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**MTRL 466 – Adhesive Bonding in Al Alloy Automobile Panels**

# Types of Al alloys in Automobiles

* Selection criteria *[1, V. Aluminum Alloys for Commercial Vehicles, pg. 44]*:
  + Availability of semi-finished products
  + Mechanical properties
  + Physical properties
  + Suitability for fabrication
  + Weldability
  + Corrosion resistance
* More detailed general requirements *[2, Alloys for Car Bodies, pg. 367, 368]*:
  + Small grain sizes, usually less than 50μm
  + 0.2% yield stress in the quenched and naturally aged state no higher than 150 MPa
  + 0.2% yield stress elevated up to 300 MPa in artificial aging
  + Good formability, high corrosion resistance
  + Absence of Luders line to provide mirror surface after painting
    - No local yielding variation
  + Uniform thickness, high-quality surface
* Aluminum debuted at the turn of the 20th century
  + Uses have developed ever since in terms of aluminum alloy applications in automobiles
    - Better performance (weight), energy cost savings, variety of applications
* Multiple manufacturing processes:
  + Rolled aluminum (sheet is the focus)
  + Extrusion
  + Casting

## What is their composition?

* Most commonly used rolled (sheet) Al alloys in automobiles *[3, Products → Rolled products → Alloys]*:
  + 5xxx series, Al-Mg
    - 5005, **5052**, 5454, **5754**, 5182, 5083
    - Medium strength, corrosion resistance
  + 6xxx series, Al-Mg-Si
    - 6061, 6181, **6111**, 6022
    - Good formability, high strength
  + Select 1xxx and 3xxx alloys
    - 1050A, 3003
    - Heat transfer, thermal stability
* Formability depends largely on grain structure, morphology
  + Coarse grains cause material roughness, leads to fractures

## How are they strengthened?

*[4, Wrought Aluminum Alloys]*

* **5xxx series:**
  + The presence of magnesium as main alloying element leads to solute hardening of the alloy, and efficient strain hardening, resulting in medium strength
    - Strain hardening (work hardening) is achieved by plastically deforming the material
      * Energy is being added to the material
      * Dislocations move and are also produced during this process
        + Dislocations hinder lattice movement; deformation becomes more difficult; higher stresses are necessary
  + Generally stronger than the medium strength 3xxx series alloys, while having also very good formability
* **6xxx series:**
  + Can be strengthened by heat treatment (**precipitation/age hardening**), through the presence of their main alloying elements silicon and magnesium
    - Second phase particles cause lattice distortions, impede movement of dislocations
    - For up to 12% **silicon**, precipitation hardening of the alloys is possible when silicon is combined with magnesium
      * More than 13% Si reduces machinability
    - Magnesium and silicon form Mg2Si precipitates
    - Furthermore, Si improves the corrosion resistance compared to other alloys except for those of the 1xxx series
  + These alloys are generally less strong than the 2xxx and 7xxx series, but have good formability and are weldable.

## Where are they used?

* 4 key application areas for Al alloy products *[3, Products → Rolled products → Alloys]*:
  + Power train
  + Chassis
  + **Car body**
    - Body-in-white (BIW), doors, hoods, wings (fenders), bumpers, seats
  + Interior
* 5xxx series:
  + Chassis, structural parts, wheels, **inner panels**
    - Bending and torsion stiffness
* 6xxx series:
  + BIW, **Outer panels**
    - Static bending, torsion, stiffness
    - Dynamic dent resistance
    - High surface quality
* 1xxx series:
  + Heat shields, fin stock
* 3xxx series:
  + Heat exchanger

## References

[1] Aluminum in Commercial Vehicles <http://www.eaa.net/upl/4/en/doc/Aluminium%20in%20Commercial%20Vehicles.pdf>

[2] Aluminum Alloys: Promising Materials in the Automotive Industry <http://www.springerlink.com/content/l605843182pv7774/fulltext.pdf>

[3] The Aluminum Automotive Manual <http://www.eaa.net/aam/>

[4] AluMatter: Wrought Aluminum Alloys <http://aluminium.matter.org.uk/content/html/ENG/default.asp?catid=214&pageid=2144417044>