ABSTRACT

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ALUMINUM AS A PROMISING MATERIAL IN THE AUTOMOTIVE INDUSTRY

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Aluminum alloys are extensively applied in the transport sector and contribute to sustainability, lean production and circular economy as well; their widespread use can be considered as accelerators for transition to Industry 4.0 and Industry 5.0 concepts. One of the features is that at the end of a vehicle`s life cycle almost all aluminum can be recycled for production of new products. The presence of aluminum in all kinds of transport provides an increase of speed, safety, energy savings and decrease of transport emissions. Thus, with a 10 % reduction in the total weight of the car a fuel saving of 5...10 % is achieved in the total spent fuel per kilometer [Tolun, 2019]. Replacement of 1 kg of steel on 1 kg of aluminum / aluminum alloy in automobile construction decreases the overall carbon dioxide emissions by 5...8 kg CO2-eq. for the life cycle (or per 200,000 km of mileage) [Geyer, 2008; Peppas et al., 2021]. There is also a reduction of total life cycle energy consumption up to 20 % [The Aluminum Association]. Aluminum discs ensure a smooth ride and improved heat dissipation from the braking system. In the event of an accident, aluminum absorbs the impact more effectively than steel.

One of the pioneers in the use of aluminum as a structural material is the German automotive manufacturer Audi: in 1994 the model Audi A8 with an all-aluminum body was presented. Due to the use of aluminum, the Ford-150 car became 315 kg lighter than its predecessor, which led to reduction of fuel consumption and CO2 emissions, increasing the load capacity and improving the dynamics of the vehicle. Such brands as Audi, Jaguar Land Rover, BMW, Porsche, Ford, McLaren, Renault, Mazda, Nissan and others actively use aluminum for parts of the engine, heat exchangers, transmission, suspension elements, chassis, body structure, wiring, etc..

A promising and relevant area of aluminum use in the transport sector is the production of electric vehicles. The Tesla electric cars already 50...70 % consist of aluminum (Roadster, Model S, Model X, Model 3 and others) [Thomas & Maine, 2019]. Saving weight cools down the battery and improves safety of the electric vehicles. It is assumed that the aluminum-ion battery will replace an internal combustion engine in the automotive industry [Li et al., 2017; Shen et al., 2021].

Nowadays nearly 10,000 parts and automobile details can be recycled [Jensen & Remmen, 2017]. As the average lifetime for automobiles is 10...12 years nearly 40.2 mln and 7.8 mln automobiles reached their end-of-life globally and in the EU

respectively. The block head, cylinder block, bearing cups and other parts of modern automobiles are made of recycled aluminum alloys. The REALCAR project (Jaguar Land Rover, Novelis Corporation) foresees the use of the RC5754 alloy, containing up to 75 % recycled aluminum for automobile construction [BusinessEurope]. The project RecycAl [RecycAl, 2022] is aimed to develop innovative technologies of processing of low-grade aluminum scrap with a high content of impurities into raw material suitable for manufacturing of high-quality aluminum alloys.

Renault is that automotive manufacturer who has committed to the implementation of a circular economy strategy, creating a subsidiary company Renault Environment, which provides control over the flow of automotive waste and parts. As a result, vehicles are created 85 % reusable and contain up to 95 % end-of-life parts. The application of the principles of the circular economy allowed the company to reach an income of 0.5 billion euros per year [Renault Group, 2020].

A new aircraft has an estimated life cycle of 20…30 years, after which it is either stored or demolished or recycled [Jensen & Remmen, 2017]. It is assumed that nearly 8,500…12,500 civil planes will be at end-of-life within the next 20 years [Striuk & Rassovytska, 2014]. One of the major studies on aircraft recycling was initiated by Airbus (PAMELA project). It was demonstrated that up to 85 % of the plane could be recycled, reused or recovered [Ribeiro & Gomes, 2015]. In 2006, Boing launched the AFRA initiative on recycling of aircraft to support the development of industrial standards [Jensen & Remmen, 2017]. Similar to PAMELA, the AFRA has promoted best practice within end-of-life and has developed guidelines on best management practices.

Nowadays industrial transport engineering focuses on the tasks and concepts in the transport sector from manufacturers and suppliers to service providers for both engineering and business decision-making. Advanced technologies in the area of recycled aluminum alloys, technologies for their manufacturing as well as organization of production, the choice of business-models and industrial policies have the potential for achieving almost zero emissions and depletion of resources

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