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A Software Demonstrator for Measuring the Quality of PSS

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Abstract

Machine tool manufacturers realized that offering a high quality technical product is not sufficient considering the rising customer requirements. To commit customers and differ from the competitors machine tool manufacturers provide services which support the production of their customers. To guarantee a high quality Product-Service Systems (PSS) machine tool manufacturers have to analyze how well their PSS fulfills the requirements of the customers. Therefore, an assessment tool is necessary to control the quality of PSS.
In this paper a software demonstrator is presented that serves for assessing the quality of PSS. The demonstrator is developed during a project with machine tool manufacturers. An overview of the project results will be presented by means of developed use cases and determined requirements of the lead-users of the project partners. Based on the customer requirements of the lead-users quality criteria are developed and clustered to generally valid PSS quality criteria. To measure the PSS quality criteria Key Performance Indicators (KPIs) are developed with the project partners. These KPIs are monitored within the software demonstrator which supports machine tool manufacturers to measure and control their PSS.

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Keywords: Product-Service Systems, Quality Assessment, Machine Tools, Software Demonstrator

1. Introduction

Increasing customer requirements and rising international competition force machine tool manufacturers to focus on a quality leadership instead on a technical leadership of capital goods. For this purpose, a quality leadership in technical Product-Service Systems (PSS) is a promising strategy for machine tool manufacturers [1]. PSS consist of different services which enhance the product over its entire life cycle [2, 3, 4]. With PSS machine tool manufacturers aim at reaching a higher customer satisfaction and a long-term customer relationship.

The assessment of PSS quality is necessary to achieve a quality leadership in PSS. Objective of each assessment from the view of business management is to take an evidence based decision [5, 6]. In order to assess quality, quality criteria and Key Performance Indicators (KPIs) have to be identified. Data have to be collected and information allocated with which the responsible employee can establish improvements [7]. To make the machine tool manufacturers use such a KPI system as efficiently as possible, a software-based implementation of the KPI system is necessary. The software demonstrator serves as a (semi-) automation for the application of the KPI system.

This paper presents a software demonstrator for measuring the quality of PSS. In the second part of the paper, an approach is introduced to assess the quality of PSS. This includes the main steps and results of a research project for which the approach was developed. Therefore, use cases of project partners of the research project “Lifecycle-oriented quality assessment of technical Product-Service Systems in the machine tool industry (Q.PSS)” will be described and results of the customer interviews revealed. Furthermore, defined PSS quality criteria and a KPI system will be explained. In the third part, the demonstrator and profiles of the KPIs will be presented. Finally, the results of the project are summarized and further research work for quality assessment tools for PSS suggested.

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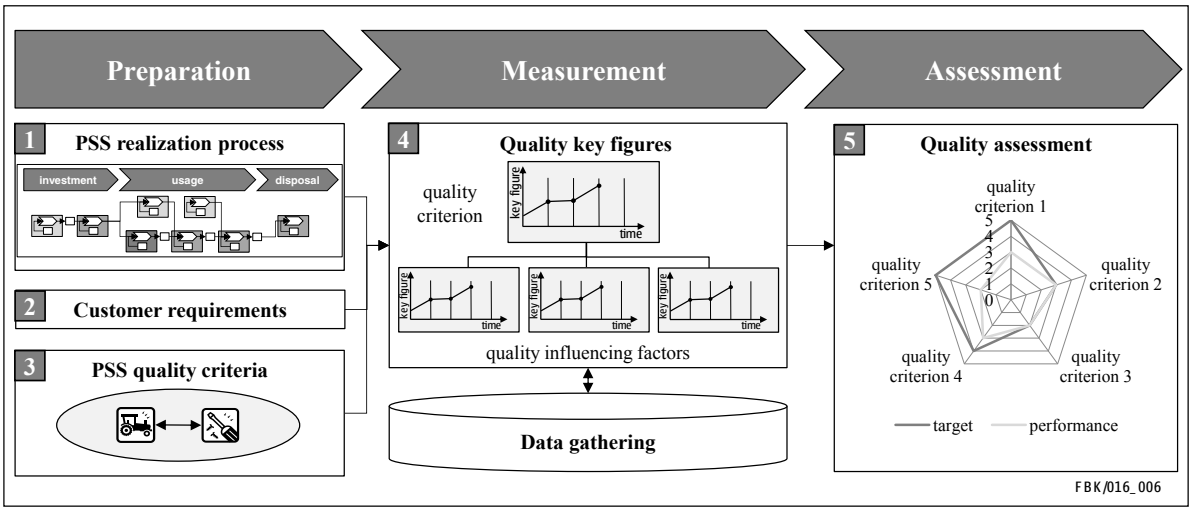

