Advanced engineering: How to sustain the ability for innovation operations

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Abstract

The climate challenges are confronting companies’ development activities in many ways, but particularly in terms of how to coherently address sustainability operations in advanced engineering tasks. Advanced engineering tasks are recognized to incorporate the early stages of technical product development, thereby specifically focusing innovation and the possibilities to rethink both businesses and products. This paper’s purpose is to contribute to the reflections on how to operate engineering tasks and drive innovative and sustainable thinking. The paper presents the climate challenges and a sustainable development perspective to provide a background, and in line with other researchers create a reminder for the basics. It exemplifies an industrial initiative for meeting the climate challenges, in which the work across a whole industry has been identified as important. The conclusion is that it is not straightforward to operationalize sustainable development, mainly due to the relational complexity among stakeholders and their different perspectives.

Keywords: advanced engineering, knowledge intensive work, sustainability challenges, mind-set, product development.

1 Introduction

WWF’s climate savers programme states that: “Climate change is no longer a debate. It’s a business factor” [1]. This highlights that adapting to new challenges, and preferably transform the way in which organizations, businesses and markets operate increases their chance to stay competitive. Thus, addressing the topic of sustainable development is important in all organizations and firms. Yet, manufacturing companies seem to have a particular responsibility due to producing not only products, but also, e.g. waste and pollution. Despite this, few manufacturing firms address sustainable development in early stages of product development as a
change in mind-set for leadership of engineering tasks. However, many companies work hard with incorporating sustainable development as an additional strategy to the established engineering one. Such an approach only produces minor incremental changes instead of the significant and radically new ways that are needed. This is from an environmental perspective described as a “lock-in” mind-set of management systems for innovation [2]. Contemporary leadership is today more about managing changed conditions and business environments, and the climate challenge is the greatest one that has a high impact on how to run modern product development. This implies that each company has to go beyond the company’s own engineering projects and implement sustainability measures throughout the whole supply chain. This extended responsibility, and thus closer collaboration, is a key to contribute to a solution to reach the climate goals. Yet, it is easy to say, but not straightforward to practise.

An often-cited quote comes from P. G. Gyllenhammar, former president, Volvo Group in Sweden; he stated that “companies are part of the problem, but also part of the solution”, thus simultaneously arguing that companies have an obligation to care for the environment. The Volvo Group has since long incorporated environmental care as a core company value, and it has been – and remains – dedicated to reducing harmful emissions from both their products and their facilities. In 2012 Volvo joined the WWF Climate Savers programme. Recently, Volvo Construction Equipment, part of the Volvo Group, launched and hosted an initiative to address the climate challenge in the construction industry, dubbed the Construction Climate Challenge [3]. At the heart of the initiative is the idea that grand challenges cannot be met by solitary efforts but can only be addressed through collaboration all along the supply chain. Martin Weissburg, CEO of Volvo Construction Equipment, has said, “As a construction equipment manufacturer we recognize that we can only do so much by focusing on the areas where we have direct impact. Approximately 90% of the climate impact comes from the use of our equipment, and our machines are used in nearly all steps of the construction industry lifecycle”. Thus, it indicates that the climate challenge is not only related to technical issues but is also far more relationally complex than one might first think. This paper is part of a pre-study within the CCC initiative and elaborates on the complexity issue to discuss enablers for innovation. This is done in order to support rethinking how to operate engineering tasks and drive sustainable thinking already in early stages of product development.

2 Perspective of the paper

The paper does not present particular and specific empirical data from industry, but its theoretical and conceptual perspective is grounded in longitudinal studies in manufacturing industry. The studies are firmly addressing early stages of product development, and specifically engineering work; see, for example, Holmqvist [4].

Product development organizations are described in simple terms as two-folded, i.e. early stages of planning and concept development, and later stages of detail design and production. From a project management point of view the early stages
concern advanced engineering teams, which manage new technology, innovation and exploration issues, and new product development teams, which manage exploitation and production processes. Metaphorically speaking, there must be a continuous flow of information and/or knowledge between the projects. Typically, both types of project consist of knowledge-intensive work, therefore transferring knowledge and experiences within and between projects’ teams are crucial [4]. Product development models, starting in the mid-1980s, visualize, for example, integration between expertise areas [5] and a life cycle view, from ideas to disposal or reuse [6]. The idea of knowledge transfer and expertise sharing is thus part and parcel of the processes, and its importance has been even more recognized due to sustainable development issues [6]. The paper’s perspective of assuming a change in mind-set to meet the climate challenges is thus established in literature, but how to rethink the operations in engineering tasks to drive sustainable thinking is still a valid industrial challenge.

