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ScienceDirect

Procedia CIRP 50 (2016) 448 – 453

www.elsevier.com/locate/procedia

26th CIRP Design Conference

Driving process innovation: a structured method for improving efficiency in SMEs

Alessandra Papetti[a]*, Eugenia Marilungo[a], Fabio Gregori[a], Michele Germani[a]

[a]*Università Politecnica delle Marche, via Brecce Bianche 12, Ancona 60131, Italy*

* Corresponding author. Tel.: +0712204880; *E-mail address:* a.papetti@pm.univpm.it

Abstract

This paper proposes a method to drive process innovation toward the increase in efficiency of a production plant.
The work defines a structured method, supported by a classification tool, to correctly organize whole plant information with a mayor focus on energy consumptions. The method was tested in a medium enterprise with the target to increase the efficiency of the entire production plant. The method is the basis for a web application tool. A correct data management permits to plan the best practices to improve processes and systems involved in terms of environmental and economic impacts, meaning a process sustainable innovation.

Peer-review under responsibility of the organizing committee of the 26th CIRP Design Conference

Keywords: process innovation; energy efficiency; data management; lean manufacturing; energy measurement.

1. Introduction

The efficiency in terms of costs and carbon dioxide emissions are the most important drivers of firms on 21th century. World regulations are tighter year by year and to remain on the market firms have to improve efficiency by newer working methods, processes and products. However, newer solutions are not enough to fit this challenge, there is the real need of innovation. As defined by Carlile [1], novelty pushes innovation but not all of novelties embed innovative values. In this paper, focusing on the production process, the key aspects for moving toward innovation are identified. Acquiring new powerful machinery, increasing speed of drills or reducing number of human controlled operations are only novelties that not automatically mean innovative solution; innovation has to be planned. It will be shown that innovation means firstly having a deep knowledge of the current state of processes in order to completely avoid mistakes in the future. The paper proposes a method to plan actions toward effective innovative solution on a production plant. Plant sustainability is the final goal that the method embeds; with this perspective, the idea of sustainable innovation will be introduced. After a clarification of the innovation meaning, main criticalities in the field of energy efficiency and process data acquisition will be identified. The paper shows a methodology for a detailed manufacturing data acquisition process. Data will be classified through a specific tool that encompass the whole knowledge about a firm production. The work proposes the philosophy and the interfaces used by the tool for data management. The presented tool permits to understand cost trends, classifying processes and machineries and putting in relation productivity with energy consumptions. Moreover, a report could be generated to understand the environmental impact of the production site related to the energy flows needed for the product development. The method proposed is firstly applied to an Italian SME in the sector of carbon fibre component production.

2. State of the art

2.1. Toward the sustainable innovation

A suggestive definition of innovation was given by Kao in 2007 [2]: he defines the idea of innovation as the ability of

Peer-review under responsibility of the organizing committee of the 26th CIRP Design Conference
doi:10.1016/j.procir.2016.04.143

individuals, company or entire nations to continuously create their desired future. Therefore, a novelty become innovation if it affects positively the future generation. Different planes of innovation exist; in the present paper the focus is on the process one. Process innovation includes the implementation of significantly improved production or delivery method. Changes in processes mean also implementing new techniques, equipment or software [3]. The innovation on the mentioned plane can be mainly of two different kinds: incremental or radical [4]. Incremental process innovation consists in implementing continuous optimization to the production process remaining in the original level of production technology. Radical innovation occurs when a process is completely changed and there is the switch off of an old process, to implement a newer process that embeds new techniques for improved products. Yamamoto in 2013 [5] argued about the topic of Manufacturing process innovation (MPI). Such document defines four types of process innovation depending on the different levels of solutions introduced. On 2010 Polder et al. [6] proposed a model that put in relation product, process and organizational innovation. They asserted that positive effects of product and process innovation exist when combined with an organizational innovation. Actually, it exists a further direction that innovation can follow that permits to reach the sustainability: in such case, it is introduced the sustainable innovation. Sustainable innovation is a process where sustainability considerations (environmental, social, and financial) are integrated into company systems. It is applied to products, services and technologies, as well as new business and organisation models [7]. Brown in 2009 [8] defined the innovation as the propeller of manufacturing sustainability. The proposed method is thought with this last perspective and it tends to favour the process sustainability. The method moreover has the basis on a double rail, linking lean thinking with sustainability. Few works exist with such relationship and how lean thinking pushes manufacturing sustainability; these are collected within the work of Hartini and Ciptomulyono of 2015 [9]. Furthermore, interlinks and similarities between lean and “green” are pointed out by Kurdve et al. [10]. On the latter work, sustainability aspects are integrated into the company-specific production systems.

