Environmental Load Evaluation of Reuse Parts for Automobiles

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Abstract

Reuse parts are parts removed from scrap automobiles that can be still used. In general, reuse parts reduce not only the cost for replacement of failed parts but also the environmental load. This study quantitatively evaluates environmental loads, such as the amount of CO_2 emission during the production of brand new parts, in order to quantify the beneficial effect of the reuse parts. The amount of CO_2 emission can be calculated from the power consumption and operating time of each tool and machine employed. Reuse parts generate 0.62 kg of CO_2 per automobile when produced, which corresponds to 1,212 kg per year. However, the amount of CO_2 emitted from scrapping automobiles without producing new replacement parts is 3,063 kg per year. Therefore, the production of replacement parts emits three times less CO_2 than scrapping.
Keywords: environmental load, automobile, reuse parts, disassembly

1 Introduction

Reuse of old car parts has gained much attention recently. When scrapping old automobiles, many parts are still functioning and can be recovered for reuse. These parts are called reuse parts. In general, reuse parts not only considerably reduce the costs but can also reduce the negative effects on the environment. However, the quantification of these effects has not been assessed yet. This study focused on the determination of the amount of CO_2, which is one of the greenhouse gases causing global warming. We calculated the amount of CO_2 emission generated during the life cycle from the procurement of the materials for producing automobile parts to the manufacture of automobiles and scrapping. This study aimed to calculate the amount of CO_2 emission from the reuse parts during their production, which is the first step to quantify their impact.

2 Life cycle assessment

Life cycle assessment (LCA) [1, 2] is a method for assessing environmental effects in parallel with the calculation of the consumption of the entire life cycle resources and emission matters, such as CO_2 and sulfoxides (SOx). **Figure 1** shows the procedure of LCA. First, we have to establish the research purpose clearly, then perform life cycle inventory assessment (LCI), and finally, life cycle impact assessment (LCIA). Based on the results, the extent to which the assessment targets are affecting the environment can be determined. LCI is the process of creating an inventory data that clarifies how many inputs and outputs were present in each process in the entire life cycle of the assessment object. LCIA, based on the inventory data created in the LCI, evaluates the environmental impact by analyzing and assessing the amount of substances, such as CO_2, listed in the inventory data, which contribute to each environmental concern (e.g., global warming and ozone depletion). If the LCI results match to the purpose of the study, the LCA can be stopped at the level of the LCI. Therefore, we ended the LCA at the LCI stage because the purpose of this study was to quantify the amount of CO_2 reduction when using reuse parts.

3 Observation result

To understand the production process of reuse parts, we visited the factory of Marutoshi Aoki Corporation, which scraps automobiles, produces reuse parts, and is a reuse parts dealer. We recorded the working process for the disassembly of automobiles on a video camera and counted the working hours. From this information, we extracted the amount of CO_2 emission of each working process.

Figure 2 shows the flow of the scrapping process and the reuse parts production process. The automobile scrapping process involves removing the tires, processing the airbags, recalling the Freon gas, removing oil, LLC (long life coolant), and fuel, the work of the nibbler, and the press process. During the flow of reuse parts production, the vehicle is checked to identify reusable parts (**Fig. 2**(a)), which are eventually removed (**Fig. 2**(b)).

