Research on the Ecological Performance Index System of Automobile Products Based on End-of-Life Vehicle

Meng Hou1*

1 Automotive Data of China Co., Ltd., City, Tianjin, 300300, China
*Corresponding author’s e-mail: houmeng@catarc.ac.cn

Abstract. Automotive hazardous substances and recyclables (ELV) are important indicators of the ecological design of automotive products. With the acceleration of the green transformation and upgrading of the automotive industry, the ELV performance of automotive products has gradually attracted the attention of enterprises. How to evaluate the pros and cons of ELV performance of automotive products has become a common problem facing the industry. This article is mainly for passenger car products, focusing on the ELV performance evaluation method of the whole vehicle, aiming to build a more systematic ELV evaluation index system to measure the pros and cons of the automotive eco-design level, and guide the automotive companies to achieve ELV performance and product front-end design Fusion. Some exploratory researches in this article hope to provide useful reference for the evaluation of the ecological design level of automotive products.

1. Introduction

The pollution caused by the automobile industry has begun to threaten the natural environment and human survival, and has attracted more and more attention[1]. It is estimated that by 2020, the number of scrapped automobiles in my country will exceed 14 million, and the weight of scrapped automobiles will exceed 31.08 million tons. The weight of heavy metal materials such as lead and mercury in the waste materials generated by scrapped cars will reach 386,400 tons, and the quality of materials containing brominated flame retardants will reach 28,000 tons[2]. For example, lead can cause serious pollution to soil and water sources. The limit of lead content in drinking water in my country is 0.01mg/L. The human body’s weekly lead intake should not exceed 0.025mg/kg, and heavy metals are in the soil. Residues, accumulation and migration will occur in the ecological system and cause serious harm to plants, animals and humans. The main impact of lead on the human body is the damage to the nervous system, hematopoietic system and kidneys. It is especially harmful to children and can cause many diseases such as children's mental retardation and hyperactivity. Therefore, it is particularly necessary to restrict the use of hazardous substances in automotive products.

In order to reduce the use of hazardous substances in automobiles, the European Union issued the ELV directive as early as 2006, which imposed requirements on prohibited substances and recycling rates in automobile materials[3], prohibiting the use of lead, cadmium, and mercury in automobile products. Hexavalent chromium, and set up a list of exemptions, grant a certain transition period, and set limits on the recyclability and recoverability rate, requiring that after January 1, 2015, the recyclability rate of scrapped cars shall not be less than 85%, and the recoverability rate shall not be Less than 95%. In June 2015, the Ministry of Industry and Information Technology issued the "Management Requirements for Automobile Hazardous Substances and Recyclable Utilization Rates" (2015 No. 38) (hereinafter referred to as the "Management Requirements"). Since January 1, 2016,
Hazardous substances in new models of M1 vehicles must comply with the requirements of GB/T30512-2041, and the recyclability and recoverability rate calculation shall be carried out according to GB/T19515-2015, and the implementation shall be delayed for two years after the production vehicle.

This paper analyzes the current status of the recycling and utilization of hazardous substances in M1 automotive products and automotive products in my country in recent years, gives ELV management requirements, and proposes an evaluation index system to measure the performance of automotive ELVs to provide a reference for the green development of automotive products.

2. China ELV management requirements

2.1. The reusability rate and recyclable rate
Recoverability rate ($R_{cyc}$) and recoverability rate ($R_{cov}$) are the main criteria for judging the recyclability of automotive product resources. The calculation of the theoretical two rates is based on GB/T 19515-2015 "Calculation Method for Recyclable and Recyclable Rates of Road Vehicles", through auto parts and materials in mP, mD, mM, mTr, mTe and non-recyclable parts6 The weight ratio of each stage is used to calculate the two rates of the whole vehicle.

In order to improve the two rates of automobiles, reduce the cost of back-end recycling, and increase the benefits of recycling enterprises, it is required that plastic parts weighing more than 100g and rubber and thermoplastic elastomer parts weighing more than 200g in automotive products must be based on QC/T797-2008 "Material Identification & Marking of Automotive Plastic, Rubber & Thermoplastic Elastomer Parts" to print polymer identification for easy sorting and recycling.

