Consideration of Changing Impact Factors for Optimization of Post-series Supply

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Abstract. The increased use of electric and electronic components is a trend in several branches of industry. The short life cycles of these innovative components compared with the life cycles of the primary products lead to challenges regarding an effective spare parts management. To guarantee an availability of spare parts during the whole period of the post-series supply, a period of up to 15 years in the automobile industry, a structured planning process is needed. The current approaches for the planning of the post-series supply concentrate on static impact factors to evaluate a supply scenario for the post-series supply, but for a detailed assessment of possible supply strategies changing impact factors have to be considered. A methodical approach for this will be described in this paper.

Keywords: Spare Parts Management, Post-Series Supply, Changing Impact Factors, Product Development

1 Life-Cycle-Oriented Spare Parts Management

The efficient supply of spare parts during the whole product life cycle is a quality aspect of manufacturing companies, which can lead to a better customer loyalty and thus to a stronger market position [1]. However, the increasing product complexity and shorter product life cycles cause a higher effort in the spare parts management. Especially the increased use of innovative components like electric and electronic components is a challenge for many companies because of the short innovation cycles of these components and the fact, that these components are often assembled in primary products, which have a life cycle that is much longer.

1.1 Supply strategies and supply scenarios

The model of the life-cycle-oriented spare parts management focuses on this specific problem and contains several supply strategies to realize an efficient post-series supply. Common supply strategies are the development of a compatible successive product generation, storing a final lot, the periodical internal or external production, the reuse of used components and the repair of used components. [2], [3] These six strategies are explained in the following part.

Compatible parts: In this strategy parts from the current series production are used for the spare parts supply of the previous product generation. A requirement for this strategy is the backward compatibility of the new product generation. It has to be sure that the functionality, the interfaces and installation space of the new part generation are matching the specifications of the older product.

Storing a final lot: This strategy is based on a forecast of the all-time demand of the spare parts. The all-time demand is manufactured in a final lot and stored in a warehouse. The spare part demand during the supply period is satisfied from this existing stock. Due to the long supply period, the lack of historical data and the random failure behavior of many electric and electronic parts, the forecasts are afflicted with a high uncertainty. So the risk of under- or overstocking is given. In addition, a long storage time of the spare parts might lead to technical problems and high storage costs.

Internal production: A periodical internal production over the entire supply period avoids the difficult forecast and technical problems due to a long storing period. However, a production could become impossible because of a discontinuation notice of required components. In addition, the internal production may be inefficient as a result of poor capacity utilization of testing and production facilities.

External production: Using the strategy external production companies try to minimize the inefficiencies of the periodical internal production by outsourcing the production process to a third company. The external manufacturer has adjusted its production to the requirements of the post-series supply (e.g. high flexibility, small quantities) and can produce more efficient.

Reuse of used components: According to new laws more and more products are taken back by the manufacturers at the end of the primary products life cycle. Well functioning components (e.g. electronic control units) can be reused as an overhaul spare part after the reliability was checked. [4]

Repair of used components: This strategy includes the repair and overhaul of used defective parts. Mainly due to increased legal framework in the field of environmental protection, this strategy is gaining more and more importance.

In many cases it is not possible for the manufacturers to use only one of these strategies for the entire period of the post-series supply. Therefore supply strategies are combined to a supply scenario as shown in figure 1. In this example after the end of production of the primary product, the demand of spare parts is first covered with the strategy of internal production. At a certain point it becomes cheaper for the company to store a final lot. To compensate missing parts due to a wrong forecast of the all-time demand, it can be necessary to change the strategy again at the end of the supply period. In this phase it is appropriate to use the strategy repair of used components. Because the original production and testing equipment probably is not available any more, in most cases this strategy is the only way to satisfy the customers' needs. A detailed planning process under consideration of the specific circumstances of the company is necessary.

