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QUALITY PLANNING METHODS, DEVELOPMENT POSSIBILITIES OF RISK MANAGEMENT TOOLS BASED ON FUZZY EXPERT SYSTEM

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Abstract:
We would like to show APQP which is a project management tool in automotive industry to open up possible issues before serial production. The weak point of it is the lot of administration what it needs. If we can get over this difficulty with a well developed software, but it needs to make a mathematical model for the whole process. Some elements of APQP are defined yet, but there are gaps in handling of “customer voice” and the FMEAs. We believe we can cover this gap with fuzzy logic. We would like to examine this field and work out the software background.

1. Introduction

We would like to show APQP (Advanced Product Quality Planning) in this paper, which is a project management tool used in the automotive industry principally. It is a structured method for determine and perform the activities, which can provide the final product will satisfy the customer’s demands. It gives a frame for customer’s and supplier’s communication and ensure to involve all attendance of the process and execute every necessary steps in time.

The weak point of this project management tool is the lot of administrative work needs. When we start a project need to estimate the customer’s demands and later need to perform FMEAs for the product and the process as well what need to repeat to reach manufacturability and the best quality. 50-60 documents can be born when we do an APQP, which means a lot of manual work and really hard to handle them.

The authors’ aim is to get over these difficulties to make the chance of large spread of deeply and well implemented quality planning, which can improve the product quality in all fields of industry.

Mainly a well developed software could help to reach this aim, what needs to make a mathematical model for the whole process. Some elements of this project system are defined yet, for example statistical elements (SPC), but there are gaps in case of transformation of customer demands into engineering parameters and the FMEAs. We believe we can cover this gap with fuzzy expert system. We would like to examine this field and work out the software background.

The rest of the paper is organized as follows: In the Section 2. we learn the background of APQP and set it geographical and temporal. The best start to learn more about this project management

tool is to review the official standard, so in the second chapter we skim through APQP guideline (APQP Reference Manual, 2008). In the Section 3. we open up a potential developmental field of quality planning. We introduce FMEA and fuzzy set theory and the advantage of the combination of them (Pokorádi 2009). In the last section, the summary of this work and autors' future work are given.

2. Temporal and geographical set of APQP

APQP is an acronym for Advanced Product Quality Planning. This is a project management tool, which is a structured method to determine and proceed activities, which will ensure the product will adequate the customers' demand. It gives a frame for the communication between the supplier and the customer to provide every necessary steps will execute in time.

APQP was developed at the end of 1980's by a quality expert team of american automotive factory giants so called Big Three" (Ford, General Motors and Chrysler). This team spent five years with investigating the developing attitude of automotive industry, they learnt the details of it in America, Europe and mainly in Japan. The japanese factories won higher and higher renown in the American market in that time. The development of the process was happened in some steps. The first step was the conformation of Planning for Quality. This concept was concentrated mainly for the so called quality technics, which are suitable to increase the efficiency and the quality of processes.

The next step was the Advanced Quality Planning, which emphasized the project-planning-like approach of quality planning process. After it they get to Advanced Product Quality Planning. A QS 9000 guideline got this title to represent the project orientated approximation, the general nature for the preparation of future products. Till now the automotive factories require the application of APQP processes and techniques from tier one suppliers, furthermore ISO/TS 16949 certification to enjoy their advantages for example resource control to reach customer satisfaction, early recognition of necessary changes, or prevention of changes in late lifecycle of products.

Now we will learn, what cause the development of quality planning.

An average car contains thousands of parts. At the beginning automotive factories produced almost all the parts and built in their cars. During the industrial development mass production caused standardization, which based, that suppliers produce parts instead of automotive factories. With the evolution of production and transportation background, supplier background was built up around the automotive factories.

The automotive factories came over gradually for only assembly, as they have to concentrate for it only with the development on supplier background.

The new structure takes risks as well. The growing supplier background (in some case it means ten thousand supplier for one factory) become more difficult to handle. The other main issue was, that the quality of the cars depended on suppliers.

