

DISASSEMBLY - FMEA AS PART OF A PLANNING SOFTWARE OF ROBOTIZED DISASSEMBLY CELLS

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Abstract: Engineering for disassembly of waste products is becoming increasingly complex. Furthermore, customer expectations are growing, competition is becoming harder, legal requirements are stricter and the quality of technical products is continuously improving. FMEA is a formalised, analytical method for the systematic, consistent collation and prevention of potential sources of errors and their results, not only in Design, but also in Planning and Production and in the future especially for Disassembly in the field of Recycling. The aim of the method is timely recognition and information on sources of error, and the evaluation and reduction of their risks to a manageable level. This means that all possible faults are considered, discussed and documented. The actions require finding corrective measures and, more important, their implementation. The used Planning Software at the Institute allows a (semi-) automatic selection of disassembly cell components by manual selection of possible disassembly operations. The proposed paper outlines the main idea of this system and gives a detailed description of how to use the Disassembly FMEA with this planning system or without, when planning a robotized disassembly system.

Keywords: Failure Mode Effects and Analysis (FMEA), Disassembly Cell, Recycling

1 INTRODUCTION

FMEA is used as a method of risk analysis and prevention of faults in the area of ensuring preventive Quality, but more importantly in cases of new development of production technology with the aim of avoiding potential faults rather than correcting faults which have occurred.

The use of FMEA means thoughtful and systematic examination for weaknesses experienced or possibly expected in relation to

- a product (Design - FMEA) and
- a production process (Process - FMEA ⇒ Assembly, **Disassembly**)

By means of feedback (what has already happened and must not be repeated?) and by critical consideration and questioning (what could happen?) to avoid faults by controlling weaknesses (= sources of error) recognised.

The rough sequence of phases (Figure 1) shows the different used of Process FMEA for Production Technology in the way for assembly and disassembly.

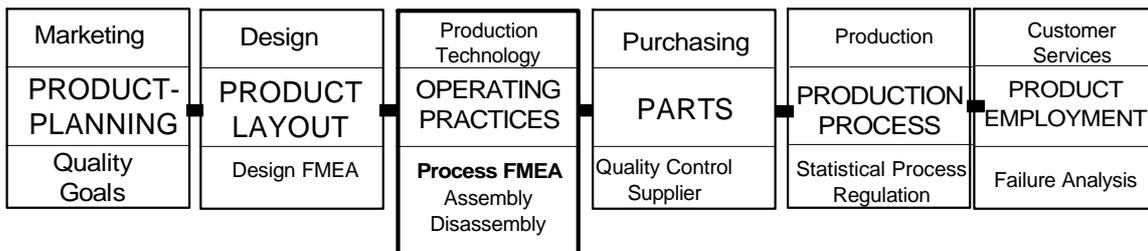


Figure 1. Where FMEA is used

The aims of FMEA are:

- to find critical components and weaknesses
- timely recognition of failures and estimation of the resulting risks
- to avoid repetitions
- to reduce development times
- to reduce failure costs
- to reduce the number of amendments to serial production
- to agree on design and production (assembly, disassembly)

2 SCHEDULE FOR FMEA

In practice, three types of FMEA have proved the most important in accordance to the individual task and depending on the project phase of the product development to be processed.

In **Design FMEA** the components, the function elements of a product, a function group, etc. are central to the examination. Primarily, their constructive interpretation, dimensions and material choice are examined. Influences of the production and assembly procedures used are taken into consideration insofar as they have effect on the constructive interpretation. Failure sources are uncovered if possible by means of design-proven trials or tests and mainly corrected by constructive measures.

In **Process FMEA** the production, assembly and disassembly processes planned for the production of the design element are central to the examination. This includes the analysis of planned production and assembly and disassembly sequences, the production techniques and devices, such as checking processes with which the fulfilment of the Quality requirements can be achieved. The potential failures are mainly in the production technology area and must be consistently corrected by means of an improvement in the process steps in question.

