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ScienceDirect

Procedia CIRP 28 (2015) 34 – 39

www.elsevier.com/locate/procedia

3rd CIRP Global Web Conference

A tool-supported approach towards water efficiency in manufacturing

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Abstract

Many manufacturing companies fail to exploit hidden potentials in optimizing their water operations. This aspect is often shown by unorganized water efficiency effort with sub-optimal results. Against this background, the paper presents a structured approach for systematically improving the water efficiency in manufacturing companies. It comprises the identification and visualization of water related hot-spots subdivided into different respective water flows as well as six different water consuming sectors of a factory. Based on the outcome, the approach further proposes basic principles each represented by promising measures to increase water efficiency which can be assessed individually.

Selection and peer-review under responsibility of the International Scientific Committee of the "3rd CIRP Global Web Conference" in the person of the Conference Chair Dr. Alessandra Caggiano.

Keywords:Resource efficiency; Water efficiency; Manufacturing; Water system; Work steps

1. Introduction

A growing world population and rising living standards require a higher demand of new products and an increased use of resources. Considering the world's contemporary situation in regards of resource consumption per capita, today's population already exceeds the planets natural bio-capacity [1,2]. This trend is expected to continue moving upwards causing an increased demand for energy and water by 40% over the next twenty years, provided that no major policy changes are realized. It is estimated that there will be a 4 to 10 fold increase in resource efficiency necessary by 2050. Taking this prediction into account each product will have to be produced using respectively 25% and 10% of today's resource inputs [3,4].

Therefore, implementing sustainable concepts focusing on reducing the overall resource consumption seems to be a prerequisite for a sustainable business development. To achieve such a sustainable development, resource intensive enterprises need to tackle and structure their consumption patterns, not only from an environmental but also from an economical perspective. In that context, enterprises need to understand that resources comprise different mediums such as electricity, gas, oil, raw and auxiliary materials as well as water [5]. Due to rising gas, coal and oil prices entailing strong cost pressure and competitiveness issue, enterprises have lately put a strong emphasis on increasing their energy efficiency. This endeavor favors not only their reputation and image towards the environment but also entails economic potentials for cost reduction [6,7].

Thus, many efforts have focused on reducing energy consumption and greenhouse gas emissions by increasing energy efficiency through different approaches [8-12]. However, resource efficiency comprises more than solely energy. Raw and auxiliary materials and resources are just as important for a production system as energy.

One vital resource that has often been neglected when it comes to considering resource consumption in industry is water. This awareness has recently gained momentum. Although natural water is covering 71% of the Earth's surface, usable freshwater is limited to only 3% [13,14]. Regarding the rising demand of freshwater and its seasonal variation of availability, a survey

Selection and peer-review under responsibility of the International Scientific Committee of the "3rd CIRP Global Web Conference" in the person of the Conference Chair Dr. Alessandra Caggiano.
doi:10.1016/j.procir.2015.04.007

approved by OECD countries has predicted that by 2030 half of the world population will be facing severe water shortage [15].

Global industry uses around 22% of the available freshwater. However, the amount of freshwater used in industry can vary depending on the water quality as well as the local perspective. Generally, industrial countries tend to have a higher water consumption compared to the global average due to more water-intense industrial production processes [16]. Thus, industrial countries, and in particular European Countries, waste 20-40% of its available freshwater by failing to deploy technological improvements which alone can account for up to 40% improvement in water efficiency [17].

This development includes manufacturing enterprises, as being a strong part of the global industry. Above that it has been acknowledged by the United Nations that there exists a gap of knowledge, particularly in manufacturing, concerning the amount of water withdrawal and consumption used for purposed manufacturing transformation and production needs [18]. This issue is of high of relevance for small, medium and large sized manufacturing enterprises alike since this gap of knowledge results in missing starting points for water minimisation efforts [19]. Information regarding water withdrawal and consumption are usually only monitored on a factory level and assigned to the respective process chains via allocation rules.

Against this background of insufficient information about possible starting points for exploiting hidden potentials there is a need for an easy-to-handle and systematic concept allowing a structured identification of water consuming hot spots and related measures for improvement. As known from other disciplines (e.g. lean management), the objective is to establish a structured improvement process for resource efficiency in manufacturing. This objective is also addressed by recent standardisation principles and guidelines like DIN EN ISO 14001 (environmental management system [20]). The proposed concept fosters resource efficiency by following three major steps that are all supported by user-friendly tools:

- Production data acquisition to provide transparency about the current situation
- Analysis of the current situation and derivation of measure for improvement
- Holistic assessment of the derived measures for improvement.

The initial section of this paper emphasizes different use of water in industry and underlines that water can vary in terms of quality. The subsequent section presents the proposed concept including a detailed description of the separate concept steps as well as selected remarks on a few supportive tools.

2. Use of water in industrial processes

Water for industrial purposes is usually withdrawn from aquifers, from surface water or the public drinking water net. Industry often considers water as a utility and uses it for different purposes, as shown in Table 1 [21]

Table 1. Functions of water use in industrial processes [21].

Function of process water	Examples
Product, reactant	Production of beverages, hydrolysis
Solvent, absorption	Gasscrubber, pickling
Washing, adsorption	Textile finishing
(Energy) Transport	Cooling, steam circuits, solid wastes, sugar canes
Washing and rinsing	Cleaning of equipment, installation and piping

Table 1 indicates that water can either be used as a raw material or an irreplaceable utility due to its chemical properties. Industry uses an intensive amount of water particularly for cooling cleaning and rinsing purposes respectively. During the transformation process in manufacturing, water becomes polluted by conditioning and cleaning activities as well as through direct contact with water-soluble components. After that the water's quality is deteriorated in such a way that it requires treatment prior to re-using it in the production or disposing it as wastewater [21]. Typical water treatment comprises water softening (e.g. by removing Ca, Mg), removal of suspended solids, iron (Fe), manganese (Mn) and glycol as well as other constituents which cause negative effects on the product and the production [22]. The amount of contaminants and water used for an industrial process can certainly vary significantly depending on the required product and production specifications.

Despite having suitable technologies for industrial water efficiency improvements available, enterprises often fail to seize opportunities for implementing such improvement technologies. Due to very different use of water within enterprises for various purposes and its demanding treatment processes afterwards, there exist several obstacles which impede the implementation of water efficiency improvements:

- The typical water system within an enterprise is fairly unknown
- Water is, as e.g. electricity or compressed air, an invisible resource in the production
- Water is needed in different qualities and amounts for different purposes
- High water demand for continuous supply and conditioning of water
- Very specific process knowledge is necessary