As shown in **Fig. 2**, processes (c), (d), and (f) are the same irrespective of the removal of reuse parts. Therefore, we did not calculate the amount of CO_2 emitted during these processes. However, in the process of scrapping and sorting by the nibbler (**Fig. 2**(e)), the working time of the nibbler changes depending on whether the engine was previously removed from the automobile. We calculated the CO_2 emission of both conditions. **Figures 3** and **4** show images relative to automobile scrapping. The operating time of each tool is shown in **Table 1**, which includes the time of the lift (L_t) used to raise and lower the automobile, crane (C_t) used to carry and hang heavy parts, pump (P_t) to remove the fuel, flashlight (F_t), driver (D_t), high pressure washer (H_t) to clean the removed parts, press machine (Pr_t) used in the last process, engine (E_t), nibbler operating time with the engine inside the car (N_{t1}), and nibbler operating time with the engine already removed as reuse part (N_{t2}). **Table 2** shows the annual production and sales analysis of Marutoshi Aoki Corporation. Annual power consumption of the entire factory Pa [kWh], total amount of fuel consumed per hour of Nibbler (light oil amount) N [l], part annual removing number of automobiles D [car], annual part removing number of automobiles R, average production number of parts per automobile A. Based on those data, we calculated the amount of CO_2 emission by stacking the emission of each tool used in the reuse part production. The amount of CO_2 emission of each tool used calculated on the basis of the operating time of each tool (Method 1) was verified by calculating it from the power consumption of the entire factory (Method 2), because Method 2 also considers the amount of CO_2 emitted from processes that are not directly involved in the reuse parts production; therefore, the amount of CO_2 emission calculated using Method 2 must be larger than those obtained using Method 1.

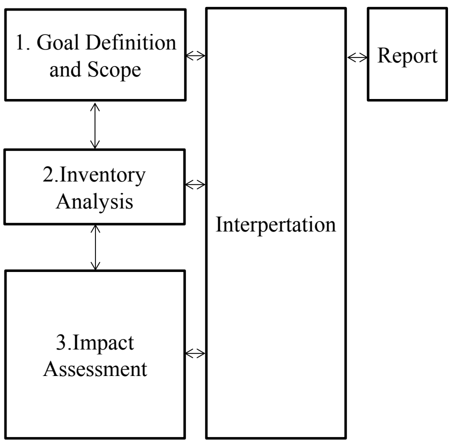

Fig. 1 LCA sequence

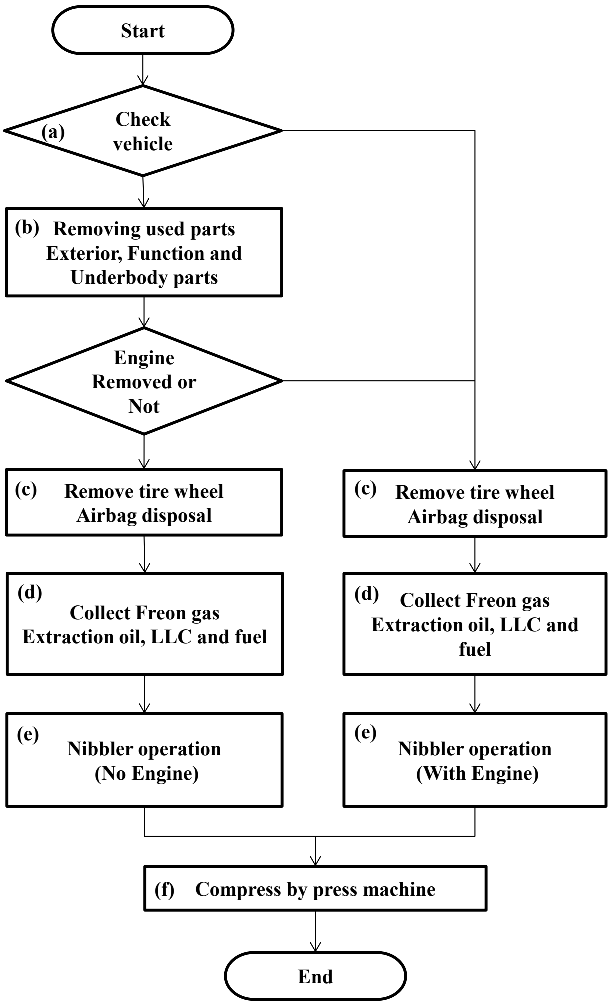

Fig. 2 Reuse flow

Fig. 3 Nibbler

3.1 CO_2 emission from working hours (Method 1)

The data used to calculate the amount of CO_2 emission in Method 1 are the operating time of each tool, which are summarized in **Table 1**, and the power consumption of each tool, reported in **Table 3**. Likewise, the power consumption of each tool corresponds to those of the lift (L_p), crane (C_P), pump (Pu_P), flash light

