Energy and Material Stream Mapping

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Abstract

The limitation of resources, i.e. materials and energy, linked with increasing prices forces enterprises to operate economically with their material and energy consumption. But many companies, as experience shows, are not able to take action as they are unaware of ways to identify efficiency potentials within their production processes. This applies primarily to small and medium enterprises, where existing energy and material flow tools prove too complex and time-consuming. This paper deals with the development of a method that allows a first quick, easy and comprehensive analysis of energy and material flows within the production processes.

Keywords: material flow management; resource efficiency, optimization of production.

1 Introduction

The cost structure in Germany's manufacturing industry is currently undergoing dramatic changes. In just ten years the proportion of material consumption (excluding energy) has increased by 5 percentage points to now approx. 40 % of the costs. During the same period labour costs decreased and account for approx. 21 % (Statistisches Bundesamt 2005). This development is on the one hand the result of rationalisation measures in industry, but on the other hand also an expression of the growing disintegration of production and decreasing vertical range of manufacture in companies (Sinn 2005). German industry is using a growing number of valuable intermediate products.

Furthermore, the prices of raw materials on the world markets have changed drastically and will involve a further rise in material costs for companies. The raw materials index of the Hamburg Welt-Wirtschafts-Archiv (HWWA) shows that raw material prices rose by over 80 % between the beginning of 2003 and the end of 2006 (BDI 2007). The price of crude oil rose by 100 % between the beginning of 2003 and the end of 2006, while at the same time - largely unnoticed by public and political debate - the price of iron ore and steel scrap increased on average (depending on type and quality) by 100 % and the price of non-ferrous metals by over 128 %. The price of some individual metals even rose by over 500 %.

The Federation of German Industries (BDI) therefore draws attention to the fact that the rise in costs has exerted direct pressure on the earnings situation of companies. This applies in particular for companies where procurement of raw materials and substances is a dominant cost factor.

Under ecological aspects we have now reached the point at which dealing thriftily with scarce natural resources is important not only for reasons of environmental protection, but also on the grounds of cost effectiveness. Ecological and micro-economic actions thus no longer run contrary to each other at this point, but instead support each other mutually. It should therefore be expected that companies will do all they can to reduce their material costs – not

only by negotiations with suppliers and skilful purchasing, but also by reducing the quantities of material inputs and enhancing material efficiency.

However, present experience shows that in many manufacturing enterprises there are high levels of inefficiency in material use. In recent years and decades too much attention has been paid to rationalise labour. Recent estimates of the potential possible savings in material consumption by companies lie in the range of 5 to 10 % (LfU 2004), and partially even at 15 % (Baron et al. 2005). Macroeconomic analyses see a considerable need for action here in order to enhance productivity in Germany (Fischer et al. 2004).

Despite this, companies still have difficulties in taking appropriate measures in the field of material use. The German Government has launched various promotion programmes to advance the idea of material efficiency more strongly in companies. For instance a national material efficiency agency has been set up (www.demea.de) that provides government subsidies for consulting projects for small and medium-sized companies. Some German states, for example North-Rhine/Westphalia or Baden-Wuerttemberg have funded similar programmes.

2 The problem

If potentials for saving energy and materials are to be identified in manufacturing enterprises, both the quantity and the value framework of material movements in the company must be recorded. In many practical cases this repeatedly proves to be the core problem. Generally detailed data are available on the costs and earnings of a company, but it is not possible to tap the concrete volume flows in the company from such information. Or the technical processes and quantity flows are known, but in these cases an economic assessment is difficult.

Efficiency potentials concentrating on the time throughput of orders, the time-specific utilisation of human and machine resources, and faster response capability with regard to the market have been the focus of many analysis methods, for example within the framework of lean management. For instance Rother and Shook (1999) suggested a method with their Value Stream Mapping with which the production in a company is paced off by experts and further time-related features are recorded with pencil and paper. The analysis of the throughput time and processing time of a product then indicates potentials for improvement, which generally lie in skilful arrangement of the process cycles and improved utilisation of the input factors.

A corresponding analysis method would be helpful for the use of energy and materials in production, as potentials for savings are seldom located only at a single technical processing stage, but instead evolve from the interplay of several processing stages along the value chain. That is why the analysis method must be able to map this value chain of a product altogether. Value Stream Mapping is a first outpoint for this, but is not suitable for mapping energy and materials. That is why data and information with which a weight-related and value-related quantity structure can be drawn up must be surveyed during the tour of the plant.

3 The Idea of Material Stream Mapping

Within the framework of a network of companies looking at material efficiency set up by the Chamber of Industry and Commerce in Freiburg, South Germany, a method for determining

such efficiency potentials in manufacturing enterprises simply in a first assessment analysis was developed. This method is called Material Stream Mapping, as it usually follows the material flows along the value chain in an establishment and tries to present these graphically as a map. A tour of the production facility should allow a first survey. Standardised symbols and special characteristics are used for these that can be queried concretely. The outlay for data survey and an analysis is limited and much lower than the cost of modelling the production facility using corresponding professional software from the field of material flow analysis or life cycle assessment.

