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A review of innovations in disbonding techniques for repair and recycling of automotive vehicles

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ABSTRACT

The recycling, recovery and reuse of End-of-Life Vehicles (ELVs) have raised worldwide concerns. This paper identified drivers for new joining solutions in the automotive industry and specifically reviewed current use of adhesive technology. From an ELV recycling point of view, rapid assembly and disassembly joining solutions were identified as key technology drivers. Innovations in adhesive disbonding technologies were reviewed and suggestions for the most promising future disbonding technologies have been proposed.

1. Introduction

Data issued by the International Organisation of Motor Vehicle Manufacturers showed that the global automotive industry has gradually recovered from the economic crisis in 2008; global vehicle production reached 84.1 million units in 2012 compared to 61.8 million units in 2009 [1]. This can mainly be attributed to the significant increases in vehicle ownership seen in developing countries such as China and India. In 2009 for example, car production in China was the highest of all car producing countries, reaching 13.79 million [2]. From a sustainable development perspective, growing concerns have been raised about the environmental impacts of automotive vehicles and their increasing numbers, including energy consumption, greenhouse gas emissions, waste generation and End-of-Life Vehicle (ELV) recycling.

The objective of this paper is to investigate the latter of these concerns, particularly focusing on ELV recycling problems from a joining solution perspective. In Section 2, current ELV processing procedures and legislative initiatives have been reviewed and analysed. Challenges which are likely to be incurred by the production of future vehicles have also been taken into consideration. A new joining solution with the essential characteristic of rapid disassembly is identified as a key technology driver. Section 3 discusses the current use of adhesive bonding in the automotive industry and a thorough review of recent innovations in adhesive disassembly technology is provided in Section 4.

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2. Drivers for change

There are two main drivers for change. These are international legislation on ELV and the demand (including future security of supply) of materials.

2.1. End-of-life Vehicles (ELVs)

2.1.1. Processing of End-of-Life Vehicles

End-of-Life Vehicles are normally either scrapped for recycling or simply abandoned on the road. In terms of the latter choice, the abandoned vehicles not only cause obstruction and safety problems in the public place but also waste resources. The research conducted by Melissa et al. showed that the devaluation of scrap metal, a poor vehicle registration system, weak legislation and the growth of cheap second-hand vehicles all contributed to an increase in the amount of abandoned vehicles [3]

The recycling, recovery and reuse of ELVs have already raised worldwide concerns. Various nations have implemented different strategies to deal with the issues which vary considerably in severity [2,4–7].

As product-take-back and legislation requirements on producer responsibility are implemented, the use of recycled materials is increasingly important [8].

In the EU, to ensure End-of-Life Vehicles are disposed of properly, ELV legislations and Environmental Permitting Regulations require all vehicles to be taken to Authorised Treatment Facilities (ATFs) for depollution, dismantlement and deregistration. A Certificate of Destruction (CoD) will be issued for the last owner of the vehicle after deregistration. Updated information of all the registered ATFs in the UK can be found on Environment Agency's

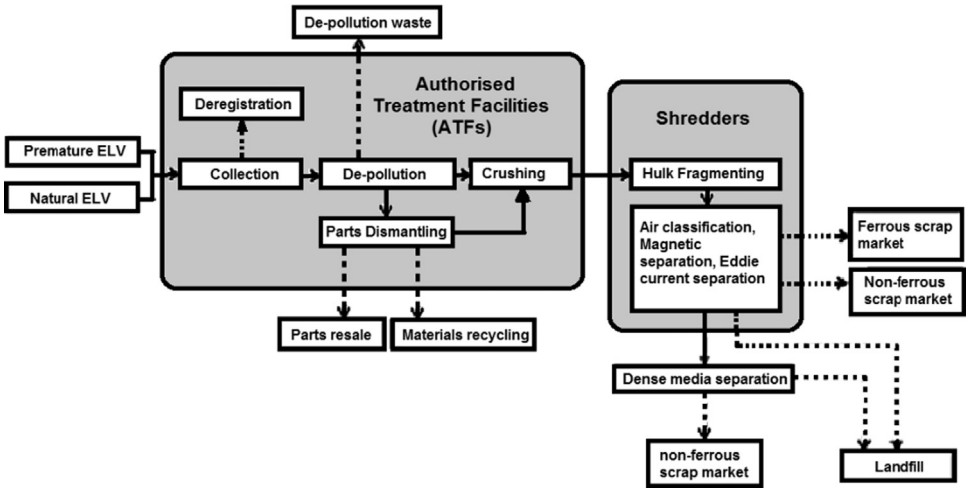

Fig. 1. Flow of a vehicle through the different end-of-life operations [96].

