Post Doc Position (*1 year*)

Circular Manufacturing enhanced by the quantification of Remaining Usage Potential (RUP) of products and its integration in Digital Product Passport (DPP)

Keywords: Circular manufacturing; circular economy; digital product passport; remaining usage potential; sustainability.

Organisation:

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Starting date: between September and November 2024.

Duration: 1 year

Gross salary: between 2100 and 2650 Euros/month depending on experience (salary per month before taxes)

Description:

The concept of maintenance-centred circular manufacturing (CM) appears for the first time in the literature with Takata (2013), who highlighted the relevance of maintenance engineering, diagnosis, restoration and upgrading technologies as enablers of the CM. Nowadays, the concept of CM is well-defined, and manufacturers are compelled to implement the CM strategies to limit their resource consumption and pollution generation (Acerbi et al., 2021). Acerbi and Taisch (2020) identified the circular economy (CE) principles that the manufacturers adopted and called them CM strategies. These strategies include remanufacturing, reuse, recycling, closed-loop supply chain and reverse logistics, industrial symbiosis, disassembly, circular design practices, resource efficiency and cleaner production, waste management and servitization. Among the CM strategies, according to Govindan (2022), the 3R strategies of recycling, remanufacturing, and reusing are the key ones that help the manufacturing industry close the loop towards sustainability. A circular manufacturing system is therefore defined as "a system that is designed intentionally to close the loop of products/components, preferably in their original form, through multiple lifecycles" (Asif et al., 2017; Roci et al., 2022). Another definition is provided by Asai et al., (2020), who reported that CM system is "a manufacturing system in which products, modules, parts, and materials (collectively called items) are reused and recycled as much as possible so that we can decrease the number of resources and environmental load for providing functionalities to the customers and increase profits".

In this complex CM ecosystem, evidently also the products are key elements that must be designed intentionally to be used for multiple life cycles (Asif et al., 2021) and correctly managed in order to be easily recovered/reused/remanufactured/recycled. As such, in CM ecosystem, interaction between product and manufacturing systems should be considered in order to optimize the usage of resources in a holistic manner.

When a product reaches its end of life (EOL) or its 'end of usage' (EOU), different CM strategies are possible (Diez et al., 2017; Vanson et al., 2023). Nevertheless, choosing the best CM strategy requires to have the right data and information related to its lifecycle management, i.e., how a product has been designed, what are the main components, how the product has been used and maintained along its life cycle and what it is its "state" at the EOU. Often, inadequate or no information is available to effectively support the choice of CM strategies with respect to the real state of the product and decision of the best/optimal CM strategy remains difficult and turns usually into recycling (i.e. the worst of the CM strategies).

In this regard, recently, the Digital Product Passport (DPP) concept has emerged as a promising enabler of circularity and sustainability. Indeed, the DPP is a digital entity that act as '*a centralized data storage system aggregating key data across a product's lifecycle, designed to enhance manufacturing transparency, traceability, circularity, and sustainability, while meeting the specific information needs of various actors including manufacturers, distributors, regulators, and end-users*' (Psarommatis and May, 2024). Several typologies of data should be included into the DPP, like material data, environmental data, manufacturing data, maintenance data, circularity data and value network data and each of them may concern several actors (Psarommatis and May, 2024). Considering the different points of view coming from different stakeholders' needs, a DPP should fulfil several purposes and requirements: therefore, a DPP has to be considered as an ecosystem constituted of different sub-systems with several specific core functions (King et al., 2023).

As such, DPP could be a backbone where lifecycle data is stored and enable data-informed decision-making at EOU. To that end, one core function of the DPP should be to provide information concerning the "state" of the product through its life cycle. Such stored information should enable the evaluation of the "Remaining Usage Potential", in order to choose the best CM strategy based on the stakeholders' points of view.

As stated by Bentaha et al. (2020; 2023), the "state" of an EOL system could not simply be a "state of health", as the concept used for maintenance decisions. For example, the decision to disassemble and then reuse should be made over a longer term. The authors, therefore, introduced the concept of Remaining Usage Potential (RUP), defined as the quantification of the component's capacity to re-enter a new cycle of use. Therefore, the difference between the Remaining Useful Life (RUL) – adopted in industrial maintenance – and the RUP is that the RUL time horizon is limited to the next maintenance action, whereas the one of the RUP is over a longer horizon. However, although Bentaha et al. (2020; 2023) have introduced this concept, they did not go further: they hypothesized the RUP as a known normal probability density function truncated in 0 and 1; the probability density function is built from statistical analysis of several EOL products. Indeed, Bentaha et al. are interested in stream of EOL products. Nevertheless, as predictive maintenance aims at customizing decision for each product, the RUP shall also be customized enabling customized and product-optimized decision. Therefore, the challenge of precisely defining the RUP (different RUPs can be defined based on the stakeholders' need/point of view) and of integrating it with/into the DPP remains.

Considering all the above, the proposed research objective aims to develop a framework for defining and quantifying the RUP of products, to then integrate it (or the main information needed for its calculation) into the DPP. The outcomes will facilitate informed decision-making for consumers, manufacturers, and policymakers, enhancing the transparency and utility of the DPP. Indeed, the RUP concept can be relevant for promoting circular economy practices, as it helps stakeholders understanding the residual value and usability of products, thereby encouraging CE processes, like reuse, repair, and recycling, and facilitating the decision-making process.

For achieving this objective, the following steps for the Post Doc are envisioned:

Step 1 – Conduct a literature review in the domain of interest to: (i) define the main elements characterizing the CM ecosystem; (ii) explore how, in the current state of the art, the products along their lifecycle are managed/orchestrated in the CM ecosystem in order to maximize their use and minimize their impacts on sustainability; (iii) identify the technological, organizational and managerial factors enabling the orchestration/management of the products along their life cycles; (iv) analyse the role and use of the DPP in this context and (v) the indicators adopted for assessing the circularity of a product along its lifecycle; (vi) identify the current gaps and research challenges in the investigated domain.

Step 2 – Define the information needed in the DPP for the RUP calculation, considering several factors such as material degradation, technological obsolescence, environmental impact, the several stakeholders involved, and user behaviour. This framework will be then validated through interviews to industrial stakeholders and academic experts in order to ensure its practical relevance and applicability.

Step 3 – Develop a multicriteria framework for the RUP calculation and identify a potential product (for example, a smartphone) as a case study/proof of concept in order to apply the framework developed at step 2.

Candidate profile: PhD in Industrial Engineering, with a background on circular economy, manufacturing, sustainable performance and indicators. A good knowledge in multi-criteria decision-making approaches and industrial maintenance are considered as a plus.
Excellent English writing and speaking are mandatory. Also, management skills (organization of meetings, working in team at international level) are expected.

How to apply → Send an email to the email contacts indicated above, attaching:

1. A Curriculum Vitae including referee
2. A motivation letter
3. The PhD thesis

The selected candidates will be contacted for an interview.

References

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