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Maintenance best way for meeting the challenge of regeneration

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Abstract: The circular economy is an economy that meets sustainable requirements, and that advocates a new paradigm, the paradigm of regeneration. This paradigm allows creating new businesses, new jobs and new skills all along about the product lifecycle. This is especially the case for maintenance and retirement processes. Indeed, these processes are the regeneration core. Those of retirements do not sum up to destructuring process but match also with repair, reuse and disassembly processes. As for maintenance, it becomes the cornerstone of all this. Through all its current skills, it allows managing and optimizing the regeneration by deciding when to stop a use and where studied items should go. Besides, maintenance must adapt to the regeneration. In other words, tools and methods used by maintenance can be able to maintain the regeneration potential of an item, and thus, create new jobs and experts. The purpose of this paper is to highlight the major challenges brought by the paradigm of regeneration to maintenance.

Keywords: Maintenance, maintenance services, maintenance management, sustainability, regeneration paradigm

1. INTRODUCTION

To resolve the problem of the climate change, the increase in the greenhouse gases and the consumption of goods, the exhaustion of natural resources, the accumulation of wastes, etc., the political powers orientate their strategy towards sustainable development. This development is defined as a "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*" (WCED, 1987). In this sense, several conferences and projects expand such as United Nations Conference on Sustainable Development (UNCSD), Rio+20 and COP21, and the Europe 2020 project.

Thus, the current economic model, the linear economy (take-make-jump), does not meet new requirements of sustainable development. It becomes obsolete. Therefore, we must change paradigm and turn towards, for example, the circular economy (make-use-return indefinitely). The circular economy considers that natural resources are limited and that waste does not exist (Foundation Ellen MacArthur, 2014). The idea of this economy is to create closed loops by reusing the manufacturing goods so that waste becomes resources. It is also called the "paradigm of regeneration". The principle of the circular economy in based on several schools of thought:

- Biomimicry (Benyus, 2009) is the study of nature to design goods and to develop new technologies. For example, the form of eagle has inspired the high-speed train, and the skin of sharks has inspired the swimsuit;
- Industrial Ecology (Despeisse et al., 2012) is the study of material and energy flows through the industrial system to add value to wastes produced by a firm. For this, a firm uses wastes produced by another firm as resources. Kalundborg area (Zhu and Ruth, 2014) is a good example;
- Regenerative Design (du Plessis, 2012) is the study of environment and communities of a place to design in harmony with them. The permaculture is an application of this concept;
- Cradle-to-Cradle (McDonough and Braungart, 2010) is the popular term for regenerative design, which uses a biomimicry approach to design a good. These authors use the term of nutrients to talk about resources. (Diez et al., 2015) have approached this notion.

These schools of thought are oriented design and consider a perfect exchange of wastes between different firms. The model regrouping all these concepts does not exist, but we can approach it.

Indeed, research areas such as maintenance turn towards the sustainable problematic with new concepts including the three sustainable pillars. They include:

- Green maintenance focuses on the elimination of all wastes produced and associated with maintenance, by practicing the pollution prevention, toxic use reduction and design for environment. (Ajukumar and Gandhi, 2013) propose an approach to evaluate it by basing on a multi-criteria decision-making and on green maintenance requirements (environmental compatibility, energy efficiency, and human health and safety risks);

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- Maintenance-centered Circular Manufacturing (Takata, 2013) is based on the circular manufacturing but sees maintenance as a core activity in a system. In this vision, manufacturing, reuse and maintenance merge to create a cohesive flow forward/feedback loop and to increase the product longevity.

Our works are in the same logic as (Takata, 2013), but our point of view is directly inspired by nature. In this sense, the purpose of this paper is to highlight the major challenges brought by the paradigm of regeneration to maintenance.
For this, section 2 develops the concept of regeneration in nature and the industrial world. Then, section 3 describes the industrial processes emerging from this concept and their impact on maintenance. Section 4 focuses on the regeneration influence on maintenance, and vice versa. Finally, section 5 concludes this paper.

