Available online at www.sciencedirect.com

ScienceDirect

Procedia CIRP 61 (2017) 382 – 386

www.elsevier.com/locate/procedia

The 24th CIRP Conference on Life Cycle Engineering

Internet of Things for Real-time Waste Monitoring and Benchmarking: Waste Reduction in Manufacturing Shop Floor

Yen Ting, NG*, Yee Shee, TAN, Sze Choong, LOW Jonathan

Singapore Institute of Manufacturing Technology
2 Fusionopolis Way, #08-04, Innovis, Singapore 138634.

* Corresponding author. Tel.: +65 6319 4432. *E-mail address:* ytng@simtech.a-star.edu.sg

Abstract

In today's manufacturing IT system (e.g. ERP), waste streams in operations are rarely tracked in real-time. Therefore, operational decision that is based on late and incomplete information becomes untimely and not optimal. This paper presents an approach for real-time waste monitoring, analysis and discovers waste reduction potential in manufacturing shop floor. The objective of this study is to learn the waste performance in manufacturing shop floor. Data Envelope Analysis (DEA) is conducted to perform waste benchmarking analysis and the outcome is presented as relative efficiency. The efficiency values are then classified using quartile into 3 performance classes: normal, warning and abnormal. With the performance status, it leads manager to discover achievable waste reduction targets and hence empowers optimization of operational efficiency. A case study using microfluidic device manufacturing line is studied to demonstrate real-time waste monitoring and benchmarking.

Peer-review under responsibility of the scientific committee of the 24th CIRP Conference on Life Cycle Engineering

Keywords: Waste monitoring; waste benchmarking; data envelopement analysis (DEA); waste reduction; manufacturing shop floor

1. Introduction

Owing to the widely available broadband Internet, lower connectivity cost, more devices are being equipped with Wi-Fi capabilities and sensors built, the Internet of Things (IoT) becomes a growing trend. IoT is an extended concept of current Internet that provides connection, communication, and inter-networking between devices and physical objects. With multitudes of connected devices and machines anywhere, IoT provides huge amount of actionable data in almost real-time. As such, industries across all kinds benefit out of it to create new business strategies, bring product to market in shorter time, and even develop more efficient operation processes.

The term Internet of Things was first termed by Kevin Ashton in 1999, who was introducing the new idea of information tracking using RFID [1]. However, application of IoT through RFID technology was limited to object tracking and extracting of information in the proximity boundary. The advancements in technology in this era allowed a wide variety of IoT services that create value in different settings. These include factories, where it helps in operations optimization, predictive maintenance, inventory optimization, health and safety. The others are traffic management in cities, customer relationship management in retail environment, condition-based maintenance in vehicles, smart home technology and healthcare [2].

Leverage on the characteristics and merits of IoT, waste could be better managed in manufacturing. The motivation for waste reduction in this study is started from the concept of sustainable development which defined the awareness of earths limited resources has been in growing attention. Following on, industrialization has growing demands on materials and hence shortcoming of resources. As a result, material efficiency is becoming increasingly important in manufacturing companies' operational strategies [3]. On the other hand, the importance of end-of-life phase from environmental perspective has been reported in several studies [4, 5] and economical potential for salvaging the waste by climbing the waste hierarchy has been

Peer-review under responsibility of the scientific committee of the 24th CIRP Conference on Life Cycle Engineering
doi:10.1016/j.procir.2016.11.243

demonstrated [6, 7]. According to a study, waste is the major contributor to pollution and environmental damage worldwide, where much of this waste is caused by industry.

This is partly because of waste management remains gap in current industry practice, especially in Small and Medium Enterprises (SME) [8, 9]. The reason for this is SMEs lack of waste information, resources, technical expertise and experience required to manage the waste. Often time, waste management involves several personnel from different departments where highly structured management hierarchy is required. Moreover, waste management used to be less operational importance than producing the main products. As waste is always assumed as the lowest value as compare to product price (publication). However, many have ignored the fact that waste could be managed strategically and turn it into valuable resource that could be used internally or by other entity. Moreover, if the waste is handled timely and in proper manner, the waste value could be retrieved or even increased. Industry like manufacturing sector often has large or substantial potential in improving waste management [10].

