The Use of Aluminium in Automotive Industry

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Abstract

Over the last few years, the growth rate of aluminium consumption has been at the level of 4 – 6 %. One of the main drivers for consumption increase is automotive industry. For example, 10 years ago the average aluminium content was 90 – 100 kg per car, whereas today this number has been increased up to 150 kg per car. The growth of aluminium consumption for automotive applications is caused above all by a necessity to reduce the weight of a car in order to increase its energy efficiency and consequently to reduce the carbon footprint. It is expected that due to the tightening of ecological norms, the aluminium content in American and European cars will exceed 220 kg per car by 2030. Reducing the automobile weight by increasing aluminium content can decrease the energy consumption by 20 % and CO_2 footprint by 12.6 % compared to the steel car constructions. This paper presents an overview of the trends of aluminium use as a way to decrease the fuel consumption and carbon footprint while maintaining or enhancing the reliability and safety of the vehicles. In addition, it briefly describes current RUSAL projects in the field of implementation new aluminium solutions in automotive industry.

Keywords: Aluminium, automotive industry, lightweight car construction, carbon footprint.

1. Introduction

Aluminium has been used in the automotive industry for many years to some extent, now its penetration is gaining momentum and the trend will go on.

Aluminium is significantly more expensive than steel but its main advantage is its weight. An aluminium component can substitute as steel component by providing the same mechanical characteristics for up to half the weight. This is the main reason why car manufacturer are using aluminium.

Countries all around the world are continuously implementing stricter emission and CO_2 legislations. Europe is usually on the foreground followed a few years later by China and the US. In 2021, in Europe the target will move down from 130 g of CO_2 per km to 95 g. By 2030 a further 37.5 % reduction will be required. Simultaneously penalties for not achieving such targets could cost billions to original equipment manufacturers (OEM).

Therefore all automotive brands are working on drastic reductions of their fleet emissions by improving and downsizing engines, improving aerodynamics, developing hybrid and electric powertrains and light weighting their cars.

We expect Battery Electric Vehicles (BEV) to reach 15% of the European market by 2030, hybrids will go up to 30%. Therefore more than 50% of sold vehicles will still rely on Internal Combustion Engines with always tighter CO_2 targets. The recent issues with VW and diesels contributed to worsen the situation, because diesel engines are by definition more efficient than gasoline engines.

Simultaneously other trends, like improving safety, durability, acoustic, better comfort are driving vehicle's weight up. This implies even further effort to reduce weight in order to compensate.

All of the above demonstrate that the need for light weighting will become more and more important.

2. Aluminium versus other materials

According to automotive engineering specialists, the intensive use of optimized steels (UHS, boron) enables a further weight reduction of 15%, aluminium enables 40% to 45% savings at a reasonable cost. Magnesium and Carbon Reinforced Plastics (CRFP) can drive the weight further down but at significantly higher costs (Figure 1). Therefore in the coming 10 years, mover 50% of the mass savings in cars will be provided by aluminium.

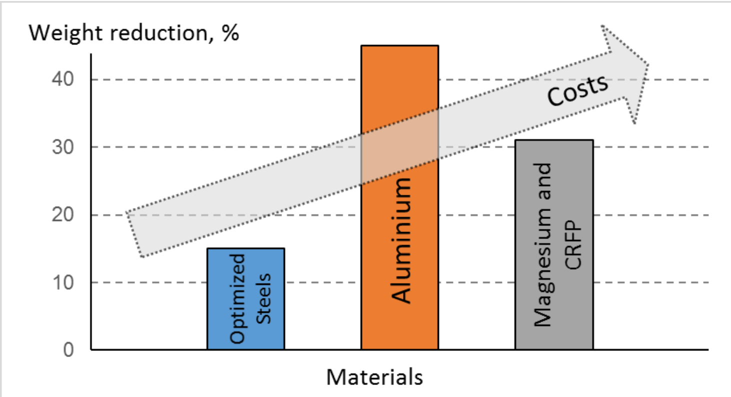


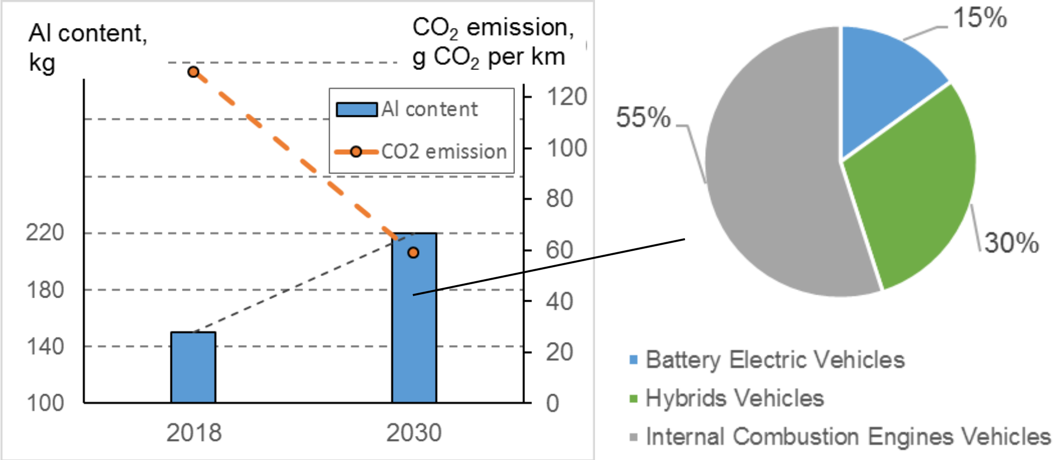
Figure1. Relative materials weight reduction and costs