2.2. Lean Manufacturing

As mentioned, the method described in this paper refers to lean manufacturing. The work of Sahah and Ward of 2003 [11] clearly describes such topic, including a description of several tools related to lean manufacturing philosophy aiming at reducing manufacturing wastes. Lean manufacturing, in fact, focuses on avoiding seven cardinal wastes and on respecting customers, employees and suppliers [12]. The final goal of lean manufacturing is to be highly responsive to customer demand by reducing waste [13]. The seven wastes by lean manufacturing are argued firstly by Liker [14]. Wastes are meant as limits for a production system. One of the seven wastes is the inventory. Referring to Womack [15], it is important to optimize the inventory process in order to not occur in “infobesity”, having more data than the ones really needed. The efficiency of the inventory phase moving toward production sustainable innovation is one of the main goal of the present work. Considering manufacturing system, a key driver for innovation would be the energy efficiency. Nowadays, such assertion gains value since the increasing of industrial consumptions highlighted into the document of the International Energy Agency [16]. Referring on 2013, the consumptions of industries were 2702 Mtoe, at a worldwide level.

2.3. Energy Efficiency

The increasing pressure as regards the availability of fossil fuels, energy prices and emerging environmental legislation are leading manufacturers to adopt solutions to reduce their energy consumption as well as their carbon footprint [17]. Energy efficiency has been the primary factor in driving down energy consumption in IEA countries over the last decade [18]. Patterson [19] defines the energy efficiency as the ratio of the useful output of a process to the energy input into a process. He defined several indicators to evaluate this performance, namely measures of energy efficiency performance (MEEPs). Introducing these measurements in a real industry context means dealing with energy management. An interesting energy management study pointing out criteria and MEEP to choice was proposed by Tanaka in 2008 [20]. The work by Thiede et al. [21] proposes a method to assess then optimize energy efficiency of a production system; the latter focuses on electric energy and a map of energy flows was carried out. A roadmap for improving energy efficiency was proposed by Ghadimi et al.[22]; materials and energy flows there were remarked as very important issue to fully understand. The method proposed by the present paper could boost the previous approaches, permitting moreover to have a simplified and structured data acquisition phase, favoring the repeatability, in future, of the innovation procedure. Main standard about energy management is the ISO 50001:2011 [23]; such document specifies requirements applicable to energy use and consumption, including measurement, documentation and reporting, design and procurement practices for equipment, systems, processes and personnel that contribute to energy performance. This paper considers the mentioned standard and develop a structured method to boost the execution of such guidelines. Finally, few case studies are already available in literature with the aim to manage energy in a manufacturing system (de Carvalho and de Oliveira Gomes[24], Xie et al. [25], Haragovics and Mizsey [26], Jovanovic et al. [27]). Such studies are focused on specific systems. This paper wants to propose a method that will be effective not only on a singular case study, but replicable on different manufacturing systems.

3. Method for improving process efficiency

In order to make the manufacturing process innovation able to achieve tangible benefits from an environmental and economic point of view, the full knowledge of business flows and current inefficiencies is necessary. For this aim, a structured approach that favors the process innovation starting