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LCA of Industrial Metal Cleaning Processes

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1. Introduction

Cleaning and degreasing of products and intermediate products are important process-steps in the metal processing and electric industry. Today the most frequent metal cleaning technologies base on aqueous cleaning agents, non halogenated hydrocarbon solvents or halogenated hydrocarbon solvents. These three technologies have a market share of over 90 % and can be used alternatively in many cases. The study "Integrated Assessment of Technologies of Industrial Component-Cleaning and -Pretreatment" [BMBF, 1998], had two goals: Optimisation analyses of metal cleaning processes and comparison of alternatively applicable technologies with regard to their environmental impacts using LCA. Data for cleaning processes were assessed in companies on site by measuring the input and output flows of cleaning machines, whereas for the preceding and following processes literature data were used mainly. Altogether four machines of each technology were analysed in detail.

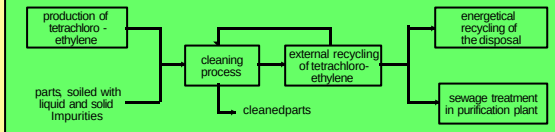

Fig. 1: Simplified life cycle of a metal cleaning process based on a chlorinated hydrocarbon solvent

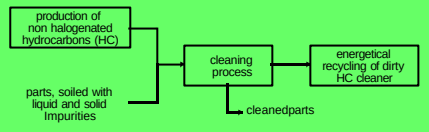

Fig. 2: Simplified life cycle of a metal cleaning process based on a non halogenated hydrocarbon solvent

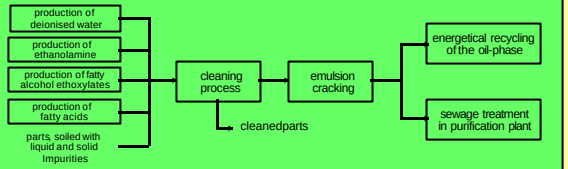

Fig. 3: Simplified life cycle of a metal cleaning process based on aqueous cleaning agents

2. Function and Functional Unit of metal cleaning processes

Detailed analysis of metal cleaning processes revealed the complex nature of the function of cleaning processes. It comprises several aspects which can be described with functional parameters (Fig. 4). Hence, the function of a cleaning process is the cleaning of work pieces, filled in loads, under the following boundary conditions:

- The work pieces are of a certain form, a certain material composition and are soiled with certain impurities.
- The work pieces are cleaned to a tolerated amount within certain boundaries.
- A total daily throughput of work pieces during a certain working time is taken as a basis.

With regard to this definition the functional unit was chosen as 1000 reference loads (commonly used basket, volume 32 l).

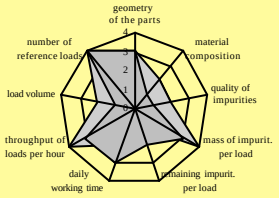

Fig. 4: Functional parameters and schematic representation of two different functions of a cleaning process

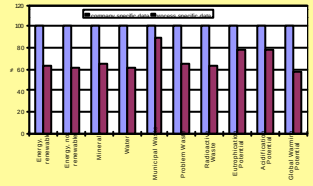

Fig. 5: Example of the company specific and process specific data of a cleaning process

3. Modelling different functions: Company specific and process specific data

- As in industrial practice the **functional parameters differ from company to company**, it was not possible to find cleaning processes having an equivalent function. Hence, an environmental comparison of different technologies was not directly feasible.
- A **process model** was developed (Striegel, Oetjen and Ruhland, 1998) relating the input and output flows of cleaning processes to the essential functional parameters. The input and output flows were calculated for a **reference function**.
- Data, collected in production plants on site (**company specific**) were used for optimisation analysis while **process specific** data, calculated for a selected reference function were used for the comparison of different cleaning technologies (Fig. 5.).

4. Comparing the technologies

- None of the cleaning technologies analysed is generally superior or inferior from a holistic point of view.
- Two out of four sets of cleaning processes analysed showed advantages for the systems based on non halogenated hydrocarbon solvents. In case of the two other sets including the example illustrated in figure 6, none of the technologies was preferable.
- Each technology has some typical pros and cons in certain impact categories.
- However, more than the different technologies, the various practices of machine use, described by the functional parameters, can cause great differences in specific environmental effects.

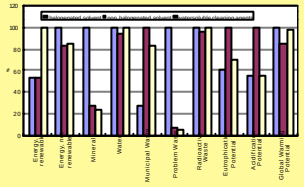

Fig. 6: Impact scores of one example out of 4 analysed sets of cleaning processes

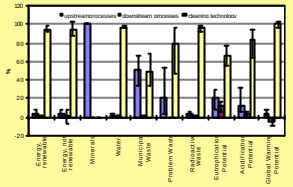

Fig. 7: Contribution of the subsystems to the total impact scores of the analysed cleaning systems based on halogenated hydrocarbons

5. Optimisation potentials of cleaning technologies

Figure 7 illustrates the contributions of the subsystems to the total impact scores of the analysed cleaning processes based on halogenated hydrocarbons. With regard to all cleaning processes analysed it can be summarized:

- In most of the impact categories, the contribution of the **cleaning process itself is dominant**.
- The big contribution is mainly caused by the **current demand of the cleaning machines**.
- Reducing the cleaning machine's demand for electric energy is one of the most efficient optimisation potentials (i.e. using a gas or oil fired heating station instead of electric heating).
- **Capacity utilisation** has a big influence to the environmental performance of cleaning systems.
- An **appropriate adaptation** of the cleaning process to the cleaning task given is very important.

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