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Development and assessment of strategies to ensure economic sustainability of the U.S. automotive recovery infrastructure

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ABSTRACT

Currently, 95% of all the vehicles discarded in the U.S. enter the recovery infrastructure. The material recovery efficiency of the infrastructure is approximately 80% by weight. Significant changes are being pursued by automotive manufacturers to reduce the environmental impact of vehicles during the use phase. However, the effect of these changes on the automotive recovery infrastructure is uncertain. In addition to vehicle changes, calls for higher material recovery efficiencies from the government and society also add to the uncertainty. In order to characterize the effects of these uncertainties, a Material Flow and Economic Exchange (MFEE) model has been established. The model-predicted results showed that higher material recovery rates can only be achieved if the business entities within the recovery infrastructure employ new technological strategies such as increased plastic recovery rates. However, the economic sustainability or profitability of the business entities was found to be jeopardized. This paper will focus on certain profit-enhancement strategies that may be employed to ensure the economic sustainability. The MFEE model is used to assess the adequacy of these strategies to improve the profitability of the business entities within the recovery infrastructure. Based on the analysis of these strategies it is shown that the economic burden of achieving higher material recovery rates will have to be shared by all the stakeholders within the recovery infrastructure. A discussion on the potential government policies that may be enacted to implement the technological and profit-enhancement strategies is presented.

1. Introduction

In the U.S., vehicle recycling is extremely successful as compared to other products such as aluminum cans, home appliances, and paper products. While recycling rates for aluminum cans is 55%, home appliances is 52%, and paper products is 42%, about 95% of all retired vehicles enter the automotive recovery infrastructure (EPA, 2006). Of the vehicles that enter the recovery infrastructure, approximately 80% of the vehicle by weight is recovered in some form (either as subassemblies or as material). The 20% of the material that is not recovered (also know as automotive shredder residue – ASR) is landfilled as municipal solid waste. This ASR may contain substances such as urethane, fabrics, vinyl upholstery, rubber, plastics, polymer composites, glass, sand, and wood (Klempner et al., 1999). ASR may also include toxic materials such as heavy metals from electronic parts and polychlorinated biphenyls.

The European Union has reported similar figures for vehicle recovery efficiency (Gerrard and Kandlikar, 2007). However, unlike many locations in the U.S. where the recovery infrastructure is profit-driven, lack of landfill space is the main driver for recycling in Europe and Japan. Irrespective of the geographic location, government regulations/policies throughout the world also have a large impact on the vehicle recovery business. One such policy that has been enacted by the European parliament is the end-of-life vehicle (ELV) directive (ELV Directive, 2000). This directive calls for increasing material recovery rates to 95% by the year 2015. In the U.S., few ELV regulations currently exist. For example, there are no government mandates asking for business entities in the vehicle recovery infrastructure to improve recovery efficiencies. However, growing concern that toxic materials may be landfilled is causing business entities to explore technological options similar to those in Europe. The implementation of such technological options in the U.S. may jeopardize the economic health of the business entities, and ultimately lead to adverse impacts on the environmental sustainability of the infrastructure.

Other initiatives and trends may also place the recovery infrastructure in peril. Government regulations, e.g., engine emission standards and corporate average fuel economy (CAFE, 2000) requirements, rising fuel prices, and changing consumer attitudes, are causing the auto industry to undertake changes in the material composition (greater use of aluminum, plastics, and composites) and powertrain technologies (introduction of hybrids and fuel cells) (Dearing, 2000; Orden et al., 2004) of vehicles. The aim of these

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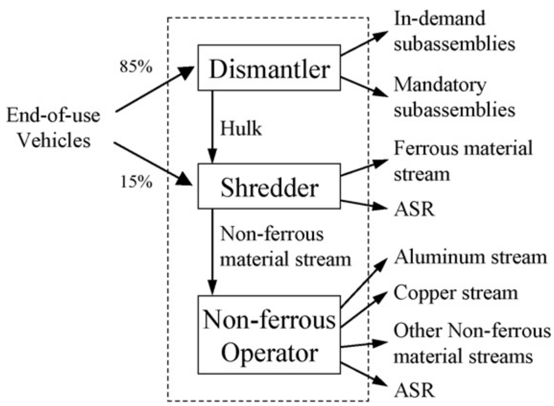

Fig. 1. Material flow through the automotive recovery infrastructure.

changes has been to reduce the environmental impact of the vehicle during the use phase; however, the associated effect on the automotive recycling infrastructure is unknown. With this in mind, a Material Flow and Economic Exchange (MFEE) model was developed to understand the impact of vehicular changes with respect to its material composition on the waste generated by, and profitability of, each business entity within the recovery infrastructure (environmental and economic sustainability).

