Available online at www.sciencedirect.com

ScienceDirect

Procedia CIRP 57 (2016) 286 – 291

www.elsevier.com/locate/procedia

49th CIRP Conference on Manufacturing Systems (CIRP-CMS 2016)

A Novel Approach for Mission Reliability Modeling of Manufacturing System Based on the State Change of Machines and Materials

Changchao Gu[a] *, Yihai He [a,b], Xiao Han[a]

[a] School of Reliability and Systems Engineering, Beihang University, Beijing, China.
[b] Department of Systems Engineering and Engineering Management, City University of Hong Kong, Hong Kong , China.

* Corresponding author. Tel.: +86-10-82338673; fax: + 86-10-82338673. *E-mail address: buaagcc@buaa.edu.cn*

Abstract

Traditional reliability modeling for manufacturing systems often pays too much attention to the basic reliability of their components, which ignores the dynamic polymorphism characteristics of the multi-station manufacturing system. To resolve this dilemma, a novel mission reliability modeling approach of manufacturing systems is proposed at the first. This method regards the dynamic state change of machines and materials in the manufacturing process as the focus, and integrated three indicators of task demands, machine processing capacity and the qualified rate of machine in manufacturing process respectively. Then, a decomposition method is proposed for describing the change of the number of materials in each state. Subsequently, the specific process of mission reliability modeling for a multi-station manufacturing system with reworking action is described. Finally, a case study of piston ring manufacturing system has been used to validate the proposed approach.

© 2016 The Authors. Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).
Peer-review under responsibility of the scientific committee of the 49th CIRP Conference on Manufacturing Systems

Keywords: manufacturing system, mission reliability, reliability modeling, state change

1. Introduction

Nowadays, consumers need faultless assurance that the products produced by the manufacturing system have good quality and continued functionality. Many scholars have been aware that the upper bound of product reliability is determined in design stage, and the manufacturing stage has a crucial role in the assurance of product inherent reliability [1][2][3]. Therefore, in order to satisfy the increasing requirements of zero-defect manufacturing, the reliability analysis of the manufacturing system has been paid more attentions by many scholars.

Alexander [4] studied the method of reliability evaluation of equipment in mechanical system under the special condition. Sharma [5] studied the usage of fault tree analysis (FTA) and failure mode and effects analysis (FMEA) in conjunction to analyze the reliability of a complex mechatronic system in both qualitative and quantitative manner. Li and Ni [6] developed a maximum likelihood estimation method to modeling reliability of manufacturing system based on actual operational data of manufacturing systems. Li et al. [7] put forward a reliability prediction model of manufacturing system by using the grey model.

However, those above studies are mainly focused on the basic reliability of the components of the manufacturing system. They are more concerned about the manufacturing system reliability as the reliability of related machines, components and fixtures. Fortunately, there are a few studies have been carried out on the expansion of the connotation of manufacturing system reliability. Chen and Jin [8] put forward that the reliability model of manufacturing system should be integrated into reliability of manufacturing system component and product quality. He et al. [9] proposed a method of reliability modeling and optimization strategy for multi-station manufacturing system based on RQR chain. From the point of view of product size, based on the state space model, Zhang et al. [10] evaluated the reliability of the manufacturing system by establishing a quantitative relationship between key product characteristics and key control characteristics. Lin and Chang [11][12] regarded the

2212-8271 © 2016 The Authors. Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).
Peer-review under responsibility of the scientific committee of the 49th CIRP Conference on Manufacturing Systems
doi:10.1016/j.procir.2016.11.050

manufacturing system as a stochastic-flow network and studied the method of its reliability evaluation.

From the above literature review, we can see that although some scholars have begun to expound the reliability of manufacturing system from the systemic perspective, and realized that products are part of manufacturing systems. The polymorphism of manufacturing systems has been neglected for a long time, which leads to the reliability of manufacturing systems is often computed purely based on historical failure and degradation data collected from manufacturing process. However, in the manufacturing process, the manufacturing system reliability is often dynamic because of the state change of machines and materials caused by different task demands as well as other factors. Therefore， in order to resolve this dilemma, a novel approach for mission reliability modeling is proposed in this paper, which regards the dynamic state change of machines and materials in manufacturing process as the focus, and integrated three indicators of task demands, machine processing capacity and the qualified rate of machine in manufacturing process respectively.

2. The foundations of mission reliability modeling for manufacturing system

2.1. Connotation of mission reliability of manufacturing systems

Classical reliability is defined as the ability to complete a set of required function in the stipulated condition and within the stipulated time. Reliability is generally divided into basic reliability and mission reliability. The mission reliability of product is related to functions of the components. However, the mission reliability of manufacturing system is not only related to machines, inspection, materials and other process elements, but also associated with the actual dynamic task demands. In the life cycle of a multi-station manufacturing system, when implement different tasks according to production plan, the machines involved in those tasks may be different, the work load and reliability demand of those machines will be different too. That is, because the task demands are "dynamic", the list of involved machines is “dynamic”, and work load of each machine is "dynamic".

The purpose of running manufacturing systems is to output a certain amount of qualified finished or semi-finished products within the specified time. Given a specific task, the mission reliability of the manufacturing system can be referred as the ability that the manufacturing system can complete the production task under specified conditions and within the specified time.

2.2. Definition of the state of materials and machines

Definition 1： State of materials

The state of the material is normally divided into two kinds in the manufacturing process, namely, qualified and unqualified. However, in some special process, reworking action may exist, which lead the nonconforming state can be divided into two "to rework" and "non-rework" two states in the whole manufacturing system. So in this paper, the state of the WIP (work in process) can be divided for three quality states: a good state (s_1), a defective repairable state (s_2) and a scrapped state (s_3). Wherein, the state (s_1) can be divided into a good state without repair (s_1') and a good state after repair (s_1'') .In the absence of special instructions, generally considering that there is no difference between state (s_1') and state (s_1'').

Therefore, the state of materials can be expressed as below:

$$S_{material} = \{s_1', s_1'', s_2, s_3\} = \{s_1, s_2, s_3\} \tag{1}$$

Definition 2： State of machines

The machine state is not as fixed as the state of the material. It is a random fluctuation in a certain range. In this paper, the state of the machine is represented by the processing capacity of the machine (C_{ix}) . Due to the maintenance, partial failure, failure and other factors, the processing capacity of each machine is often stochastic.

Thus, the state of machines can be expressed as below:

$$S_{machine} = \{C_{ix}\} \tag{2}$$

2.3. Overlapping decomposition and quantity relation of the state of materials

To analyze such a manufacturing system with a serial production line, multiple inspection stations, and reworks, an overlapping decomposition method is proposed to decompose the complex process into two simple processes as shown in Fig. 1. And the quantity relation of each state of materials can be obtained too.

For the purposes of this paper, a number of assumptions about the state of materials are made:

- No defective repairable state (s_2) will appear unless there is a rework process;
- Each material with defective repairable state (s_2) is reworked by the same machine only once. That is, if a defective repairable material after reworking is still defective, it will enter into the scrapped state (s_3).

Download English Version:

https://daneshyari.com/en/article/5469833

Download Persian Version:

https://daneshyari.com/article/5469833

Daneshyari.com