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Tuesday, September 13th 2011

**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>