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Product-Service System for the Pharmaceutical Industry

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Abstract. This article presents an industrial workshop on the design of the Product-Service System (PSS) for the pharmaceutical sector. The result of the research is a new PSS solution for high-value machines with advanced technology used in pharmaceutical production. When designing this PSS, the attention was paid to the specific features of the pharmaceutical sector and pharmaceutical production, problems as well as the needs and requirements of a pharmaceutical company. Taking into account all these elements aim to develop a comprehensive solution. The workshops were divided into stages and presented in a very synthetic way. The article illustrates the collaboration between the machine selling company (manufacturer's representative), pharmaceutical company and scientists to co-design effective PSS solutions.

Keywords: Product-Service System (PSS), Pharmaceutical industry, Pharmaceutical machine.

1 Introduction

Recent decades have brought advances in the design of the Product-Service System (PSS) [1-4]. The researchers' attention is focused primarily on the development of new design methods or the use of already well-known tools in PSS design [5-8]. Much less importance is attached to the co-design of the PSS in order to generate effective solutions. The combination of products and services in PSS opens up a number of opportunities that both producers and users should take advantage of [8-10]. These opportunities often only become apparent when both sides work together. There is therefore a strong need to develop this area of PSS design [11-13]. Nevertheless, the article undertook the co-design of PSS for the pharmaceutical industry in a research workshop. An important element on which the emphasis was placed was the cooperation of the company selling the machines (manufacturer's representative), the pharmaceutical company and scientists. This made it possible to generate a specific solution.

The paper is structured as follows: the first part is the introduction. The next part contains the research methodology. The third part presents the literature analysis. The next part presents results. The fifth part is the discussion and conclusions.

2 Research Methodology

The aim of this paper is to develop a PSS for the pharmaceutical sector in collaboration with scientists, the machine selling company (manufacturer's representative) and the pharmaceutical company. The following research question was posed in the work:

- Can PSS bring benefits to entities operating in the pharmaceutical sector?

The research carried out in the article emphasizes the role of cooperation and provides suggestions for practitioners regarding the design and use of PSS in the pharmaceutical sector.

This paper adopts the methodology consisting of the following stages:

1. Systematic literature review. At this stage, two parallel literature reviews were carried out. The first focused on the analysis of the PSS found in industry, the second on the analysis of PSS design methods.
2. Analysis of the pharmaceutical industry. On the basis of industry reports, the pharmaceutical industry was characterized at this stage. The focus was on the analysis of users and manufacturers of pharmaceutical machinery.
3. Researching the user of pharmaceutical machines. This stage was carried out in the form of industrial workshops. This study was conducted on manufacturing issues, tablet press needs and requirements, and related services.
4. Product-Service System project. This stage was carried out in the form of industrial workshops. This is the result of cooperation between scientists, the company selling the machines (manufacturer's representative) and a pharmaceutical company. It was developed based on practical knowledge and information obtained at the earlier stages of the research.

3 Literature Review

3.1 Product-Service System in Industrial Practice and Product-Service System Design

This stage concerned the analysis of the literature related to the PSS used in industry and PSS design methods. The table presents guidelines for a systematic literature review.

The investigated industrial PSS cases were created by large companies operating on the global market. These solutions target many sectors of the economy. Innovation plays an important role in them. Their use is aimed at creating lasting added value for customers. The characteristic features of the analyzed PSS are high value and long ser-

vice life of the products, the use of advanced technologies and an emphasis on environmental protection. In most cases, the PSS material element is a product composed of many systems and parts. On the other hand, the services that guarantee its continued use constitute an intangible element. The flagship examples of PSS include: Philips Lighting (pay per lux) and Ivchenko-Progress ZMKB (Support serial production. Repair). The industrial PSS cases conducted closely did not demonstrate the use of this solution in the pharmaceutical sector.

Table 1. Guidelines for Systematic literature review

	Product-Service System in practice	Product-Service System design
Analysis period	2001-2019	
Information sources	ProQues, Springler Link, Science Direct, Taylor & Francis Online, EBSCOhost, Scopus, Emerald, Insight, Web of Science, Ingenta, Dimensions, Wilma, IEEE Xplore Digital Library and Google Scholar	
Keywords	„Product-Service System in industry" or synonyms	„Product-Service System in design" or synonyms
Result	150 works describing PSS functioning in industry	60 PSS design methods

The conducted literature study on PSS design provides information on 60 PSS design methods. Out of 60 analyzed methods, 12 were verified in industrial practice, and 21 research projects. The rest are scientists' proposals. Out of 60 methods (Fig. 1), as many as 12 are universal methods that have not been assigned to any industry. The remaining methods were targeted at one or more industries simultaneously. Most of the methods are directed to the mechanical engineering sector. There are: cutting tools, metalworking machines, production machines, valves and tank control systems, heavy machinery for road construction, hoists and elevators, compactors, industrial laser systems, refrigeration equipment, agricultural machinery and aviation. The conducted analysis does not provide information on the PSS in the pharmaceutical sector [6,7].

