Circular Asset Management
- Conceptual Model and Applications in the Process Industry

HZ University of Applied Sciences (HZ UAS) – Asset Management Research

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Contents

Overview of articles

The details of the research presented here are sub-divided in separate articles in order to make the work more readable. The layout is as follows:

Article 1 - Theoretical Framework for Circularity in Asset Management

Article 2 - Application of circularity models to Maintenance in the Process Industry

- Case Study: Industrial cleaning of shell-tube heat exchangers

Article 3 - Recommendations on the application of circularity models in Asset Maintenance in the Process Industry

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led by

Knowledge and Innovation Center Maintenance Process Industry (KicMPi) and the Belgian Maintenance Association (BEMAS)

Main research question

How can an organization make structured decisions to maximize sustainability and circularity in their asset management?

Background - context

In recent years the awareness of the need for a circular economy has grown enormously. There is a worldwide drive, within most industries and organizations, to reduce material and equipment waste and disposal, reduce energy usage and (CO_2) emissions, with increased focus on circularity.

The process industry is very strong in the Zeeland-Flanders region. However, as factories become older, more maintenance is needed to safely continue operations and to extend asset life. Investment in new plants and equipment is expensive, but also results in a higher impact on the environment.

The present study has been carried out as part of the regional Interreg project Circular Maintenance (https://circulaironderhoud.eu/). In this project, several public and private partners worked together, led by the (Dutch) Knowledge and Innovation Center Maintenance Process Industry (KicMPi) and the Belgian Maintenance Association (BEMAS), to improve the material footprint of the process industry in the South of the Netherlands and Flanders, while at the same time achieving economic benefit. The project was subsidized by Interreg Flanders-Netherlands.

The project was divided into 4 themes, each with 2 sub-themes:

i. Lifetime prediction and lifespan extension
   a. Predicting status and remaining life of electric motors (wp 4.1)
   b. Predicting (residual) life of control valves (wp 4.2)

ii. Minimize waste and reduce emissions
   a. Minimization of the release of waste during industrial cleaning (wp 5.1)
   b. Emission reduction through better repair of pipe and equipment seals (wp 5.2)

iii. Chain renewal/ sharing economy (maintenance tools); and
   a. Sharing of specialist maintenance tools (wp 6.1)
   b. Light-on-demand/ servitisation (wp 6.2)

iv. Reuse of equipment
   a. Electric motors (wp 7.1)
   b. Transformers (wp 7.2)

Wp 4.1-7.1 were case studies which were aimed at finding solutions for real-life concrete practical problems in the field of life extension, reuse, renovation, reparability and recyclability. The common thread running through the case studies was the aim to make the performance of installations, systems and processes with regard to circular maintenance measurable and then to be able to manage this. Prior to the above packages, wp 3.1 was executed in which measurement models for circular maintenance were developed.

Characteristic of the case studies was that they were all in-depth, but each specifically focused on the maintenance of a certain part of a total installation, and in particular aimed at the direct operational feasibility of the maintenance. In that sense, considering these 8 cases could be seen as a bottom-up approach to investigate and develop circular maintenance in the process industries step by step, with small sub-projects, mainly on an operational level.

Background - Relevance

HZ UAS conducted research in wp 3.1, 4.1, 4.2, 5.1 and 7.1. This compilation of articles reports the findings of the work in wp 3.1. and 5.1. It describes the work of the authors and also integrates a compilation of the work conducted with other researchers, students at HZ UAS and project partners.

As indicated, the subprojects mainly concerned bottom-up sub-studies of circularity maintenance in the process industry, often aimed at quantifying one or a few Key Performance Indicators (KPIs). This provided good insight into the concrete practical translation of the circularity objectives into the daily practice of the process industry. One the major pitfall in this field is that too much focus is placed on individual KPIs and not all aspects of the pursuit of an optimal circular economy are considered as a total system. Therefore, when considering the theoretical measurement model of wp 3.1, a broader, strategic approach has been followed to obtain a complete top-down overview of how to effectively integrate sustainability. A framework of asset management models has been used as a basis for this and these have been supplemented with instruments/ tools at every level for implementing the sustainability aspects, including elements that can be used to set up decision models. The term circular asset management is used to indicate the higher abstract level of the approach as it also includes the tactical and strategic level of Operations and Maintenance (O&M) work. With the mix of the bottom up approach of the case studies and the additional top down approach (based on asset management theory), the aim is to obtain the most complete and robust approach possible. Furthermore, in a number of studies the initial bottom-up approach has been supplemented with a further elaboration at a higher abstraction level in order to also make the link with associated tactical and strategic decision-making.

Problem statement

The overall problem that is investigated in the sub-studies is that there is relatively little knowledge and experience at the companies with regard to structured circular maintenance, embedded in organizations, and in particular with regard to its quantification and use in making business decisions. In general, sustainability is still mainly considered qualitatively. But the translation of objectives into concrete performance measurement models, the determination of associated performance requirements and the management of this is still relatively unexplored and unexploited territory.

HZ UAS asset management research on this topic in the project, has focussed on work packages 3.1 and 5.1:

- Wp 3.1 Measurement models for circular maintenance

  For all themes/ topics of the 8 case studies measurements models were not yet available. For example, regarding wp 5.1, a model was needed that measures the environmental footprint of the industrial cleaning operation. More concretely, a practical model was

needed to quantify CO_2 emissions, water waste and other material waste/ inefficiencies that determine the total footprint. It is important to include the total impact of activities from shutting down the plant, through transport, cleaning, until the equipment is back in operation. Furthermore the relative degree of circularity of the equipment must be quantified. These quantified values then form the basis for measurement and development of KPIs. How to set up and effectively manage these KPIs is also a topic of research, since there is limited insight into how management of circularity objectives should be integrated into the organizations.

- Wp 5.1 Minimization of the release of waste during industrial cleaning

In addition to theoretical models, it is not known what their practical application will look like, how the various cleaning methods currently applied in the field perform with respect to sustainability and how they can be prioritized on the basis of this criterion alongside the normal considerations of cost, safety, efficiency etc. A decision model was needed to compare equipment and cleaning methods. As a specific case here the cleaning of a heat exchanger has been considered.

Goal

The overall aim of the research was to develop methodologies/ models with which the maintenance of installations, equipment and processes in the process industry can be carried out more sustainably. The aim here is to develop theoretical concept models which are as practical and concrete as possible at the implementation/ operational level and to test the workability on the basis of practical case studies. To this end, the methodologies/ models must be as SMART as possible, i.e. measurable and quantitative. In addition to the above goal at operational level, mainly focusing on the measurability of individual performance indicators, the objective was also to zoom out and develop an asset management-based framework with which the entire top-down management process (from strategic, tactical, operational) of achieving the sustainability objectives can be overseen and managed.