SUSTAINABLE DEVELOPEMENT IN AUTOMOTIVE COMPANIES

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ABSTRACT: The automotive industry plays an important role in Europe. The "made in Europe vehicles" are delivered all over the world. To remain sustainable and competitive the car industry is investing constantly in research and development - the automotive industry is the largest private investor in research and development and one of the major approach theme is represented by sustainability. This paper proposes a closer radiography on the sustainability issue in the context of automotive companies, providing information regarding specific strategies to mitigate greenhouse gas, ways to implement them, action directions for lower energy consumptions and enabling technologies for assuring sustainable manufacturing.

KEY WORDS: sustainable development, automotive industry, energy saving manufacturing technologies.

1. INTRODUCTION

Operating in over 290 vehicle assembly and production plants in 25 countries across Europe and producing over 16.2 million cars, vans, trucks and buses the automotive industry may be called the heart of Europe, with a major role in the Europe economy. With a turnover of 6.9 % of the Europe's Gross Domestic Product - 839 billion euro - and employer for around 12,9 million people, the automotive industry plays an important role in Europe. The "made in Europe vehicles" are delivered all over the world, 6,6 million vehicles are delivered with a 92 billion euro trade surplus. To remain sustainable and competitive the car industry is investing constantly in research and development - the automotive industry is the largest private investor in research and development, in 2012 the amount spent in this area was around 32 billion and the applied patents number in an year is around 9,500 (Association, 2013). One of the important research theme is represented by sustainability. The sustainability issue is approached during the entire life time of the product: sustainability during the manufacturing process - the European manufacturers are constantly decreasing the waste energy, Co_2 and waste values and sustainability in vehicle utilisation.

This paper proposes a closer radiography on the sustainability issue in the context of the automotive manufacturing companies, providing information regarding specific strategies to mitigate greenhouse gas emission, ways to implement them, action directions for lower energy consumptions and enabling technologies for assuring sustainable manufacturing activities.

1.1. The sustainable manufacturing concept

Human actions take place, grow, interact affecting the environment. Studies shows the severity of the low interest in human actions impact on the environment, the most known and important being the climate change. Among the first measures taken we find the awareness of the result of the human-environment interaction. The embodiment of all the results of the human interaction with the environment was named carbon footprint: "Carbon footprint is one way to illustrate humans' impact on the environment. It is quantified by converting our use of fossil fuels (e.g. for electricity, heating and transportation) to metric tons of carbon dioxide emission" (Carbon footprint, 2011). In this context we can easily understand the target European Union set until 2020: to decrease the greenhause gas emissions with 20% from 1990 levels, to increase the contribution of the regenerable energy in the energetic consumption with 20% and to increase the energetic efficiency with 20%.

1.1.1. Green manufacturing or sustainable manufacturing?

The word green, is frequently met as a synonym for eco, bio, environmentally friendly, environmentally-conscious, clean etc. and can be defined as "concerned with or supporting environmentalism and tending to preserve environmental quality (as being recyclable,

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biodegradable, or non-polluting)" (Merriam Webster Dictionary, 2010).

A generally known definition for sustainable development showes that this is the "developement that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Development, 1987).

Analizing the two definitions we can see that adopting the green principles leeds the way through sustainable development, development that has as a central figure present generations and "the future generations" - *the social pillar of sustainability*. The present and future generations have "needs" - *the economic pillar* - that have to be "met" considering all the repercussions of our actions on the environment - *the environmental pillar*.

2. MANUFACTURING TECHNOLOGY AND SUSTAINABLE DEVELOPEMENT

Reffering to a typical autovehicle we know that it represents an assembbly of about 15,000 components (Kalpakjian & Schmid, 2010) Consequently, the processes necessary to produce a vehicle includes a great deal of energy. A report of the European Union from Iuni 2011 (EU 27, 2014) shows that the industry is responsible for an important energetic consumption of 24% from the final consumption. A projection of the global energy demand (Battaglini & all, 2009) estimate that the future energy demand will grow by 60% by 2030. Consequently, the automotive industry is responsible for an important energy consumption and these means, also, an important greenhouse gas emission.

3. LITERATURE REVIEW ON SUSTAINABLE MANUFACTURING PRACTICES

A good introduction in the sustainability theme is done by Prof. Paul G. Ranki's and Prof. David Alan Dornfeld. A part of their studies provides the necessary tools to understand the basic concepts of sustainability in industry (Dornfeld A. D., 2013), (Ranky's, acc. 13/05/2014).