(F_P), driver (D_P), high pressure washer (H_P), press (Pr_P), and air tool (A_P). These data are not the actual data relative to the tools used in the factory, but those of the marketplace. Moreover, the amount of CO_2 emission (C [kg]) can be calculated from the following equation:

$$C = P \times H \times C_v \quad (1)$$

Here P is the power consumption, H is the operating hour, and C_v (emission factor) is obtained from the literature [3] and corresponds to 0.55 kg CO_2/h.

The amount of CO_2 emission of each tool corresponds to those of the lift (L_C), crane (C_C), pump (Pu_C), flash light (F_C), driver (D_C), high pressure washer (H_C), press (Pr_C), and air tool (A_C). The amount of CO_2 emission of each tool is calculated from the following equations:

$$L_C = L_p \times L_t \times C_v \quad (2)$$
$$C_C = C_p \times C_t \times C_v \quad (3)$$
$$F_C = F_p \times F_t \times C_v \quad (4)$$
$$D_C = D_p \times D_t \times C_v \quad (5)$$
$$H_C = H_p \times H_t \times C_v \quad (6)$$
$$A_C = A_p \times A_t \times C_v \quad (7)$$

As previously reported [4], the amount of CO_2 emission from idling for 1h (I_c) is 0.54kgCO_2/h. The amount of CO_2 emission from the engine when scrapping an automobile (E_C [kg/car]) is calculated using the following equation:

$$E_C = I_c \times E_t \quad (8)$$

Table 4 shows the amounts of CO_2 emission calculated from each equation above.
Additionally, from reference [5], the amount of CO_2 emission from the use of light oil (Lf) is 2.613 kg/L. Furthermore, the working hour of the nibbler process (**Table 1**) was reduced to 4 min. We then calculated N_{C1} and N_{C2} because the amount of CO_2 emission from the use of the nibbler is large. The following equations represent the amount of CO_2 emission from the nibbler.

$$N_{C1} = N \times Lf \times N_{t1} \quad (9)$$
$$N_{C2} = N \times Lf \times N_{t2} \quad (10)$$

Using the data reported in **Tables 2** and **4,** the total CO_2 emission in one part removing automobile C_1 [kg], the annual amount of CO_2 emission from scrapped car (Cd_1 [kg/year]), and the annual amount of CO_2 emission from parts taken by scrapped car (Da_1 [kg/year]) can be calculated according to the following equations:

$$C_1 = L_C + C_C + F_C + D_C + H_C + A_C + E_C \quad (11)$$
$$Cd_1 = C_1 \times (R - D) \quad (12)$$
$$Da_1 = C_1 \times D \quad (13)$$

Table 5 shows the results of Equations (11), (12), and (13).

The amount of CO_2 emission from pump and press usage are not included in Equation (11) because the processes relative to pump [**Fig.2** (d)] and press [**Fig.2** (f)] are the same and their CO_2 emission are considered the same either when the automobile is in the scrapped flow or in the reuse part production flow.

Fig. 4 Taking off the engine

Table 1 Operating time of each tool and machine

Type	Tool	Time
Power use	Lift [s] (L_t)	125sec
	Crane [s] (C_t)	22sec
	Pump [s] (Pu_t)	459sec
	Flash Light [s] (F_t)	22sec
	Driver [s] (D_t)	6sec
	High Pressure Washer [min] (H_t)	15min
	Press [min] (Pr_t)	7min
	Air Tool [s] (A_t)	147sec
Fuel use	Engine [min] (E_t)	44.6min
	Nibbler [min] Engine In (N_{t1})	17min
	Nibbler [min] No Engine (N_{t2})	13min

