

## **Energy and Resource Efficiency and Effectiveness in Industrial Manufacturing**

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Nowadays the target system of production companies is more and more influenced by originally environmentally driven aspects. Issues like rising energy and resource prices, shortage of strategically relevant natural resources, stronger regulations or rising public awareness regarding resource consumption and climate change are just some examples that incorporate a very strong economic relevance for the company. As a consequence, the efficient and effective use of energy and raw materials is a key challenge for the manufacturing companies trying to cope with these challenges. Due to their nature, the production process is critically important for economic success and environmental as well as social impact. Production can be defined as a combination of production factors, such as labor, material, energy, and technical equipment for the purpose of value creation in the form of products. To be able to evaluate realistically the impact and to avoid problem shifting, a holistic perspective on all input and output flows of production processes (besides the raw material input) is necessary (e.g. Herrmann et. al, 2007a). This includes a detailed coverage of energy (e.g. electricity, compressed air, steam), auxiliary material/media inputs (e.g. coolants) and emissions (e.g. special material waste, heat).

It is important to consider that consumption as well as emission of energy and media are not static but rather highly dynamic depending on the actual state of the machine or process respectively. On a production plant level, with diverse production machines involved, this leads to cumulative demand or emission profiles. Within a manufacturing site it is the task of the technical building services (TBS) to provide dynamically demanded energy and media and to ensure the needed production conditions in terms of temperature, moisture and purity of the air. In order to do that TBS also needs energy in form of electricity, gas oil. Altogether this underlines the role of the production plant as a complex control system with dynamic interdependencies between different internal and external influencing variables (e.g. local climate). To cope with its influencing factors and strong interdependencies simulation is necessarily needed and applicable for deriving measures for improvement on a realistic base (e.g. Herrmann et. al, 2007a and 2008). In recent research coupled simulation approaches of production, TBS and also building shell are proposed in order to maximize energy efficiency from a holistic perspective (Hesselbach et. al, 2008).

Besides increasing the efficiency in manufacturing sites, another research challenge is the development of appropriate systems to provide necessary energy while respecting the described requirements. Having in mind global challenges, renewable and decentralized energy systems are a promising approach towards zero emission manufacturing sites. Especially for developing countries this enables to bring value creation and welfare into rural regions without “compromising the ability of future generations to meet their own needs” (Brundtland). Examples are wind systems (electricity) or solar concentration systems for the simultaneous supply with process heat (steam) and electricity. Against the background of the difficult requirements of production plants and (dis-)advantages of different renewable energy

supply systems (e.g. storability, dependence from daytime/season/weather conditions) integrated solutions (e.g. combinations of technologies) have to be found.

In addition to the energy supply for manufacturing sites through renewable energy generation systems, another future challenge lies with the substitution of fossil resources through the cultivation of biogenous alternatives. As an example, the substitution of mineral oil by biogenous oils as an alternative coolant resource for metal working processes is considered. Machining processes (e.g. grinding) generally transform raw materials into products using coolants. These fluids are used in more than 1 million machine tools in Germany. Predominantly, mineral oil is the oil basis in cutting fluids with over 72.000 t/a in Germany. While it is easy to simply exchange mineral oil through alternative oils (e. g. palm oil), the technological, economical, ecological and social impacts of biogenous alternatives have to be thoroughly observed for shifts of benefits or detriments in all life cycle phases from raw material cultivation and extraction, to use as well as disposal. This also includes regional and global aspects as raw material availability (e.g. jatropha cultivation in African and Indian decentralized farming networks). Based on these exigencies, several biogenous oils have been analyzed as potential substitutes for mineral oil coolants – starting from palm oil, rapeseed oil to jatropha oil as well as glycerol (Herrmann et. al. 2007b). Further alternatives have been found in used cooking oil and technical animal fat, which imply a cascading use of materials (Dettmer 2006). Subsequently, ecological, social and economic benefits of these alternatives have been substantiated through Life Cycle Analysis. Through integrated consideration of all aspects of a sustainable development, beneficial biogenous materials can be derived for companies in the metal processing industry.

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