We are IntechOpen, the world's leading publisher of Open Access books
Built by scientists, for scientists

6,900
Open access books available

185,000
International authors and editors

200M
Downloads

Our authors are among the

154
Countries delivered to

TOP 1%
most cited scientists

12.2%
Contributors from top 500 universities

CLARIVATE ANALYTICS
BOOK CITATION INDEX
INDEXED

WEB OF SCIENCE™

Selection of our books indexed in the Book Citation Index
in Web of Science™ Core Collection (BKCI)

Interested in publishing with us?
Contact book.department@intechopen.com

Numbers displayed above are based on latest data collected.
For more information visit www.intechopen.com

The Application Research of Intelligent Quality Control Based on Failure Mode and Effects Analysis Knowledge Management

Zhao Xiuxu

Wuhan University of Technology, Wuhan, Hubei, 430070,
China

1. Introduction

SPC provides statistical techniques and graphical displays control charts to enable the quality of conformance to be monitored and special causes of process variability to be eliminated(Montgomery D.C. 2005). Combining with computer technology and the automatic control technology, SPC has realized the product quality on-line control. With online SPC system, a large amount of manufacturing process quality data can be collected and stored in SPC database. These data can be visited via the operation in SPC database, and many kinds of quality reports can be generated for specific using. However, this technology has not been all well applied in enterprises(Venkatesan G., 2003). In practical manufacturing process, after the operators getting the analyzed results from SPC system, they need to make decision to eliminate the fluctuation in manufacturing process. But it is largely dependent on the personal knowledge and experience level of the operator on-site. Under this specific situation, the decision results are uncertain, and it may also lead to the quality problems can't be solved in time. So, it is very important to find appropriate methods to support the operators' decision making, especially the techniques which can facilitate the operators make right decision in time.

Considering the existing limitations discussed above, this research is prompted by the need to have a technique that will enable the intelligent acquisition of Failure Mode and Effects Analysis (FMEA) knowledge for the decision making in the quality control process. The study specifically looks at the intelligent knowledge searching and reasoning in FMEA repository, which can facilitate the operators decision making.

In this chapter, FMEA knowledge sharing in the manufacturing process quality control will be discussed after the brief review of FMEA, and an application system named IQCS has been developed to manage the FMEA knowledge for the manufacturing process quality continual improvement.

2. FMEA and manufacturing process quality control

2.1 The origin and development of FMEA

FMEA is a technique that identifies the potential failure modes of a product or a process and the effects of the failures, and assesses the criticality of these effects on the product

functionality. According to BS 5760 Part 5, "FMEA is a method of reliability analysis intended to identify failures, which have consequences affecting the functioning of a system within the limits of a given application, thus enabling proofs for action to be set." (British Standards Institution, 1991) It provides basic information for reliability prediction, product and process design (Sheng-Hsien Teng & Shin-Yann Ho, 1996).

In the early 1950s, Grumman Corporation in U.S. applied the FMEA firstly and got very well results (Hai ZHANG & Zhi-bin ZHOU, 2007). Since then, FMEA obtained widespread applications in the military system design, such as the aviation, astronautics, ships, weapon etc. Under the leadership of Ford Company, Big Three auto makers started to introduce FMEA in the product quality improvement (Daimler Chrysler Co., Ford Co. & General Motor Co., 2008). Then, FMEA had been widely applied in vehicle safety assurance. With the application value of FMEA had been widely recognized, FMEA has been applied in more and more other fields, such as machinery, medical equipment, nuclear power, food safety assurance etc. After a long time development and improvement, FMEA has become a necessary reliability analysis work which must be completed in system development (Stamatis D.H. 2003).

