Reducing Time for the Product Development Process by Evaluation in the Phase of Solution Searching

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Less and less time is available for product development process. To prevent product failures and the resulting time intensive and cost intensive iteration steps, some preventive measures must be taken. Within the scope of quality management, FMEA anticipates possible problems concerning product and process properties. Nevertheless, in industrial practice designed products can have failures which were not considered within FMEA. The time pressure is immense, and efforts which do not make a contribution to a successful solution are regarded as lost time.

This paper introduces a systematic approach to troubleshooting, with the aim of reducing the time for solution searching by considering the feasibility of ideas at an early stage.

Keywords: troubleshooting, change management, concurrent use of methods.

1 Introduction

Due to global competition, industrial companies need to develop competitive products in a shorter time. The methods of Integrated Product Development are aimed at supporting designers in this endeavour [2]. The methods and tools of Integrated Product Development are objects of investigation in design research. The circumstances in an industrial environment, such as time pressure and immense quality requirements, necessitate an effective and efficient approach.

Fig. 1 illustrates possible stages in the product development process. The x-axis represents the life cycle of a product. The y-axis represents the requirements which are not fulfilled yet (maximum number at the beginning of a project), or the failures which have occurred.

Curve 1 shows a trouble free procedure. The conceptual design of the product is detailed step by step according to the design approach analysis, searching solutions, evaluating and selection. Before launch deadline the product meets all criteria required by the customer.

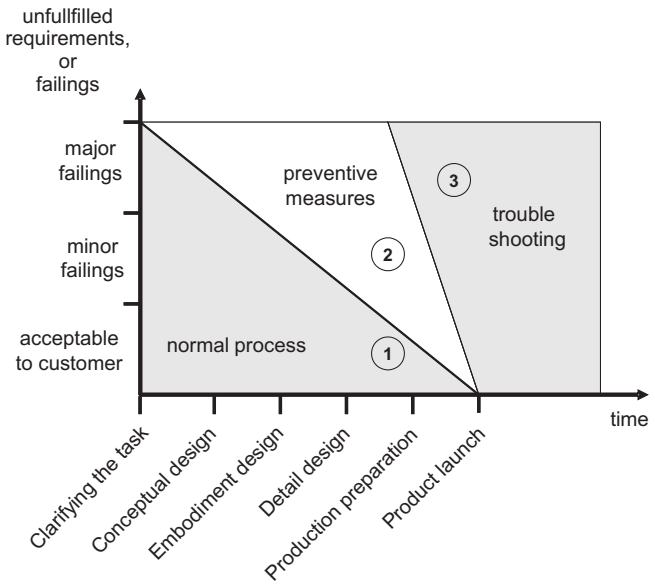

Fig. 1: Possible stages in product development process

Curve 2 represents a project which is characterised by some failure. To handle the situation, the results of preventive measures (i.e., FMEA) are implemented.

Curve 3 exemplifies a project disturbed by extensive failures. Compared to curve 2, the results of preventive measures are not applicable. This situation is well known in industrial practice. Despite methods of risk management and quality management, troubleshooting situations caused by product failure occur in the product development process. This can be due to time reasons: it is impossible to consider all possible contingencies within the scope of quality management. As shown in Fig. 1, the time for searching a solution is very short (the worst case would be a serious failure after product launch). Therefore there is extremely high pressure to succeed.

Curve 3 is a case for troubleshooting. An error has occurred which seriously endangers the success of the project extremely.

The basic steps of conventional product development are usually supported by methods and tools. Methods for systematic searching (i.e., a list of physical effects) and creativity techniques (i.e., brainstorming, TRIZ) support the design teams in the phase of solution searching. The goal is to create a lot of innovative solutions.

Afterwards the ideas are evaluated. The criteria for evaluation result from the customer's requirements and the economic and technical feasibility. Depending on the level of detail of the solutions, and on the number of solutions some provisional criteria are considered for evaluation. Accordingly, simple or more extensive evaluation methods can be used.

In troubleshooting situations, time spent on creating ideas which are not appropriate for solving the problem is lost. Due to the fact that the problem occurs shortly before or after product launch, a characteristic feature of

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a troubleshooting situation is lack of time. Furthermore, engineering change costs rise progressively during product development [2].

The inadequacy of an idea frequently results from lack of feasibility. This can be due to manufacturing tools which would be necessary but are not available. Another reason can be a very high level of risk, because the company has no experience with the technical princip of an innovative idea, and appropriate testing tools are lacking.

The established approach and the established methods and tools do not take these boundary conditions into account. Therefore, there is a growing need for a systematic approach and an adaptation of methods, aimed at avoiding time and cost intensive iterations in troubleshooting phases.

2 Approach to troubleshooting situations

Evaluating and searching for solutions should not be strictly separated [1]. Concurrent searching and evaluating solutions provide an opportunity to reduce the process time (Fig. 2).

