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Component Standardization: A Code of Sustainability

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Abstract

To make mass manufacturing industries more sustainable, there is a need to unify regulations and embrace shared principles to ensure that the products we produce are more sustainable. With attention to reducing the impact on the natural environment. In this paper, we argue that a code of sustainability regarding component standardization would help in this regard. It would contribute to extending the life of what we produced by facilitating the reuse of components as well as improving their recycling once they deteriorate. We then apply our proposed principles to the automotive sector to demonstrate their practical benefits.

Keywords: Component Standardization; Sustainable Mass Manufacturing; Automotive Sector; Waste Prevention.

1. Introduction

The work involved with the creation of products does not end with their distribution, it must also include the responsibility for their recycling [1]. There is a desperate need for the manufacturing industry to design products that adhere to the circular economy model, which means keeping products, components, or raw materials in use [1]. Hence retaining their value instead of disregarding them as waste upon fulfilling their original purpose. Disposal should be considered the last resort, yet recycling should not be the preferred option either. As it involves the consumption of additional resources to extract and make use of the raw materials. Thus, component standardization would allow better optimization of resources, facilitating preferable actions in the waste hierarchy [1, 2] as components can be reused and consequently, fewer new ones would need to be produced. Ultimately, making the industry more sustainable as what we manufacture can remain in use for longer, before reprocessing their raw materials.

By component standardizing, we refer to adopting common parts and connections within a product, across different products and manufacturers as well as generations of the same product [2].

Sustainable manufacturing has been defined by the U.S. Department of Commerce as "*the creation of manufactured products that use processes that minimize negative environmental impacts, conserve energy and natural resources, are safe for employees, communities, and consumers and are economically sound*" [3]. In this study, we focus on the idea of strong sustainability which gives more importance to the environmental impact, while still acknowledging its social and economic dimensions [4].

1.1. Objective

This paper aims to inform managers and researchers in the manufacturing industry about our proposed technology-specific code of sustainability. The code collects existing observations in literature to promote a targeted discussion on how component standardization could be a valuable step toward more sustainable manufacturing.

2. Literature review

Sustainable design is a poorly regulated process. Requirements are often found to be conflicting and it is missing unified guidance on what should be done to make manufacturing practices more sustainable [5]. This is resulting in components being manufactured within a narrow range, where the main objective is to last long enough to guarantee a few years' warranty for their original product. Highlighting an emphasis on a disposable rather than reusable product [6]. To change this trend there is a need to establish codes of sustainability that are more specific to each industry's technologies [7]. Plus, economic incentives encouraging product designers to adopt more sustainable practices [8]. Component standardization is often referred to as a major contribution to sustainable development [9]. This would allow for a higher degree of interoperability where parts can be reused across various products as well as generations of the same products [2]. Furthermore, great emphasis is being placed on the use of eco-friendly energy production, ease of disassembling products to recover their materials and formulate policies to implement a sustainable circular economy [8].

The lack of specificity when it comes to what defines sustainability has also been identified as an issue [4, 5]. Exploring what metrics could be used to measure sustainability in manufacturing companies would help collaborative development [7]. Hence the need to establish a framework to collect and share data so that research can be conducted to issue a specific global directive on how to make manufacturing more sustainable [10].

To our knowledge, no other publication clearly highlights a set of specific guidelines for component standardization. Hence, our novel code of sustainability is the result of the integration of component standardization literature from other technologies' codes of sustainability.

2.1. Sustainability issues

Shifting to more sustainable operations is typically seen as an unfeasible upfront cost by most companies. As equipment needs to be adapted and customers' loyalty may be lost in the transformation [11]. The same applies to the standardization of components which have been believed to be justifiable only when the perceived benefits outweigh the disadvantages [2]. In particular, the financial perspective is often raised against this topic, however, this is no longer as relevant. The consumers' ever-increasing attention to their environmental footprint, is making sustainability a business investment and competitive advantage [5]. Investors favour companies that are willing to embrace sustainable development. It is becoming evident that the cost of ignoring environmental implications is significant from multiple perspectives.

Once they are in place, standards can become inappropriate while being difficult to change. This has held back the introduction of standard components, as less flexibility would be available compared to using custom parts. Yet scarifying some design freedom can go a long way to make the industry more sustainable. It highlights, however, the importance of cooperation across the entire supply chain and multiple products' life cycles, so that the standards and their implications can be well questioned before being established [5].

An opposing argument to component standardization is the possible lack of personalization and customer dissatisfaction [11]. However, standardizing the interaction between parts would make them more interoperable while retaining the opportunity for diversification. Indeed, component standardization has been found to positively influences innovation and mass customization [9]. Therefore, the major issue with achieving sustainability in manufacturing through component standardization is upfront planning and sector-wide collaboration.