In the manufacturing technology field, where sustainable is considered survival (Seok, 2012), a basis for research initiation have the critical studies undertaken by (Blizzard&Klotz, 2012), (Baines, 2012), (Young, 1997).

In terms of production technology field there are some definite directions of approach, and they are summarised in the following paragraphs.

3.1. Machine tool

Only 25% of the consumed power is used for the effective machining (Peng, 2014) and that is the reason why it is important to understand and control the energetic consume of the machine tool.

The undertaken studies in this area aims energy modelling techniques in machining processes, energy monitoring, energy reduction and predictive models of energy consumption (Yingjie, 2014), (Vijayaraghavan & Dornfeld, 2010), (Yang, Li, Gao and all, 2013). Another direction is set by (Kengpol, 2011), (O'Driscoll, 2013) and (Vindoh, 2013) which proposes various energy performance indicators across the enterprise. Helu in his work analyzes the relationship during the accuracy of a manufacturing process of a product and the environmental impact (Helu:a, 2011).

3.2. Cutting fluid

Another stream of great importance in manufacturing is the cutting fluid flow. Its use is a way to control the heat dissipated in the cutting process and a way to remove chips from the work area. Also, the cutting fluid protects the work against material rusting, improves the surface finishing, and prevents the formation of built-up edge. The disadvantages are its the cost and the negative impact it has on the environment. Thus, a first aspect of the problem of the of cutting fluid is represented by knowing the volume of fluid consumed. For this purpose we can use sensors: flow meters and the information obtained can then be analyzed at different levels ranging from the entire enterprise to the tool-chip level (Dornfeld D. , 2013). A second issue is to reduce the amount of liquid consumed. One way out would be dry cutting, which also raises problems in terms of chip evacuation. Contributions in this area, the reduction or total surrender of the cutting fluid brought (Zhong, 2010), (Avram, 2011), (Paris, 2012), (Meena, 2013), (Ferri, 2014), (Yan, 2014).

3.3. Process improving

Parameters optimization - at the micro-level planning - meaning process parameters - there are researches that have as purpose the optimization of the cutting regime parameters relative to the environmental impact in combination with other factors such as - optimization of cutting parameters taking into account energy

consumption and compressed air (Xiong, 2013), considering the optimization of the energy consumption parameters and surface roughness (Guo, 2012), (Li, 2012), or taking into account the energy consumption and cost (Wang, 2014), (Linke, 2012).

The decisions taken on the production elections must be taken considering the environmental impact and cost, mehodologies based on performance indicators, support decision-making, etc. Thus, in order to establish the *workpiece material* (Huang, Zhang, Liu, and all, 2011) propose an index that reflects the environmental impact, at the *material selection* activity; (Deshamukhya, 2014) propose a decision support dedicated for *tool selection* and based on analysis of the environmental impact, cost and quality in the *selections of cutting fluid*. Studies on the choice of the *cutting path* and impact that this has on sustainability were made by (Afifi, 2011), (Daeyoung, 2011), (Kong, 2011).

3.4. Production planning

In terms of production planning with taking into consideration the sustainability principles we meet works that propose energy flow analysis on four levels in the company process, machine tool, production line and plant (Fyskopouluos, 2014)), studies aimed at dynamic planning based on energy consumption and efficiency (Zhang, 2013) or studies on the development of decision models such as that proposed by (Tan, 2011) which presents a decision model dedicated to the establishing of the production process with taking into consideration the cost, quality, machining time and environmental impact.

4. CASE STUDY ON AUTOMOTIVE COMPANIES

In order to illustrate the tendencies regarding the implementation of the sustainability principles in Romanian production organisations from the automotive area important information was gathered through interviews and questionnaires applied to the selected companies.

4.1. Methodology

To achieve the object of the research the present survey went through following stages:

- the first step consisted in carrying out a rigorous research-based on the scientific literature, case studies and reports aimed to identify the current directions sustainable technologies that characterize the global automotive companies - a comprehensive review of manufacturing technologies was made for the automotive industry and from this study were selected key technologies and presented in this paper in the Literature review section on sustainable manufacturing practices;

- in the second stage the information from the research results was used to elaborate a tool to evaluate the current directions which are characterizing the manufacturing technologies developed by the local automotive companies;

- the final step consists in presenting and analysing the obtained information.