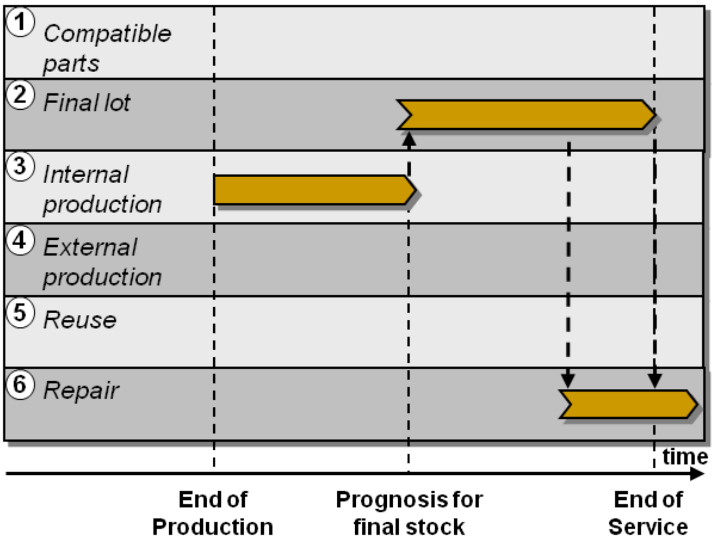

Fig. 1. Supply strategies and supply scenarios

Support for the selection of a supply scenario may be given by a decision matrix which is a result of a joint research project. Figure 2 shows a decision matrix for the pre-selection of possible supply scenarios by using three different impact factors. The first impact factor is the possibility of using compatible parts. The storability of a specific spare part and the ability of an uncomplicated reconditioning are further impact factors in this decision matrix. The impact factors compatible parts and the storability are subdivided into two categories, whether compatible parts exist or not and if the shelf life is high or low. The impact factor reconditioning is subdivided into three categories. These describe if it is generally possible and if it is reasonable from an economical point of view or not. If a recondition might generally be possible but uneconomic the strategy recondition can merely be used as a contingency strategy. However, if it is technical and economical feasible, the strategy of recondition can be used as main strategy.

In comparison with the described supply strategies the matrix contains five modified strategies. The internal and external production are combined to the strategy periodical production and the strategy recondition integrates the repair and the reuse of used components. Figure 2 shows an example for a chosen strategy by using the decision matrix. The selection of a supply scenario is shown for a spare part with no compatible parts. However there is no problem by storing the spare part for a longer period. From the technical point of view the spare part has the ability to be reconditioned but using this strategy is uneconomic. This leads to the supply scenario PFA. The spare parts supply is ensured by the internal production in the first phase. If the production is no longer economically possible, for example because the quantity of demanded products is too low, it will be switched to the strategy of storing a final lot. Because it is technically possible to recondition used parts it is not necessary to have a high safety stock. Thus the risk of overstocking is minimized; a shortfall can be intercepted by reconditioning. The matrix can vary depending on the products and the approved supply strategies (e.g. no reconditioning for security-related components). Therefore, the matrix has to be adapted company specific. [1]

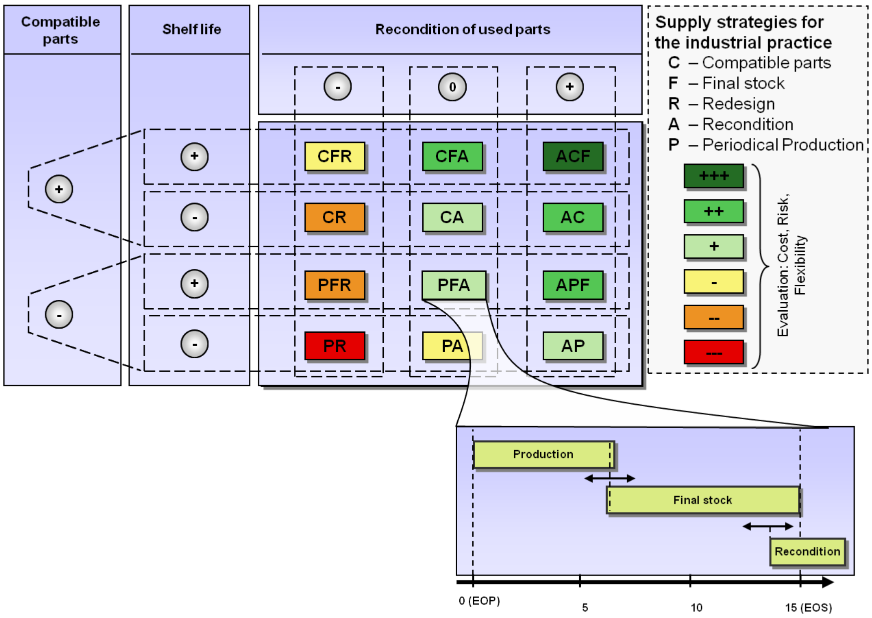

Fig. 2. Selection of a supply scenario [1]

1.2 Deficits of the current planning process of the post-series supply

In the field of electronics for the automobile industry the period of post-series supply is about 15 years. In this period the availability of the products has to be ensured. The previously mentioned impact factors are only a small selection of factors which have an impact on the choice of a supply scenario. To ensure that the post-series supply is assured it is necessary that all relevant impact factors are considered in a structured process. In the current planning process only static impact factors are considered even though the development over time of each impact factor is important and has an influence on the suitability of a supply strategy. Furthermore, the current process only supports planning the post-series supply of existing product structures and does not provide a feedback to product development. This feedback is necessary in order to develop products according to the requirements of the post-series supply. In the following part an approach to avoid the identified deficits will be described.