3. Code of sustainability

3.1. Principle 1: Standardization over customization

Where reasonable, standard components should be preferred over custom ones. Hence avoiding the need to maintain distinct parts having the same functionality. Not all systems share commonalities. Hence it is not encouraged to strive for ‘Swiss army knife’ parts that can fit all usages. As it would result in a wasteful excess of functionality (parts that do more than is needed). Instead, a balance should be reached by identifying appropriate ranges covering different sets of requirements, such as size or quality.
This would return major benefits including:

- Increasing the manufacturing plant performance due to a reduction in component variety, as shown by empirical studies [2].
- Reduction in logistic complexity, as suitable components would be easier to find [12].
- Reduction in the retail price, due to economies of scale as parts can be produced and purchased in larger volumes with a lower risk of becoming obsolete (unsellable products) [12].
- Lower storage cost, as fewer rare components would need to be kept in stock [11].
- Reduce the risk of components and labour shortages, as the demand would be more common [6].
- More sustainable from a social and environmental point of view as purchased goods could be repaired more easily. As replacement parts would be easier to find, extending the lifetime of products. In fact, “Standardized parts reduce the replacement part cost while increasing the part availability” [2]
- Less specific tools and machinery would be required to work with standard components.

Once introduced, standard components might be complicated to change. Thus, flaws in designs would have a larger impact on the industry and reduce the opportunities to innovate. Yet this can be mitigated with the adoption of the fourth proposed principle, industry-wide research.

3.2. Principle 2: Research possible common connections to adopt

Designers should strive to identify common requirements to create interfaces that facilitate the introduction of parts that can be more easily reused [9].
This means looking for patterns within what is produced in-house as well as by other companies. The aim is to standardize component connections to facilitate interoperability [3]. Ultimately leading to the benefit of the first principle. As this research is a way of progressively identifying cases where standard components or ranges could be introduced [6].

3.3. Principle 3: Prioritize waste prevention

Careful consideration should be made to how waste can be reduced. Hence developing products and processes that are more resource-efficient in terms of raw materials, energy usage, equipment, storage, and by-products like pollutants [1, 8, 12]. The necessity of this focus is explicitly expressed in many publications including governments’ sustainability objectives [13]. Furthermore, when possible managed services should be considered, as they allow for more efficient use of resources and sustainable disposal management [13].
Interoperability is strongly linked to this principle because ‘end of life’ issues can be reduced by designing components that can be reused directly elsewhere when their original product fails or is no longer needed [8].

Standardization of components can prioritise waste prevention by:

- Reducing the need for excess production to keep some replacement parts before their design is changed in future generations. As standard components would remain relevant for longer, hence only the parts needed could be produced without worrying about their production being discontinued.
- Facilitating the repair of products as technicians would be more familiar with products' structure as they will need to learn less system-specific notions, hence their knowledge would be more applicable across their industry [9].
- Allowing for parts to be more easily recovered for use in other products instead of going to landfills (as remarked by the fifth principle).
- Allowing for mass recycling by leveraging the benefits of economy of scale.

3.4. Principle 4: Cooperation between manufacturers

Companies should collaborate to uphold the creation of more maintainable products. Hence share ideas and agree on common interfaces on which standardized components can be developed and maintained [3]. This includes discussions between companies to promote reliable industry standards and release a wider range of data in a conventional form to compare the sustainability of their operations [7].

This is crucial to assist in the identification of optimal practices and foresee risks. Thus, being more confident that the components to be standardized would fit their purpose.
Such cooperation might result in the loss of competitive advantages, yet it should be recognized that mass manufacturing companies hold great responsibility when it comes to sustainability. Hence the risk should be accepted to leverage the benefits generated by collectively discussing and establishing standards.

3.5. Principle 5: Cooperation with recycling facilities

Manufacturing companies should cooperate with recycling facilities, by involving them in design decisions as well as supplying detailed instructions and supporting the development of equipment to disassemble their products [1].
Recycling is often challenging due to the large variety of products and techniques used in mass manufacturing. Component standardization would not only facilitate the reuse of components by simplifying their separation, yet also support more efficient recycling [2].
Cooperation needs to be in place to ensure that recycling facilities can handle the upcoming waste. Hence products should be designed to easily separate their components, and allow them to be reused directly or recycled. In other words, we need to be capable of productively breaking down to raw materials the majority (if not everything) that we produce.
The presence of standards and disassemble instructions would foster the introduction of machinery to separate components as well as extract materials when they can no longer be reused due to deterioration or being outdated. This is crucial because it would not just speed up the recycling process, but it would also reduce the number of goods that do not get recycled given the unconventional way their materials are assembled.

