Design and development of a lab-scale aluminum extrusion simulator

Design et développement d'un simulateur d'extrusion d'aluminium à l'échelle laboratoire

Justin Plante[1], Farzaneh Vahidi[1], Xinyan Yan[2], Francis Caron[3], Guy Laliberté[3], Nicolas Giguère[4] and Carl Blais[1]

[1]Dept. Mining, Metallurgical and Materials Engineering, Université Laval, Quebec, Canada. [2]Alcoa Technical Center, Pittsburgh, United-States. [3]Alcoa Technical Center, Deschambault, Canada. [4]Quebec Metallurgy Center, Trois-Rivières, Canada.

INTRODUCTION

Al in automotive industry

- Vehicle lightweighting
- Reduced fuel consumption
- Increased autonomy (electric vehicles)

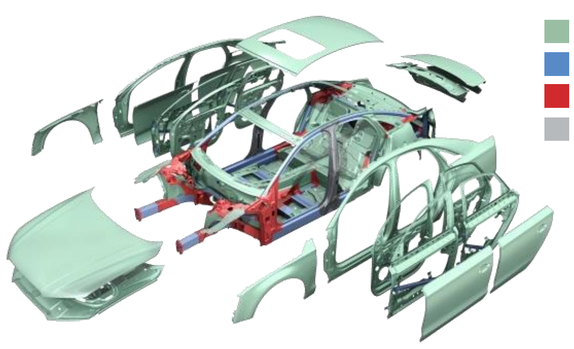


Fig. 1 : Typical materials for body structure of modern vehicles [1]

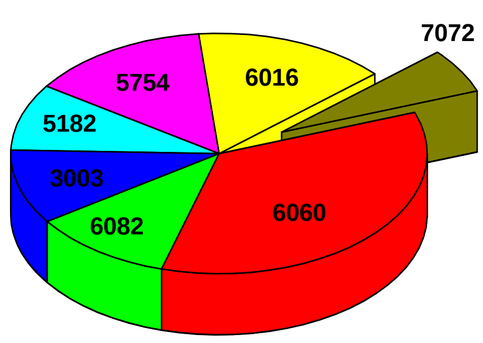


Fig. 2: Wrought aluminum alloy mixture from automobile [2]

Problematic : Alloys 7xxx

- Difficult to recycle
- High cost $$

Project scope

- Develop novel high performance Al-Mg-Si alloys to replace Al-Zn alloys for crash components in automobile

Objectives

- Develop a lab-scale extrusion simulator to reproduce industrial process
- Reduce lead time and cost of alloy development

Desired properties

- Yield strength ≥ 400 MPa
- Elongation ≥ 10 %
- Intergranular corrosion ≤ 150 µm

METHODOLOGY

Materials

- Billets ø1.405 x 2 in
- Experimental alloy : Al-Mg-Si+…+Cr

Extrusion with industrial process

Extrusion with simulator

- Billet preheating time : 0 - 90 min
- Extrusion speed : 5 - 12 in/min

Heat treatment (T5 temper)

