S. Suzuki, N. Totsuka, T. Kurisu, T. Ichida, and T. Mouri: *Kawasaki Steel Technical Report*, (1992)27, 46
2) M. Yamashita, Y. Sugimoto, K. Sasaki, A. Takagi, and M. Kumagaya: *NKK Technical Report*, (1996)153, 32
3) H. Odashima and I. Kikuchi: *Tetsu-to-Hagané*, **77**(1991)8, 1359
4) M. Tsuji, S. Hikino, M. Soura, and H. Tsuchiya: *Sumitomo Metals*, **48**(1996)3, 55