Product Design Considerations for Improved Integrated Product/Service Offerings

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Abstract

In society today, there is increased awareness about escalating environmental problems, for example, climate change and pollution. The main reasons for these problems are tied to society's use of products. During the last two decades, industry and academia have proposed and tried to implement a large number of potential strategies and solutions to reduce these problems. One such promising concept that has emerged is the Integrated Product/Service Offering (IPSO) (also known as Product/Service System (PSS)). This concept is based on research from several areas such as business economics, engineering design, and environmental technology. An IPSO is "an offering that consists of a combination of products and services that, based on a life cycle perspective, have been integrated to fit targeted customer needs." The focus is on providing a function, not a product or service; this means that the provider can put more focus on optimizing the total life cycle cost (both from the provider and customer perspectives). In many cases, the service provider retains responsibility for the physical products in the IPSO during the use phase.

The objective of this chapter is to introduce product design considerations to consider when developing an IPSO. The chapter begins by providing insight on why IPSOs require a new design mindset, followed by the presentation of useful guidelines for developing IPSOs. These guidelines are illustrated with three industry examples.

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This chapter is based on studies by the authors but also draws from studies found in the literature. While the focus is on business-to-business IPSOs, several of the proposed guidelines could also be valid for business-to-customer IPSOs.

1 Introduction

In society today, there is increased awareness about escalating environmental problems, for example, climate change and pollution. This, in combination with a concern about the shortage of natural resources, has resulted in increased pressure to find innovative solutions and strategies that can tackle these problems. The main reasons for these problems are tied to society's use of products and are in general caused by:

- The number of products used – The growing population requires a constantly increasing number of products. The number of products per capita increases at the same time as the average active use time per product decreases.
- The time products are used – The average time a product is used before it is scrapped decreases. The reasons are several, such as poor quality and changed needs.
- The way material and energy in products are used – The material and energy invested in a product is, in general, not reused or used in an inefficient way.

This implies that, in principal, a solution and strategy for managing and reducing these problems needs to consider and manage the three reasons listed above, as well as their underlying root causes. An additional challenge, given the sharp increase in these problems, is that the effect of the desired strategies and solutions must be significant compared with the existing situation.

During the last decades, a large number of potential strategies and solutions have been proposed, and some have been implemented; however, the impact from these has in general been minor. One promising concept that has emerged is the Integrated Product/Service Offering (IPSO) (also known as Product/Service System (PSS)). This concept is based on research from several areas such as business economics, engineering design, and environmental technology. An IPSO is "an offering that consists of a combination of products and services that, based on a life cycle perspective, have been integrated to fit targeted customer needs." The focus is on providing a function, not a product or service; this means that the provider can put more focus on optimizing the total life cycle cost (both from the provider and customer perspectives). IPSOs often create close contact between the supplier and customer (Östlin et al. 2008), leading, for example, to offers being customized and improved to better suit the customer. In many cases, the service provider retains responsibility for the physical products in the IPSO during the use phase.

In parallel with the environmentally related issues, today's increasingly global world forces manufacturers, especially in developed countries, to rethink their traditional business models in order to increase their profits and profit margins. Examples of factors that push this development are increasing raw material and energy prices, increasing competition among manufacturers, saturating markets, low labor cost competition from developing countries, increasing environmental regulations, and, not the least, changed customer requirements and behaviors. In general, today's customers want more than just a physical artifact; they also want a solution/offering that fulfils their needs.

The objective of this chapter is to provide an introduction to product design considerations that should be considered when developing an IPSO. The chapter begins with insight as to why an IPSO requires a new design mindset, followed by five guidelines useful when developing an IPSO. These five guidelines are also illustrated with three practical examples from industry. In addition, it is important to note that even though this chapter focuses on the design of the products, the product design is still linked and discussed in relation to the design of the service content, as also mentioned by Weissenberger-Eibl and Biege (2009).

2 Integrated Product/Service Offerings

Representatives from academia have advocated that one way to overcome the above challenges is for providers (companies) to take greater responsibility for their products' value chain, especially during the use phase and end-of-life. This will also enable them to earn more profit along the value chain, and specifically during the offering's use phase (e.g., by services), and to use ingoing artifacts in a more efficient and effective way, for example, by reusing and reducing the need for those artifacts. The possibility to earn more money implies that an increasing number of manufacturers, especially in developed countries, must transform their physical artifact-focused production philosophies toward philosophies that incorporate service content from a life cycle perspective.

Integrated Product/Service Offering (IPSO) is a concept which can be used to obtain a larger share of the market and control a larger share of the offering's value chain. The focus is on providing the function, not a product or a service; this means that the provider can put more focus on optimizing the total life cycle cost (both from the provider and customer perspectives). An IPSO is "an offering that consists of a combination of products and services that, based on a life cycle perspective, have been integrated to fit targeted customer needs." IPSOs often create close contact between the supplier and customer, leading, for example, to offers being customized and improved to better suit the customer. In many cases, the service provider retains responsibility for the physical products in the IPSO during the use phase.

