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Planning of maintenance activities – A current state mapping in industry

Maheshwaran Gopalakrishnan [a]*, Jon Bokrantz[a], Torbjörn Ylipää[a], Anders Skoogh[a]

[a]*Chalmers Univeristy of Technology, Göteborg 41296, Sweden*

* Corresponding author. Tel.: +46 72 963 6517. *E-mail address:* mahgop@chalmers.se

Abstract

Industrial Product Service System (PSS) thinking can be applied to production system by considering it as a product. Prior studies show that strategic planning of the maintenance activities in manufacturing industries holds great potential to increase productivity. Planning of maintenance activities is therefore an integral decision making aspect for maintenance engineers and it is important to analyze how industries are currently working with planning of maintenance activities and what additional support is needed. This paper aims at mapping the current state of the work procedures for maintenance engineers and planners in the industry and analyzes the gap from current practices to the strategic planning which could increase productivity. The study specifically focuses on how industries work today with finding critical resource, performing criticality analysis, and planning maintenance. A descriptive research approach is followed, where empirical data is collected in Swedish industry through three different data collection methods. The results show the state-of-art industrial practices and the gaps in maintenance planning.

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Keywords: maintenance planning; criticality analysis; system bottleneck

1. Introduction

Industrial Product Service Systems (PSS) offers business innovation and sustainable development for industries by integrating production and service for their products. Manufacturing industries have complex production systems producing different products. In order to produce products of high quality the production system needs maintenance [1]. However, overall equipment effectiveness (OEE) in manufacturing companies is about 50 – 55% in manufacturing industries [2]. These production losses are due to direct down time (failures) and system losses (blocked and idle states) of machines in flow-oriented production system. These result in economic sustainability losses to the company. Ecologic sustainable losses occur as 30% energy losses are due to system losses [3]. By considering the production system as a product, the PSS thinking can be employed to the production system. This will make the production system highly productive, sustainable, and reliable.

A prior study shows that through strategic planning of maintenance activities, productivity can be increased by about 5% [4]. Therefore maintenance activities planning is an integral decision making aspect for maintenance engineers, requiring support from modern methodologies, data analysis approaches, and Information and Communication Tools (ICT). Currently, the maintenance department in industries on the contrary use limited tools and analyses to assist their decision making on an everyday basis [5].

Critical sections of the production system should be effectively utilized. Dynamic decision support is needed for maintenance and existing maintenance management systems are insufficient [6]. There are different ways in which critical sections of the system could be classified. Failure mode effect and criticality analysis (FMECA) is the frequently method [7]. Throughput criticality classification can be used for decision support system for planning of maintenance tasks [8] and an analytic hierarchical process (AHP) based [9] can also be used for maintenance. Criticality analysis needs to be continuously updated every day to prioritize maintenance activities [10]

With complex production, prioritization of maintenance work-orders becomes crucial and challenging [11]. Throughput improvement can be achieved through

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prioritizing maintenance activities for the static and dynamic bottleneck machines [4]. The highest criticality is given to the equipment that is most important for a specific purpose, which normally is production. The equipment with the highest criticality gets the highest priority code and is thus scheduled first when performing maintenance [1]. Effectiveness is achieved through prioritizing machines' criticality, and focusing on specific components [9].

Hence there is strong motivation to understand the use of criticality classification and bottleneck detection in the industries in relation to planning of maintenance. In order to do that, a current state mapping of how companies currently working with planning of maintenance activities and the additional needed support is necessary. Therefore the authors formulate the following research questions (RQ):

RQ1: To what extent are companies working with criticality classification?

Finding the extent to which companies work with criticality classification is an important starting point as this will help in identifying the critical resource of the system, as in RQ2.

RQ2: What is criticality from a maintenance perspective, and how are critical resources identified?

Criticality classification can be created in many different ways and from different perspectives. Finding the critical resource from a maintenance perspective will help in prioritizing maintenance activities, as in RQ3.

RQ3: To what extent are maintenance activities prioritized, and how are the criticality classification used for this purpose?

Maintenance activities for production system needs effective planning. This paper will identify the extent to which maintenance activities are prioritized and the use of criticality classification for the same.

2. Methodology

Three mixed method research questions were stipulated, with the intent of increasing knowledge about how criticality and bottleneck detection is used from a maintenance perspective in industry. A descriptive survey research approach was adopted [12, 13], aiming to provide additional information about the use of these practices in industry, where the three questions serves to explore and explain the current situation. The three data collection methods were used to form empirical evidence to answer the research questions. Quantitative data was collected using a web-based questionnaire survey and structured interviews during a maintenance fair, and a combination of quantitative and qualitative data was collected using semi-structured interviews. Throughout the paper, the three data sets will be referred to as the "survey", "maintenance fair", and "interviews". The three data collection methods were chosen in order to investigate the subject area from both a general and a specific perspective. The survey and the maintenance fair describe the general perspective since it was collected from both small and large companies in various industrial branches and production contexts. In contrast, the interviews depict a specific perspective since they were conducted in two of Sweden's largest discrete manufacturing companies.

2.1. Survey

Quantitative data was collected in Swedish industry through the use of a web-based questionnaire. Invitation to the questionnaire was sent by e-mail to selected respondents, and an open invitation was listed publicly on the website of Sustainability and Maintenance Global Centre (SMGC), as well as included in an SMGC e-mail newsletter. SMGC is a non-governmental maintenance organization with over 50 member companies. A non-probabilistic judgement sample was used [12], where the primary target group were maintenance or production experts.

62 out of 82 selected respondents answered, resulting in a response rate of 75 percent. The open invitation resulted in 22 additional responses. Out of the total 84 submissions, non-experts were excluded, and the respondents with the highest management level were chosen at plant-level for each company. The final selection consisted of 76 responses from 71 companies, where the 5 duplicates represent individual respondents from different plants within the same company, but separated geographically and operating with different management. A majority of the respondents can be classified as the maintenance department. The companies represent various production contexts such as manufacturing, energy, nuclear, paper and food industries. The questionnaire covered the topics of criticality, bottleneck detection, and maintenance prioritization. The remaining part of the questionnaire covered other areas such as production disturbances, tools and methods in maintenance etc.

2.2. Maintenance Fair

Seven structured interviews were conducted during one day of Scandinavia's largest maintenance fair, which was held during 4 days in March in Gothenburg with 250 participating companies. These interviews were short (less than 10 minutes), and focused specifically on the topics of tools and methods used in maintenance planning, use of priorities, criticality, and bottleneck detection. The interview questions were formed as a combination of closed questions with multiple choices and open-ended question.

2.3. Interviews

Four semi-structured face-to-face interviews [14] were conducted with personnel of the maintenance department from two of the partner companies in the research project "StreaMod". Three maintenance managers and one maintenance strategist were selected as interviewees since they represent high strategic level within large multi-national corporations, thus indicating a specific context that could benefit from using bottleneck and criticality analysis in maintenance. The interview template was created on the basis of the previous two data collection methods, and covered the topics of criticality and bottlenecks. The interviewees received information regarding the covered topics prior to the interviews. The concepts were not explained in further detail at this point, thus assumed to be familiar to the interviewees. The interviews were structured to first ask about the critical