Traditionally, FMEA is used in hard copy or spreadsheet format to capture the potential problem of a design or process. The knowledge captured is aimed for reuse. However, as the knowledge in the FMEA grows, it gets harder and harder to be reused. The implementation of a highly manual FMEA system is a difficult task. FMEA is found to be not user friendly, hard to understand and not very flexible.As a result, many companies use FMEA merely to satisfy the contractual requirements of their customers (Dale B.G., & Shaw P., 1996). Users always find FMEA is a "tedious and time-consuming activity" (Price Chris, Pugh David R., Wilson Myra S., & Snooke Neal, 1995). It is especially true when FMEA is used in complex systems with multiple functions (Hai ZHANG, & Zhi-bin ZHOU, 2007).

2.2 The significance of FMEA knowledge acquisition in process quality control

With the increasing complexity of modern manufacturing system, there are more and more uncertain factors in manufacturing process, and the difficulties of process reliability analyzing increased greatly. Meanwhile, the quality problem dealing and analyzing are restricted enormously by the personal knowledge and experience level of the on-site operators. FMEA knowledge resources, which have been accumulated in the earlier periods, can not only facilitate the comprehensive decision making, but also improve the quality problem analyzing process. So, it is significant for the manufacturing process continual improvement to utilize the FMEA knowledge resources.

3. Intelligent quality control system

3.1 The structure and orinciple of IQCS

As shown in Fig.1, the structure model of the IQCS mainly contains three tiers:

1. Function tier: It makes the real-time data acquisition and analysis in the manufacturing process. It can output the statistical analysis results in the form of quality report, and input the data of manufacturing process into the SPC system database.
2. Data tier: It implements the FMEA process, which is conducted by the experts coming from different area, such as design, manufacture and quality management etc. The knowledge and experience of experts will be extracted by the "Brain Storming" activity. Then, the FMEA results will be transformed into FMEA knowledge according with specific method, and put into FMEA repository.
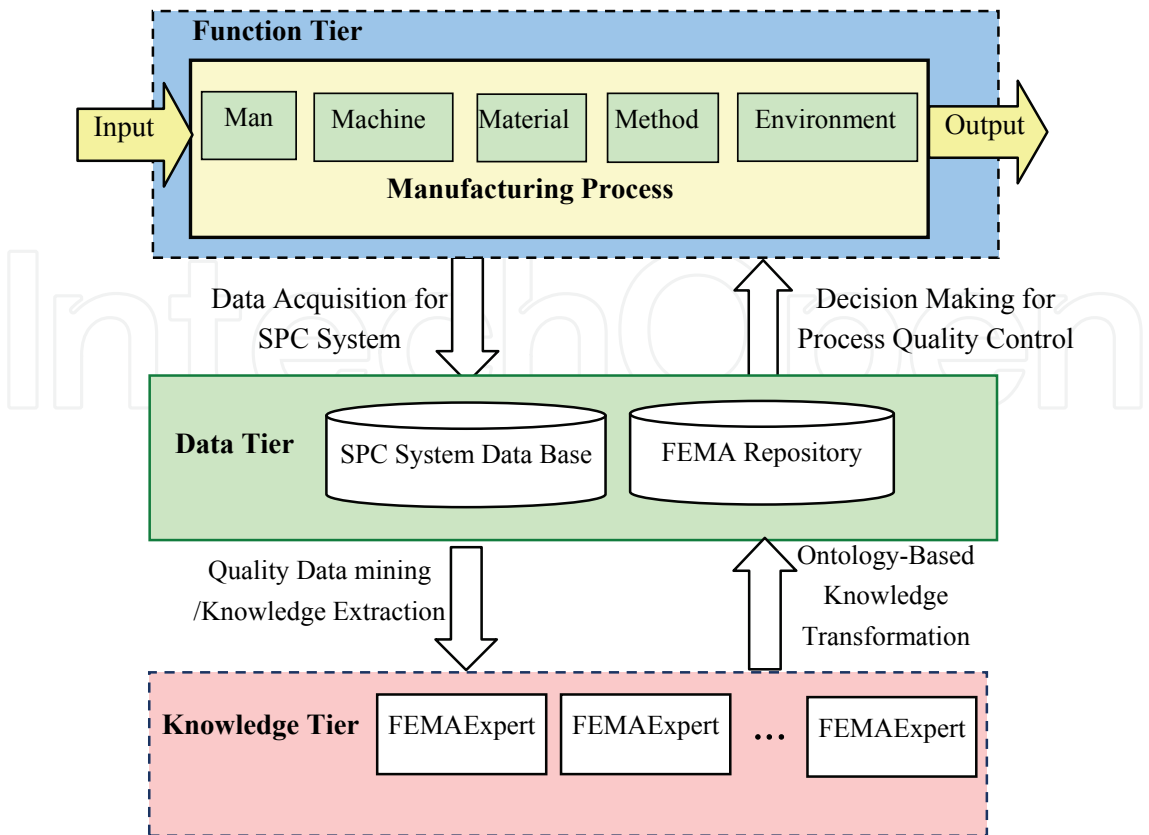
Fig. 1. The principle of IQCS based on FMEA repository

