Investigation on thermomechanical properties of high nitrogen nickel-free austenitic stainless steels, commercially pure titanium and Ti-6Al-4V.

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1. GOAL OF THE PROJECT

Cold rolling is a well-suited shaping process for many metals and alloys (e.g., austenitic and ferritic stainless steels, copper, aluminium, etc.). Some problems may however arise for certain classes of materials. Two main issues are commonly encountered:

- Roll mills overload: it typically occurs for alloys having high initial yield strength and/or high work hardening rate, and thus require high stresses to be plastically deformed.
- Surface defects: edge cracking is the most common defect. It typically occurs in alloys having limited ductility.

CHALLENGES

Limiting factors in cold rolling

METHODOLOGY

How to overcome these issues?

- Measure the evolution of the properties as a function of temperature for three problematic materials currently used by Précimat SA³. Compare the results to a reference (here: 316L stainless steel).
- Evaluate, whether a slight increase in the rolling temperature (typically 200 – 400°C) could overcome issues encountered during cold rolling.

2. EXPERIMENTAL METHOD

TENSILE TESTS

Determination of the appropriate warm rolling temperature

WARM ROLLING TESTS

Evaluation of process efficiency

1. Process
2. Roll mill

Wire
Flat oval

YIELD STRENGTH VS. TEMPERATURE

Power proportional to \( \sigma_y \)

WARM ROLLED WIRES

Warm rolling temperature: 200°C

Path performed: 10 - 7 - 5 - 3mm (no intermediary annealing)

Maximum crack size (thickness 3mm): 17pm

- enables overcoming problems encountered during cold rolling.

3. BIODUR108

Challenge: Biodur108 is a high nitrogen nickel-free stainless steel containing about 1.1 wt%N. Consequently, it has a high yield strength at room temperature (~700MPa) and a high strain hardening rate. Cold deformation of Biodur108 tends to be difficult due to the limited power of the roll mills.

4. TI GRADE 2

Challenge: Ti Grade 2 (or commercially pure titanium) has limited ductility at room temperature (A ~ 60%). During cold rolling, edge cracks thus tend to appear at relatively low deformations.

5. TI GRADE 5

Challenge: At room temperature, Ti Grade 5 (or Ti-6Al-4V) possesses a high yield strength (>900MPa) and limited ductility (A ~ 45%). Both roll mills' power and surface defects are thus limiting factors.

6. WARM-ROLLING RELATED ISSUES

INFLUENCE OF NITRIDES ON BIODUR108 CORROSION RESISTANCE

Nitrides precipitation at 800°C
Pitting corrosion tests

7. CONCLUSION

Warm flat rolling is advantageous for:
- Ti Grade 2
- Biodur108

Issues related to warm rolling must be taken into account. For example:
- Effect of nitrides precipitation on Biodur108 corrosion resistance