Kobe Steel Develops Pre-coated Titanium with Excellent Press-formability

September 16th 2009

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Contents

✓ Lubricant and press formability
✓ Design of pre-coated titanium
✓ Characteristics of pre-coated titanium
✓ Result of mass-production
✓ Conclusion
Press Formed Products of Titanium

Cutlery

Exhaust Systems

Camera bodies

Photo: MINOLTA Co, Ltd.

Photo: Yoshimura Japan Co, Ltd.
Plate Heat Exchanger (PHE)

An example of corrugated pattern

Working principle of PHE

PHE product

Courtesy of Alfa Laval
ITA 2008
“A Newly developed Press-formable High-strength Titanium alloy”

PHE needs

- Higher performance
  > Higher pressure
  > Higher heat transfer rate

Solution

- Higher strength with good press-formability
  - Simulation technique for plate forming considering forming properties of the material
Good balance of strength and stretch-type formability
Simulation of Herringbone type forming (ITA 2008)

Thickness order

1

2

Thinnest part is correspondent with the crack area

<Ti-1.5Fe>
thickness: 0.30mm
An Evaluation Method of Formability for PHE

Herringbone type test die

Die Size 100mm X 100mm

Scoring at each circled point

Formability(%) = \frac{\text{Summed marks}}{\text{Full Marks(No crack)}} \times 100
Formability of Ti-1.5Fe, if well lubricated, is as good as Gr.1’s
# Lubricant for Press Forming

## Comparison of usual lubricant method

<table>
<thead>
<tr>
<th></th>
<th>Oil</th>
<th>Film</th>
<th>New method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Press formability</td>
<td>Not good</td>
<td>Good</td>
<td><strong>Good</strong></td>
</tr>
<tr>
<td>Dimensional accuracy</td>
<td>Good</td>
<td>Not good</td>
<td><strong>Good</strong></td>
</tr>
<tr>
<td>Productivity</td>
<td>Good</td>
<td>Not good</td>
<td><strong>Good</strong></td>
</tr>
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**Lubricant and press formability of Titanium Sheet**

- Material: ASTM G1
- Grade: Grade 2B
- Thickness: 0.8mm
- Finish: 2B

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**Erichsen value (mm)**

- Without lubricant
- Oil
- Film (P.E.)
Design of the newly developed pre-coated titanium

- Excellent press formability without lubricant
  >>Easy to flow by low frictional coating layer

- Preferable adhesive
  >>Hard to break after severe forming

- Enough thin for high precision forming

- Easily removed by alkaline cleaner
## Constitutions of pre-coat layer

<table>
<thead>
<tr>
<th>Contents</th>
<th>mass%</th>
<th>Roll</th>
</tr>
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</table>
| Acrylic Resin          | 80    | 1) holds sufficient adhesive strength.  
2) maintain enough flexibility to severe deformed surface.  
3) dissolves easily into alkaline solution. |
| Silica                 | ~10   | 1) gives moderate hardness.                                           |
| Polyolefin Wax         | ~10   | 1) leads to low static/dynamic friction.                              |

Contains no harmful metal and organic chemicals
Effect of friction on the press formability

Optimizing!

Formability with Polyethylene film

+ Wax

Resin + Silica

Low friction improves the press formability

Coefficient of dynamic friction (= μk)
An evaluation method of formability for PHE

**Herringbone type test die**

Die Size 100mm X 100mm

Pressed sample

Scoring at each circled point

2 : No crack  
1 : Necking  
0 : Crack

Formability(%) = \( \frac{\text{Summed marks}}{\text{Full Marks (No crack)}} \times 100 \)
Pretty tough coating layer

Layer keeps stable

Bended surface of pre-coat titanium

Comp. SEM

Mapping of Carbon

R/t = 1.5
Bending Radius: 0.75mm
Thickness: 0.50mm

Pre-coat film covers the bended surface without break
Pre-coated titanium shows excellent formability compared to one using polyethylene film as lubricant.
Effect of thickness on the press formability

Sub-micron thin layer coating keeps the excellent press formability
Removable coating layer by alkali cleaner

Only 60 sec. dipping in alkali cleaner can remove pre-coating layer perfectly.
Evaluation method of formability

1. Evaluation Points and their number
   - Apex: 18 (Concave) 18(Convex)
   - Ends of beams: 56

2. Scoring at each point (E)
   - 4: No Crack
   - 3: Necking
   - 2: Severe Necking
   - 1: Small Crack
   - 0: Large Crack

Score (%) = \( \frac{\sum E_{1,2} \times 100}{(18 \times 4 \times 2 + 56 \times 4)} \)

- Forming Height: 4.5mm
- Radius of beams: 3.4mm
- Pitch between beams: 14.9mm
20% stronger pre-coated titanium has same excellent press-formability as conventional cp titanium for PHE using press oil as a lubricant.
Conclusions

KOBE STEEL has developed pre-coated Titanium with excellent press-formability

> with press-formability without lubricant close to one with polyethylene sheet as lubricant.

> with extra thin coated layer supporting good dimensional tolerance of products.

> easily removed by alkaline cleaner and suits for mass-production.
Thank you for your kind attention!