Figure 1: Approach for analysing the quality of PSS [According to 1]

2. Approach to analyze the quality of PSS

In this part, an approach will be presented to measure the quality of PSS (see Figure 1) [8]. The approach has an integrated view of physical products and services. It considers the interaction between physical products and services, and their influence on the overall PSS quality. Hereby, quality is defined as fulfilling customer requirements at best [9]. Many empirical studies presented that satisfying customer expectations secures future revenues [10, 11] and is the best indicator of a company´s future profit [12]. So, the approach is strongly customer-oriented and the PSS realization is analyzed from the customer´s view. The quality assessment takes any point of contact between a customer and the PSS provider into account [8]. The added value network is also considered because it has an influence on the fulfillment of requirements. It includes all service partners, branch officers, salesmen and different supplier of the PSS [13].

2.1. Identification of the PSS realization process

In the first step of the approach, the PSS realization is mapped by identifying different use cases with the project partners. The use cases illustrate the entire PSS realization, containing a telephone service, condition monitoring, maintenance and retrofitting.

According to Donabedian [14] three different quality dimensions exist for services:

- Quality of potential: This means all kind of resources of the service provider and of the customer might influence the quality.
- Quality of process: It assesses how the service employee performs during a service process.
- Quality of result: It describes the quality of the result of a process step.

These dimensions are connected over a linear sequence with each other [14]. If the quality criteria according to the three dimensions meet the customer requirements, the service quality exists [14]. These three quality dimensions of services were considered when identifying customer requirements. Before modeling the four use cases, all resources like information, materials, human resources, process steps, and all results of each process step were determined. The use cases were modeled with the OMEGA Process Modeller because it offers the possibility to assign all resources to the process steps.

2.2. Identification of customer requirements for the PSS realization process

After modeling the use cases, lead-users of the project partners were interviewed for identifying customer requirements. From the customer requirements quality criteria were deduced for each use case. According to [15] quality criteria should be proved because of three reasons: legal requirements, guidelines and customer requirements. In this research project the quality criteria were proved by the customer requirements and internal guidelines of the machine tool manufacturers.

The quality dimensions for services according to [14] were considered in the interviews with the customers. Aim of the interviews was to figure out the requirements related to each process step, to resources which are necessary for the process steps and to the results of the process steps. Therefore, the OMEGA model was used to show the PSS realization for each use case to the customer during the interview. Based on the Kano model customer requirements can be classified in basis, performance and enthusiasm requirements [16]. Usually the customers named performance and excitement requirements. The basic requirements, e.g. a fault-free working during a retrofitting process is also important. So, the basic requirements which were not mentioned from the customers were complemented

Use case				
Process steps	**Customer requirements**	**Quality criteria**	**Influencing factors**	**Quality KPI**
Call of customer	• No waiting time for reply	• Time	• Availability of service employee • Amount of service employee • Average duration of a call	• Average time for reply
…	• …	• …	• …	• …

Figure 2: Deriving quality KPI

subsequently. After that, the requirements were prioritized with the customers. To determine the most quality critical process step, a comparison of pairs was carried out. The comparison of pairs is an easy and fast method to evaluate requirements [17]. Based on a list of the relevant customer requirements, it has to be analyzed which requirement is compared to the other requirement more important, same important or less important (rating points 6, 3 and 1). So, all requirements were compared pairwise among each other [17]. For each requirement the weight of importance were calculated by summing up the rating points [17].

The requirements which are scored low of the customer and are less important for him, have a lower relevance for the PSS provider. So, prioritizing the requirements offers the possibility to take relevant requirements in the focus [18]. By determining and evaluating the customer requirements the targets are clearly defined [17].

By doing the comparison of pairs, the most important process steps were identified. In the case studies, these were usually at the beginning of the PSS realization, e.g. when the customer calls the telephone service or when a new customer gets the first call from a service employee about a new service product. If it is a new employee or a new customer the first contact is crucial to satisfy the customer. The second most important process step was commonly the services itself, e.g. the maintenance, the hotline support or the implementation of improvement measures.