If during Design FMEA a faulty function of the production process was determined as failure source, this faulty function is taken up and further analysed in the Process FMEA to determine why the production process failed.

Over the last few years, so-called **System FMEA** has been developed for the observation of all-inclusive total systems. This FMEA examines the function capability of the total system, including the interaction of system components, of the components together with emphasis on the analysis interfaces between components with regard to their interactions and with regard to the disturbance parameters and influences effecting the interface parameters.

2.1 Work schedule for FMEA

An FMEA is always carried out according to the following plan (Figure 2).

The basic team of a System or Design FMEA consists of employees from Design, Testing, Production Planning and Quality Management. In the Process FMEA (assembly – disassembly) one person from Production takes the place of one person from Testing. For specialist subjects, additional experts may be invited. The Team Leader is also responsible for the methodic and meeting protocol.

The schedule for the FMEA should not give in this paper a repetition of the different steps, it shows the new view under changing conditions for the Process FMEA for Production Technology in the way for disassembly. The team members and the principal work for the FMEA should be the same as before. The different the focus now was only on "**assembly problems**", that mean the different steps of the assembly process are well known. For the "**disassembly problems**" the incomplete product knowledge and therefore the different steps of the disassembly process are not well known. So the graduate plan for the steps to make an Process FMEA is more important as in the past. For Preparation, the FMEA representative collects all necessary documents. The function elements and the functions are defined. Now all possible potential failures, their possible results and the possible sources of failure must be listed.

2.2 Risk evaluation

After completion of the failure analysis, the FMEA team carries out a risk evaluation on the current situation. The evaluation is made for the **occurrence**, the **importance** as well as for the possibility of **detection**.

Then the Risk Priority Figure (RPF) must be determined for all failure sources by multiplying the individual values.

$$RPF = O * I * D$$

This value is a means of judging with what priority correctives should be developed.

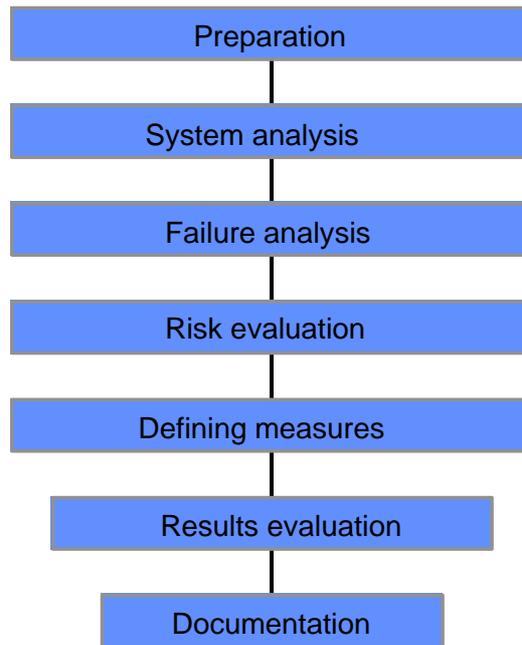


Figure 2. Graduated plan for a FMEA

In specialist literature a *threshold* of "RPF" > 125' can often be found for the determination of correctives. This threshold should only be used as a guide and must always be seen in connection with the individual values.

Each *individual value* in Occurrence or Importance of "> 8" must be submitted to at least one careful check.

The evaluation criteria for the probability of:

the occurrence of a failure,
the seriousness of the results and
the discoverability of the failure

In the specialist literature there was no information about the threshold of "RPF" for Process FMEA's in the way of disassembly. So the future will give us a value for the Risk Priority Figure and this could be a standard in the way to prepare a Process FMEA in the way of disassembly.

3 DESIGN OF A DISASSEMBLING CELL

A very high standard in the field of automation and robotics have been reached, but focused only on assembly. Few parts of electronic scrap are recycled after disassembling, however, the degree of automation is still very small - only some pilot or demonstration projects are realized mainly in research institutes. For the expected mass of products which will come back to recycling and dis-assembling companies in the future, the existing manual disassembly is totally insufficient. Especially parts of high quality products, i.e. those which contain precious metals, are disassembled in order to reuse some components.