- Water quench
- Natural aging : 24 hr
- Artificial aging : 8 hr, 175°C

Comparison simulator vs industrial process

- YS, UTS & El.
- Microstructure

THE EXTRUSION SIMULATOR

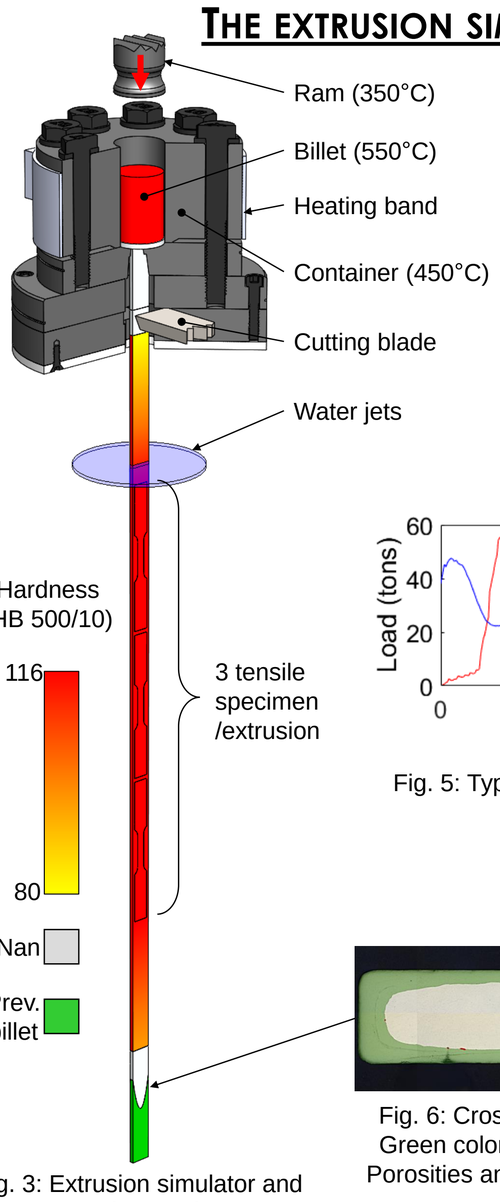


Fig. 3: Extrusion simulator and extrusion product

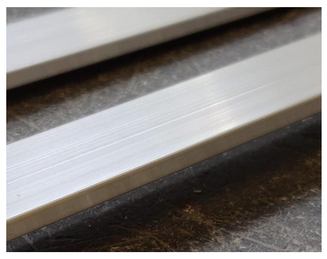


Fig. 4: Typical surface finish of extrusions from the simulator

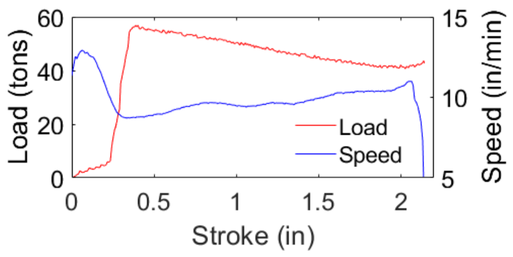


Fig. 5: Typical extrusion data acquired from the simulator

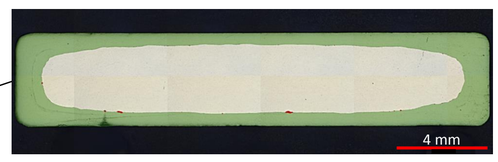
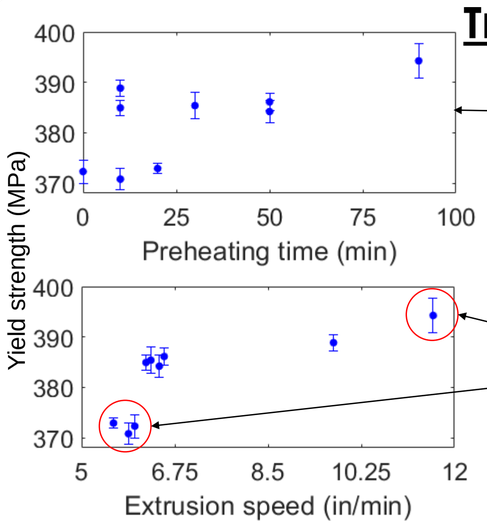


Fig. 6: Cross-section of transverse weld. Green color indicates the previous billet. Porosities and impurities are shown in red.