The organisations were selected from the automotive manufacturing area and they are medium and large-scale companies. The companies profile is presented in Table 1;

Table 1 - Organisations profile

Medium employs number - (companies number)	**net turnover in 2013 in Romanian currency - (companies number)**
<200 - (8)	< 100,000,000 - (7)
200-600 - (3)	< 200,000,000 - (4)
>1,000 - (5)	< 500,000,000 - (3)
	> 500,000,000 - (2)

A total number of 48 employes from 16 companies completed the questionaire and/or have discutions on the proposed subject.

4.2. General section regarding sustainable development strategies

In this section data was collected in order to build a profile of the organization in terms of sustainability.

The information gathered shows that each of the organizations has a strategy for sustainable development. These strategies were developed by the Steering Committees of the group - at the multinational companies or by employees at the national companies.

All organizations follow objectives aimed at efficient use of raw materials, efficient use of the equipment and the reduction of energy consumption, 50% of them track the efficiency of waste management and only 44% aimed campaigns to inform on sustainability issue - Figure 1.

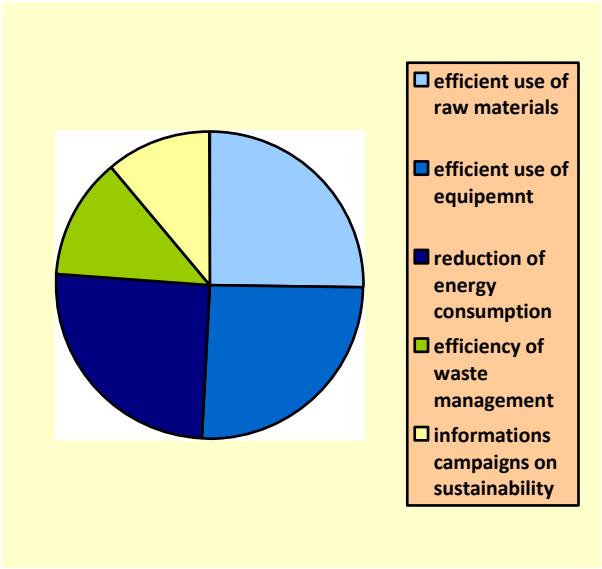

Figure 1. Targets for sustainable strategies

An average value that defines the extent to which the targets regarding sustainability have been met is 85%.

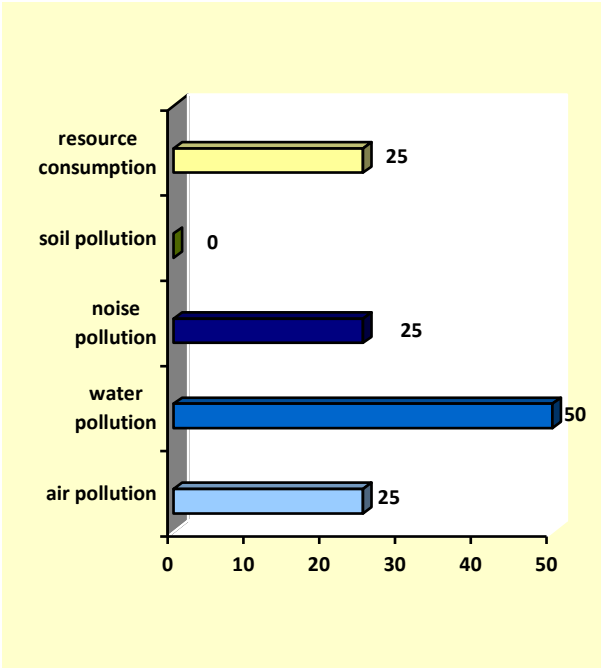

Figure 2. Enviromental aspects to improve

Figure 2 presents the environmental aspects that can be improved and were identified by companies are: air pollution - identified by 25% of the companies, water pollution - 50% consider that can be improved, noise pollution - was identified by 25% of the organisations, soil pollution - was not identified -0% and resource consumption - was considered an aspect that can be improved by 25% of the companies.

All employees are involved in environmental issues but they are not persons specially designated for this task. Responsible for implementing the strategy are the department heads.