3 The climate challenge

Human actions of life and business are identified as the main driver of disturbance of the Earth system’s capability to remain its environmental stability. The industrial revolution has been identified as the point of departure from the stable era, called Holocene, and the start of a new era, the Anthropocene [7]. The Anthropocene era is recognized to, for example, include a tenfold increase in human population, a rapid growth in the number of cattle to 1,400 million and a 40 times growth in industrial output [7]. The use of fossil fuels is causing large emissions, and while the situations in regions like Scandinavia and Northeast of North America have improved, the problem is getting worse in East Asia [7]. However, it should be noted that even though the situation is perceived as being improved, the largest single component of the ecological footprint is carbon emissions. If all people on Earth consume like this, we would need 3.7 planets [8]. There is no doubt that the climate challenges are global, as should also the solutions be. Crutzen [7] talks about the need to “develop a world-wide accepted strategy leading to sustainability of ecosystems against human induced stresses” as the greatest responsibility of mankind. Moreover, this effort requires “intensive research efforts and wise application of the knowledge” for the progress of the knowledge society [7] (p. 17). Included in a solution for mankind is not only stopping waste products that pollute the environment and quitting plundering the Earth resources, but also to increase technological radical innovations. Crutzen [7] views our contemporary technologies as “primitive”, which emphasizes that we need to rethink our efforts in order to save the planet.

A framework of planetary boundaries has been developed to better understand the environmental challenges, and thus establishing thresholds and their control variables for a “safe operating space” for 10 systems [9]. The 10 planetary systems are: climate change, ocean acidification, stratospheric ozone depletion, nitrogen cycle, phosphorus cycle, global freshwater use, change in land use, biodiversity loss, atmospheric aerosol loading and chemical pollution [9]. Three of
those have already been exceeded (rate of biodiversity loss, climate change and human interference with the nitrogen cycle) [9] (p. 472). And, worryingly, the chemical pollution cannot yet be measured though we know it is bad, but we cannot really judge how bad it is. The application of a systems perspective on the challenges visualizes that human actions also have an effect on subsystems and processes and can undermine the balance of them too, i.e. the stable Holocene state [9]. The importance is to understand how the nine systems are tightly coupled, thus have to be managed simultaneously, or as Rockström et al. [9] express it: “We do not have the luxury of concentrating our efforts on any one of them in isolation from the others” (p. 474). Still, our knowledge of the intertwined and complex links between the Earth’s systems and subsystems is incomplete, but Rockström et al. [9] give some hope for the future: “as long as the thresholds are not crossed, humanity has the freedom to pursue long-term social and economic development” (p. 475).

4 Sustainable development

The terms sustainability and sustainable are used in many different contexts, but the most cited Brundtland report [10] describes its relation to the environment (i.e. where we all live in) and to development (i.e. what we all do to improve our part of it). These two are concluded as inseparable units of a long-term perspective that also includes generations to come. Three dimensions of sustainability are typically mentioned, i.e. environmental, economic, and social. Over time the interpretation of the dimensions as separate, but related, entities have been criticized (for example [11]). Seeing the entities as separate challenges implies for example that trade-offs between them can be made, but this is far from real life [11].

Today, three concentric circles commonly illustrate the integrated and intertwined view of sustainable development, instead of the previously used three pillars. The illustration highlights that the three dimensions are part of a holistic entity (the environment) where all sublevels (social and economic) clearly have an effect on each other and the whole. Such a perspective demands a change in mindset. It also requests that companies have to rethink their position amongst more stakeholders than usually to be able to provide sustainable development based on innovation.

Sustainable innovation makes an effort to address a large group of stakeholders with demands that essentially affect or are affected by the companies’ actions [12]. Relating the term “sustainable” to innovation indicates that it addresses a mass market or intends to provide benefits to a larger part of society. From such description it can be said that it addresses the social entity of sustainability directly. This could provide a change in mindset that goes beyond the traditional approaches. Trade-offs and contradictions in sustainable development are more common than not [13] and letting short-term economic interests guide decisions is described as a problematic approach [12]. Yet, there are also some problems with the perception that a balanced harmony among environment, economy, and social entities spontaneously will create a win–win situation in which sustainable development
will be reached [13]. The indicators for environmental sustainability are, for example, material use, energy use, water use, waste and emissions [14], the indicators for economic sustainability are, for example employment, financial situation of the residents, regional products and services, and profitability of the company, the indicators for social sustainability are, for example, equity, health, comfort, empowerment, and awareness [14]. Many of those are not straightforwardly assessed and judged. It has showed that environmental and social issues inform decisions in a delimited way and mainly if they contribute to enhancing the corporate finances [13], i.e. profitability of the company. Trade-offs in sustainable development that are based on an economic perspective is a barrier to make the sound choice of a minor loss in corporate economic performance for a greater gain of social and environmental performance [13]. More often “...minor gains in economic performance alongside modest improvements in environmental or social performance...” [13] (p. 220) is a guiding company principle.