3. Knowledge tier: It is a database that is designed to store the data collected by SPC system, and the knowledge will be stored in the FMEA repository which is designed with specific structure.

In the practical manufacturing process, the function tier of SPC system will do the collecting and analysis of the real-time process data, then, the statistical analysis results will be output according to the users' specific requests, and the manufacturing process data will be put into the SPC system database. The function tier of FMEA is to complete the FMEA process. The interaction tier, which includes SPC system database and FMEA Repository, is responsibe for the dynamic interaction between FMEA and SPC system. There are two tasks: the first one is to extract information dynamically from SPC system for FMEA process, and the other one is to visit FMEA repository to provide decision supporting for quality control and system adjusting in the manufacturing process. So, it is very important to establish the interaction mechanism of the interaction tier.

3.2 The operation of IQCS system.

In manufacturing process, the function of IQCS is realized by the operation of FMEA and SPC system through data mining/ information extracting process and dealing with problems and decision process. The data mining/ information extracting process collects manufacturing process data dynamically from SPC system, and these data will be provided for the experts to conduct FMEA process. The results of FMEA will be transformed and put into FMEA repository, provide real-time decision supporting for operators to analyze the quality problems, and adjust manufacturing system in time. In this process, the most

important keys are Data mining/Information extracting, FMEA knowledge transformation, and the interaction between SPC and FMEA.

3.2.1 Data processing and FMEA knowledge extracting.

To make full use of the large amount of quality data and messages in manufacturing process in SPC system database, the main function of Data mining/FMEA Information Extracting is to develop specialized algorithm of knowledge discovery and data mining based on Knowledge Discovery in Databases.

3.2.2 FMEA knowledge transformation based on ontology

Because of the diversity and complexity of FMEA knowledge, object-oriented knowledge expressive method, process model method and predicate logic method, frame described method and production rule method now often used all have disadvantages in some extent. These methods can not express the meaning of FMEA knowledge precisely. Ontology has accurate form of expression and explicit semantic which can definite the relationships between concepts, concept and object, also objects. This useful expressive form reduces the misunderstandings of relationship of concept and logic, and makes the share and reuse of knowledge possible. It is the important theory evidence of FMEA knowledge system based on ontology.

The expressive method based on ontology can depict basic knowledge system of certain domain through normal description of concept, term and the relationship between them. The method can not only depict the object-hierarchical model, such as organization, resource, product, but also denote nonfigurative affair, such as faith, target, plan, activities. Using ontology to denote knowledge can make FMEA knowledge-frame legible. FMEA knowledge may be organized systematic and constructional through knowledge-modeling based on ontology. The well-organized model can promote analysis and answer of quality. Meanwhile, it is useful to share and reuse the knowledge inner corporation even between corporations in the same domain.

