Digital Knowledge Exchange for Circularity of Materials

Jan Martin Keil[1], Diana Peters[1], Tom Lorenz[2], and Sirko Schindler[1]

[1]Institute of Data Science, German Aerospace Center (DLR), Jena, Germany
[2]Institute of Low-Carbon Industrial Processes, German Aerospace Center (DLR), Cottbus, Germany
{*jan_martin.keil,diana.peters,sirko.schindler,tom.lorenz*}*@dlr.de*

Disruptions of international supply chains, increasing demands for raw materials, and a growing awareness of sustainability increasingly direct attention to the use of end-of-life products. Often enough, valuable resources are still wasted by either downcycling them into products of lesser quality or even disposing of them altogether. However, in times of expected resource scarcity, developed economies can not afford such a resource sink and have to work towards reclaiming most if not all components of their waste products. But currently various challenges impede efficient recycling processes. In particular, we see two shortcomings that need to be addressed on the way to establish a circular economy: First, new products are designed in an increasingly complex way paying only little attention to corresponding end-of-life processes. Second, during the recycling process detailed information about the certain products is often unavailable, preventing more sophisticated dismantling and/or sorting approaches.

The implementation of an efficient circular economy requires the cooperation of many stakeholders along the entire product life-cycle. So, the exchange of information between parties with quite heterogeneous systems and interests is of utmost importance. Recyclers need to know contained materials and envisioned dismantling processes to effectively extract valuable parts or materials. On the other hand, designers need to know available recycling strategies to optimize products for easy dismantling. Manufacturers need to implement this to reduce CO_2 emissions and fulfill the requirements of the ecodesign directive (if they want to sell their products in Europe). Further, such an approach will reduce their dependency from rare material suppliers located in regions of the world that can or should not be relied upon for, e.g., political or humanitarian reasons.

In the project "Methods and Technologies for an intelligent Circularity of Materials" (MaTiC-M) we aim to support the communication between stakeholders –or make it possible in the first place– using digital technologies, in particular using knowledge graphs[1] to capture the most relevant information.

A common understanding of the basic concepts is the prerequisite for the digital representation of relevant information. E.g., do different stakeholders mean the same thing with the terms "chemical composition", "composition", or "elemental composition"? If not, what exactly are the differences? In a joint effort between domain experts and knowledge engineers, we will capture the essence of these and other relevant concepts forming the basis for a semantic knowledge graph. In the process, our work will consider and –wherever possible– reuse relevant efforts from initiatives like NFDI4Ing[2], MaterialDigital[3], or OntoCommons[4]. Besides avoiding redundancies, this will also increase interoperability with these and other efforts. A main goal is to develop additional tool support allowing domain experts to safely evolve this knowledge graph in the future with less knowledge engineer support necessary. The knowledge graph will accumulate, consolidate, and interlink data relevant for the design for circularity that already exist at the German Aerospace Center (DLR) or will be developed during the project MaTiC-M. It will form the basis for additional services like generic interfaces for data integration or decision support in both design and recycling phases: An automated assessment of recycling routes could ease the selection of the most efficient recycling route for products at hand as well as help to optimize new products for easy dismantling and efficient recycling. For example, joining poorly recyclable material combinations with techniques that are difficult to dismantle, can be avoided.

In our talk, we will give an overview of the project goals as well as its current status. Further, we invite the audience into the discussion and want to collect feedback on our approaches.

[1]Knowledge graphs are large networks linking different concepts to one another, give meaning to these connections, and provide additional context where appropriate.
[2]`https://nfdi4ing.de/`
[3]`https://www.materialdigital.de/`
[4]`https://www.ontocommons.de/`