In order to arrange the solution search more efficiently, the possibilities of modification should be already considered within the solution search. The possibilities of modification reflect themselves in the degrees of freedom of the product and the degrees of freedom of the process (Fig. 3).

The aim is to concentrate on generating solutions which can be realised with adequate efforts, and which promise

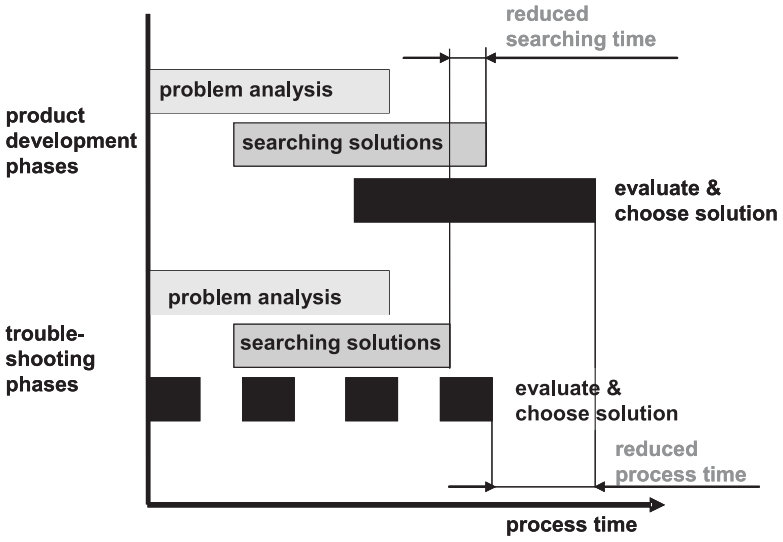

Fig. 2: Reducing time by concurrent searching and evaluating

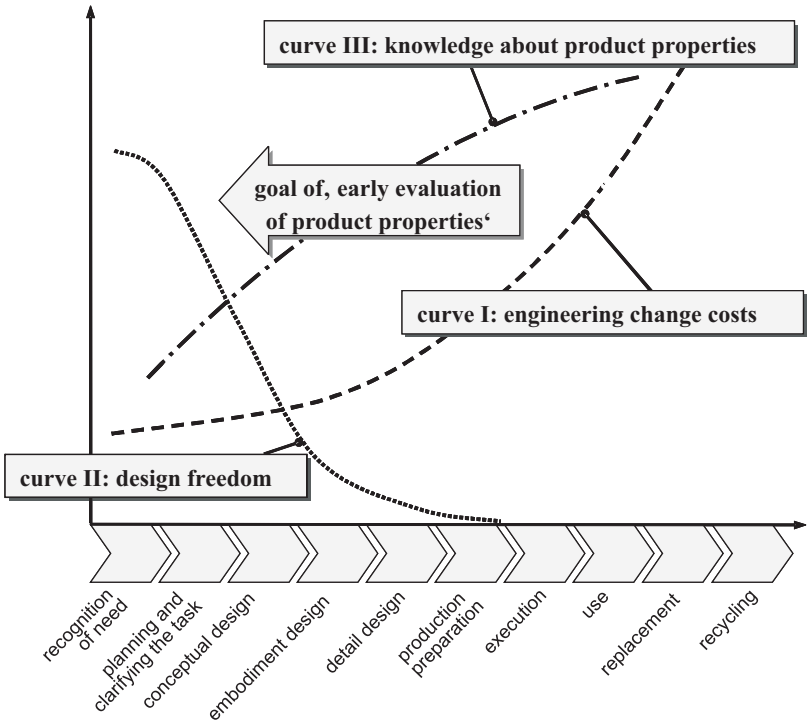

Fig. 3: General trends relating to design freedom, knowledge about product properties, and engineering change costs (acc. to [2])

a successful troubleshooting outcome. Considering this, the first step is to identify the company's specific capabilities, concerning production, assembly and testing.

The aim is to identify system components which can be modified with minimum effort. Based on this information, solution searching should concentrate on modifying of those components.

3 Cause analysis

The first step is to analyse the causes of the problem. For this purpose the system behaviour should be visualised (Fig. 4). Usually the unwanted effects give a first indication of the possible causes. Structuring the problem using the TRIZ-method, the correlations between the effects of system components are represented by an arrow. An arrow linking two effects means that one effect is caused by the other (i.e., effect 1 is caused by effect 4). No other types of arrows are used, because the visualisation should be as simple as possible. This ensures that the information can be communicated easily to other persons who are or will be involved in the process of problem solving. It is important to identify parts or assemblies of the product which are associated with the effects. Based on this visualization of system behaviour, it becomes apparent which system components are causing the failure, or which system components are affected.