2.2. Hazardous substances
Automobile hazardous substances generally refer to the six hazardous substances restricted for use in the GB/T30512-2014 "Requirements for Prohibited Substances in Automobiles", namely lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls and polybrominated diphenyl ethers. The limit of cadmium is less than or equal to 0.01%, and the limit of lead, mercury, hexavalent chromium, polybrominated biphenyls and polybrominated diphenyl ethers is less than or equal to 0.1% (weight percentage). Taking into account industry technology and cost reasons, some parts and materials are exempted.

3. Current status of ELV management in China

3.1. The recyclability and recoverability rate of passenger car in china.
According to statistics, the industry average of the recyclability and recoverability rate of passenger cars in China exceeds 90%, and the recyclability rate has increased from 91.5% in 2016 to 92.6% in 2019, with an average annual increase of 1.2%; The recoverability rate has increased from 96.4% to 96.9% in 2019, with an average annual increase of 0.5%, as shown in Figure 1.
3.2 Hazardous substances in passenger cars in China

The lead content of passenger cars in China has been declining year by year from 2016 to 2019, from 12100.2g/model to 10823.9g/model. The average lead consumption per vehicle model has decreased by 1276.3g, a decrease of 10.5%. In 2019, model exemptions The average lead content was 10823.9g, a slight decrease from the previous year, with a decrease of 0.62%, and the decrease slowed down; the lead content of exempt items except for batteries dropped from 133.6g in 2016 to 116.7g in 2019, a decrease of 13.2%. In 2019, the lead content of the exempt items outside the battery decreased by 0.7g compared with the previous year, a decrease of 0.60%, which is basically the same as the decrease in lead content of the exempt items.

In addition, according to the analysis of the lead content distribution in the various exemptions for passenger cars in China in 2019, it is found that lead content in batteries is the most concentrated, accounting for 98.93% of the total lead content, followed by aluminum, copper alloys and solder, followed by lead content, steel and The lead content in electronic components is relatively close, only higher than the 0.2g lead content level of shock absorbers.

4. ELV performance index system

4.1. ELV performance index system construction

It is an internationally accepted practice to carry out ELV management through material data. Companies pay more attention to the consistency of material data and product ELV, and even verify material data through dismantling of actual vehicles, forming a closed-loop component material data management guarantee system to ensure Accuracy and validity of material data[4].

Therefore, it will be based on material data and fully consider the front-end design of the car,
combined with the actual car dismantling ELV performance index system, which has certain guiding significance for product development optimization and back-end recycling and dismantling.

The ELV performance of automobile products mainly includes dual rate and hazardous substances, which respectively reflect the resources of automobile products, energy recycling and harm to the environment, as the first-level indicators. At the same time, quantifiable secondary indicators and tertiary indicators are set to jointly construct an automotive product ELV performance indicator system to measure the ELV performance of automotive products.

![ELV performance index system for automotive products](image)

**Figure 3. ELV performance index system for automotive products**

4.2. **Analysis of ELV performance index system**

The construction of the ELV index system for automotive products considers both the resource input at the design end of the automotive product and the resource recyclability and environmental hazard risk assessment at the recycling end. Therefore, in the ELV performance index system, the number of types of materials, the amount and proportion of recycled materials used (polymer), the amount and proportion of degradable materials (polymer), the amount and proportion of precious metals, rare metals, and homogeneous components are introduced. The average weight, the content of hazardous substances in recyclable materials, and the content of hazardous substances in non-recyclable materials are secondary and tertiary indicators that comprehensively measure the ELV performance of automotive products.