It was a huge problem for automotive factories, they must handle it. The first step was the inspection of parts received from suppliers which needed a lot of human resource, who can checked to quality of received items. The second step was to change the small suppliers for biggers, who make complete units like gearbox, running gear, and steering-gear. This was not mean the shrinkage

of supplier number, but the automotive factories had to work less partners. The bigger suppliers (tier one supplier) took the tasks of producing units for sub-contractors (tier two), so the tier ones had to control the quality made by tier two, hereby they established a multi level supplier system.

The other important step was the born of quality insurance and quality control and to require them from the suppliers. It took some advantages. The quality of supplied parts become smooth and the quality was better. The high human resource demand for inspection at receiving became unnecessary because of the smoothly reliable quality. This made the base for just in time system. At the beginning the automotive factories worked out their quality insurance system on their own (for example Chrysler made the Supplier Quality Assurance Manual, General Motors made the NAO Targets for Excellence or Ford made the Q-101 Quality System Standard. The suppliers usually produced parts for more factory, so they had to according to the requirement of every customers. Furthermore the automotive factories audited the conformance individually, so the suppliers have to take audits almost every week. The demand was arisen to standardize the quality requirement systems. The three biggest works (Chrysler, Ford, GM) made the mutual supplier requirements, the QS 9000. They agreed to accept a third partner’s audit instead of individual verification.

Every country with big automotive industry background worked out their own requirements for suppliers. Some different standards were born based on it for example VDA in Germany EAFQ (Evaluation Aptitude Qualité Fournisseur) in France, AVSQ (Valutazione Sistemi Qualitá) in Italy. These standards were similar in structure and in rules and all of them was built based on ISO 9001.

The world wide globalization caused the same phenomena what we could see above in the United States. Supply chains was built up among continents, countries which make the standardization necessary on world level.

That is why automotive factories in corporation with the International Organization of Standardization (ISO) worked out ISO/TS 16949 standard based on similarities of existent requirements. The first edition was published in 1999, the reviewed version was made in 2002. One main reason of this standard was to change the region specific standards. At the beginning it started really hard, but some fusion in the automotive industry accelerated this process (for example Chrysler and Daimler).

Nowadays VDA and ISO/TS 16949 standards are used, QS 9000 has not used since 2005.

These standards are similar, the basis is ISO 9001 and the different points of it were completed with automotive industry requirements. To make the usage easier, the writers make guidelines, which give samples for the different points and tools. One of them is APQP guideline, part of QS 9000.

The built up of ISO/TS 16949 has a similar structure what we have learnt above, use ISO 9001 as a basis, and complete it with automotive requirements. The difference is, that it has not got own guidelines, it only refers for existent guidelines of VDA and QS 9000.

It standardizes the previous requirements, but leaves the possibility for the factories to use their systems and tools (like APQP, FMEA, SPC). So in case of previous requirements the guidelines of basic rules were abrogated, but the additional guidelines stay in use.

3. Build-up of APQP briefly

APQP can be used as a guideline during the development/design phase; furthermore it is a standardized frame to ensure the communication of the results between customer and suppliers.

APQP guideline determines three main phase:

- Development
- Industrialization
- Product Launch

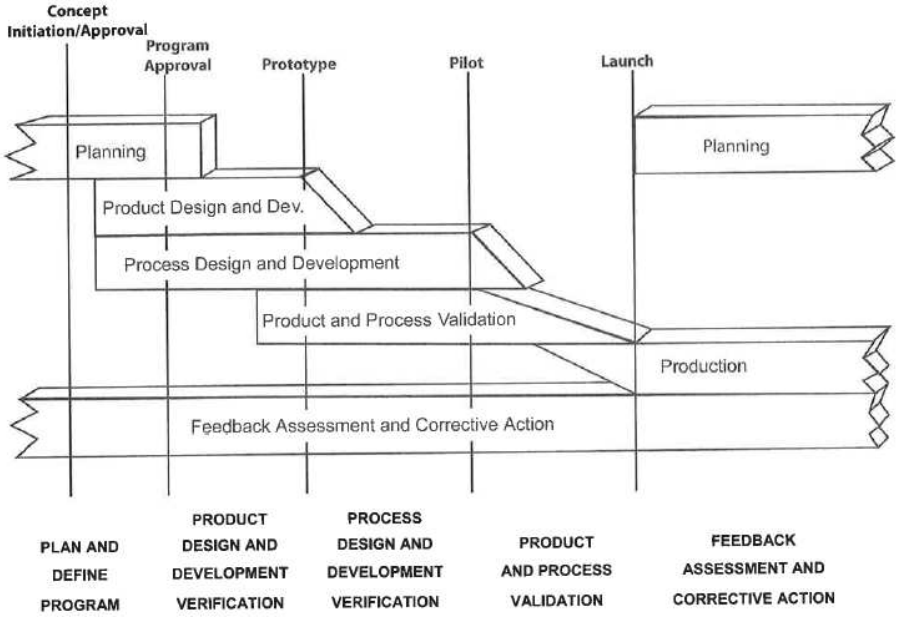

Figure 1. Product Quality Planning Timing Chart
*source: (*Chrysler Corporation, 2008)

These chapters contain 23 topics, all of them are recommended to go through before mass production. Some of these topics: durableness, test planning, specifications, quality inspection

requirements, specification of packaging and the process capacity, testing of finished products or training plan for operators. The main questions of APQP: quality planning, measurement of customer satisfaction and transformation customer demands into engineering parameters. The guideline builds up from five chapters: plan and define program; product design and development; process design and development; product and process validation; feedback, assessment and corrective action. Central elements: learn customer demands, proactive feedbacks and corrective actions, planning within the process capability, failure mode and effect analysis and mitigation, review and validation, check plans, control of special and critical factors.

In Figure 1., we can see the timing chart of APQP.

4. The Failure Modes and Effects Analysis

Based on our initial research we found, FMEA has the biggest potential to develop in APQP. That is why we start our work to learn FMEAs applied in quality management. We can see the development with combination of FMEA and fuzzy logic. First we introduce FMEA and fuzzy in general.

The Failure Modes and Effects Analysis (FMEA) is a method of reliability analysis intended

to identify potential failures which have significant consequences affecting the system performance. In a Failure Modes and Effects Analysis the Probability of Failure (PoF), Consequence of Failure (CoF) and detectability (DoF) of an undesired event may be determined using engineering judgment and/or based mathematical models, where the result is expressed in a terms. The terms qualities and quantities are sometimes used to distinguish these methods. The fuzzy FMEA is a quantitative method of reliability or risk analysis which involves the study of the failure modes can occur in every part of an integrated system. Fuzzy Logic is a form of logic used in some expert systems and other artificial-intelligence applications in which variables can have degrees of truthfulness or falsehood represented by a range of values between 1 (true) and 0 (false) (Zadeh, 1965). With fuzzy logic, the outcome of an operation can be expressed as a probability rather than as a certainty. For example, in addition to being either true or false, an outcome might have such meanings as probably true, possibly true, possibly false, and probably false.

Fuzzy logic seems to be a powerful mathematical tool capable of combining linguistic and numeric variables in order to estimate the subjectiveness involved in risk analysis and determine whether a risk or criticality level is acceptable or not. To prepare the fuzzy logic-based failure mode and effect analysis firstly the occurrence, severity, detectability and criticality level categories and they membership functions should be determined with an eye to characters of investigated system or process. Practically [1, 10] scales should be used, similarly to traditional FMEA.

APQP guidelines distinguish process FMEA (PFMEA) in case of assembly type processes and the design FMEA (DFMEA) during design phase.

FMEA is not just a planning and design tool, but a monitoring method as well. It is useable in implementation phase and in case of an applied process also to further grade up of product and process by historical failure data. Strongly recommended to repeat FMEA again and again to get continuous feedback and the best results in development and failure prevention.

5. Summary

In this paper we met with APQP which is the standard of quality planning. We learnt the structure of it and set it temporal and geographical as well to determine its place in the muddled jungle of standards. We discussed the essence of FMEA (the part of APQP which has the most resource demand, so it hides the highest potential to develop), essence of fuzzy logic and the advantage of combination of them.

The authors' aim was to get over the high resource and the lot of paper work demand of quality planning to make the chance of large spread of deeply and well implemented quality planning, which can improve the product quality in all fields of industry.

Mainly well developed software could help to reach this aim, what needs to make a mathematical model for the whole process. We start our future work with learning the APQP and investigation of possible fields to develop. In this paper we examine FMEA only, but our plan is to go ahead on this way and continue other field like “voice of costumer”.

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