The results mostly reflect with the statements of [19, 20]. According to [19, 20] the customer expectance on a service quality is influenced by four different impulses. These impulses are the oral communication of the customers, the personal situation of the customers, the past experiences with the provider and the communication of the provider.

2.3. Deriving of PSS quality criteria

The customer requirements were the basis for developing general PSS quality criteria (see Figure 2). So, based on our customer interviews and on the literature, general PSS quality criteria were developed during the project to assess the quality of every PSS. These nine PSS quality criteria include all service- and product-oriented quality criteria and extend over the entire life cycle:

- Time,
- Flexibility,
- Price-performance ratio,
- Accuracy,
- Reliability,
- Availability,
- Problem solving,
- Interaction,
- Material.

With the PSS quality criterion time, all quality criteria that are related to time are meant, e.g. the arriving on time of the service technician or the time for solving a problem. The PSS quality criterion accuracy includes all quality criteria related to a process step in which an accurate process is highly important, e.g. a fault-free retrofitting or maintenance. The PSS quality criterion quality of interaction describes all quality criteria which are related to the communication, the kindness and professionalism of an employee (e.g. in cases of time pressure). Another PSS quality criterion is the quality of material, for example the quality of spare parts or of reports.

These nine PSS quality criteria cover all quality criteria which were determined by the customer requirements and were served to evaluate the quality of PSS over its entire life time. It ensures, the quality assessment is not only usable for the use cases but also for other life cycle oriented services of machine tools.

2.4. Developing of a quality KPI system for PSS

For operationalizing the PSS specific quality criteria, new quality KPIs were required. These were developed together with the project partners and brought in a KPI system in context.

In literature, there are KPIs to evaluate the quality of services. [18] differs between purely and linked quality KPIs. The pure quality KPI refers to costs, to use or to the relation between cost and use. The latter can be determined by e.g. the amount of controlled processes over the costs for the quality control. Linked quality KPIs are monetary KPIs, e.g. the cost of defects divided by sales. Part monetary KPIs are for example costs of rework over the amount of employee. A non-monetary KPI is the amount of improvement suggestions over the amount of employee.

To measure a PSS, there are KPIs which consider the usage phase [21]:

- First time fix rate,

- Operating time,
- Process stability,
- On time delivery (OTD),
- Mean time to problem solution (MTPS),
- Mean time between failure (MTBF),
- Mean down time (MDT),
- Travel time proportion [%],
- Resource utilization [%],
- Rescheduling quota [%],
- Acceptance rate [%].

2.5. Quality assessment of PSS

For a life cycle oriented quality assessment of PSS KPIs are necessary for all life cycle phases: procurement, usage and end-of life phase. So, during the project a KPI system were developed to control the quality of a PSS and which considers all life cycle phases. It also presents the influencing factors of all determined quality criteria. Hereby, the focus was on influencing factors which can be controlled by the PSS provider himself, so called adjusting lever. Other influencing factors like from the environment or of the customers are not considered. To make the influencing factors measurable, KPIs were determined together with the project partners of the machine tool industry and based on the literature. For example the PSS quality criterion time has KPIs like average time for retrofitting, first time fix rate per year over the amount of operations per year or average time from customer order till delivery of spare part to the customer. Furthermore, target values and tolerances were defined together with the project partners for each KPI. Based on experience and the internal targets of each company, the target values and tolerances could be decided.

After developing the KPI system, the fifth step of the approach was done. It includes the assessment of the KPIs regarding the degree of performance. Before doing this, information about the developed quality KPI should be documented in a KPI profile (see Figure 3) [22]. The KPI profile includes all relevant information about a KPI like name, its allocation to a PSS quality feature, a description what it means and how it can be determined. In the description the target value and the acceptable tolerance of each KPI is written down and a graph of the KPI can be presented. Based on the description and the formula in the KPI profile, it was determined which data is necessary for assessing the KPI. After this, target values were specified which should be opposed to the real values during the life cycle oriented quality assessment.

Finally, the approach has to be transferred into the software demonstrator for a (semi) automation application of the approach.

