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Industrial application of RAM modeling Development and implementation of a RAM simulation model for the Lexan® plant at GE Industrial, Plastics

P.M. Herder[a,*], J.A. van Luijk[b], J. Bruijnooge[c]

[a]Department of Technology, Policy and Management, Energy and Industry group, Delft University of Technology, P.O. Box 5015, 2600 GA, Delft, The Netherlands
[b]GE Quartz Europe GmbH, Borsigstrasse 1-7, 21502 Geesthacht, Germany
[c]GE Industrial, Plastics, Bergen op Zoom, The Netherlands

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Abstract

A RAM (reliability, availability and maintenance) model has been built for the GE Industrial, Plastics Lexan® plant in Bergen op Zoom, The Netherlands. It was based on a Reliability Block Diagram with a Monte Carlo simulation engine. The model has been validated against actual plant data from two different sources, and against local expert opinions, resulting in a satisfactory simulation model. The model was used to assess two key decisions that were (to be) made by GE Industrial, Plastics concerning operation and shutdown policies of the plant. The model results showed that the operation and maintenance could be further improved, and that in doing so the annual production loss could be reduced further.

Keywords: Ram modeling; Industrial application; Systems engineering; RBD; Monte Carlo simulation

1. Introduction

The operational availability of equipment in process plants plays a key role in the actual production capacity of plants and their financial returns. The reliability of the plant and its equipment, therefore, determines whether the output of the plant is as planned and whether the plant is profitable or not. Second, reliability is of interest to the process industry from a maintenance engineering point of view because it helps in determining what and how much maintenance should be performed. The field of reliability engineering in the process industry has received a lot of attention in recent years, and many tools and techniques are available, such as availability modeling, RCM (reliability centered maintenance), RBI (risk based inspection), etc.

Another incentive for the process industry to take a closer look at reliability engineering are the ever more stricter environment, health, safety (EHS) regulations. It is anticipated that an increase in the reliability of the plant will lead to fewer people working in the plant and lower probability for personal or environmental accidents. This decrease of risks is an important factor for the license to operate. In addition, the rules and regulations set by government are becoming stricter. Many international operating directives states that every operating company should produce a safety report (e.g. Seveso II directive [1]). Even more so, the Dutch implementation of this directive requires every plant to have quantified scenarios of how accidents might occur and of their possible consequences (CPR 20 [2]). A structured approach to reliability engineering, for example in the form of reliability models, can support the processing industry in developing these scenarios.

Finally, reliability engineering is expected to fulfill a communication function between maintenance and operating departments on the one hand and the plant's higher

*Corresponding author. Tel.: +31 15 27 82823; fax: +31 15 28 83422.
E-mail addresses: p.m.herder@tudelft.nl (P.M. Herder), hanna.vanluijk@ge.com (J.A. van Luijk), john.bruinooge@ge.com (J. Bruijnooge).

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Nomenclature

BPA	bis phenol acetone
CMMS	computerized maintenance management system
DAS	dent administration system
EMPAC	enterprise maintenance planning and control
EHS	environment, health and safety
GE	General Electric
GEAM	General Electric advanced materials
MTBF	mean time between failures
MTTR	mean time to repair
RAM	reliability, availability, maintainability
RBD	reliability block diagram
RBI	risk based inspection
RCM	reliability centered maintenance
RE	reliability engineering
TTF	time to failure
TTR	time to repair

management on the other. For example, well-informed decisions can be made as to which investments would be profitable for the company in the future. These decisions can relate to various stages of the plant life cycle, from design through redesign and modifications to maintaining existing plants. Well-informed decisions, based on sound reliability engineering models, can vice versa be used to convince and motivate operating and maintenance personnel of the necessity of certain strategies and changes in the plant.

Currently within GE Industrial, Plastics (or: GE Plastics), which is part of the General Electric Company, the planned production output is not realized due to unexpected equipment failure and due to too little insight into what equipment is responsible for these so-called output shortfalls. The GE Plastics Lexan® plant management has become conscious of the fact that proper maintenance in combination with structured reliability engineering will contribute to the Lexan® production and profitability. To that extent, maintenance should be properly planned and executed according to sound reliability engineering models. In order to achieve the necessary insights into the availability status of the plant, and to allow decision making on planning of (preventive) maintenance (what should be done when, on what pieces of equipment), GE Plastics decided to build a quantitative reliability/availability/maintenance (RAM) model based upon historic plant data. The use of such a model was expected to increase the efficiency and effectiveness of preventive and corrective maintenance actions and accordingly to result in higher plant reliability and less unexpected output shortfalls.

Thus, the objectives of the RAM simulation model within GE Plastics are:

- Identification of equipment logic; for example, in which way are the various pieces of equipment interrelated and dependent of each other?
- Identification of critical equipment, either due to frequent failures or due to high maintenance requirements.
- Identification of the influence of existing redundant equipment and integrated buffers on (system) reliability.
- Identification of knowledge and data availability and needs for thorough reliability engineering.
- Identification of the optimal allocation of resources in the plant.

RAM is considered to be one of the two most significant areas for profitability improvement [3]. Moreover, RAM modeling will contribute to an increased safety and environmental performance, which is an important factor in maintaining the license to operate, by providing real and up-to-date data concerning the actual state of the plant. This paper describes the feasibility and prerequisites for implementing RAM simulation modeling in industrial practice, by means of developing, implementing and using a RAM simulation model for the GE Plastics Lexan® plant in Bergen op Zoom, The Netherlands.

2. Theoretical background

2.1. RAM modeling

We have adopted the following definitions in our paper:

- Failure is the termination of the ability of an item to perform a required function.
- Reliability is the probability that an item will perform a required function without failure under stated conditions for a stated period of time.
- Availability is defined as the ability of an item to perform its required function at a stated instant of time or over a stated period of time (BS4778 [4]).
- Maintenance is ensuring that physical assets continue to fulfill their intended functions.

Reliability and availability issues have been the subject of many scientific studies in the past decades. Until now, research has mainly gone deeply into one of these fields in order to optimize a plant's performance in the design and/or operational stage, and mostly for theoretical cases. It is not intended to give a full account of the entire research field of RAM simulation modeling in this paper, but a few representative and recent examples of these fields and research areas, that cover the breadth of the field, are:

- optimization of preventive and corrective maintenance actions in process design [5];
- optimal allocation of reliability in conceptual process design [6,7];