3.2.3 The interaction between SPC system and FMEA repository

In order to combine FMEA with SPC dynamically, the internal relations between SPC system and FMEA repository must be established combining with specific manufacturing process, and knowledge discovery in FMEA is driven by the results of SPC system. The coordination mechanism of database and repository is introduced in the transformation of tacit knowledge which mainly come from the experience of experts(You-zhi XU, Dao-Ping WANG, & Bing-ru Yang, 2008). Based on the learning form above references, the IQCS system operation process was developed. Firstly, the structured data of product key quality characteristics value are founded according to the manufacturing process, secondly, intelligent searching and reasoning process in FMEA repository will be started through the association of product and its corresponding characteristic value, finally the FMEA knowledge responded to the key quality characteristic value will be attained.

3.3 An illustrative example Of IQCS

Combining with specific manufacturing quality control process, the quality data extracting and the abnormal quality problem analysis process in IQCS are as follows:
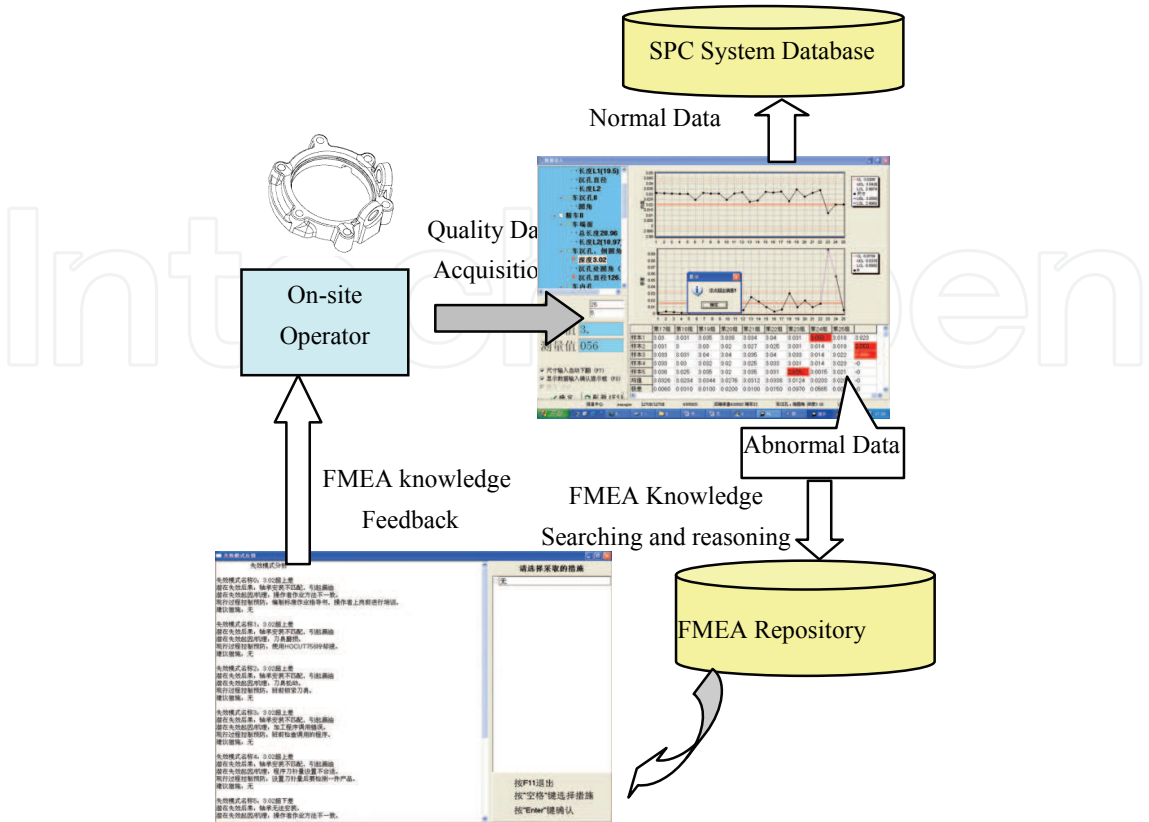
Fig. 2. A specific quality control process based on FMEA repository and SPC system

Step 1. The operator extracts the quality data according to the key quality characteristics. The regular data will be put into the SPC database, if the irregular data appear, then switch to step2;

Step 2. The system will remind the on-site operator with a pop-up message and start to the searching in FMEA repository at the same time.

