The 6th International Conference on Life Cycle Management in Gothenburg 2013

MFA AS A TOOL FOR PRODUCT END-OF-USE MANAGEMENT

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Keywords: MFA; product end-of-use management; company-level; closed loop

ABSTRACT

Material flow analysis (MFA) has been widely used as a tool to assess national and regional material flows. Using a case study, this paper demonstrates one other way to use MFA: as a tool for a company's product end-of-use (EoU) management. Three main activities emerged during the study with valuable results: (1) the *traditional MFA* provided flow diagrams, (2) *inflow analysis* allowed basic feasibility analysis of EoU product capture, and (3) *product chain description* provided a rough sketch of key actors and their decisions. Together, results can be used as the foundation for understanding product fate and reveal potential avenues and barriers to improving a company's EoU management.

INTRODUCTION

As part of a larger life cycle management (LCM) initiative, an international steel component manufacturer (*the company*) declared an interest in understanding the end-of-use (EoU) of its products. The company's questions included: "*What is the fate of our products after use?*" and "*Are there opportunities to prevent losses?"* Material flow analysis (MFA) was identified as a tool to help answer these questions. Thus the questions addressed by this paper are, "*Is MFA valuable for use on a company's downstream flow?"* and "*If so, how can it be used?*

Product EoU management is the subject of the study, whereas MFA is the tool used to assess it. EoU management (*how to handle EoU products*) encompasses both technical and management research areas. In the technical arena, EoU is addressed in many subjects, from theoretical limits to metals recycling (Reuter et. al. 2005) to eco-efficiency gains from remanufacturing (Kerr and Ryan 2001). The management research area focuses primarily on business strategies and operational issues related to extended producer responsibility (e.g. Steger 1998). MFA, on the other hand, has been widely used as a tool to assess the flows and stocks of regions, countries (e.g. Davis et. al. 2007), and industrial sectors or areas (e.g. Sendra et. al 2011). This paper presents how MFA was used as the first step for assessing a company's product EoU management. Hence, it offers one way in which MFA can be used at the company-level.

METHODS

The MFA in question was designed using guidelines from Brunner and Rechberger (2004). Starting with the company's question statements, flows, processes and system boundaries were determined. Three non-consumer business segments were chosen as subjects for the investigation based on internal interest and information availability. Product and raw sales data were gathered for the segments of interest. Product weights were added to the sales data for use in this study. Substances of interest were chosen from selected product compositions. Initial substance flow from the company was determined by multiplying product substance composition with sold amount of product. Sales data were also analyzed based on product type, sales value, weight, and size as well as customer, customer location, and customer type.

Key processes were identified and included: product use, remanufacturing, material handling (separation), steel production, and slag handling. With these key processes in mind, information sources were identified. Company representatives, customers, and material handlers (brokers) were the three categories of informants. Informal interviews with company representatives provided details about remanufacturing and described sales and market aspects. Seven customers were approached with a six-question product EoU questionnaire. Questions were both quantitative and qualitative in nature. With customer responses, follow-up discussions were conducted. In-person discussions were conducted with representatives from one large Swedish material broker. Literature, two company representatives, and one metallurgist researcher provided data related to steel metallurgy and slag handling.

Quantitative data was compiled in a simple spreadsheet-based, linear model. Scenarios were generated based on customer responses to determine varying product fates. Software was used to display results in Sankey diagrams. Descriptions provided by informants were compiled to make an overall understanding of the system and relevant actors. These descriptions also yielded indications of potential opportunities and barriers to improved EoU management.

RESULTS

Some results from the case study are presented briefly. First, flows are displayed showing losses and revealing opportunity. This provides an indication of *the magnitude of the problem or opportunity* (namely what losses there are and where they can be mitigated). Then, sales data analysis provides a *rough feasibility assessment* of the opportunities. Finally, review of discussions with actors reveals *potential barriers and opportunities.*

Sankey diagrams from two scenarios are shown in Figure 1 (next page). Product (material) fate varies greatly. Either (*Good)* - the product is used multiple times and most of recycled material ends up in alloyed steel or (*Bad)* - the product is used one time (60% more material is needed to deliver the same function achieved in *Good*), most of the recycled material ends up in carbon steel, in which full alloy function is not realized. Also, more material is lost to disposal or slag. Differences between the two scenarios highlight two potential *opportunities to mitigate losses*, steel scrap segregation and remanufacturing.