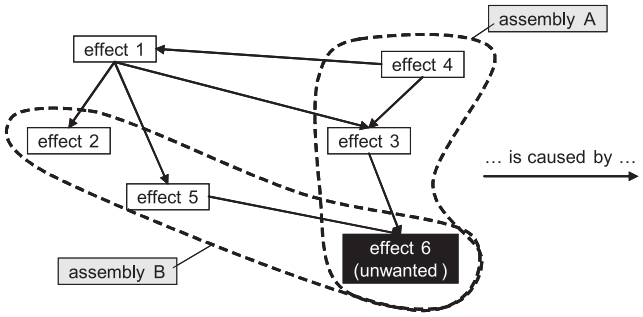

Fig. 4: Structuring of the problem

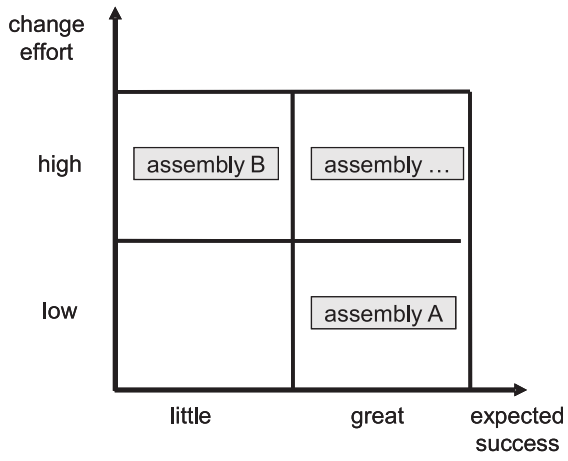

Fig. 5: Matrix for prioritisation

4 Identifying the degrees of freedom of the product

As mentioned above, the degree of design freedom decreases during the development process with increasing level of detail of the product. Change management deals with basic aspects of the effects caused by changing the system components. A small initial change can instigate numerous other changes, which may have serious cost implications [3]. Therefore, in a troubleshooting situation the impact of the changes has to be considered. The aim is to solve the problem without causing too many changes. For this purpose the system components have to be analysed concerning their impact and the expected success in solving the problem. The results of this analysis are shown as an example in Fig. 5.

5 Identifying the degrees of freedom of the process

The next step is to identify the process steps which can be modified easily. For this purpose it is necessary to record the company's manufacturing and assembly capabilities. Depending on the level of detail of the product, the modification of some process steps is eliminated. For example: if expensive tools have already been bought, changing the tool would have intensive cost implications. Furthermore, it is not advisable to use new process steps without experience. In a troubleshooting situation, the risk of yet another failure has to be reduced.

6 Searching solutions by expressing questions

Degrees of freedom are not just a basis for obtaining criteria for evaluation. The fundamental idea is to use the degrees of freedom systematically in searching for solutions. It seems beneficial to present some aims of a problem solver in terms of simple structures of problems [4]. In the style of TRIZ, a systematic approach is to express terms which simulate the designer to create solutions according to realistic possibilities.

On the basis of the earlier steps, the table in Fig. 6 lists the degrees of freedom. An appropriate term is expressed :

"Try to find a solution by modifying /component X/
by /process-step Y/."

degrees of freedom			
product / process	assembly A	assembly B	…
welding			
forming			
turning			
milling			
…			

Fig. 6: Morphological box of degrees of freedom

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This ensures that the focus in solution searching is on realistic ideas. Not the most innovative idea, but the most efficient idea is sought.

7 Example: troubleshooting in the automotive industry

In cooperation with an automobile supplier the procedure was applied in practice. A new product was derived from an earlier successful product. However, the redesigned product did not maintain the product quality. The main problem was some unwanted acoustic effects, caused by an unexpected gap between two parts of the product.

This problem occurred just before the start of production. Cost-intensive forming tools had already been installed. The customer was dissatisfied und demanded a quick solution.

The first meeting a cause analysis. Specialists in technical design, manufacturing and assembly analysed the situation. It was found that the gap was caused by a difference in temperature of the parts. Compared to the earlier design, the length of an edge of the redesigned product was longer. Due to this, the expansion effect had a greater influence and caused the gap.

In the subsequent analysis of degrees of freedom, it became clear that modifications could hardly be realised. Geometric modification of the affected parts would have involved cost- intensive modification of the forming tools.

One option which resulted from the degrees of freedom was:

"Try to prevent the gap by modifying part A by welding."

The answer to this question produced quite simple solutions which were easy to realise. By welding the two parts, the expansion and thus the gap could be prevented. There was no unwanted acoustic effect anymore. The company has a lot of experience in welding, and has the appropriate tools. The customer was satisfied and production started as scheduled.

8 Conclusions and/or recommendations

A troubleshooting situation is characterized by intensive time pressure. Thus, not so much innovative as practicable solutions should be the aim of product development in this situation. In conventional product development procedures the search for a solution is followed by an evaluation of the generated ideas. An important criterion in the evolution phase is the necessary effort, taking into account technical realisation and the cost impacts.

The degrees of freedom concerning product and process should be taken into account, leading to the development of suitable solutions. The introduced approach reduces the time for solution searching and feasibility studies, and is appropriate not only in troubleshooting situations but also in ordinary product development process.

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