TOWARD SUSTAINABLE TRANSPORTATION THROUGH ALUMINIUM

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Aluminium is the second most consumed metal in the world, after steel. Major aluminium users are transport, construction, equipment and packaging manufacturing industries. After over thirty years of research and development, Al alloys became the most attractive automotive material because of its low density (one third the density of steel) and almost equivalent specific strength (strength/density), formability, crash resistance and superior corrosion resistance. Recent study showed that using Al instead of steel may achieve 50% weight saving in body-in-white (BIW) application, which may lead to a 30-40% overall weight reduction. This option becomes further attractive for the automotive manufacturer to meet the government's "Road to Zero" strategy through the e-vehicles (EVs), where battery weight is approximately 400-800kg, which needs to be compensated through weight saving in other parts. Al plays an important role in the EVs through innovation, and most recent study concludes that EVs have approximately 30% higher Al than internal combustion engine (ICE) cars. It is expected that use of Al in cars to continuously grow by as much as 30% in the next ten years, not only for the structu`ral components but also from the use in e-motor case, electric wire, battery cell and modules, cathode aluminium foil etc. At the same time, there is limitation on what we can achieve through existing Al-alloys and manufacturing routes. Therefore, new research is required to develop advanced high strength Al-alloys in conjunction with the processing routes such as heat treatment, forming process, joining etc whilst maintaining both cost and production cycle time.

In the last ten years, most of the major Al suppliers have been developing new 5xxx (Al-Mg) and 6xxx (Al-Mg-Si) alloys to meet OEMs demand by altering alloy chemistry and processing conditions. 7xxx (Al-Zn-Cu) alloys automotive sheets are also developed for greater strength, however, this type of alloy is not attractive in terms of cost and corrosion. Most current trends show that automotive sheet alloys tilt more and more towards 6xxx alloys from 5xxx mainly because of higher strength and formability. At the same time, there is a high demand from OEMs to develop high strength (> 400 MPa, tensile strength) Al alloys for bumper, safety cage and battery pack to replace steel. Formability of Al-alloys is also an issue that needs further research and development as 5xxx and 6xxx have slightly less formability, approximately 10% lower than the steel counterpart. This limitation can be overcome through hot-forming and quenching. Besides the formability, many more aspects of the forming process are needed to consider – e.g. forming speeds, tooling, cooling, etc. Also, welding between different aluminium alloys, and with other metals, need to be the focus of research before claiming success in the development of materials for automotive applications. In the future, it is unlikely that cars will ever be manufactured using just aluminium or steel. Currently EVs, facing one specific challenge to weld dissimilar materials (Cu/Al) in battery enclosure and defect free weld at module level. It therefore becomes essential to develop joining techniques for dissimilar metals, and even between different classes of alloy systems. Above all, it is essential to put complete recycling management from alloy design to end-of-life vehicles (ELVs), which will increase recycling and lead us to complete suitability.

WMG work on this multifaceted problem by integrating material science, processing, and advanced tools like Machine Learning (ML)/Artificial Intelligence (AI) and supply chain management. On Al-alloy our research centres adopting fundamental and applied research to engineer microstructure for transport applications, including recycling to increase residual elements tolerance such as Fe on Al alloys. Our research on forming focuses on improving material formability through hot-forming and quenching. On welding and joining, we are using Self-Piercing Riveting (SPR), ultrasonic welding and Remote Laser Welding (RLW) for BIW and battery construction. We also use ML/AI tools to improve scrap metals separation and waste management. Our research and development is enabled by the world leading material testing facilities at WMG capable of testing materials from the coupon to component level and the characterisation facilities capable of analysis materials up to nanometers (nm) by using advanced microscopes.

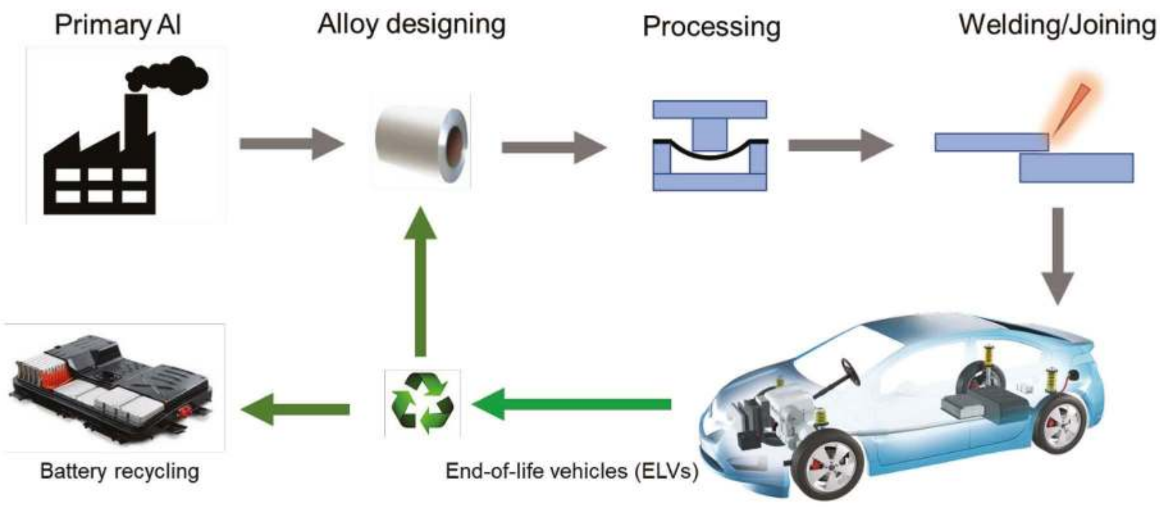

Figure 1. WMG research activities starting from the alloy designing to the materials recycling.