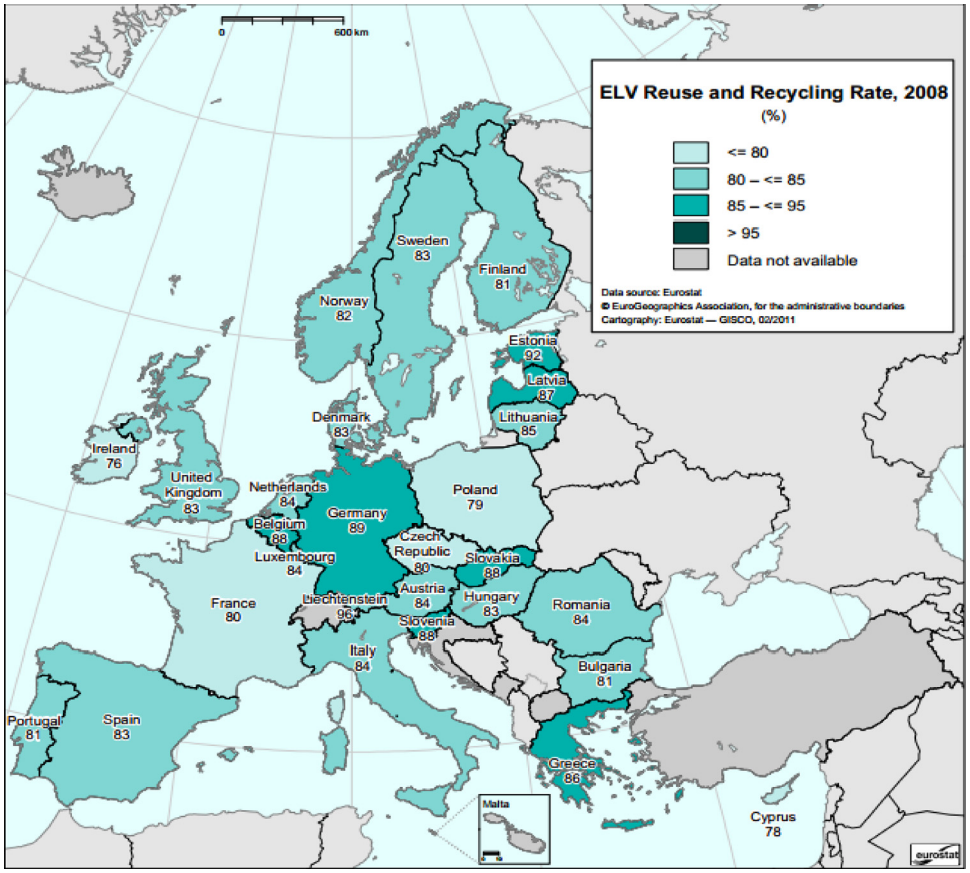

Fig. 2. The recycling and recovery rate of ELVs at European Union in 2008 [97].

website [9]. Autogreen and Car take back are the two major free take-back service providers with ATFs throughout the UK. Within the ATF process, a network of companies cooperates in the recycling process. For example, in the UK, EMR focuses on the scrap metal recycling while sending the plastic rich fraction to their joint venture partners, MBA Polymers Inc, which specialises in separating and recycling different types of polymers.

Fig. 1 reviews the general processing procedures of ELVs. The recycling process of a range of separated materials at this stage was detailed in the studies conducted by Baeyens et al. [10,11]. The remaining parts pass through a shredder and separation process for ferrous and non-ferrous metals. The resulting residue is termed as Automotive Shredder Residue (ASR), also referred to as 'auto fluff' or 'auto shredder fluff' [12]. Fig. 2 illustrates the size and scale of ASR production in Europe in 2008.

2.1.2. *Automotive shredder residue (ASR)*

Vigano et al. [5] estimated that EU countries produced approximately 1.9–2.3 million tons of ASR annually. This accounted for approximately 10% of the total number of hazardous wastes produced and up to 60% of the total shredding wastes [13]. ASR,