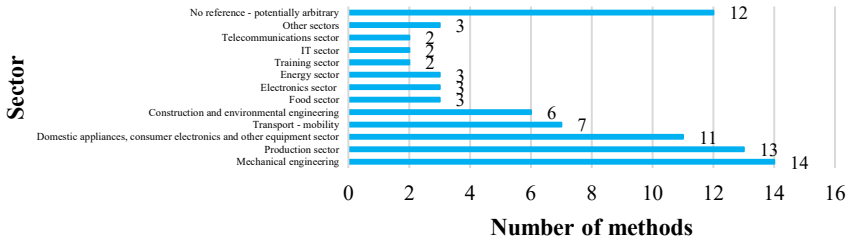

Fig. 1. Classification of PSS design methods by sector [7].

3.2 Pharmaceutical Industry and Pharmaceutical Machines

The pharmaceutical sector is an innovative branch of the economy that focuses on the development and production of drugs and medical devices. Pharmaceutical products

are used to save the health and life of people and animals. Their production is characterized by, among others, meeting strict requirements, high accuracy and cleanliness. Asia, Europe and North America are currently the largest pharmaceutical markets. The pharmaceutical sector of the European Union consists of 4,106 enterprises employing 595,751, and the production value is around 287.89 EUR billion [14-16].

One of the key resources of the pharmaceutical sector is the production machinery (e.g. capsule presses, tablet presses, blister machines). These machines differ significantly in size, level of automation and the way they are operated. The production of the drug in a specific form (e.g. a tablet) can only be carried out on a specific machine equipped with specific format parts (tablet press). Currently, leading manufacturers of machines and lines (for example Norden, Citus Kalix, HAPA) for the production of pharmaceutical products offer machines in various equipment variants. Services, on the other hand, constitute a narrow part of their offer. In 2018, pharmaceutical companies operating in the European Union invested approximately 6.73 EUR billion in production machinery [14-16].

4 Results

This part of the paper deals with research workshops carried out with the participation of the company selling the machines (manufacturer's representative), a pharmaceutical company and scientists.

4.1 Company Problems and Needs

The aim of this phase of the workshop was to find out what problems the user of pharmaceutical machines is facing. In addition, it was possible to precisely define and what needs related to the said machine.

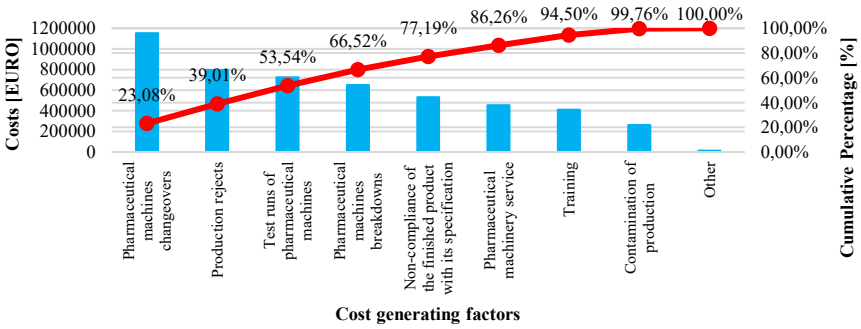

Fig. 2. Pareto-Lorenz analysis - problems causing losses for the user of pharmaceutical machines.

Despite its experience and tradition, the pharmaceutical company struggles with many problems during production. The implemented improvements are aimed at reducing losses, but not always these actions bring the expected results. In order to illustrate their diagnosis, the Pareto-Lorenz analysis was used (Fig. 2). The losses presented in the figure are very characteristic of the analyzed sector. The problem with the greatest losses is the retooling of pharmaceutical machines.

The workshops also allowed to identify the needs of the manufacturer of pharmaceutical products related to the machine. The needs relate to four main areas: machine purchase, training, drug production process, and sanitary and hygienic requirements (Table 2).

Table 2. The needs of a pharmaceutical company and pharmaceutical machine manufacturer

	Purchase of the machine	Training	Drug production process	Sanitary and hygienic requirements
Pharmaceutical company	Elimination of high purchase costs	Operator training related to new machines	Support for the production process	Meeting the sanitary and hygienic requirements for pharmaceutical production
Pharmaceutical machine manufacturer	Full machine service	Training of new employees	Error diagnosis	Adequate protection of production workers
	Payment schedule	Information about needed training and schedules	Collection of data on the operation of the machine	Reporting changes
	Declaration of the period of use of the machine	Cooperation with human resources	Constant contact with the company	Information about the problems and difficulties of the enterprise

4.2 Interest in Machine User Services and Product-Service System Design for Pharmaceutical Industry

At this stage, the service preferences of the pharmaceutical company were examined. The study covered the company's employees. All the services the machine user is interested in have been sorted and presented in the table below. Preferred services will be an intangible component of the PSS. This is to adjust the designed PSS to the requirements of the machine user. Additionally, it is aimed at complete elimination or reduction of emerging problems. At this stage, the user company confirmed its interest in the PSS with the machine rental option.

