# Development of extruded 6xxx series aluminum alloys with improved mechanical properties

## *Développement d'alliages d'aluminium extrudés de la série 6xxx avec des propriétés mécaniques améliorées*


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## Introduction

AA6xxx series aluminum alloys are considered as vital candidates in the automotive industry [1]. These medium-strength heat-treatable alloys have significant advantages such as high strength to weight ratio, excellent extrudability, and corrosion resistance, making them a good choice for automobile parts [2, 3]. Currently, the extrusions for the absorption boxes and side reinforcements are designed in 6000 series alloys, but the bumpers are produced using 7000 series (Al-Zn). In the present work, these three types of parts have been produced from AA6xxx since AA7xxx alloys have difficult recycling and quench sensitivity [4]. The objective of this project is to develop a new generation of 6000 series alloys that will be used to manufacture extrusions in the automotive bumpers and impact absorption boxes. Comparison with conventional alloys, these developed extruded alloys presented higher mechanical properties and superior corrosion resistance. Therefore, yield and tensile strength respectively greater than 300 MPa and 340 MPa were attained.

## Methodology

**Casting** → **Hipping** 103.5 MPa, 6 h → **Homogenization** 570 °C, 1 h → **Preheating** → **Extrusion** Lab simulator, Ratio: 20, Speed: 1.3 mm/s → **T6 Heat treatment** SHT : 575 °C, 1 h, Aging : 185 °C, 10 h

### Composition of aluminum alloys

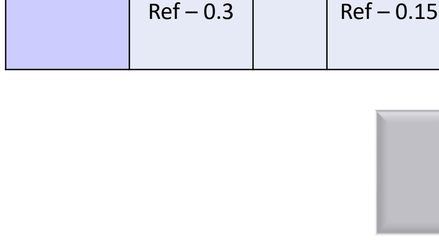
| Alloy ID | Si | Fe | Cu | Mn | Mg | Cr | Zr | Ti | B | wt.% |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Reference | | | | | | | | | |
| 2-19 | Ref +0.4 | Ref | Ref+0.3 | Ref + 0.12 | Ref+0.25 | Ref+ 0.2 | Ref+ 0.2 | Ref | Ref | Max |
| | Ref – 0.3 | | Ref – 0.15 | Ref – 0.28 | Ref-0.25 | Ref+0.05 | Ref + 0.05 | | | Min |

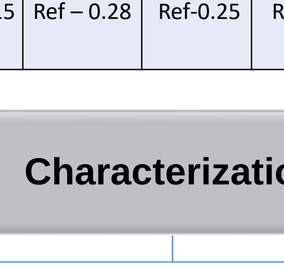
**Characterization**

- **Microstructural analysis** OM, SEM
- **Mechanical testing** Tensile, Hardness

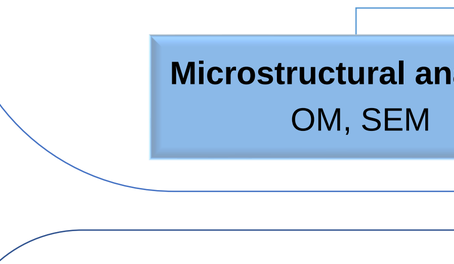
## Results

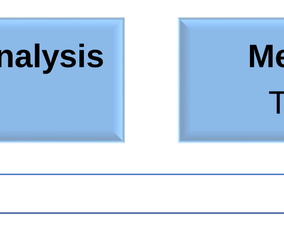
### ❖ Homogenized alloys




*SEM micrograph of homogenized Al-Mg-Si alloy containing Zr and EDS spectrum of $Al_3Zr$ phase.*



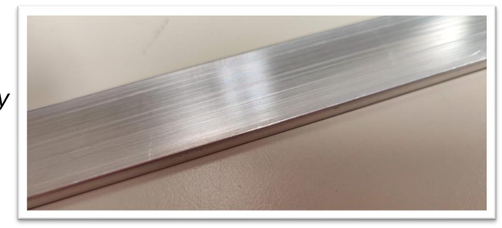




*SEM- EDS results of homogenized Al-Mg-Si alloy containing Cr.*

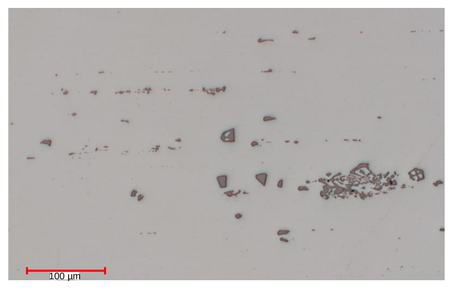
AlFeCrMnSi phase with small contents of Mg and Cu can be seen.

### ❖ Extrusion product

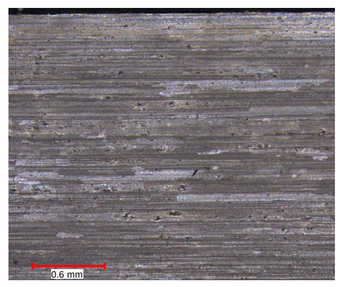
*Surface finish of initial extruded alloy*



### ❖ Metallographic analysis of extruded alloy

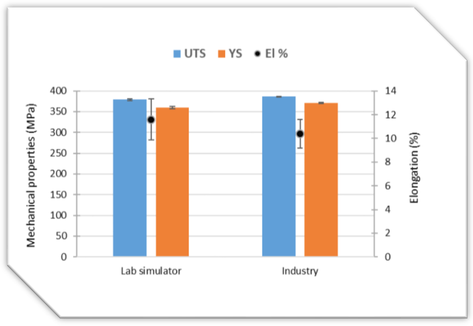



*As-polished microstructure*




*Grain structure*

### ❖ Mechanical properties




## Conclusions

- Extrusion microstructure without any large $Mg_2Si$ shows adequate thermal treatments.
- The grain structure is partially recrystallized with some very elongated grains oriented in the extrusion direction.
- No peripherical coarse grains layer was noted in this material.
- Alloys with the optimum amounts of Zr and Cr are expected to reveal yield strength greater than 300 MPa. For instance, fine $Al_3Zr$ dispersoids can enhance alloy strength by pinning grain boundaries in the structure.

## Future works

- ✓ Optimization of extrusion conditions.
- ✓ Extrusion of 19 alloys; after that investigation of mechanical properties and microstructural features and determine 3 to 4 final alloys for mass production.
- ✓ Optimizing the aging conditions.

## References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[4] Bauser, et al., Aluminum-Verlag 2006 (2) 195.



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