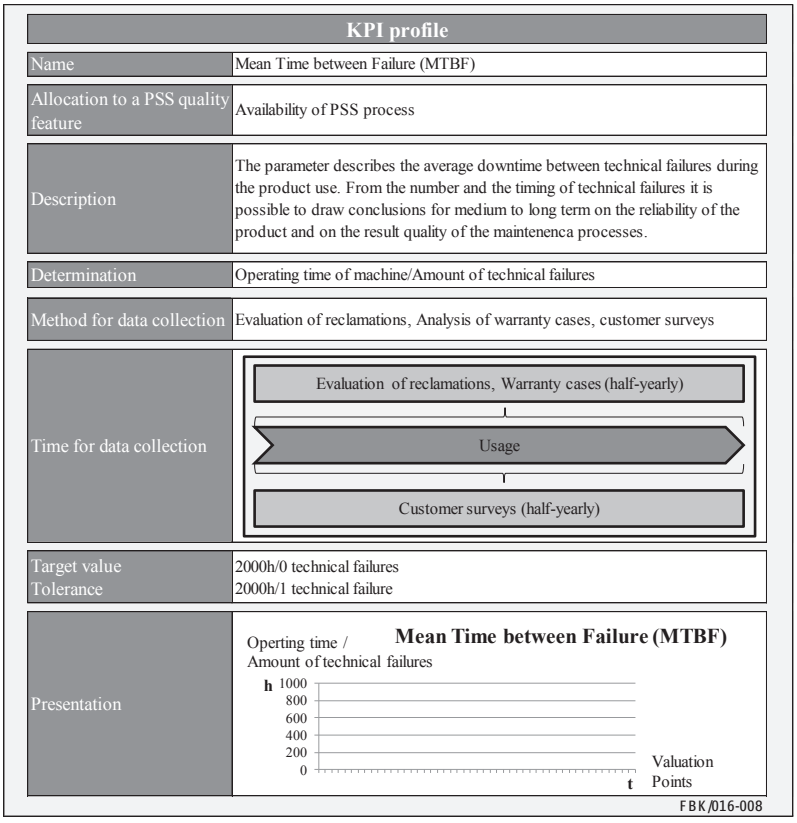

Figure 3: KPI profile [According to 22]

3. Software demonstrator for measuring the quality of PSS

In this part, the quality assessment of PSS monitored in a software demonstrator is shown. The assessment is performed by a demonstrator which is specially developed to measure the quality of PSS. For each project partner and its use case a specific demonstrator is generated. Together with the project partners of the machine tool industry the most important KPIs were selected to be monitored in the tool. The selection of the KPIs was carried out on the basis of what is legally allowed to monitor, which KPIs can be collected internally and the assessment of the effort to determine the KPI to the benefit of the KPI. Usually about 10 to 20 KPIs were selected of the project partners to be monitored in the tool. The selected KPIs are different for each company according to their use cases.

Before developing the tool, the data acquisition is very important for determining the quality KPIs. This step depends highly on the customer and includes different processes in the customer environment. The data acquisition will be carried out on internal and external basis by a responsible employee. Therefore, the internal data will be collected by the ERP system and the external data by customer surveys. However, the data collection needs some time. To keep the effort for a minimum, the data collection and assessment will be done once to four times per year.

The tool was developed with Microsoft Excel. The focus was to provide an easy implementable tool which is developed user-friendly. The first worksheet of the tool presents the KPI system with four levels (see Figure 4). The graph of the first level describes the total quality of the monitored PSS. It is composed of the nine PSS quality criteria (2. Level). According to the selected KPIs there could be more than one graph for each PSS quality criterion. In the third level the results of the customer surveys are detected. For one PSS quality criterion several quality criteria might exist. Therefore, the survey might include one or more questions according to one PSS quality criterion. So, in the third level there might be several graphs. For example the PSS quality criterion material has quality criteria regarding the spare parts, the machine tool, the instruments of the service technician etc. In this case, there is more than one graph in the second level. So, the customer survey has more than one question for the PSS quality criterion material and in the third level are also several graphs representing each criteria. This setting was chosen to allow a clear structure for the tool. The results and the statistical evaluation of the surveys are on a second worksheet of the tool. In contrast to the third level, the fourth level does not represent the customer perspective but the perspective of the PSS provider. It means, here are the internal KPIs of the PSS provider. These have to be compared with the results of the customer surveys. If the evaluation of the data discloses wide-ranging