1. **Recyclability and recoverability rate**

   The recyclability and recoverability rate value: Calculate in strict accordance with the requirements of GB/T19515-2015. The higher the two rates, the better the recyclability;

   Number of material types: Refers to the types of materials used in automotive products. The fewer the types of materials are used, the better their recyclability. This guides companies to reduce the use of material types, which is conducive to reducing recycling costs and increasing recycling value;

   The amount and proportion of recycled materials used: Refers to the total weight and proportion of recycled polymer materials used in automobiles. The higher the proportion of recycled materials used in materials, the better the recycling performance. The use of recycled materials in the design and manufacture of automobiles is convenient for recycling, reducing resource waste and improving recycling efficiency[5].

   The amount and proportion of biodegradable materials used: Refers to the total weight and proportion of biodegradable materials used in automotive polymer materials. The higher the proportion of biodegradable materials used, the lower the environmental hazard;
The amount and proportion of precious metals and rare metals used: The amount of precious metals and rare metals has a positive impact on the value of automobile recycling and the economy of recycling;

Average weight of homogeneous parts of the vehicle: Mainly calculate the average weight of pure metal parts and polymer parts, encourage the integrated design of parts, and reduce the number of parts;

Weight ratio of polymer marking parts: The printing of polymer logos is conducive to the identification of materials recycled at the back end and improves the recycling rate.

2. Hazardous substance index
Total content of hazardous substances: Total content of six hazardous substances: Content of Pb, Hg, Cd, Cr\textsuperscript{6+}, PBBs and PBDEs: The content of each hazardous substance: Pb content except battery: Refers to the lead content of automobiles except for starter lead batteries. Lead in automobile starter batteries accounts for more than 95% of the total lead content of the vehicle[6]. Therefore, the lead content in addition to batteries is an important indicator to measure the lead level of automotive products.

Content of hazardous substances per unit mass: Refers to the content of hazardous substances per unit weight of the vehicle;

Number and average content of parts containing hazardous substances: This indicator mainly evaluates the distribution and concentration of hazardous substances in automobiles. The more concentrated, the easier it is to recycle, and the lower the risk of harm to the environment;

The content of hazardous substances in recyclable materials: Hazardous substances in recyclable materials are easier to recycle together with the materials, and are less harmful to the environment, such as lead in steel, aluminum and copper alloys;

The content of hazardous substances in non-recyclable materials: Hazardous substances in non-recyclable materials are easier to enter the environment and cause harm. They are hazardous substances that should be focused and controlled in automotive products. For example, lead oxide content of PZT as traditional piezoelectric ceramics is around 60%[7].

5. Conclusion
This paper also considers the resource input at the design end of automotive products and the resource recovery and environmental hazards at the recycling end of end-of-life vehicles to construct the ELV performance index system for automotive products. This indicator system comprehensively evaluates the green design level of automotive products from the aspects of automotive materials, product design, hazardous substance content and concentration, and aims to provide evaluation methods and improvement methods for automotive product environmental protection design to achieve the improvement of the ELV level of Chinese automotive products.

References
[1] Zhang H.S.(2013) Inventory Analysis on the Effect of End-of-Life Passenger Vehicle Plastic Bumper Recycling in China. Plastics and Recycling Technology,29:21-38.
[2] Shui Z.L.(2019)Analysis of the current situation of domestic and foreign automobile prohibited substances contro. Internal combustion engine and accessories,10:164-165.
[3] Wei C.Q., Long S.H., Zhang S.L. (2016) Hierarchical control of hazardous substances in automobiles. Automotive technology and materials,2:59-62.
[4] Zhang W. (2019)Research on Dismantling of Vehicles for Recycling Certification. Comprehensive Utilization of Resources in China,37:65-83.
[5] Huang J.s., Lu J.F.(2019) Review on the recycling technology of valuable components from scrapped automobiles. Metallurgical Management,12:53-55.
[6] Zhang C. Yao S. Wu G. Xu S.N. (2015) Shen Peikang. Study on the Electrochemical Corrosion of Lead Alloy Grid. Power Technology Research and Design,8:1694-1696.
[7] Wang K., Shen Z.Y., Zang B.Q. (2014) Current status, opportunities and challenges of lead-free piezoelectric ceramics based on potassium sodium niobate. Journal of Inorganic Materials, 29:13-19.