4. Case study: The automotive industry

4.1. Application of "standardization over customization"

The collision sector of the automobile industry is a perfect example to illustrate the benefits of component standardization. As the failure of single components can result in entire vehicles being scrapped. Thus, the introduction of more standard components would make repairs more feasible and cost-effective. Because replacement parts would be available more easily and it would decrease the labour cost as mechanics would be more familiar with them [2]. This would directly benefit both the environmental and social aspects of sustainability as consumers would have the value of their cars last longer while fewer resources would be utilised to replace cars that could and should be repaired. Yet, the application of such practices would see the revenue of manufacturers decrease which could restrain companies from adopting this principle. However, as previously discussed, sustainability is also a business opportunity and component standardization will also decrease the cost for manufacturers (including product development, processing, transportation, inventory, and warranty [2]). Thus, even if fewer cars are sold a large margin of profit on each could be made.

To some extent this is already happening, for instance, there already exists a standard range of tyres that manufacturers can choose based on their requirements instead of using unique ones for each model. However, a more substantial effort should be made to increase the number of components being standardized or made into interoperable ranges. Especially for components with which customers do not interact directly, like radiators, or have a minimal impact on customer satisfaction like doors' hinges, proximity sensors and other electronics.

4.2. Application of "research possible common connections to adopt"

Standard components cannot always be adopted. Customers want customization and companies want to deliver it to distinguish their products from those of competitors [11]. Yet product variety (especially for the automotive industry), increases logistics complexity and thus cost [14]. Therefore, there are good incentives to reduce the number of custom parts. However, when they are necessary or desired, for instance, while designing the aesthetic of a car, those can still follow standard component interfaces. This would allow customization while preserving benefits such as interoperability and standard assembly and disassembly [9].

Car manufacturers should research standard ways that components could be attached or communicate with each other. Thus, even if not standards, parts could be swapped with different ones. Side mirrors are a good example of this, if they were connected in standard ways, then the same custom mirror could be used for different models. Plus, when a replacement is needed, the customer would be able to choose any other mirror sharing the same connector.

There are already examples of this happening, where algorithms are being designed to identify commonalities to reuse existing components as well as identify what properties can be standardized [6].

4.3. Application of "prioritize waste prevention"

Waste prevention needs to be considered at all product life cycle phases. Allowing vehicles to be repaired more easily is a key opportunity in this sector. As cars often lose all their value due to the failure of a few components. Hence the application of this principle would see an increase in modularity and the ease of disassembling. Good examples of this would be gearboxes and alternators. Their self-contain natures would even facilitate standardization and by having common shapes and specifications, repairs due to their failures would be more feasible (both in terms of being fixed and replaced).
Regarding managed services, the automotive industry can benefit by outsourcing shared components such as sensors and digital systems. This in turn will also support the first principle by facilitating the use of common components across different manufacturers. The same can also be applied to the industrial machinery used in the production line [15].

4.4. Application of "cooperation between manufacturers"

Applying this principle means volunteering time and effort to interact with other manufacturers to establish standards about what components and interfaces could be shared across the industry. For instance, agreeing on how to attach components, like airbags, interiors and even mechanic components.

Even though challenging, this level of cooperation is feasible as demonstrated by the ongoing Global Lighthouse Network which given recent changes due to the COVID-19 crisis they are implementing standards to manage supply chains more efficiently [16]. The complexity of applying this principle to the automotive industry is further reduced by its tendency to agglomerate companies into giant multinational groups like Volkswagen, General Motors, Stellantis and the Renault Nissan Alliance. Thus, many companies already share strong connections which would facilitate cooperation.

4.5. Application of "cooperation with recycling facilities"

The application of this principle would see the automotive industry designing cars for their raw materials to eventually be extracted as well as supplying details about the adopted standards and interoperability. So it would be possible to:

- Specialize facilities for the dismantling to common standards.
- Know how to efficiently tear cars apart.
- Know what components can be reused as spare parts and for what other models.
- Collect specific recyclable components to facilities better equipped to separate their raw materials.

Hence such cooperation and standardization would decrease the need for manual recycling by fostering the introduction of specialized processes and machinery able to separate components as well as extract materials.

5. Conclusion and recommendations

Current codes of sustainability are too generic and optional to drive a substantial change. We recognize that the transition is challenging and requires wider dissuasions. Yet we have highlighted why component standardisation is a promising candidate to improve the sustainability of mass-manufactured products. Thus, it should be a key focus when establishing sustainability guidelines within an industry. Environmental protection is often seen as a trade-off to economic growth. However, our proposed principles would foster all aspects of sustainability. As they have the potential of reducing the overall life-cycle costs.

A graduate transition could be given by the introduction of standard ranges of components and custom parts adhering to conventional interfaces and connections. As the similarities within ranges would still offer some of the advantages of standardization while retaining some flexibility in metrics like size and quality. Whereas more regulations around custom parts would still offer personalization while having some interoperability. Ultimately it should not be forgotten that environmental protection is no longer a choice. Without more sustainable considerations, economic growth will not be feasible either.

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