Sustainability by Design surface treatments using Tribological and Lifecycle Assessment Tools

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Abstract

Tribological research and developments are substantial and hidden contributors to climate protection and sustainability through friction reduction and wear protection. Techniques, like condition monitoring, repair and reuse as well as recycling extend longevity and limit the material hunger with its embedded CO_2. The consequent reduction of friction and improvement of longevity contributes on the long run to reduce 6-10 gigatons of CO_2eq emissions [1-2] out of 33.6 gigatons of direct or energy related CO_2 emissions (fossil or anthropogenic) in 2019. Tribology is one of the tools to design sustainable usage of materials and processes in systems submitted to relative movement [3].

Surface treatments solutions (eg. physical vapour deposition, plasma electrooxidation, laser texturing) can help to reduce friction and increase lifetime. On the other hand, the **Lifecycle environmental assessment** can take into account the global environmental impact during the production and use of the coating. The energy consumption during operation friction losses dominates the CO_2 emissions during the product lifecycle and countermeasures are needed to minimize the carbon footprint impact. The presentation will briefly explain several examples on how surface treatments can help to increase durability of the components and reduce emissions, evaluating the environmental impact using lifecycle environmental assessment tools [3,4].

The white paper "**The Role of the Materials for Post Covid Society**" edited by EUMAT-A4M and published by EU Commission is a reflection on how Materials will enable solutions for society and citizen's demands. [5] contains positioning, potential solutions, and recommendations from the European Materials community (A4M) towards Horizon Europe. Compiles Strategic Research Agendas (SRAs) from Materials stakeholders, addressing lessons learned in current COVID19 pandemic, and aligned with Green Deal Priorities and Recovery Plan.

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Life Cycle Sustainability toolbox enabling Safe and Sustainable by Design development of materials and technologies

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Abstract

Life cycle sustainability assessment (LCSA) is a comprehensive methodology to account for the triple bottom line associated to a material/technology lifecycle. Following the UNEP (2011) guidelines, this approach combines life cycle assessment (LCA), social LCA (S-LCA) and life cycle costing (LCC) to comprehensively support the sustainable and circular design, manufacturing and use of new materials and technologies. In practice, the implementation of this assessment is challenging due to the lack of quantitative data and the high variability associated to those phases when scaling up from lower TRL (lab tests/prototypes) to higher ones (industrialization and market use). Also, special care should be given to the overlap and connections between indicators (e.g. environmental health damages and social impact on workers) to avoid double counting. “Sustainability by design (SbD)” is often suggested as an approach to tackle this challenge, from the early design stage to the technology transfer. It often lacks, however, of operationalisation.

In this contribution, we present the proof-of-concept of how a LCSA toolbox can be effectively combined to a pragmatic SbD approach, using as an example the case of composite materials development. The approach aims at framing the degree of sustainability integration, depending on the level of sustainability objectives (e.g. industrial expectations or funding programme requirements) and the TRL of the technology development. The number of sustainability criteria and the degree of quantification increase proportionally with these two framing parameters. Two evaluation tools are used: 1) semi-qualitative, generic and sector specific criteria (e.g. life cycle energy use, avoidance of chemicals of concern, classification of polymers recyclability), which are particular useful in the (early) design phase and 2) (simplified) quantitative LCSA models, which can effectively steer the more advanced design phases and inform about the prospective impacts and benefits of the implementation of materials and technologies once transferred to the markets. Performances are always compared to the available market alternatives. In the LCSA toolbox, a comparison with sectoral targets (e.g. 2°C scenario for well-to-wheel emissions from passenger cars using the new composite) is also provided.

As a result, the approach allows identifying the technological and market/use conditions (e.g. minimum car mileage required) which makes the technology sustainable, compared to equivalent alternatives or to absolute targets, as well as potential trade-offs to guide the future development.

Bauhütte 4.0 - Perspectives for the construction of tomorrow

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Abstract

In order to achieve national and global climate targets and reduce environmental damage caused by the extraction of primary construction raw materials, the field of housing and construction must be rethought and profoundly revolutionized. The construction and building sector are responsible for approximately 38 percent (9.95 Gt CO_2) of global CO_2 emissions. The United Nations Environment Programme's Global Status Report for Buildings and Construction: Towards a Zero-emission, Efficient and Resilient Buildings and Construction Sector (2020) attests that building CO_2 emissions must be halved by 2030 to be on track for a net-zero carbon building stock by 2050. In view of the ambitious European and national climate targets, Bauhütte 4.0 can make an immense contribution. The timber construction industry is currently characterized by a more artisanal or manufactory-like production with individual standards and as yet untapped profitability effects. Based on the innovation idea of the Bauhaus and the Bauhütten movement as well as the concept of circular economy, the development of a horizontally and vertically digitally networked value chain "forest-to-city" for urban housing construction is the overarching goal of Bauhütte 4.0. The aim is to establish highly efficient and (partially) automated manufacturing, assembly and logistics concepts as well as to achieve a close, stringent connection between sustainable urban development and (supra-)regional forestry. In addition, open standards to be developed make a significant contribution to increasing efficiency, improving quality and shortening assembly and construction times. Regional value-added networks consisting of timber construction companies, digitally driven companies (start-ups) are to be integrated into a highly efficient production system to be developed and an efficient use of sustainably produced and today still hardly used regional renewable raw materials such as wood for a bio-based circular economy is to be ensured.