When developing an IPSO, it is important to, as the name indicates, do so with an integrated approach or in other words develop the offering's physical product and service content in parallel. However, this is a challenge for many manufacturers that have been traditionally focused on producing artifacts for as low a cost as possible and with little or no contact with the final customer. In addition, they normally have little or no experience with developing service content. In industry, there is a need for support of ISPO design including concept selection; however, very little support exists (Meier 2004; Aurich et al. 2006; Sakao et al. 2009; Sakao and Lindahl 2009).

This chapter is an attempt to contribute to this support, with the objective to first describe and illustrate some of the principle engineering-related reasons why it is important to rethink the development of the physical products and services used for IPSOs. These reasons create the foundation for some general guidelines that are described and later illustrated with industry examples. It is important to note that even though this chapter focuses on the design of the products, the product design is still linked and discussed in relation to the design of the service content, something also mentioned by Weissenberger-Eibl and Biege (2009).

3 Integrated Product/Service Offerings Requires a New Design Mindset

This section describes the main engineering-related reasons why it is important for IPSO providers to rethink their way of developing ingoing physical products and services.

3.1 Traditional Product Development

All companies have some sort of product development within their operations that could have various levels of formality and regularity. Product development has been defined by ENDREA (2001) as: "all activities in a company aiming at bringing a new product to the market. It normally involves design, marketing and manufacturing functions in the company." Even though the word "product" is stated in this definition, a product in this context can be both physical and nonphysical.

When developing new products, designers normally follow a procedure/model (sequence of activities) that can be more or less defined, a so-called product development model. Those procedures often describe when and how to perform design, marketing, and manufacturing activities. The literature is full of various forms of product development models (see, e.g., Ulrich and Eppinger 2000; Ullman 2002).

Today's product development models are, for the most part, adapted to the current predominant business model in the industrialized world. In other words, they are based on the concept that the customer should buy the product (and pay for it up front) and be responsible for the product's use phase. This implies that the focus in product development is normally on reducing costs for the manufacturing company, for example, cutting down the cost of manufacturing and delivery in order to get a competitive price for the customer. At the same time, this implies that manufacturers pay little attention to the later phases of the product's life cycle, for example, the use phase (with activities such as use of energy and consumables, service and maintenance, and upgrading) and end-of-life (with activities such as material recycling, product and component remanufacturing).

From a customer perspective, however, this focus on the product development process is often negative. Life cycle cost studies and life cycle assessments have

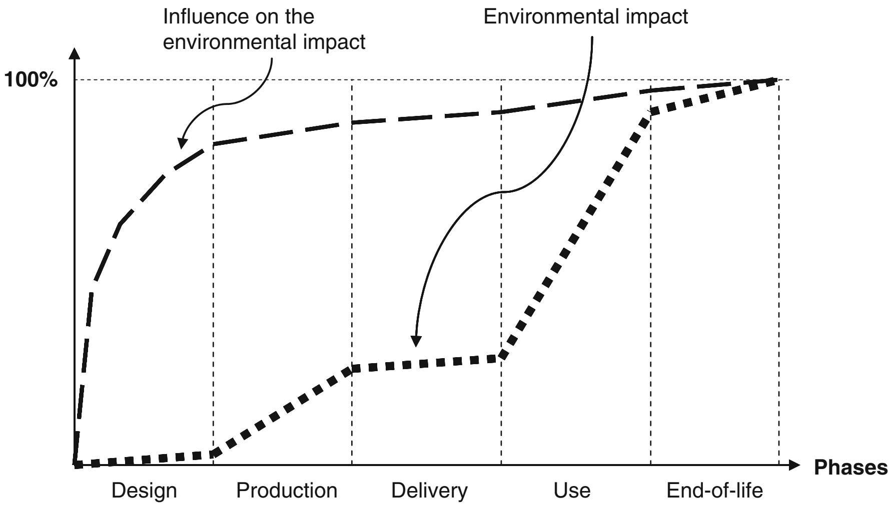

Fig. 37.1 Example of the environmental impact accumulation over a product's different life cycle phases and the possibility to influence that environmental impact

shown that, for many products, the major costs and environmental impact for the product occur during the use phase (in reality, often the longest phase of a product's life) and its related activities. Figure 37.1 shows, in a simplified way (different products have different profiles), the environmental impact accumulation over the product's life cycle and the chance to influence that environmental impact.

3.2 The Life Cycle Perspective

When developing an IPSO, the basic principle is to consider all life cycle phases in order to optimize the offering from a life cycle perspective, something which implies new conditions for the development process. The main objective is no longer to simply achieve the lowest total cost for the product or service but rather to achieve the lowest cost for the total offering (the combination of products and service).