2 Approach for consideration of changing impact factors

The approach for consideration of changing impact factors contains four main steps. These are the identification of relevant impact factors (1), the rating of the identified impact factors (2), the evaluation of impact factors in regard to each supply strategy (3) and the analysis of conflictive impacts and feedback to the product development (4). Each step contains different tasks. A structured overview is given in figure 3.

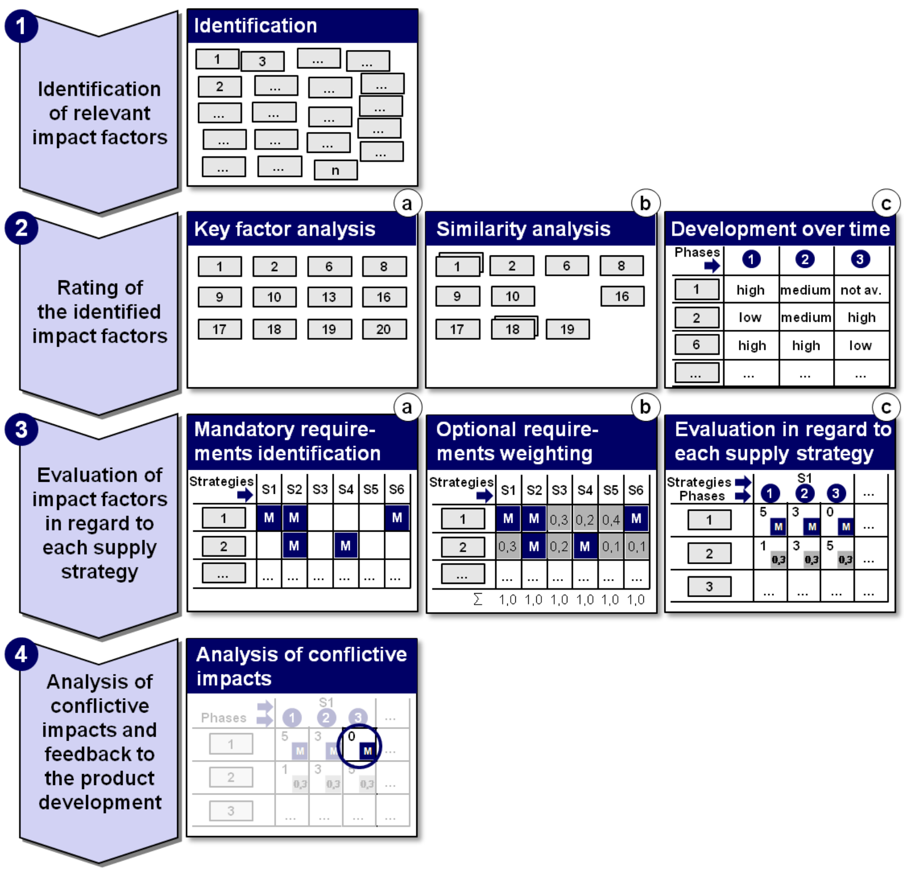

Fig. 3. Consideration of changing impact factors

2.1 Identification of relevant impact factors

In the first step the relevant impact factors have to be identified. This identification has to take place in an early stage of product development process and requires experts from different divisions of the company, e.g. sales, research, development or production. In addition to the previously mentioned factors, further factors with respect to the post-series supply of electronic devices can be named, e.g. legal terms, changes of customer requirements, prices of components, quantity of suppliers, and changes in business competition influence the post-series supply. The identification and assessment of the impact factors has to be based on experience of specialists and can be supported by the use of structuring methods, such as mind maps or the Delphi-method [5], [6]. This identification should be done for each product. However, most of the impact factors are general or depend on the branch of industry. If new relevant impact factors are identified in the course of time these can be integrated in the method.