2. PARADIGM OF REGENERATION

The biology literature defines “regenerate” as a process “to grow again”. The term of regeneration has used in two different contexts. The first is the regeneration of organic tissue. Indeed, we talk about this regeneration when, for example, the lizard’s tail grows back, or when your skin heals. Scientists have studied this phenomenon to create a self-healing rubber, metal and concrete. The second context corresponds to the trophic organization, namely, the food web. This organization is circular and reuse all that is produced by each entity. We are interested on this regeneration context and we apply it to the organization of the industrial world.

2.1 Trophic organization

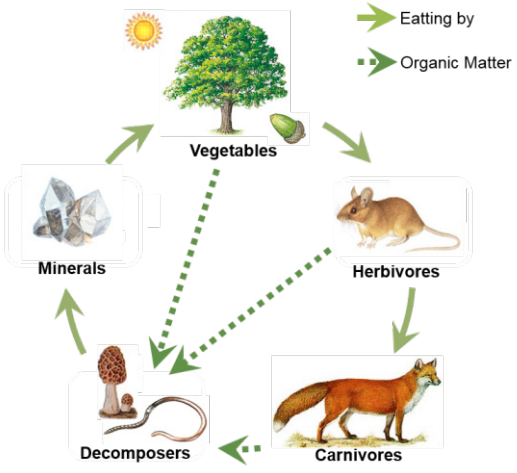

Fig. 1. Trophic organization

The concept of waste does not exist in nature. For it, all is food (Kormondy, 1969); each entity (living being) feeds another entity (Fig. 1). Indeed, vegetables eat solar energy and mineral salts. Herbivores eat vegetables and carnivores eat herbivores and other carnivores. Each entity produces organic matters that are eaten by decomposers (fungi, worms, bacteria). These decomposers produce mineral salts to feed vegetables, and the cycle continues. To summarize, all resources produced by and in nature are regenerated, except solar energy.
The essential entities are decomposers, without them, nature would be a big rubbish dump and would not be circular. Therefore, to become circular the industrial world must add the notion of decomposer.

2.2 Towards a regeneration of industrial world

Contrary to the trophic organization, the industrial organization stays linear (Fig. 2). Indeed, primary industries extract natural resources and supply secondary industries. These industries transform natural resources in goods and supply human activities. These industries and activities produce wastes. However, no or very few industries (recycling process) exist to transform these wastes into resources. No recycled waste is very numerous and is landfilled.
Therefore, if we want to meet sustainable requirements in circular economy, we must be inspired by the trophic organization (Geng and Côté, 2002). We must add more processes, called “technical decomposers”, to transform unusable items to add value to them. They create new companies and new business.

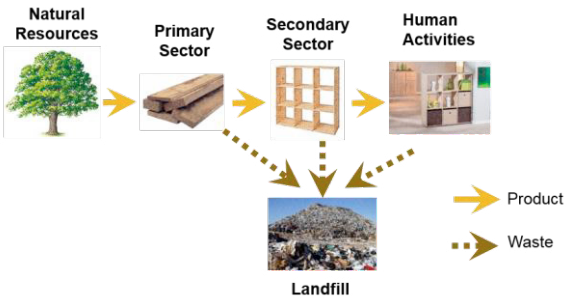

Fig. 2. Linear industrial organization

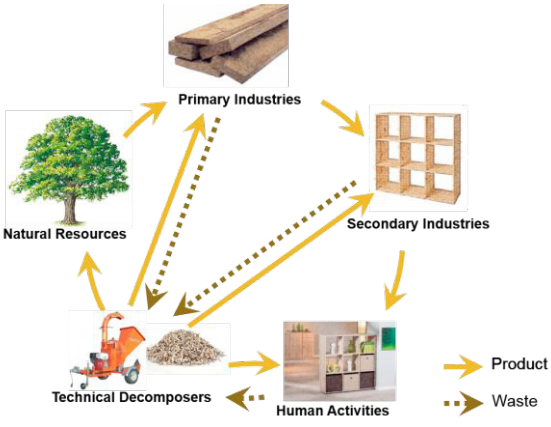

Fig. 3. Circular industrial organization

With the technical decomposers, industrial organization can become circular (Fig. 3). Moreover, contrary to natural decomposers, the technical decomposers can supply different industrial sectors, what give more possibility to regenerate an unusable item.