When the focus is expanded to cover more life cycle phases, for example, the use phase, this implies that the number of potential offering solutions increases. This is a possible challenge from a development perspective. At the same time, from an optimization perspective, the increased number of solutions is positive since it results in a greater possibility to optimize the total life cycle cost/environmental impact of the offering. Costs are often associated with the use of materials and energy, which in turn provide a negative environmental impact, implying that more cost-optimized products usually have less environmental impact.

Figure 37.1 not only illustrates the different phases' impact on the total environmental impact but also the possibility to influence that environmental impact. The greatest influence potential is during the design phase, especially the early part of it. This is at the same time logical, since it is in the early phases of product development that the product specification is set and the parameters that must/should be focused on are determined. As mentioned earlier, since in general the predominate way of earning money is by selling products to customers, many manufacturers' main concern in their specifications is often how to optimize and improve the production of their products and how to develop products that are not too durable (so their customers will come back for new ones).

3.3 The Freedom of Action: The Design Paradox

The initial product specification sets up boundaries for potential actions in the later phases. Therefore, it is important to consider them thoroughly in order to avoid unwanted lock-in effects. This boundary effect in the design process is often referred to as the "design paradox," a well-known fact for people working with product development. The challenge is that when a new design project begins, very little is known about the final product, especially if the product is a new one for the designers. However, as the work on the product progresses, knowledge is increased; at the same time, the scope of freedom of action decreases for every product decision step taken, since time and cost drive most projects. This implies that costs for later changes increase rapidly, since earlier work must be redone. Altogether, this forms the paradox – when the general design information is needed, it is not accessible, and when it is accessible, the information is usually not needed.

Figure 37.2 shows the principal relation between freedom of action, product knowledge, and modification cost (Lindahl 2000). The figure is the author's further development of three figures: the design paradox (Ullman 2002), costs allocated

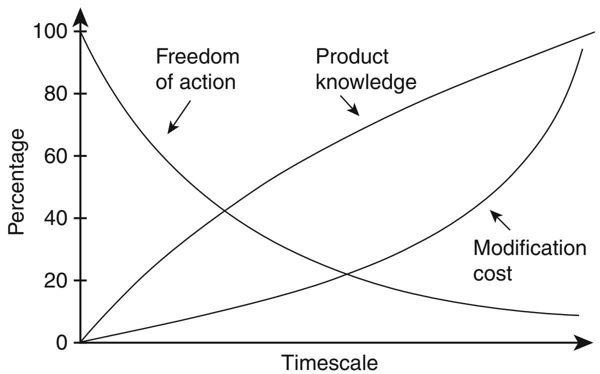

Fig. 37.2 The relation between "freedom of action," "product knowledge," and "modification cost" is shown (Lindahl 2000)

early but used late in the project (Andreasen and Hein 1987), and the cost for design changes as a function of time during the planning and production process (Bergman and Klefsjö 2003).

3.4 Increased Time Pressure and Competition

The rate of technological and market changes has accelerated in the past decade, with today's companies facing increasing competition. In order to survive and develop their business, they need to be proactive in rapidly responding to fluctuations in demand (Collaine et al. 2002). A cornerstone to their competitive success is their capability to develop new products (Gonzalez and Palacios 2002); improve, further develop and optimize old products; and do so faster than competitors (Stalk and Hout 1990). This puts pressure on designers to develop and proceed more rapidly, while at the same time satisfying an increasing number of product demands.

One concept now commonly used in industry for managing these challenges is Integrated Product Development (IPD). The basic idea behind IPD is to increase efficiency in product development by more parallel activities and a higher degree of cooperation between functions, levels, and individuals in an enterprise (Olsson 1976; Andreasen 1980). More parallel and concurrent product development provides opportunities to, for example, shorten the calendar time (from start to stop). Norell (1999) characterizes the performance of IPD as follows: parallel activities, cross-functional collaboration by multifunctional teams, structured processes, and front-loaded development. The four characteristics above are in line with what Wheelwright and Clark (1992), Wilson et al. (1995), and Cooper et al. (1998) regard as important features for successful product development.

As highlighted earlier, in "traditional" product sales, there is a need to constantly introduce new models and/or features, and do so at an increased speed to keep competitors out and at the same time sell new products to both new and existing customers. In order to provide a constant introduction of new models and/of features companies generally do not want to include all potential technical improvements at once in a new product but rather split them up over several versions to be able to sell more products over time.

However, when developing an IPSO, this mindset is normally changed and so are the conditions for the development process. The reason for this is that when providing IPSOs, the focus is not usually on selling products but rather on providing functionality to the customer. Added to that, the provider is also often responsible (owns or controls) for the offering's ingoing products during the use phase. Furthermore, the payment is often based on the functionality and performance during the use phase. For example, if the ISPO is not working, the provider gets no payment; at the same time, the provider incurs a cost for getting the IPSO into operation, for example, through service or maintenance.