Environmental issues are communicated to employees by posting in bulletin boards in all the companies, using circulars in 25% of companies and through seminars in 25% of organizations. Alternative methods identified by the companies are: verbal communication, training and simulation.

The standard used in the environmental matters is ISO 14001.

4.3. Sustainable development strategies in manufacturing technology

A large proportion of the respondents say that they are not familiar with the subject of sustainable technologies - half of the respondents. They show that, in most cases, their source of information about these technologies is the internet, followed by attending conferences and then the collaboration with other companies. An important source of information mentioned by most of the participants at these discussions are the technology suppliers - as in this case, for example, of the equipment manufacturers.

Only a small proportion of the respondents (21%) could indicate a value for the energy consumption for actual production due to the total consumption of energy in the enterprise - and its average value was 84%. Even though, all respondents agree that this value could be reduced. As a solution they indicated manufacturing efficiency and this shows that the structures which should take actions in this regard are, on the same level in terms of importance, management, design and production.

In terms of specific practices of sustainable technologies the obtained responses provided the information presented in Figure 2.

The graph shown in Figure 2 gives us an indication of the practices that enable sustainable manufacturing and the degree to which they can be found in the automotive companies from the investigated area.

Most often encountered practices are those concerning the selection the manufacturing process, the cutting fluid selection and the use of knowledge management and the most rare are those relating to cutting with minimum quantity

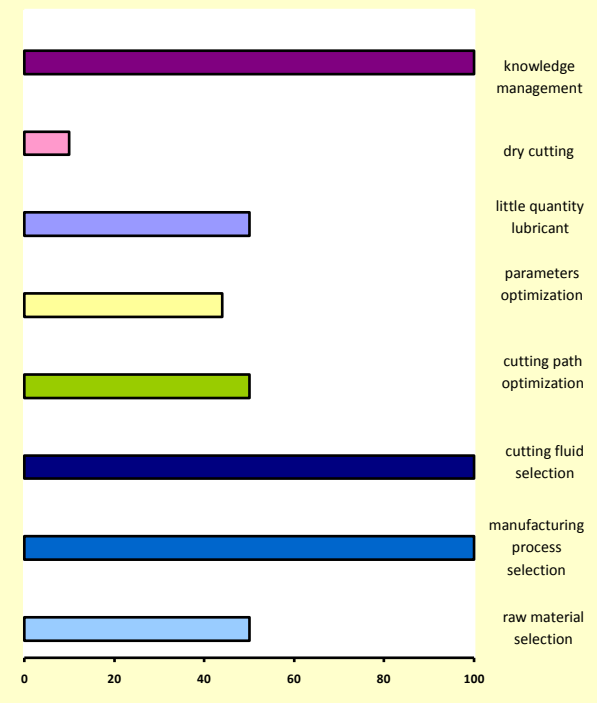

Figure 3. Sustainable technologies practices and how often we find them in companies

lubricant or dry cutting. No matter how common are these practices a relevant fact is that the interest in applying these practices is becoming higher. Another important aspect is that these practices can be found in various stages of implementation. If we take the example of knowledge management we can say that it is found in most companies. A different issue is the status in which the knowledge management is implemented and used: in most cases databases with technical documents. That means that there are a significant amount of knowledge that could be integrated in a knowledge model, thus guaranteeing the transfer, storage, safe access and continuous improvement of the knowledge concerned.

5. CONCLUSIONS

The objective of the study is to identify the extent to which sustainable manufacturing technologies present in European manufacturing technologies are found in the Romanian enterprises. In this regard the first activity performed consisted in the identification of the key sustainable technologies in the automotive manufacturing companies. It was then analyzed and identified the overlap between the identified technologies and the technologies found in the Romanian companies. The study shows that these technologies are present in the organisations but the level of their implementation differs. The most common are practices regarding cutting fluid selection, selection and manufacturing process, selection and the knowledge management and the less common practice related to cutting dry and its variants. One important reason due to which technologies found at the enterprise level are those shown is represented by the cost - for example the cost of energy consumption monitoring equipment.

6. ACKNOWLEDGMENT

This work was supported by the strategic grant POSDRU/159/1.5/S/133255, Project ID 133255 (2014), co-financed by the European Social Fund within the Sectorial Operational Program Human Resources Development 2007-2013.

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