Step 3. After finding out the corresponding FMEA knowledge in the FMEA repository, the results will be sent back to the operator through system interface to support the operators' decision making.

The specific flow chart of this process is shown in Fig.2.

4. Conclusion

In order to solve the problems of analyzing quality problems in manufacturing process and eliminate the uncertainty in manufacturing system adjustment decision making, this paper presents an approach which can transform the tacit knowledge in FMEA process effectively through a FMEA repository based on ontology.

Combined FMEA with SPC system, the intelligent searching and reasoning can be realized through the cooperation of FMEA repository and SPC database. And FMEA repository based on ontology can realize the FMEA knowledge sharing and reusing through the intelligent reasoning technology.

Based on the theoretic study, an application system IQCS has been developed for specific manufacturing process. Its application shows that it can not only improve the efficiency of

quality control, but also prevent the potential quality problem. Thus, the independence of quality fluctuation in manufacturing process will be enhanced.

This research provides an effective way for decision making of process quality improvement and the manufacturing system adjusting. Based on the current study, further research will focus on enable techniques development which can facilitate the dynamic coordination of FMEA repository and SPC system in manufacturing process.

5. Acknowledgment

6. References

British Standards Institution, (1991). Reliability of systems, equipment and components, Guide to failure modes, effects and criticality analysis (FMEA and FMECA). BS5760-5-1991

Daimler Chrysler Co., Ford Co. & General Motor Co., (2008). Potential Failure Mode and Effects Analysis, FMEA (Fourth Edition).

Dale B.G., & Shaw P., (1990). Failure mode and effects analysis in the UK motor industry: a state-of-the-art study, *Qual. Reliab. Int.* V6, No. 3, pp. 179-188. ISSN 07488017

Hai ZHANG, & Zhi-bin ZHOU, (2007). Progress of Failure Mode and Effects Analysis, *Aeronautical Manufacturing Technology*, Vol. 8, No.65. pp.64-66. ISSN 1671-833X

Montgomery D.C. (2005). *Introduction to Statistical Quality Control* (fifth ed.), John Wiley, ISBN 9780471656319, Hoboken, NJ.

Price Chris, Pugh David R., Wilson Myra S., & Snooke Neal, (1995). Flame system: automating electrical failure mode and effects analysis (FMEA), *Proceedings of the Annual Reliability and Maintainability Symposium*, pp.90-95. ISSN 0149144X

Sheng-Hsien Teng, & Shin-Yann Ho, (1996). Failure mode and effects analysis – an integrated approach for product design and process control, Int. J. *Qual. Reliab. Mannag.* Vol. volume number, No. issue number, Vol. 13, No. 5, pp.8-26. ISSN: 0265-671X

Stamatis D.H. (2003). Failure Mode and Effect Analysis: FMEA from Theory to Execution (Second Edition). American Statistical Assoc Quality Press, ISBN0873895983, Milwaukee,Wisconsin, USA,

Venkatesan G., (2003). Process control of product quality, *ISA Transactions 42*. pp.631–641. ISSN 00190578

You-zhi XU, Dao-Ping WANG, & Bing-ru Yang, (2008). Research on Tacit knowledge Transformation Model Based on Double Bases Cooperating Mechanism, *Soft Science*, Vol. 22, No.8, pp.6-10. ISSN 1001-8409

Applications and Experiences of Quality Control

Edited by Prof. Ognyan Ivanov

ISBN 978-953-307-236-4

Hard cover, 704 pages

Publisher InTech

Published online 26, April, 2011

Published in print edition April, 2011

The rich palette of topics set out in this book provides a sufficiently broad overview of the developments in the field of quality control. By providing detailed information on various aspects of quality control, this book can serve as a basis for starting interdisciplinary cooperation, which has increasingly become an integral part of scientific and applied research.

INTECH
open science | open minds