Altogether, this implies that providers start to incorporate other issues and considerations when developing their offerings. For example, once an IPSO is sold to a customer, the provider wants the customer to use it for as long as it is economically interesting for the provider and wants the IPSO to require little service and maintenance during the use phase. The longer the IPSO's ingoing products are used, the lower the initial investment cost for those products in relation to the cost for the use phase. This increases the potential to earn money if the IPSO's functionality and performance are kept equal or close to its initial status.

This also triggers companies to implement their best technology at once instead of taking it in steps. For example, if a company has a technology that can cut down energy consumption during use, it will implement that in order to avoid the customer coming back and asking for a new solution or abandoning the provider for a competitor's solution. Rather than spending time on developing different versions of a product, with an IPSO, the company has, in principle, more time for developing increasingly optimized offerings that are more cost-efficient and effective and thus result in a reduced negative environmental impact. Nevertheless, it will still be relevant for shortening the calendar time (from start to stop).

3.5 Real Integrated Product and Service Development

To summarize, Figs. 37.1 and 37.2 illustrate the importance of the design phase as well as setting relevant requirements as early as possible in the development process. It also shows the problem with traditional product development. Often, little care is taken in product development (and in its specification) for future service, maintenance, and end-of-life treatment (Sundin et al. 2009). Traditionally, the initial focus is on developing the physical product; once that is done, a possible service (intangible product) is developed, but this is hindered by the limitations set up from the physical product. When developing an IPSO, the development is accomplished in an integrated and parallel approach, as illustrated in Fig. 37.3 (Lindahl et al. 2006).

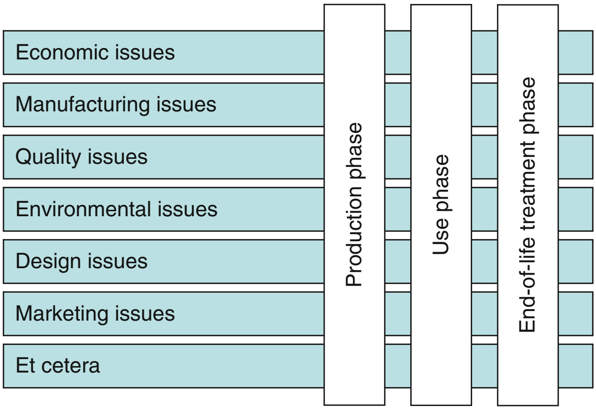

Fig. 37.3 An integrated and parallel approach for developing an IPSO (Lindahl et al. 2006)

4 Guidelines for Developing Integrated Product/Service Offerings

Based on the previous section, as well as adaptation of previous theory on IPSO development (Lindahl et al. 2007, 2009; Sakao and Lindahl 2009; Sundin 2009a, b; Sundin et al. 2009; Öhrwall Rönnbäck et al. 2009; Lingegård et al. 2010, 2011), this section describes a number of engineering-related implications and some general design guidelines that can be useful when developing an IPSO's ingoing products and services.

4.1 Manage Service and Product-Related Requirements in an Integrated Way

When identifying requirements, this should not be done with a product or a service-focused mindset but instead with a total offering-focused mindset (the mix between products and services in the final offering solution should be set later). This implies that the focus should be on what value the potential offering should provide and not on what value its ingoing components, in the form of products and services, should have.

4.2 Identify Requirement with a Life Cycle Approach

Since the ISPO provider in many cases retains responsibility for the physical products in the IPSO during the use phase(s) as well as during the end-of-life treatment, this requires a life cycle approach when identifying requirements. In traditional sales, the main source for requirements is the potential buyer (customer). In relation to the above, however, it is crucial in the identification process to identify all important actors in the offering's life cycle that might have an influence on, or be influenced by, the potential offering. It is important to identify their requirements, perceived value, and willingness to pay for the IPSO. This also implies, for example, that instead of viewing a customer company as a customer, it is important to see the actors within that company. For example, the most important actor might be the production manager or sales staff at the "traditional" customer company; it could also be the customer's production manager or in some cases, authorities or trade associations that have set up certain rules that affect the "customers" business in an IPSO-favorable way.

4.3 Develop and Evaluate Integrated Offering Concepts

Traditionally, many companies first develop their physical products and then add on service. When developing IPSOs, however, this should be an integrated process as the name indicates, begin in the concept development process, and be based on the identified actors' requirements.

When the requirements have been translated into functions that the IPSO needs to fulfill, various potential solutions are developed. Those solutions could either require physical products or services or, more likely, a combination of both. Then, as in traditional product development, the aim is to evaluate and find the most suitable solution that can be further developed into a complete IPSO.