2.2 Rating of the identified impact factors

The rating of the identified impact factors is the second step of the method. First the most relevant impact factors, the key factors, have to be identified (see figure 3, 2a). The key factor analysis can be supported by an impact matrix, which is also used in the scenario technique. By this analysis the number of impact factors can be reduced and the following steps of the methods will be less time-consuming. In addition to the impact analysis an impact factors similarity analysis can be used to combine similar factors (see figure 3, 2b). [7] This is important because these impact factors would be double-weighted in the next steps of the method otherwise.

The evaluation of the expected development over time is the following task. This is necessary because the relevance of the different impact factors varies depending on the phase of the post-series supply. For this assessment the rating scales for the impact factors and the length of the phases have to be defined (see figure 3, 2c). The literal description of the development is useful in this step because this will prevent misunderstandings. The rating scales are to be chosen according to the products, the supply periods and the required level of detail. There are also industry-specific differences which have to be taken into account. E.g. in the first phase of post-series supply the quantity of required products is higher than in the second or third phase but the predictability of the demands is best in the third phase. The availability of the components is highest in the first phase of the post-series supply. The method should not be understood as a tool for a single use but as a tool for a continuous improvement process. Initially, a low level of detail is helpful to understand the system. Later on the method can completed with additional details. The use of classic time series analysis methods, lifetime analysis methods and causal analysis methods are suitable for the evaluation of the rate curves. Also comparisons with previous series based on analogy methods can be used to identify the development over time. [8]

2.3 Evaluation of impact factors in regard to each supply strategy

The identified development over time allows evaluating the impact factors in regard to the different supply strategies. Therefore a classification of the impact factors in mandatory requirements, that have to be fulfilled to realize a strategy, and optional requirements is necessary. For this purpose a matrix can be used (see figure 3, 3a). For example, the availability of components is a mandatory requirement for the strategy internal reproduction. For the strategy of storing a final lot on the other hand the storability of parts is mandatory. The optional requirements of each strategy are weighted (see figure 3, 3b). This can be done using the pairwise comparison, a cost-benefit analysis or the analytic hierarchy process [9], [10]. The change in customer requirements can be described as an example. Customer requirements will probably decrease over the time and the customer will be satisfied with a used spare part after 15 years. Thus, this impact factor has a different relevance on the strategy production as on the strategy repair. As another example, the influences of increasing prices for purchased parts during the supply can be described. The increased costs of purchased parts are not important for the strategy storing a final lot in contrast to the strategy internal production.

To evaluate the suitability of each strategy, the identified development over time has to be quantified. E.g. the demand of spare parts has an influence on the strategy of internal production. If the demand decreases over time the suitability of the strategy will deteriorate continuously due to small lot sizes which are unsuitable for certain types of manufacturing because of long machine setup times. Furthermore the predictability of the demands can only be determined inaccurately in the first phase of the supply period. The accuracy of the forecast will increase in the following phases, so that the suitability of the strategy internal production will rise. The quantified values have to be analyzed for each strategy and each phase of the post-series supply (see figure 3, 3c). Finally the mandatory requirements and the different weighted values lead to a value of benefit for each phase of each strategy. This allows deriving adequate strategies for each phase, which are suitable for the impacts. The combination of the most suitable phases of the supply strategies finally leads to one or more preferred supply scenarios.

2.4 Analysis of conflictive impacts and feedback to the product development

In the fourth step the preferred supply scenarios are analyzed in detail. The impact factors are sometimes conflictive so that a specific supply scenario cannot be implemented. Conflicting impact factors are identified and their impacts are rated. For each of this impact factors the alternatives can be described systematically, e.g. the use of another component which has a better availability. If it would be recognized that the availability of the components are critical for a certain strategy, the availability can be increased by early negotiations with the supplier. By the adaption of the impact factors in the product development the feasibility of the supply scenarios and thereby the post-series supply can be optimized [3].

3 Summary

Due to the increased use of innovative components and the life cycles between these components and the primary products it is necessary to establish an effective spare parts management. This can lead to a better customer loyalty and thus to a stronger market position. The current approaches for the planning of the post-series supply generate an efficient supply scenario. These approaches concentrate on static impact factors to evaluate a supply scenario for the post-series supply, but for a detailed assessment of the possible supply strategies the dynamic of the impact factors has to be considered.

In this approach changing impact factors are considered in a structured process. Relevant impact factors are identified and rated and transferred to each supply strategy. Conflictive impacts are analyzed and a feedback to the product development is given. By this adaption of the impact factors in the product development the feasibility of the supply scenarios and thereby the post-series supply can be optimized.

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