This was successfully done by Jaguar Land Rover (JLR) on the Range Rover some years ago: by shifting from a steel to an aluminium body (body, closures, suspension and chassis sub-frames), they saved 300 kg. They could therefore additionally switch from V8 to a V6 engine, keep the same performance and save another 120 kg. Overall they reduced the consumption of the car by 23% (CO_2 emission are directly linked to fuel consumption).
We should nevertheless not expect cars to switch fully from steel to aluminium. The use of aluminium is first of all very different in low cost mass market cars with less than 100 kg of aluminium per car and premium Sport utility vehicles (SUV) with up to 600 kg. Beyond that, OEMs are no working on efficient multi-material solutions using the right material at the right place.

According to Ducker, in Europe, the average aluminium content of cars will grow from approximately 150 kg to 220 kg by 2030 (Figure 2). Similar trends are expected in all major markets (US, China, Japan) [1].

Simultaneously passenger cars and light Duty vehicles volumes worldwide are expected to grow from 98 million vehicles to above 125 million by 2030. This implies an additional yearly consumption of +10 million tonnes of aluminium by that time.

In terms of components, the applications of aluminium are extremely diverse.



(a) (b)

Figure 2. Average aluminium content of cars – (a) and relative battery electric vehicles, hybrids vehicles and internal combustion engines vehicles by 2030 – (b)

Aluminium castings are already common for some applications such as engine blocks, pistons and gearbox housing which rely mainly on secondary aluminium grades. Aluminium wheels are made of primary aluminium. With 10 kg per wheel, this is an important market for RUSAL. We also supply a range of other applications like for example brake calipers. The largest new trend is linked to the development of large aluminium casting into car body structures, for example shock-towers or battery housing for hybrid vehicles.

In terms of extrusions, the most common application is crash management systems and door reinforcement beams. There is also a range of smaller applications like roof bars, sun roof rails, and anti-vibration systems. Battery electric vehicle (BEV) require also a large extrusion based structure for battery housing.

Aluminium forgings are usually used for chassis and drive train components as well as suspension arms. Such volumes remain smaller. A growing opportunity is linked to the development of forged wheels either for premium cars or for trucks.

In terms of flat rolled products, heat exchangers are fully relying on aluminium cladded solutions for several years but the main topic is the tremendous growth opportunity linked to the development of body in white application. Hoods, fenders, doors are gradually switching over from steel to aluminium. This represent the largest opportunity for our industry despite high end quality requirements.

3. Rusal today

RUSAL has over the last years strongly developed its links to OEMs and Tier 1 suppliers. We are one of the main supplier of aluminium to wheel makers, but also developing European, Asian and other non-wheel automotive customers. We supply for example Primary Foundry Alloys (PFA) for engine heads or structural components of leading OEMs. We are delivering automotive slabs to several rolling mills both for inner and outer applications in Asia and in Europe. We are also qualifying billets for crash relevant applications. Beyond that RUSAL is partnering with several customers to co-develop new alloys for future vehicles.

Among the new materials without heat treatment should allocate Al-Mn-Ca system alloy as an alternative to heat treatable Al-Si-Mg system alloys. The use of material without heat treatment will significantly reduce the cost of producing castings from aluminum alloys. The cast structure of the Al-Ca-Mn alloys consists of eutectic, which provides good castability, and solid solution containing the alloying elements, which allow to provide a hardening effect already in as-cast state. A small crystallization interval of the new alloy ensures good processability in producing of thin-walled castings. In addition, Al-Ca-Mn alloys show excellent corrosion resistance compared to existing 3xx series alloys.

RUSAL is also offering an additional key benefit to the automotive industry which is more and more concerned by sustainability topics. In fact OEMs are now assessing and trying to reduce the carbon footprint not only of the car but also of the full value chain, from the mine to the wheel. As far as this is concerned, thanks to its access to more than 95% of hydropower, RUSAL's low carbon aluminium, ALLOW™, has a carbon footprint of 1/3 from the industry's average (scope 1 = direct plant emission, scope 2 = emissions from energy supply). This is currently gaining strong momentum worldwide in particular in Europe and Asia where carbon footprint and Aluminium Stewardship Initiative (ASI) certification are starting to be systematically requested.

RUSAL, with a global footprint, competitive prices, good quality, reliable supply chain, R & D capabilities and low carbon aluminium, is well positioned to be recognized as the aluminium supplier of choice of the automotive industry.

4. Conclusion

Today and in the future, aluminium is the ideal solution to save weight in mass production without compromising safety. Further growth in consumption depends on the growing market increasing penetration of new structural components, such as car body design named Body in White (BIW) in the industry. New solutions for the use of aluminum for mass consumption should provide cost reduction, increase reliability and safety.

5. References

1. Ducker Worldwide. 2016. Aluminium Content in Cars. European Aluminium Association.