A sustainable initiative that has its origin in engineering and manufacturing [15] is branded as product–service systems. The initiative has been developed from the insights that the “end-of-pipe” approach for cleaner production, i.e. controlling environment by regulating pollution at its source, is not enough to meet the climate goals [16]. Product–service systems are expected to address and attack the sustainability problem on a different level, namely by changes in consumption patterns [16]. In short, product–service systems are from a manufacturing company a possibility to radically change its businesses. Tukker and Tischner [17] propose that product–service systems change advanced engineering and product development by:

- Providing a different point of departure for early development stages, namely to directly address “functionality”, the performance that the product provide in the users’ processes, or addressing the users’ goal when using the product.
- Encouraging “green” and strategic thinking for the whole business and the firms’ position in the supply chain.

From this base it is suggested that early product development elaborates on the possibility to provide the product in three different business models, i.e. product-oriented, use-oriented, or result-oriented [18]. This also implies that the product per se has to be perceived and communicated in a different way, for example the product will be perceived by the users as an experience rather than a physical thing, the supply chain providing the experience will be perceived as a value-creation network and the users will be co-creators of value [19]. The product–service system paradigm is, bluntly, based on the idea that manufacturing firms should provide their products as services, but this does not per default result in environmental friendly solutions [20]. The expectation on product–service systems to provide and implement a sustainable strategy in product development companies has proven to be more complex than first considered. Today, the term sustainability is added to product–service systems, i.e. sustainable product–service systems, to bring the concept back to its first intentions [21]. However, product–service systems are not widely implemented in firms, and one reason is that the knowledge and know-how are still lacking in industry [21].
5 Enabling innovation for sustainability operations

The discussions presented in this paper had the purpose to contribute to the reflections on how to operate engineering tasks and drive innovative and sustainable thinking already in the early stages of product development. The climate challenges have been described as a driver for collaborative efforts; solitude efforts and solutions have shown too slow a progress in comparison to the increase and growth of the imbalance in the Anthropocene era. Identifying and measuring thresholds [9] are an important effort to create a frame of reference for understanding the environment’s capability to cope with the economic and social developments. The manufacturing industry’s economic development can be seen as a key for business in which sustainability might draw the shortest straw. However, modern industries nowadays cannot neglect the importance of social and economic sustainability. In this paper, the CCC initiative example highlights that efforts across the whole industry are necessary, but rare. It also indicates that this type of efforts is identified as an industrial knowledge gap in which sustainable development issues are not grounded in early development stages or throughout a supply chain. The other example presented in this paper, i.e. product–service systems [21], highlights that sustainability, despite being set out as a vision and strategy, is not straightforward to operationalize. The strong relation between innovation and sustainable development is one further consideration that point in the direction of relational complexity rather than a technical problem.

The supply chain consists of different stakeholders that possess different views and beliefs about economic and social sustainability, even though they might have a shared view of the climate challenges. The different stakeholders have different perceptions of the design space in which they can innovate. Product–service systems, for example, propose radical changes in business models but do not necessarily point towards disruptive and sustainable innovations of the core product or of new services. This paper has made an effort to illustrate that sustainable development is not one isolated process, but is relational complex due to (a) several different perspectives, i.e. environment, economy, and social, due to (b) being based on not yet measured goals and/or on inevitable differently interpreted indicators, e.g. perspective, culture, and ideologies matters, and (c) the anticipation of a sustainability strategy to include innovation “per default”. Product development is established as a technical task, but also as a knowledge-intensive process. Early product development in particular manages various open-ended innovation tasks; such tasks are often based on experience-based knowledge, i.e. locally produced knowledge or a tacit type of knowledge. The ways we share such knowledge and to whom depend, not only on an established knowledge sharing culture, but also on our personal preferences. Operationalizing a change in mind-set for sustainable development thus has to incorporate possibilities to address our experience sharing behaviour to enable innovation. Such experience sharing should be executed in conversations on all levels, but also throughout and beyond the supply chain. Holmqvist [4] suggests an approach for advanced engineering projects that is based on directed questions to support conversations within a project team and
in the end organizational learning. Corporate social responsibility is one effort that addresses a multi-stakeholder situation, in which it is important to identify stakeholders, obtain and analyse their specific needs in order to create a body of knowledge for actions; see, for example, Ref. [22]. More sustainable paths thus include better understanding of the intertwined relationships between production and consumption and to help advanced engineering projects to innovate a practical holistic perspective is needed, yet not straightforward.

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References