Based on the obtained service preferences and suggestions from other participants of the workshops, the PSS was developed (Fig. 3, Table 4). The main material component is a pharmaceutical production machine. The intangible component is a user-preferred service (Table 3).

Table 3. Services an enterprise that uses pharmaceutical machinery is interested in.

Services related to a pharmaceutical machine	Services related to a Drug manufacturing	Services related to health and safety at work	Additional services
Delivery, installation, commissioning	Cleaning and washing format parts	Advice, consultations and training in pharmaceutical law	Audits
Diagnostics and troubleshooting	Data visualization on cards and boards	Noise reduction	Disposal of protective materials
Financial services	Giving the right shape to products	Optimization of the supply of protective materials	Integration of data visualization on cards and boards
Machine software update	OEE analysis and optimization	Optimization of work ergonomics	Lean tools
Maintenance and inspection	Optimization and standardization of working time	Optimizing job matching	Optimization and standardization of working time
Monitoring, machine operation	Optimization of changeovers of format parts	Safety certificates and sets of standards used in pharmaceutical production	Optimizing the use of utilities (water, air, electricity)
Rent	Optimizing the supply of raw materials and materials	Security checks	Take-bake
Repair shop equipment	Packing and cost optimization of packaging materials	Sterilization	
Service agreement	Quality control of finished products	Training	
Supply of spare parts	Training and integration	Waste disposal	
Training	Waste disposal		
Updating (reconstruction, modernization) of the machine			
Warranty			
Washing and cleaning			

In the developed PSS, the manufacturer retains ownership of the machine that is made available to the user. With the machine, the user receives services tailored to his needs. The manufacturer charges a monthly fee depending on the work performed by the machine. The machine user needs to work with the machine and produce as many products as possible, not to have it. After the agreed period of use, the pharmaceutical production machine will be reconditioned and made available again. The customer also chooses whether he wants to get a new or reconditioned machine.

In this case, the manufacturer obtains financial benefits both on the pharmaceutical machine and the related services. The solution enables the manufacturer to have constant access and analysis of the machine's operation. The data collected thanks to this will be used by the manufacturer in the design of new generations of machines and the regeneration of used machines. In addition, it will allow for the efficient replacement of elements that wear out quickly and do not keep precisely defined parameters.

Thanks to this model, the pharmaceutical company does not spend a lot of money on the machine. It is no longer concerned with service and repair, so she can concentrate on her core business. In addition, thanks to the services throughout the life of the machine, it receives technical support regarding the production process and meeting the sanitary criteria set for this industry.

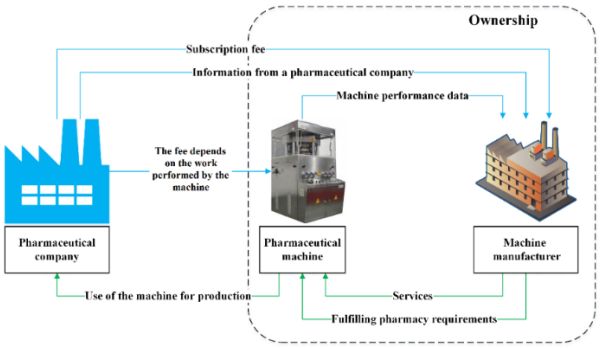

Fig. 3. Product-Service System concept for the pharmaceutical industry

Table 4. Product-Service System for the pharmaceutical industry - assumptions

Ownership	The manufacturer is the owner		The pharmaceutical company is a user	
Sale	Subscription depends on the operation of the machine			
Services	A set of services tailored to the user's needs		Services divided into packages	
Benefits for the producer	Co-creating solutions and improving relationships	Machine performance data	Machine reuse	Environmental Protection
Customer benefits		Focus on the development of new drugs	Elimination of costs related to the purchase and maintenance of the machine	Faster enterprise development

5 Discussion and Conclusion

The industrial workshops presented in the paper illustrate the collaboration between a company selling machines (manufacturer's representative), a pharmaceutical company and scientists to co-design effective PSS solutions for the pharmaceutical sector. Co-operation as presented in the article and learning about the requirements and problems of the machine user is an important point that should be taken into account in the design of the PSS.

The developed solution will be an impulse for the development of small and medium-sized pharmaceutical companies, which usually have problems with the purchase of new machines. On the other hand, large enterprises will be able to concentrate on developing new products. The framework of the PSS presented in the article shows close cooperation between enterprises throughout the life of a pharmaceutical production machine. This is an important fact that will be helpful in developing machine usage scenarios in a specific enterprise.

The paper is the first stage of research on the use of the PSS in the pharmaceutical sector. It highlights elements and aspects that will be discussed and analyzed more extensively in future studies.

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