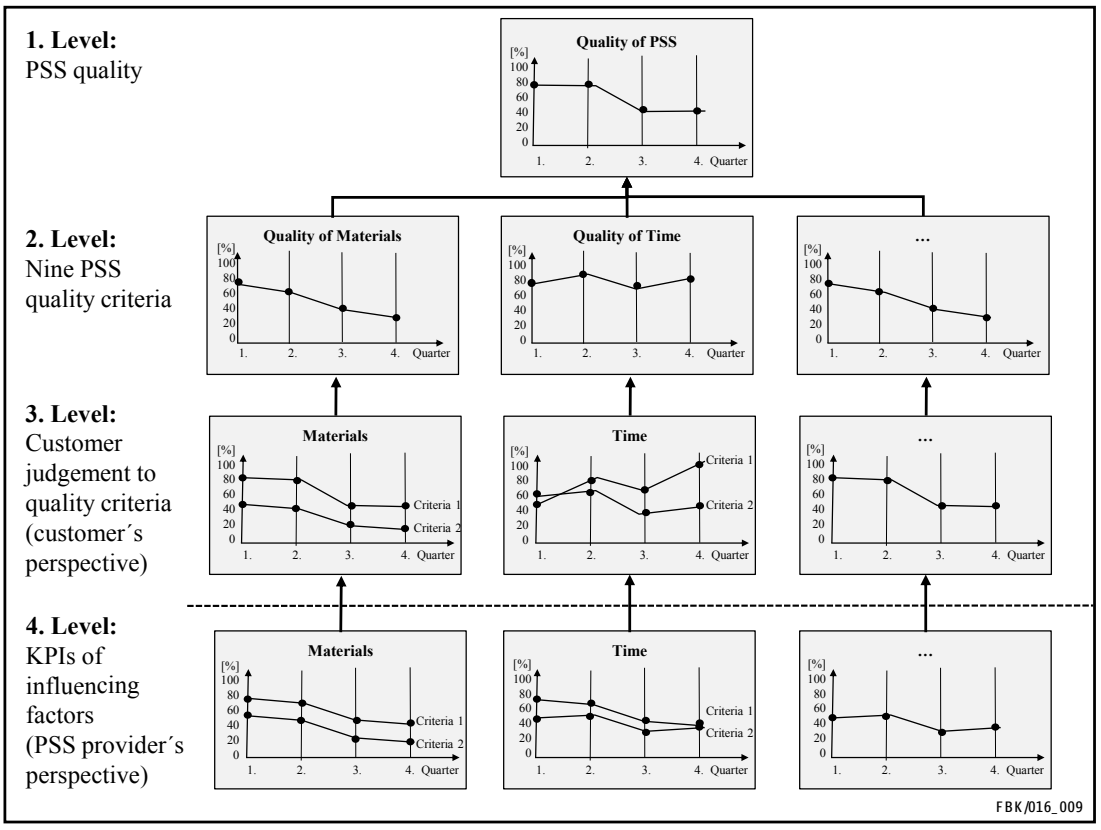

Figure 4: Exemplary illustration of worksheet 1 of the software demonstrator

differences between the internal guidelines and the results of the customer surveys, measures have to be initiated to reach the set value for each KPI [19]. These measures must be derived and implemented by each company itself. One method to derive the measures could be to analyze the influencing factors of the KPI. This should be initiated by the responsible employee in agreement with his department manager.

4. Conclusion

In this paper a software demonstrator was presented to control the quality of PSS. The demonstrator was generated as part of the research project in cooperation with four different project partners of the machine tool industry. During the project the requirements of the machine tool manufacturers were focused and adapted demonstrators were developed for each of the project partner. The demonstrator is a quality measurement tool which is adaptable for every PSS. The aim was to offer a tool which is easy to implement in the internal structure of a company and is developed user-friendly. The tool offers a basis to receive and assess the quality of PSS at a given time and to derive specific measures for ensuring and rising the quality.

Future research should be done in analyzing total quality management methods (TQM) for PSS. For realization of a TQM for PSS, operations of all areas of a manufacturer should aim to implement and assure the quality. For this purpose, PSS specific TQM methods are necessary. A tool which considers all these methods could be helpful for a centralized monitoring and controlling of the total quality for PSS. It would be an important further step to ensure the quality leadership of the machine tool manufacturers.

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