When the solution (combination of physical products and services) to be further developed is set, it is possible to accomplish this with traditional development methods and tools. The requirements on each component (product or service) are then set in the end, combined to the complete IPSO.

4.4 Develop Offerings to Facilitate Service and Maintenance

When developing and later evaluating a potential IPSO, the focus should be on finding those that, from a life cycle perspective, result in the lowest environmental and economic impact and at the same time, fulfill the set requirements. This implies a changed mindset regarding, for example, the cost of production and how to handle spare parts and maintenance. As mentioned above, in developing successful IPSOs, one must have a life cycle perspective for both physical artifacts and the service systems used during and between the customer contract periods.

In practice, this may imply that in order to reduce the need for service or spare parts during the use phase, a decision is made to develop and produce an artifact that is slightly more durable and costly. This could also imply that, instead of incrementally introducing new technologies in order to be able to come out with constantly new products, a more leapfrog, or in other words radical approach, is taken. In contradiction to traditional selling, the IPSO provider is more concerned that the artifact does not break down during use because it would lead to higher costs when the artifact is not performing at the customer, resulting in paying for the customer's downtime and needing to provide them with repairs and spare parts (Lindahl et al. 2005). With traditional selling, the customer was responsible for most of these costs that also used to be lucrative for the manufacturer. The IPSO concept, however, changes the manner in which the manufacturer/IPSO provider earns money; with IPSO, previous revenues from the aftermarket are collected from day one, when selling the IPSO. The IPSO provider can facilitate the maintenance, repair, and service by addressing the following aspects:

- *Design artifacts that are easy to service.* For example, to ease the access of service and disassembly points, use material and joining methods that do not break down during service, and use standardized components that are easy to store and do not need special tools to be disassembled.
- *Design a service system that can respond rapidly and accurately.* For example, integrate "smart" applications in the artifacts that can warn when malfunction is about to occur, monitor the artifacts during use, and schedule preventive maintenance; include more resources to perform preventive maintenance rather than unplanned maintenance, which would cost the IPSO provider more; and

make service manuals accessible through the internet with clear and easy-to-follow instructions.

The artifacts can be adapted in several ways for the product life cycle according to existing design-for-x methodologies (DfX), for example, design for service, design for repair, design for remanufacturing, and design for recycling (Huang 1996). In the same manner, the service part of an IPSO and the surrounding support system can facilitate the life cycle phases of the IPSO in order to make it work well from both the IPSO provider's and customer's perspectives.

4.5 Develop Offerings to Facilitate End-of-Life

In traditional sales, since companies normally have no ownership, they generally have little interest in what happens with their product in its end-of-life treatment. However, when providing IPSOs, companies often retain ownership or control over their products throughout their life cycle, for example, in order to be able to reuse them. In addition, substantial legislation at the European Union level strives to increase the recycling and remanufacturing of products, components, and materials, for example, the End-of-Life Vehicles (ELV) and Waste of Electric and Electronic Equipment (WEEE) directives (European Union 2000, 2003).

In order to facilitate the take back of artifacts, or in other words the three "return flows" shown in Fig. 37.4, there must be an efficient system in place for these reverse logistic flows. In addition, an economically and environmentally efficient manner of taking care of these artifacts after use by customers is also required. This could be a combination of end-of-life processes, for example, product remanufacturing, component remanufacturing, and material recycling. From a material resource perspective, it is preferable to let as much of the artifact be remanufactured and reused in the next IPSO. This means that no new artifact needs to be manufactured to provide the next customer with the IPSO. This is common for the rental and remanufacturing schemes of Toyota Material Handling (see Sundin and Bras 2005). It has been shown in environmental research that remanufacturing is

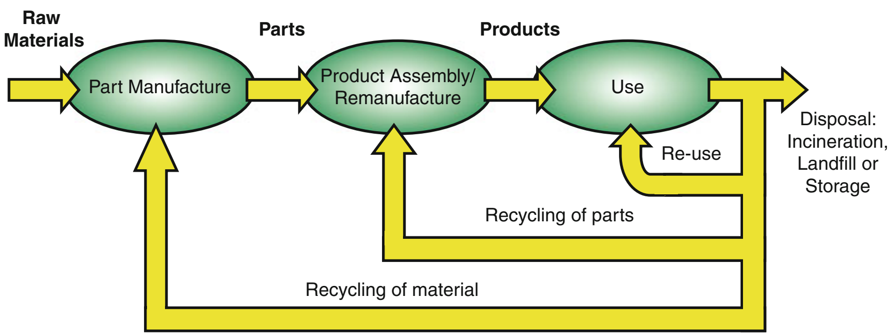

Fig. 37.4 The physical product (artifact) life cycle (Sundin 2004)

an environmentally preferable option in comparison with the manufacturing of new products (Sundin and Lee 2011). The IPSO provider can facilitate the take back, end-of-life, and remanufacturing by addressing the following aspects:

- *Design artifacts that are easy to conduct end-of-life processes on.* For example, ease the access to cleaning, disassembly, and testing points; use material and joining methods that do not break down during the end-of-life processes; use standardized components that are easy to store and do not need special tools to disassemble; and make the components easy to reassemble and perform functional tests on before being reused as an IPSO artifact or component in an IPSO artifact (Sundin et al. 2009).
- *Design the take back system and end-of-life processes to match the IPSO.* For example, implement an efficient take back system within the IPSO-providing service organization; install an IT system which alerts the remanufacturing and material recycling facilities when the used artifact is arriving at their facility and in what condition (this information speeds up the decision process of what to do with the returned artifact); implement a good communication system between designers and remanufacturers so that remanufacturers can plan a remanufacturing process that works well for the artifacts entering the market (this reduces the need for reverse engineering at the remanufacturing facilities); etc.

4.6 Guidelines

To summarize the above, IPSO developers need to consider the following five general guidelines:

1. Manage service and product-related requirements in an integrated way.
2. Identify requirements with a life cycle approach.
3. Develop and evaluate integrated offering concepts.
4. Develop offerings to facilitate service and maintenance.
5. Develop offerings to facilitate end-of-life.

5 Practical Examples

This section describes three cases and how the five general guidelines above have been considered in those cases.

5.1 Core Plugs for Paper Mills

Polyplank AB has developed a process to transform plastic waste and wood fibers into a cheap, recyclable, and moisture-resistant composite material used in different system solutions, one of which are the core plugs used by paper mills (Larsson 2009; Sundin et al. 2010). Paper mills use them to plug the cores on which paper is rolled up; thus, the core plugs follow the roll out to the customer. Through

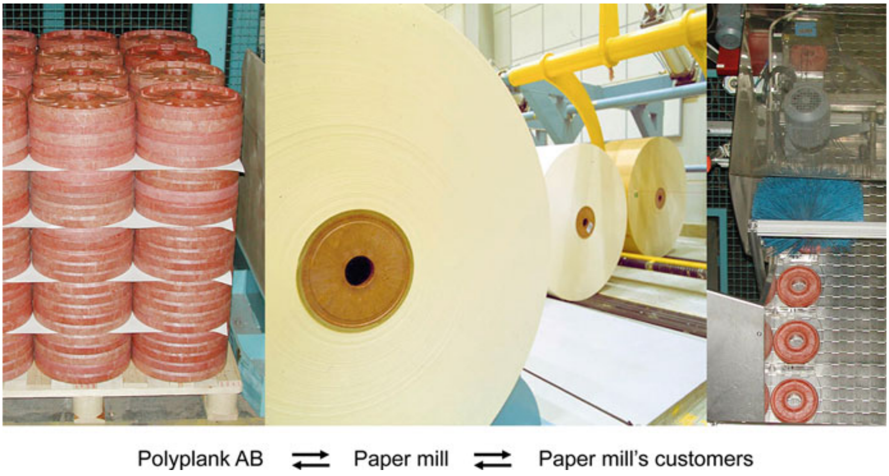

Fig. 37.5 Core plugs for the paper mill industry

selling through the concept of functional sales, Polyplank collaborates closely with their customer and the paper mill and can thus take advantage of the core plugs when the paper mill's customers send them back to the paper mill. Normally, the core plugs go back and forth three times between the paper mill and their customers before the plugs return to Polyplank. When a core plug is returned from the paper mill's customer, they are washed and checked before reuse, as seen in Fig. 37.5.

There are three main scenarios for the paper mill's customers' used core plugs:

- Disposal by the paper mill's customer – In some cases, used core plugs at the paper mill customer disappear or are discarded. This quantity is very small.
- Reuse by the paper mill (sent out to new customers) – The most common scenario is when core plugs, after a period out at the paper mill customer, are returned to the paper mill; after washing and quality control, these core plugs can be reused for new customers. If the core plug is worn out, it is returned to Polyplank where it is recycled. Normally, the core plug is reused several times. Because of its business model, Polyplank aims to achieve a level of quality that will enable their core plugs to be reused several times. Even the paper mill's customers benefit from this approach; instead of the cost and handling associated with discarding core plugs, they can easily send them back.
- Recycling by Polyplank – When core plugs are finally discarded, they are returned to Polyplank where they are grinded down and sent to injection molding in order to become new core plugs. In practice, almost 100% of all incoming used core plugs become new core plugs.

When Polyplank developed their IPSO, they worked very closely with their main customer to identify, from a life cycle perspective, the requirements that were important for the IPSO as a whole. One consideration was the fact that some of the ISPOs are actually delivered by the customer (e.g., the take back system of used

Fig. 37.6 *Left* – First version of the core plug. *Right* – Final version of the core plug

core plugs from the paper mill's customer, cleaning of used core plugs and control). Examples of identified requirements were that core plugs must be easy to clean and check and that they must not crack, resulting in a loss of paper. Another was to develop a core plug with an optimal life cycle.