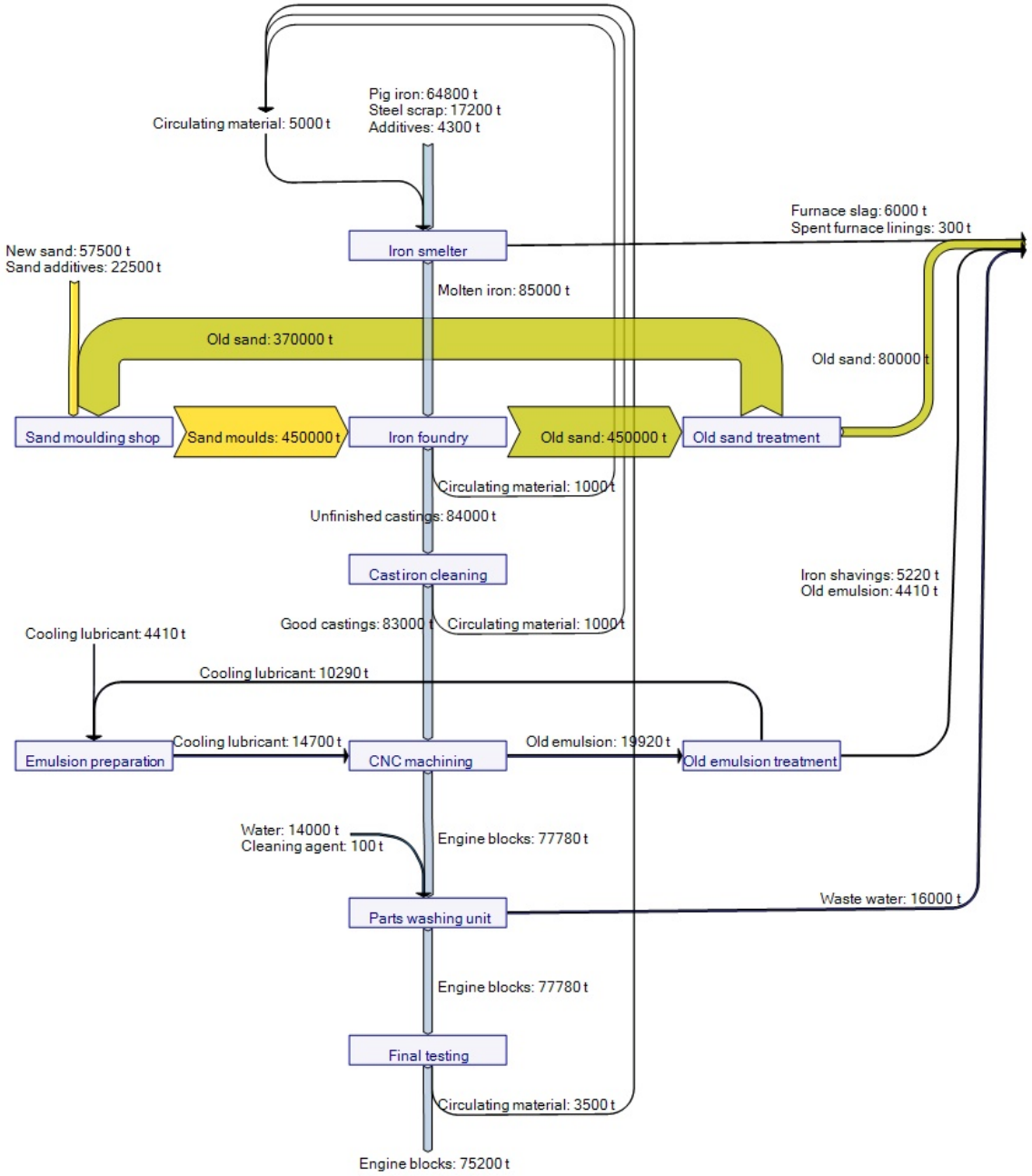

Figure 1: *Sankey diagram of the material flows in a company, in tonnes*

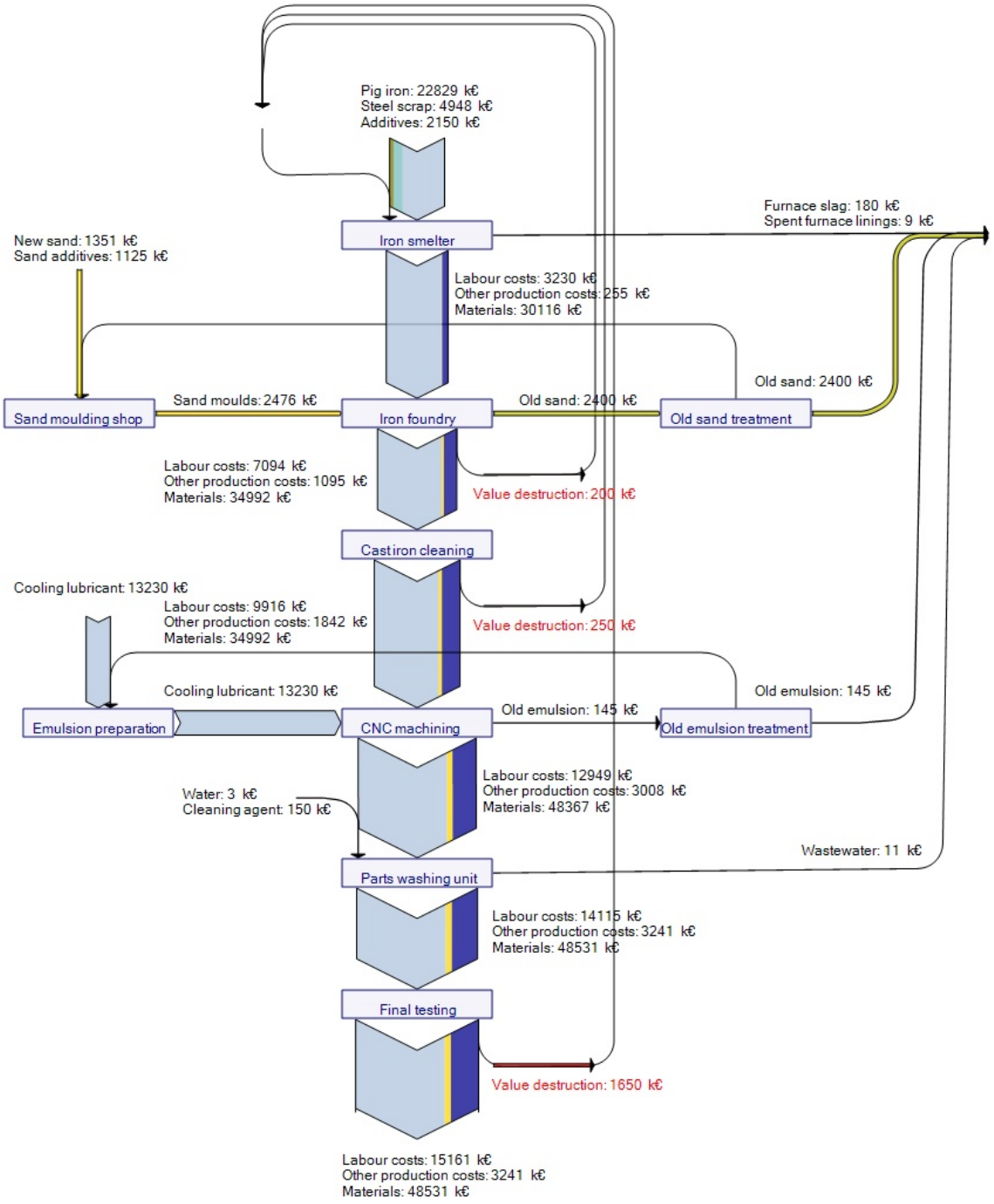

Figure 2: *Sankey diagram of the value flows in the company from Figure 1 in thousand euros (k€)*

On this basis it is possible to evaluate the data in a manner leading to a Sankey diagram (Schmidt 2006). Both the weight flows and the cost flows are shown graphically. Typical seats of inefficiency can thus be indicated clearly and their scope of costs can be quantified.

Figures 1 and 2 show two such Sankey diagrams. The company or establishment under review here is a foundry. Figure 1 shows the physical flow of the materials. In terms of weight the sand used represents the largest quantity, but this is largely recycled. However, Figure 2 shows the value chain of the product. This proceeds from processing stage to processing

stage along the product flow. The cost arrows distinguish between labour costs, material costs and other production costs – as far as this is possible with simple estimates. Inefficiencies can be identified and marked on the grounds of certain features. In this case these inefficiencies are marked red and chiefly occur in the return of residual materials or faulty product quantities.

In this case material recycling is admittedly better than if the materials were to end up as waste and have to be disposed of at considerable cost. It is not an efficient process, however, as due to the waste the actual production quantity is reduced and material that only generates costs and produces no earnings is virtually dragged through the manufacturing system. This consideration can be expanded upon by looking at the capital tied up in such material that is fed through the system and possibly placed into intermediate storage. Here, as with Value Stream Mapping, the through-times must then also be recorded.

This analysis has not yet clarified how the potentials for saving can be translated into practice. In some cases simple organisational methods are sufficient, in other cases larger-scale technical measures or investments are needed. However, the mapping method points up the potential and stimulates the innovation process within the company.

4 Conclusions

Material Stream Mapping is a simple, practice-driven analysis method with which energy and material flows in a company are recorded and visualised in their physical and value-related quantities. This makes is possible to develop certain features indicating inefficiencies in the production process.

The method is particularly suitable for advising small and medium-sized businesses that carry out multiple-stage value-adding through several processing stages. Typical areas of application are metal processing or the chemical industry. Material Stream Mapping can also be used for impulse advising of enterprises, for examining with justifiable outlay whether there is greater potential for savings in the area of material efficiency and whether further analyses and measures are expedient.

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