THESIS G-SCOP 2020

Title: Maintenance planning optimization to meet the challenge of circular economy

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Brief Description :

Since the 18th century industrial revolution, the European economy is based on a « linear model »: extract, manufacture, consume and dispose (Le Moinge, 2014). Several causes lead this model to generate more and more waste and to consume an increasing quantity of natural resources. Among those causes, we find the demographic development, the increasing worldwide consumption and the expansion of this model in emerging countries. The available resources on earth are not unlimited and waste management is really challenging. In this context, the linear model seems not to be viable anymore. To break with this model, the Circular Economy (CE) appears as one of the most promising model (Ellen MacArthur Foundation, 2019). Through the energetic transition for a green growth act of August 17, 2015 (Loi n°2015-992, 2015), the French state made CE a national objective. The definition of Circular Economy (CE) given by the Ministry of Environmental and Solidarity Transition (Ministère transition écologique et solidaire, 2019) implies that CE needs to tackle several challenges such as sustainable design, industrial and territorial ecology, service economy, responsible consumption, usage duration extension, prevention improvement, waste management and recycling…

CE is not only a political will but also an industrial challenge. A few examples showing the growing interest for CE is given below. Renault engages himself in a program to transform his waste into resource. Seb carries out several actions related to CE (repairability of products, pooling of product usage, extending product life duration and end of life recycling). Finally, Philips, through Circular Lighting, bets on service economy sector by offering a lighting service.

Environmental concerns are in the heart of many research in operational research (Giret et al.,2015, Akbar and Irohara, 2018). The G-SCOP laboratory made sustainability one of its 5 priority areas for the coming years. The G-SCOP laboratory is the coordinator for the CIRCULAR CDP (Cross Disciplinary Program) "Designing circular industrial systems for the industry of the future". The work carried out in this PhD thesis aims at contributing to this project. This PhD thesis followed in the

footsteps of the master internship entitled “Maintenance planning for circular economy: laundromat washing machines case” and funded by the CDP Circular.

Objectives

In this thesis, we will focus on optimizing maintenance planning to meet the challenges of CE. Maintenance has a very important role to play in extending the usage duration (Diez, 2017), but also in service economy or in the context of shared use.

In the context of extending usage duration, several maintenance types need to be considered: maintenance to maintain usage and maintenance to allow second life. In addition, it may be relevant for some products to consider maintenance component by component (Kamran et al., 2011). It also may be consistent not to only consider product's lifespan but also health state and usage duration of each component.

As defined by the French Ministry of Environmental and Solidarity Transition, service economy “consists in replacing the concept of good sale by the one of the usage sale". In this type of economy, the company producing the good remains its owner. Hence, planned obsolescence no longer exists and maintenance has a crucial role, not only to maintain a satisfactory level of service, but also to help optimizing the usage of various components. In addition, it has a direct impact on resource consumption (ADEME, 2017).
Usage pooling is a booming service offering. It consists in particular of replacing the product sale by the possibility of reserving and borrowing them. Once these products are returned, they must undergo maintenance, which can range from simple cleaning to maintenance that is more substantial. This type of consumption model is booming in many sectors (car and bicycle sharing, kitchen appliances, etc.). Usage pooling and service economy (Stahel, 2005) are booming and are based on efficient maintenance.

Optimizing maintenance planning taking into account economic and environmental costs and benefits is challenging. To reach a real environmental efficiency, it is necessary to take into account all the inputs/outputs of the system: resources required for maintenance, benefit of maintenance on the resources consumed, benefit of maintenance over the usage period of the whole product but also component by component…

The objective of this thesis is, based on operational research methods and tools, to propose exact, heuristic and hybrid or Constraint Programming type methods of maintenance planning to meet the challenge of CE in contexts of usage pooling or service economy or simply to optimize the usage duration of products or components.

Methods

This PhD Thesis will traditionally begin by a bibliographic study. This study will be separated in two parts. The first one will be dedicated to the role of maintenance in circular economy. The second one will concern the integration of maintenance in scheduling problem. In particular, scheduling problem considering equipment health index will be examined.

Based on this bibliographic study and on the analysis of different industrial actions in terms of CE, the objectives and constraints will be identified and prioritized.

Different problems of maintenance planning to optimize usage duration or in the context of usage pooling or service economy will be modeled. For these different problems, complexity studies will be carried out. Several exact, heuristic and hybrid or Constraint Programming type methods will be proposed, implemented and tested on instances that can be generated.

The results obtained from this work will be presented in international conference with proceedings and published in international journal.

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