The first version of the core plug (Fig. 37.6) was not optimal, as it was designed based on the paper mill's initial requirements for single-use core plugs. After some discussions with the paper mill company, Polyplank managed to convince them that another design would be more suitable. Even though Polyplank creates their IPSOs based on recycled material, they prefer to use as little material as possible in their offerings. Polyplank had performed advanced finite element method analysis to find a design that could improve the core plugs' durability while also making the core plug easier to wash, produce, and transport. The result was a core plug that was 35% more durable and at the same time 30% lighter. The higher durability implied more loops between the paper mill and their customers, and the reduced weight meant less transportation and production costs since less material needs to be managed in the production process, for example, in the injection molding used for producing the core plug.

Since the material used in the core plugs is reusable, Polyplank has focused on designing an IPSO that takes into account a high degree of used core plugs coming back to them. If not used for new core plugs, Polyplank can reuse the material for other products.

To conclude, Polyplank's material has several environmental benefits; in order to verify their claims, they have conducted a life cycle assessment (LCA) and a life cycle cost (LCC) study. In comparison with a single-use core plug of virgin plastic, Polyplank's business model/solution results in approximately 80–90% less environmental impact, and their cost for providing the core plug is also approximately 80–90% less. The largest gain with core plugs based on Polyplank's material is the use of recycled compared to virgin plastics, resulting in a significantly reduced overall environmental impact. The more times the plug's material can be reused, the less the environmental impact. Polyplank's business model has increased their ability to take full advantage of their material. Since the Polyplank core plug can be reused, the overall environmental impact per use is decreased; however, reusability puts greater requirements on quality with regard to durability. It has been confirmed that the core plug that Polyplank manufactures has sufficient quality to withstand at least five reuses, which helps reduce the overall environmental impact.

5.2 Soil Compactors for Construction Firms

Swepac International AB is a Swedish manufacturer of soil compactors. The company offers various types of soil compactors to its customers, which for the most part consist of construction firms. The company aims to produce soil compactors that can withstand tough conditions in difficult environments, as shown in Fig. 37.7. Swepac's designers have tried to reduce the cost for spare parts and maintenance. The company provides its customers with a fast supply of spare parts, technical service, and support, as well as offering pure service agreements where customers have a list of service levels to choose from.

In order to prolong the technical and economic lifetimes of its soil compactors, Swepac also conducts remanufacturing. This could also be included in the customers' service agreement. The remanufacturing process generates costs for Swepac, which they are trying to reduce; Swepac's designers, for example, are working to reduce maintenance and remanufacturing costs by choosing a smart design for their products. The plan for Swepac is to develop soil compactors which

Fig. 37.7 Soil compactors for construction sites

Fig. 37.8 *Left* – First version of the soil compactor. *Middle* – Second version of the soil compactor. *Right* – Third version of the soil compactor

have longer service intervals, and components and material will be chosen to ensure that they last throughout a normal life cycle.

Swepac have worked extensively with their product adaptation. In order to avoid unnecessary costs for maintenance work and remanufacturing, the company has introduced new materials to replace the traditional selection. Figure 37.8 shows how these design improvements have progressed for a type of soil compactor of similar size.

The Hood – In the first design version, the hood was made of painted steel. To reduce the amount of visual scratches and repainting jobs, the hood was changed to colored plastic; this also enabled faster replacement of the hood if necessary.

The Chassis – the chassis is of the first design version, made of painted steel, just as the hood. This type of chassis was found to be easily damaged, and when remanufacturing the soil compactor, much time and effort was put into the repainting operations needed to return it to newly manufactured condition. To increase quality and reduce damage as well as the need for repainting, a rubber bellow was added as seen in the second design version. For the third design version, the designers also decided to galvanize the painted steel with zinc. The galvanized steel was found to reduce scratches even more than the rubber bellow and to keep the maintenance needs to a minimum, since the zinc has a self-healing effect when damaged.

The Lifting Device – The first design version had a solid metal loop for the user when grabbing and lifting the soil compactor up and down from the ground. This is usually accomplished with a tractor or a forklift truck. The loop, however, was hard to reach, and if missed, the soil compactor could be damaged. In the second design version, a foldable textile strap with a chain was introduced, along with a larger loop area (see the right-hand figure in Fig. 37.7 above). This allowed for easier transport with less chance of damage. However, one of the drawbacks with this design solution was that it could eventually wear out and thus was a bit tricky to change. For the third design version, the designers introduced a foldable metal loop which was not as strongly attached to the soil compactor as in the first design version. The benefit with this type of lifting device is that it is long-lasting and can be easily replaced if necessary.