Now, given an idea of what losses occur and what general opportunities there may be, questions can be posed, *"What is the feasibility of these opportunities?"* and *"How many products are we talking about?"* or *"What is the potential to remanufacture more?"* Analysis of the sales data (i.e. the initial material flow) yields at least some indications. One example is presented here: analysis of the *potential to remanufacture more*. Currently, remanufacturing is performed successfully and profitably by the company, albeit at a limited scale. Size is used as an indication of remanufacturing feasibility – bigger products are preferred in the remanufacturing process. The company has established guidelines for which size of products to remanufacture, here referred to as *minimum*, *promoted*, and *profitable*. Figure 2a (next page) displays what percentage of the material would be gathered if all products of a certain size and greater were captured. For example, if all *promoted* (and greater) sized products were captured, over 50% of the material would be captured. This appears to be considerably greater than the currently achieved capture, which indicates a potential. Figure 2b shows that the products greater than the *promoted* size represent a majority of the weight but only a fraction of the product count (pcs). This can be used as an indication of feasibility of capture.

Figure 1: Two modeled scenarios, a *Good* and a *Bad*, displaying ultimate fate of materials. Realized material function decreases from top to bottom.

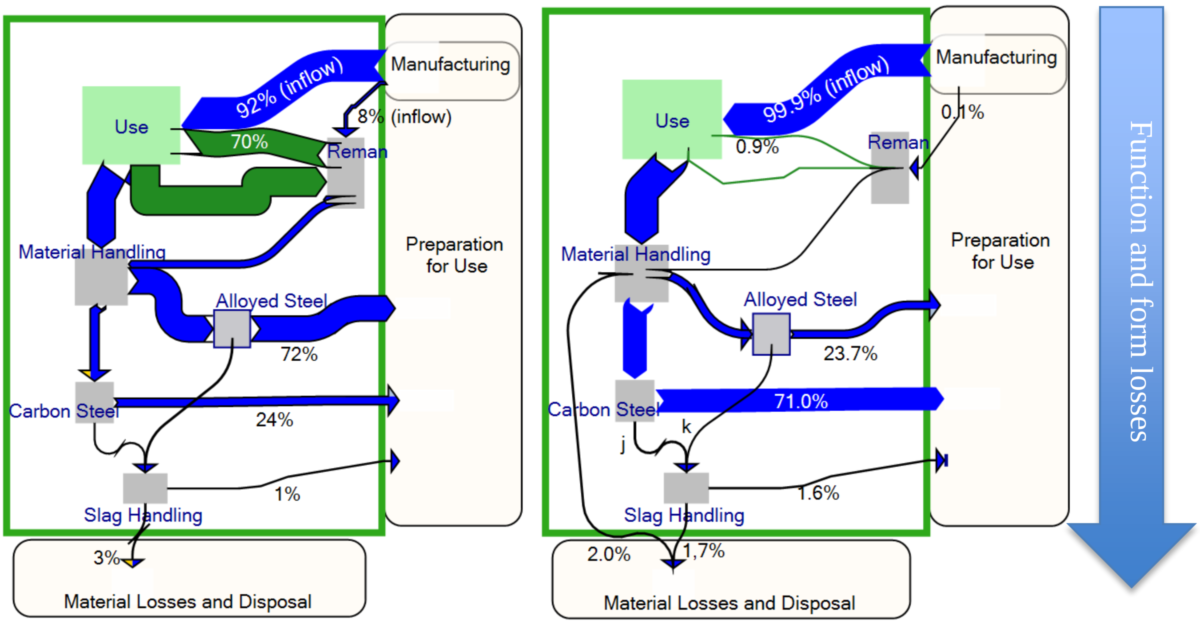
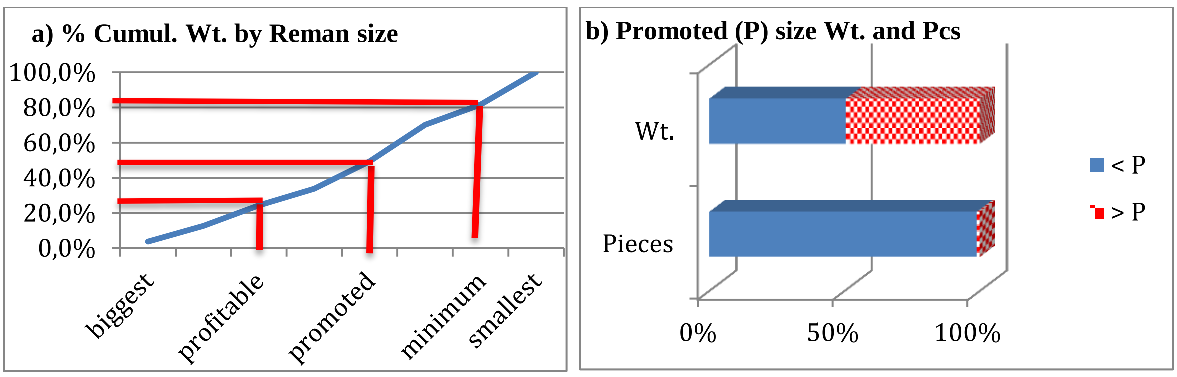