Automatized disassembly in single purpose cells – only for one product – cannot be economically operated today. The number of devices or parts to be collected and concentrated on the place of the disassembly cell is usually too low for a two shift working of the cell. Therefore forming of relevant product groups (disassembly families) will be the key factor for the whole system. Here the optimum for the characteristics of disassembly, design and recycling must be found. These so called "disassembly families" are groups of similar or different products that require nearly the same disassembly operations – carried out with the same disassembly tools. For choosing the tools in a disassembly cell it is necessary to know all the different processes in such a cell.

3.1 Planning Tool for robotized disassembly cells

The kernel of this planning system consists of four independent, relational databases (Figure 3):

Product Database: The product database has to include all necessary information to build disassembly families. For the complete description of the product, the database has to contain also a

detailed description of the part connections (how to solve them, possible tools for solving the connections). One key aspect for the disassembly process is to know the "constitution" (age, damage, etc.) of the product and expected complications caused by this conditions.

Symbol Database: The pre-defined assembly icons from the Symbol Database have to be extended with representative disassembly steps.

Component Database: The description of available cell components has to be expanded with tools and systems necessary for disassembling. Especially, a detailed description of available sensor systems and their characteristic data has to be included to the Component Database.

Planning Database: Equivalent to the planning process of an assembly cell, the results of the design phase are written into the Planning Database. As an extension for the disassembling process, the proceeds of the disassembling can be calculated (and compared to the cost of the cell) and included to this database in order to proof the efficiency of the planned cell. As an additional result, the planning database also includes the calculated disassembly depth.

Parts Database: This database defines the current industrie's need of reusable and/or remanufacturable parts. Via connection to the world-wide-web (virtual market place) this information is permanently updated and represents the actual market demand. This information allows calculation of the required disassembly depth.

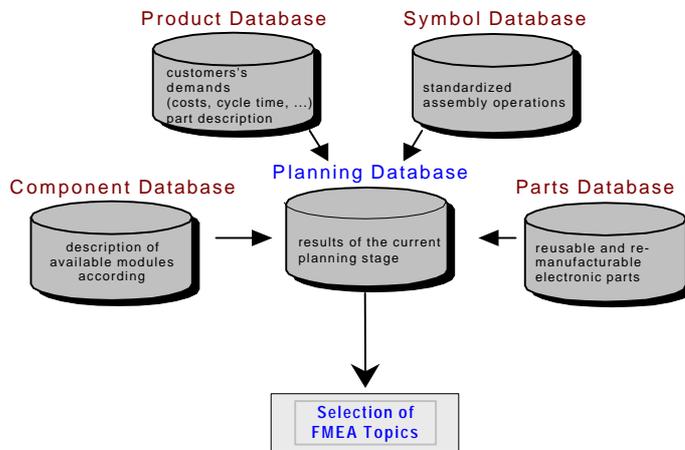


Figure 3. Structure of the planning system

3.2 Planning Software

The used Planning Software at the Institute allows a (semi-)automatic selection of disassembly cell components by manual selection of possible disassembly operations (selected from a list of predefined disassembly icons).

The centre of Software is built out of independent, relational connected parts:

- Product Database: Products, manufacturer, branches, . . .
- Symbol Database: Manufacturing symbols
- Component Database: Robots, grippers, tools, . . .
- Planning Database: Manufacturing planning
-
- **Disassembly FMEA**

In (Figure 4) you can see a **Selection Matrix** serves to allocate priorities for the total system and to limit them to a reasonable level for the implementation of an FMEA. Therefore the matrix is structured in different steps, beginning with COMPONENT GROUPS, COMPONENTS, FUNCTIONS, POTENTIAL FAILURE MODE. There are two important skills, the "communication" and "decision making" for several application programs with their own data structures and databases. This part of the software (Figure 5) creates a central information resource and can be accessed by each engineer (designer, manufacturer,.....).