This paper is focused on identifying profit-enhancement approaches that may have to be employed within the U.S. automotive recovery infrastructure in order to keep the business entities in the infrastructure profitable. These approaches are investigated under the assumption that the automotive industry will undertake substantial changes in the vehicle material composition (e.g., use of lighter weight materials such as aluminum, plastics, and composites) that may influence the environmental and economic sustainability of the U.S. recovery infrastructure. The impact of these material changes as predicted by the MFEE model has been reported in Kumar (2006). In addition, Kumar and Sutherland (2007) reported on the efficacy of several technological strategies,[1] which could be adopted by entities within the recovery infrastructure to reduce their environmental impact.

This paper first briefly discusses the current recovery infrastructure; this is followed by an overview of the MFEE model. This overview includes some background on the MFEE model, assumptions which it relies on, and its validation. Technological strategies that could be used to increase the material recovery rates in the U.S. to values similar the 2015 target set by the EU ELV directive are discussed. The MFEE model predicted that the use of these technology strategies would have an adverse impact on the profitability of dismantlers. Thus, the focus of this paper is on identifying profit-enhancement approaches for the dismantler. Three profit-enhancement approaches are examined. The impact of these profit-enhancement approaches on the economic performance of the dismantler and shredder as predicted by the MFEE model is reported. The effect of using one of the profit-enhancement approaches on the dynamics of the infrastructure is also discussed.

2. Automotive recovery infrastructure in the U.S.

The automotive recovery infrastructure consists of three main business entities: dismantler, shredder, and non-ferrous operator. Fig. 1 shows the material flow among these business entities, where it may be noted that cash usually flows opposite to the direction of material flow. The only exception is when ASR is landfilled; the shredder or non-ferrous operator pays a tipping fee to the landfill operator. The amount of the tipping fee depends on the hazardous and non-hazardous material content of the ASR.

As seen in the figure, an end-of-use vehicle is sent to either the dismantler or the shredder by the last vehicle owner.[2] To decrease the environmental impact of the vehicle, it is preferred that the end-of-use vehicle be sent to the dismantler as opposed to the shredder. However, due to dismantler capacity constraints, about 15% of end-of-use vehicles are processed by the shredder (Duranceau and Lindell, 1999). At the dismantler, certain subassemblies in the vehicles are removed and the rest of the vehicle is sold to the shredder as a hulk. The decision as to which subassemblies to remove, for subsequent re-sale, primarily depends on market demand. However, some subassemblies such as the fuel tank, tires, and catalytic converter are removed due to the requirements of the shredder. The end-of-use vehicle purchasing cost, the overhead cost, and the cost of hulk transportation are the main expenses borne by the dismantler. Dismantler revenue is derived from two sources: selling of subassemblies on the secondary parts market, and selling the hulk.

At the shredder, the hulk is fed into a shredding machine, which chops it into fist-size pieces. These pieces go through a number of separation processes (e.g., magnetic separation) producing different material streams. As shown in Fig. 1, the three main output streams for the shredder are the ferrous material stream, the heavy blend stream (non-ferrous metals), and the ASR. The ferrous material stream is sold to steel producers, the non-ferrous metal stream is sold to non-ferrous operators, and the ASR is landfilled. Selling the ferrous and the non-ferrous metal streams are the main source of revenue for the shredder. Their costs include hulk purchase price, overhead cost, landfilling tipping fee, and transportation cost of the heavy blend.

At the non-ferrous operator, the heavy blend stream is separated into several streams such as aluminum, copper, and zinc. Selling these non-ferrous metals on the secondary materials market is the main source of revenue for the non-ferrous operator. Their costs include the feedstock purchasing cost, the overhead cost, and the ASR disposal cost.

3. MFEE model

The MFEE model consists of two elements or sub-models: one associated with the vehicle use stage, and another associated with the vehicle or end-of-use product (EOUP) recovery stage. The vehicles in the model are described in terms of several subassemblies, where each subassembly is expressed using six types of materials, i.e., ferrous material, aluminum, other non-ferrous materials, plastics, other materials, and fluids. As these vehicles or entities flow through the sub-models, the associated changes, e.g., depreciation of a vehicle's value, removal of a component/subassembly, are recorded. In the sub-model for EOUP recovery, the cash flow for any transaction between the business entities is calculated and recorded. Detailed description of the price and cost assumption for the different business entities is provided in Kumar (2006). However, a brief description of the two sub-models of the MFEE model is provided here.

[1] A strategy was identified as being a specific combination of two technological options: increased levels of vehicle dismantling and improved shredder material recovery efficiency (Hond, 1998).

[2] When an individual is the owner or title holder of a vehicle, and it is involved in a serious accident, this may lead to the vehicle being declared "totaled" by the insurance company. In such a case, the individual is paid a lump sum by the insurance company, and the vehicle title is transferred to the insurance company, who then makes decisions regarding vehicle disposition.