Towards sustainable raw materials value chains

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Abstract

Knowledge is essential for the sustainable and secure supply of raw materials due to their role in the global economy and society. Proper knowledge management promotes a globally competitive raw material sector, as well as help support a more circular, sustainable sourcing and management of material resources.

The Raw Materials Information System (RMIS) is the European Commission's (EC) reference web-based knowledge platform on non-fuel, non-energy raw materials from primary to secondary sources – including Critical Raw Materials (CRMs) identified by the EC. The RMIS is a commitment in the 2015 Circular Economy Action Plan and a core component of the EU Raw Materials Knowledge Base (EU RMKB). In particular, it facilitates harmonized availability of key data and analyses, highlights priority needs, as well as contributes to coordinated dissemination.

Since 2017, the JRC RMIS team has supported the EC in the development of the triennial list of CRMs, which includes roughly 30 materials that are considered fundamental for the EU economy, but have significant risk of supply disruption. In this area, the JRC has also conducted analyses related to CRMs demand and foresight scenarios for strategic value chains identified by the EC, such as for batteries.

Life cycle thinking and assessment are recognized as essential approaches for performing sustainability assessment of resource extraction, production and use across a multiplicity of value chains, including those related to energy production and storage. For example, those approaches are now key in the development of policies focusing on batteries and their requirements, for which JRC is having a pivotal role in bridging different perspectives and disciplines towards improving sustainability thereof.

Safe and Sustainable by design for nanotechnology

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Abstract

Nanotechnology has a great potential to address social and environmental challenges through its application in various sectors from medicine to environmental remediation and clean energy. However, due to the high uncertainty about their potential risk, investigations have been carried out to increase the knowledge on human and environmental risks due to manufacturing, use and end-of-life of nanotechnologies. During the last decades, numerous efforts have been made in order to adopt Safe by design (SbD) approaches for nanotechnology, resulting in an approach heading for the development of functional and safe nanomaterials and nano-enabled product. In the frame of the finalized EU H2020 project "NanoReg2" efforts have been made to further evolve this SbD approach towards a more comprehensive Safe and Sustainable by design Approach (SSbD). This SSbD approach proposed by the NanoReg2 project can be seen as a first step towards a safe and sustainable by design approach for chemicals as envisaged by EU Chemical Strategies for Sustainability towards a toxic free environmental. Indeed, such a SSbD approach requires further developments to address the sustainability of nanomaterials and nano-enabled products. For instance, the lack of defined criteria for sustainability and the lack of decision support systems balancing functionality, safety, and sustainability needs still to be addressed.
With this presentation we introduce the SSbD approach in the frame of the NanoReg2 project and we will discuss its limits and hence, the next challenges of SSbD approach for the nanotechnology sector.

Sustainability Assessment and the Collingridge Dilema – use case of Sodium Ion-Batteries

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Abstract

A design and decision dilemma arising from the claim to develop more sustainable energy materials and resulting technologies (related to any energy conversion technology) is to find the right « shape» target (e.g., environmental vs. economic vs. social aspects). This phenomenon is often associated with the so-called Collingridge dilemma which states that: in early technology development stages opportunities to steer are plentiful, but hard to choose from, while at later stages this is reversed. This problem is reinforced by the fact that sustainability is a "wicked problem" meaning that there is no definitive formulation of it and consequently no perfect corresponding solution. The talk will provide an overview of methodological challenges for sustainability assessment that arise from early to high technology development levels of post-lithium battery research. A major goal of post-lithium battery research is to decrease sustainability impacts associated with the increasing demand for electrochemical energy storage systems. Especially, Sodium-Ion batteries (SiB) with a wide set of potential cathode material candidates are considered as an alternative to overcome some sustainability challenges, as the use of critical, expensive and toxic materials. However, in contrast to established Lithium Ion Batteries (LiBs), SiBs are an emerging technology in an early stage of development. Here examples for early screening of materials using straight forward bottom-up methods and explorative life cycle assessments are provided and discussed.