Table 2 Annual production and sales for 2012

Factory power use in a year [kWh] (P_y)	6.60×10^4
Total amount of fuel consumed per hour of Nibbler (light oil amount) [l] (N)	13.53
Part removing number of automobiles per year (D)	1963
Dismantling number of automobiles per year (R)	6923
Average production number of parts per automobile (A)	13.2

3.2 CO_2 emission from factory power consumption (Method 2)

Using the data from **Table 2** and C_v [3], the total CO_2 emission in one part removing automobile C_2 [kg], the annual amount of CO_2 emission from scrapped car (Cd_2 [kg/year]), and the annual amount of CO_2 emission from parts taken by scrapped car (Da_2 [kg/year]) can be calculated (**Table 6**) according to the following equations:

$$C_2 = (P_y \times C_v) / R \quad (14)$$
$$Cd_2 = C_2 \times (R - D) \quad (15)$$
$$Da_2 = C_2 \times D \quad (16)$$

4 Discussion

In Method 1, we calculated the amount of CO_2 emission by considering only the working time and operating time of the machines and tools used. To verify the results obtained with Method 1, we also calculated the same emission by considering the power consumption of the entire factory (Method 2). Method 2 considers considerable data that are not directly involved in the reuse parts production. When quantifying the effects of CO_2 emission from reuse parts, it is advisable to apply Method 1, which uses only the data relative to the machines and tools that are directly used in the process. By using Method 2, the values of the calculated emission might be higher than those obtained with Method 1. In fact, for Method 1, the CO_2 emission amount to 0.62 kg (**Table 5**), whereas for Method 2, they correspond to 5.22 kg (**Table 6**).

In the future, we will conduct an LCA of new parts production in order to quantify the effects of the reuse parts CO_2 emission. In calculating the CO_2 emission of new parts production, similar to what has been done here for reuse parts production, we will target the machines and tools that are used in the production.

5 Conclusion

In order to quantify the amount of CO_2 emission reduction when recovering reuse parts from automobile scrapping, we carried out an environmental impact assessment on the reuse part production. If we can quantify the amount of CO_2 emission reduction when using reuse parts, the market of reuse parts might increase, considerably reducing not only the consumers' costs but also the environmental impact. In the future, we will conduct an LCA of new parts production to quantify the beneficial effects of reuse parts on CO_2 emission.

We thank Marutoshi Aoki Corporation for its cooperation and contribution.

Table 3 Tool power

type	tool	Power(W)
Electricity	Lift (L_p)	1500
	Crane (C_p)	650
	Pump (Pu_p)	3700
	Flash Light (F_p)	8
	Driver (D_p)	40
	High Pressure Washer (H_p)	1300
	Pressure (Pr_p)	14800
	Air Tool (A_p)	182.4

Table 4 Emission from each tool and machine [kg]

Power use	Lift (L_C)	2.85×10^{-2}
	Crane (C_C)	2.19×10^{-3}
	Flash Light (F_C)	4.30×10^{-5}
	Driver (D_C)	5.90×10^{-5}
	High Pressure Washer (H_C)	1.79×10^{-1}
	Air Tool (A_C)	6.55×10^{-3}
Fuel use	Engine (E_C)	4.01×10^{-1}
	Nibbler (Engine In (N_{C1}))	10.04
	Nibbler (No Engine (N_{C2}))	7.68

Table5 Method 1 CO_2 emission

CO_2 emission total in one part removing automobile [kg] (C_1)	0.62
CO_2 emission from dismantled cars per year [kg/year] (Cd_1)	3063
CO_2 emission from parts taken car per year [kg/year] (Da_1)	1212

Table 6 Method 2 CO_2 emission

CO_2 emission from dismantled car [kg] (C_2)	5.22
CO_2 emission from dismantled cars a year [kg/year] (Cd_2)	2.59×10^4
CO_2 emission from parts taken car a year [kg/year] (Da_2)	1.02×10^4

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