Some previous design adaptations in all of the design versions for IPSOs conducted by Swepac were already made. For example, the base plate was made of Hardox steel which is very hard and will not require any maintenance and/or replacement during the soil compactor's technical lifetime. In addition, the filter for the air inlet to the engine was enlarged to stop more particles. Also, the air inlet was placed at a spot where fewer particles were flying around in the air. Since the compactors are used in an extremely particle-filled environment, this kind of filter significantly prolonged the technical lifetime of the engine. Since Swepac was not an expert in the area of engines and how to service them, this was a good option for them to reduce maintenance and repair efforts. To summarize, given the design evolutions made by Swepac designers, one can conclude the following advantages:

- Less visible damage during use
- Reduced need for repainting during remanufacturing
- Easier replacement of the hood during maintenance and remanufacturing
- Reduced wear during transport and easier replacement of the lifting device

While investigating one of the soil compactors at Linköping University, researchers found some minor areas for improvement. During a product analysis (Sundin et al. 2010), several design improvements were highlighted, for example:

- *Introducing snap-fits* on the strap cover for the strap between the motor and the chamber of revolving vibration cylinders. Using snap-fits would eliminate the use of tools, hence making the assembly and disassembly of the cover more time-efficient. Snap-fits are preferable if they provide the same quality as the existing four screws.
- *Standardize the screws* used in the entire compactor design. This would reduce the number of tools used for the assembly and disassembly of the compactor parts. In addition, costs would be reduced due to a lower number of articles to keep track of in databases and storage facilities.

5.3 Automatic Teller Machines for Convenience Stores

This case concerns an automatic teller machine (ATM) sold as a service in, for example, a Japanese convenience store. It is important to identify the different stakeholders of the ATM, for example, the users, the bank, the money transfer staff, and the convenience store staff, the IPSO developers, manufacturers, and service providers. An example of an ATM in Japan can be seen in Fig. 37.9.

Some physical requirements for the ATM machine could be:

- Amount of space that is needed for the ATM
- Type of power supply that is needed
- Security that surrounds the ATM machine

From a service perspective, it is valuable for the developers to know what kinds of service are required, for example:

- Withdrawals from credit card and bank accounts
- Available notes
- Maximum amount of withdrawal

Fig. 37.9 Automatic teller machines in a Japanese convenience store

- Types of credit cards accepted
- Languages the customer can choose from

When developing and evaluating integrated offering concepts, it is important to understand how the physical and soft requirements can be developed in an integrated way. For the ATM machine, this could mean that the button choices are not labeled but rather related to choices shown on the screen (if not a touch screen). This means that the software could be updated as the requirements of the service change and also that many different choices can be made with the same physical buttons but with different meaning, depending on what information the screen shows. The IPSO provider can facilitate the maintenance, repair, and service by addressing the following aspects:

Design artifacts that are easy to service. In practice, this means to ease access to the points where the service technician inserts diagnosis tools to understand what is wrong with the ATM during unplanned service and to check for errors during preventive maintenance. Parts that might need to be changed during service and repairs should be easy to access; keyboards, displays, and mechanical parts that handle cards and money are some examples.

Design a service system that can act fast and accurately. In practice, this means to integrate smart components to warn the IPSO provider when a break down is about to occur. This would lead to more planned maintenance of the ATM as well as more satisfied customers, since downtime would be reduced. The IPSO should plan enough preventive maintenance to keep promises made with the IPSO customer. By doing so, the customer is more satisfied and the IPSO provider achieves better customer relations and control over their products. Service technicians must have access to updated service manuals, preferably from the internet.

Design artifacts that are easy to conduct end-of-life processes on. In practice, this means that test diagnoses should be easy to perform in order to understand which parts need to be cleaned and replaced before the next IPSO use. Several more parts, for example, might need to be replaced than with normal maintenance. The parts must be easy to access and disassemble, and the parts that need to be cleaned must be easy to clean and withstand the cleaning process several times so they can be used several times. In addition, the joining methods should facilitate several disassembly and reassembly instances in order to get efficient use of resources. Screws and other joints should be standardized to avoid errors in reassembly and to lower the costs of component storage.

Design the take back system and end-of-life processes to match the IPSO. In practice, this means that to achieve efficient service as well as an efficient take back system and end-of-life process, information for the specific ATM's design, usage, and maintenance data needs to be stored during its life cycle. This could be, for example, the number of monetary transactions, the number of monetary refills, or the number of planned and unplanned services. This could also include records on which components have been changed during service.

Summary

This chapter has provided an introduction to product design considerations for improved Integrated Product/Service Offerings. This area, however, is still in its infancy and will continue to develop in the coming years, especially as companies and researchers begin to realize the great potential in redesigning "classical" products and services to better function within an IPSO. More and more detailed guidelines and methods will be developed and described in textbooks and papers, as well as guidelines and methods that, for example, will support designers, balancing trade-offs between service and product content and how to handle them in the design phase.

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