Figure 2: (a) Share of material captured if all products of a particular reference size (and greater) were captured and (b) Share of weight and product count (pcs) of products greater than or equal to the size *promoted* for remanufacture



With an indication of both the size of the problem (fates) and the feasibility of solutions, it is possible to assess non-technical aspects. The level of utilization of remanufacturing is one example. Remanufacturing appears to be a good solution to increasing resource efficiency and it appears that more products can be remanufactured than currently being done. *Why then, are more products not remanufactured?* Discussions with company representatives and customers revealed some hints. They include: (1) there may be a lack of customer confidence in remanufactured products, (2) company incentives may be more aligned to new product sales, and (3) distributors may not have incentives to offer remanufacturing. Indications yielded during the course of the MFA can be investigated further using other methods.

DISCUSSION

Although not originally planned, three main methodological activities emerged in conducting the MFA (as named here): (1) the *traditional MFA*, (2) *inflow analysis*, and (3) *product chain description.* Each of these activities was found to be necessary given the context of the study – product EoU management. The *traditional MFA* was strictly focused on defining the system boundaries and determining the physical flows in the system. This activity provided an answer to the question, "*What is the fate of our products after use?*" The *inflow analysis* involved analyzing *raw* sales data (Note: if "already-pruned" sales data had been received instead, many insights would likely not have been revealed) based on many characteristics potentially relevant to EoU management. The *product chain description* included noting basic non-technical aspects of the system, such as actors, their activities and decisions, market factors, and organizational aspects. Together, the *inflow analysis* and *product chain description* helped reveal potential answers to the question, "*Are there opportunities to prevent losses?"* At that point, the MFA appears to have reached its limits. Further investigation into product chains leads to other disciplines or tools.

CONCLUSIONS

It is found that MFA is a valuable tool and a good first step to investigating a company's product EoU management. MFA allows a manufacturer to document the effects that external processes, such as recycling processes, have on their product. Visual results provide an indication of "the size of the problem" and serve as a platform for further discussion. Assessing sales data, which represents initial flow, provides a gauge of feasibility (or value) of additional product accountability or capture. Finally, MFA demands some knowledge of processes and interaction between actors in the product chain. Acquiring this knowledge can yield a preliminary indication of what barriers or opportunities exist. Ultimately, MFA appears to serve as a catalyst to further investigation.

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