THE EFFECT OF PROCESS PARAMETERS



No significant effect : Longer soaking time does not allow to dissolve more Mg_2Si

Greater extrusion speed increases **exit temperature** and allow **faster quenching**

Time before quenching

- 1.27 sec
- 2.45 sec

Fig. 7: Effect of simulator process parameters on yield strength of T5 extrusions

Steps for precipitation hardening

1. **Dissolve**
2. **Quench**
3. Precipitate

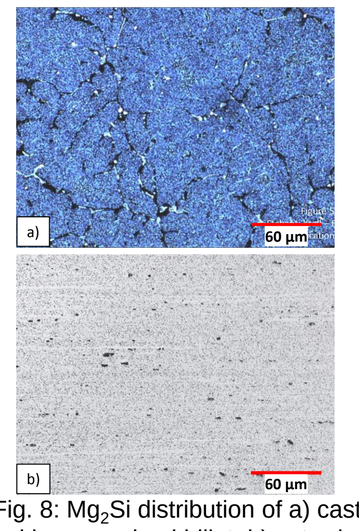


Fig. 8: Mg_2Si distribution of a) cast and homogenized billet, b) extruded and aged sample

SIMULATOR VS INDUSTRIAL PROCESS

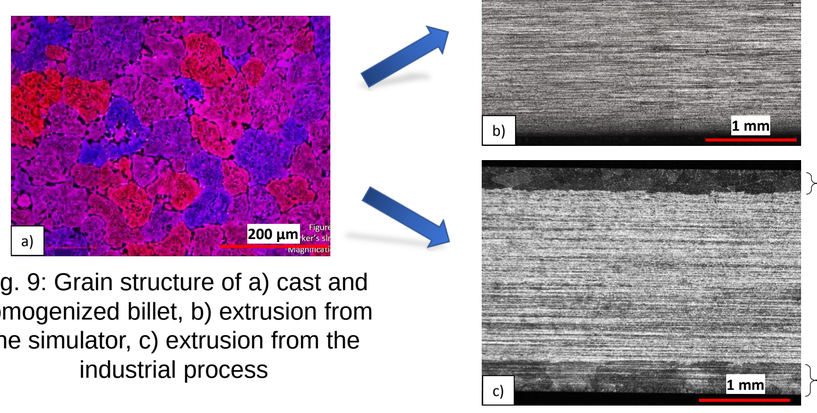


Fig. 9: Grain structure of a) cast and homogenized billet, b) extrusion from the simulator, c) extrusion from the industrial process

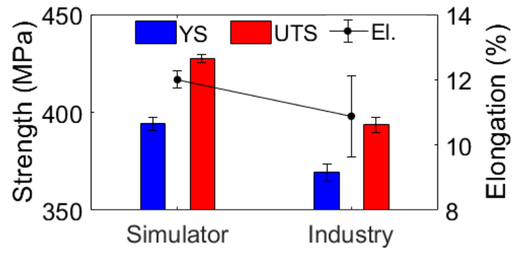


Fig. 10: Comparison of mec. prop. of extrusions from the simulator and the industrial process

Peripheral coarse grain (PCG)

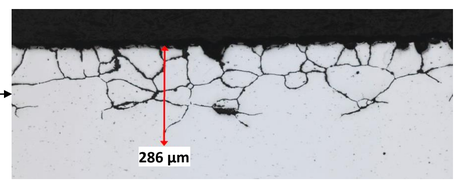


Fig. 11: Effect of PCG on intergranular corrosion

CONCLUSIONS

- Preheating time has no significant effect on mec. prop.
- Elevated extrusion speed is beneficial for mec. prop. by increasing exit temperature and decreasing the delay before quenching
- The simulator can be used as a reliable tool to decrease cost and lead time of alloy development
- The simulator could be useful to optimize the industrial process parameters for this alloy

FUTURE WORKS

- Investigate the difference in mec. prop. and microstructure between the simulator and industrial process
- DOE : ↑ extrusion speed and preheating temperature
- Measure exit temperature
- Evaluate intergran. corrosion of extrusions from the simulator
- Aging curve : 175°C (4-32hr)
- Extrude variants of the base alloy with the simulator

Acknowledgement

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References

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