It should be a single repository for all files associated with the entire development cycle of the product. I.e. from the conceptual development of product models to manufacturing models, till to the end of the life cycle the disassembly models. It establishes complete control over which users can access various product files, including changing files during different stages of the product development process and database administration with tools to archive and backup data. Most system would use a vendor independent database package, such an Oracle (kind of the main database) enabling applications and users to interact with standard database management software via SQL. The

database of the Process FMEA in the way of disassembly is written with a standard Office - database (Microsoft Access), and is compatible to the main oracle database (Engineering database).

COMPONENT GROUP		Selection Rating	Selection Parameters					Priority FMEA
Component	Function	RATING X WEIGHT:	Legal requirements	End user requirements	New production process	New material	Warranty cost	
	Potential Failure Mode	1 least important 2 important 3 very important						
		Weight						
COMPONENT GROUP	component							
	function 0							
							
							
	Function 1							
							
	Function 2							
							
	Function 3							
							
	Function 4							
							
							

Figure 4. Selection of FMEA Topics

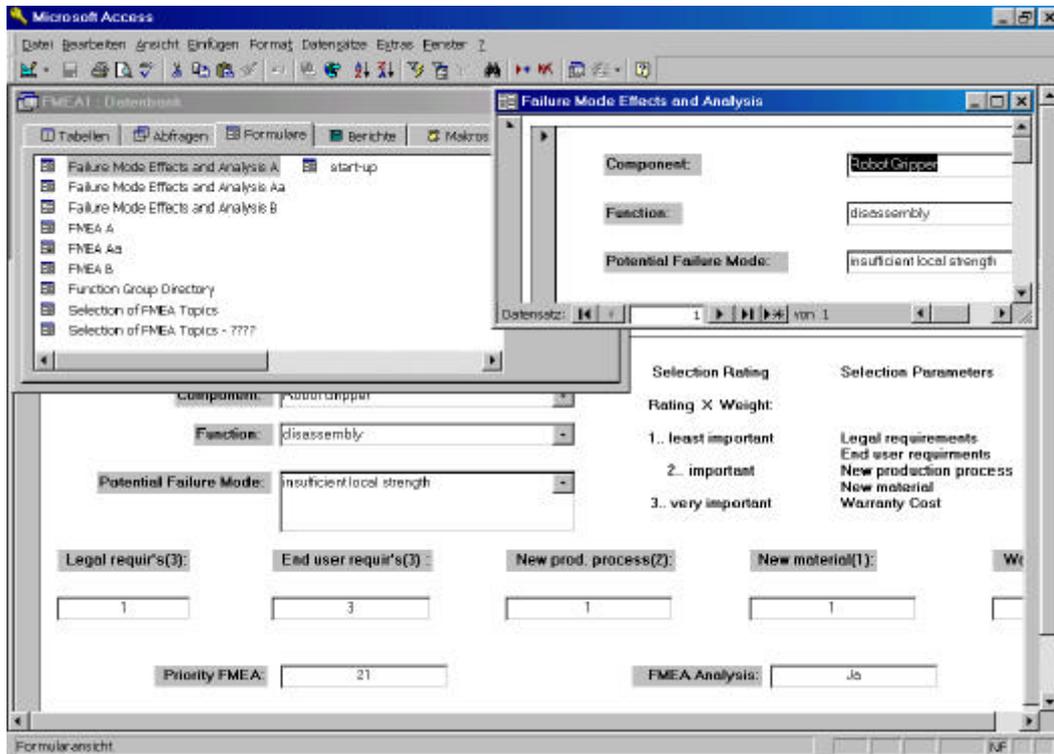


Figure 5. FMEA Database

4 CONCLUSION

The area in the field of disassembly/reuse is also new as in the field of the Disassembly FMEA in the Total Quality Control Area. The Planning software together with the FMEA tool should not only be used for Design - and Assembly FMEA it should also be used for the Disassembly FMEA and gives a view how to connect new quality areas (Quality Topics "ISO 9000", ISO 14000,...) with new technical areas, to reduce time and costs and to make things easier to handle.

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