In order to succeed in waste management in manufacturing, this paper focuses on waste benchmarking analysis to quantify the waste status and explore waste reduction potential. Analysis is done using product and process data in shop floor to support decision making in enterprise level.

1.1. Objective

In today's practice, many companies (e.g. SMEs) have limited waste monitoring system in manufacturing shop floor. Even most of the important information is captured in the Enterprise Resource Planning (ERP) system, the amount of material consumed or waste is not constantly updated and inaccurate. This is because of when there is abnormal waste generation occurs in shop floor, engineers or operators update the situation in manual and ad-hoc manner. Even it is updated, the amount of waste generated and how much the material is being used are unknown. The information is incomplete and late when it reaches enterprise level management. Thus, knowledge known by the enterprise management might be imprecise and decision made could be unreliable.

In order to improve the situation, real-time data analysis for waste benchmarking is studied in this paper. The concept can be implemented as a tool to visualize real-time waste performance on mobile devices with a network of sensors implement at production station via Wi-Fi connection. Thereby, the proposed work is suitable for IoT application.

1.2. System Architecture of Waste Monitoring

The architecture for waste monitoring system includes mobile devices, internet network, computer server, user interface development and analytics engine as shown in Figure 1. The proposed waste monitoring concept aids waste management specialist to visualize and learn the waste performance of an entity. With proper user interface design, waste management specialist able to view dashboard, query waste details, investigate and waste report using computer or mobile devices. While the backend processes such as benchmarking analysis provides timely notification.

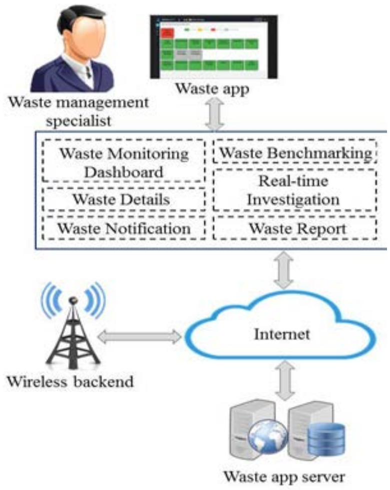

Figure 1 System architecture of real-time waste monitoring

2. Research Method

This study starts with identification of waste generation of an entity, where the entity could be a machine, station, shop floor, site or factory that comes with a set of parameters. After the waste generation entity has been identified, the relevant process data will be collected for further analysis. The data can be collected directly from built-in sensors or attach additional sensors to get the critical process data. For instance, the amount of production waste can be captured via additional load cell sensor at every station. However, application of sensors at input and output bins of every station is uneconomical. Thereby, this study uses estimation method to generate input data and then correlate with output data which is calculated based on production data. Next, the data will be used as input data for Data Envelope Analysis (DEA) model for analysis. With the right set of data, DEA model able to calculate the relative efficiency complying with certain conditions (shows in Figure 3). The efficiency values indicate waste performance of the entity, and it is classified using quartile. Besides, knowing the best efficiency values (frontier) as reference, waste reduction potential can be determined.

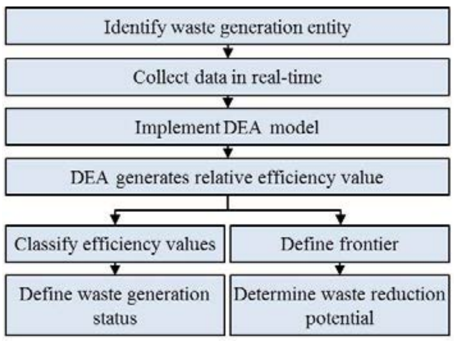

Figure 2 Research method for waste monitoring and benchmarking