# LAPORAN TEKNIKAL

# LEAN AUDIT SYSTEM

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***Abstract*—Lean assessment or lean manufacturing has gotten one of the most notable ideal models for the end of waste in the manufacturing industries. Past exploration in lean shows that there are some arrangement of methods, apparatuses and rehearses which have been applied to specific levels across firms as indicated by the separate comprehension of lean creation of the people responsible for lean activities. This situation prompted different variants of leanness estimation in the assembling operation. Therefore, this study investigated the critical dimensions of lean assessment by those works. As a result, the main modules that can be implemented in the company to overcome the problem arise. This paper is expected to provide another alternative lean audit for the manufacturing industries.**

***Keywords—lean manufacturing, waste elimination, leanness, lean assessment, lean audit***

## I. INTRODUCTION

Industries in the manufacturing sector face obstacles in minimizing operating costs, market uncertainty, competition, and endless demand. In addition, most manufacturing industries have a lack of innovation, inadequate resources and technology, less willingness of customers to improve product features, a lack of research and development culture as well as a low motivation from the top management and fear of failure for new product John Mbogo Kafuku (2019). Therefore, many manufacturing companies have implemented lean manufacturing (LM) as a response to increasing competition, globalization, raised consumer expectations and achieved significant improvement [1],[2].

Furthermore, lean production aims at minimizing non-value-added activities or waste and maximizing customer value. Due to this matter, efficient use of resources by reducing waste is essential in leanness [3]. It can be concluded that lean production able to enhance productivity and quality of a product and to reduce lead time as well as minimizing costs [4].

Krafcik (1988) first mentioned the concept of lean production to explain the manufacturing techniques by Toyota Motor Company (TMC) in minimizing costs [5]. TMC has implemented the Toyota Production System (TPS) over the past 100 years, and it has proven that the implementation of lean production is significant [6]. The success of TMC motivates companies from various industries to implement lean production. For instance, in electrical and electronics [7-11], automotive [12-14], auto and machinery [15], wood [16], ceramics [17], and high-tech industries [18].

However, the company manage its operation performance based on lean practices using theirs on the method. The lean assessment method influences the knowledge of lean, culture, ethics, and skills factors. In addition, the lean assessment method is influenced by the size and age of the company, the full support from top management, funding and leadership [10-11], [15], [19]. Hence, access to their performance all over the company and industries affected by these factors. For instance, the waste distinguishing proof procedure is likewise not a simple undertaking. The significance of taking care of an issue is typically ignored on the grounds that the issue of "where" and "how" to begin and discover squander is staying muddled. The arrangement of waste by "area," "when," "how," and "why" yet doesn't exist. [20].

In addition, lean assessments are usually carried out manually without using any supporting computing tools. Hence, it is difficult to share information between departments or production stages. Consequently, data errors can occur during the process of information flow from one stage to another, resulting in an error in decision making regarding production [21]. Excellent communication is crucial to ensure the smooth running of the operation [22]. Poor communication between multiple dimensional organizations can delay action.

The audit system has been described in [23], a systematic examination to indicate whether activities and related results conform to the planned arrangement and whether these arrangements are being effectively implemented and are acceptable for the organization policy and objective [24]. Therefore, an audit system helps users to understand the organizational capabilities based on performance achievement.

The lean audit system is estimated through norms or fundamental markings laid out by thoroughness specialists to manage implementers to actualize incline toward the correct track and effectively. The estimation assists the board with recognizing the current degree of accomplishment of its association. In addition, the accomplishment hole or improvement can be actualized constantly through occasional and orderly assessment.

The core objective of the audit system's implementation is to dissect the circumstance during the speeding up process and recognize chances to diminish expenses and lead time [12]. As indicated by Paterson in 2011, the advantages of a thorough review approach rely upon the review work and applying best practices in hierarchical tasks. Among the benefits of the review drew nearer are recorded as follows [25]:

i. The formation of an audit culture focuses on value-added.
ii. The audit plan is proven consistent in line with the values-driven by the organization.
iii. The function of the auditor plays a vital role in understanding the overall risk assurance of the organization.
iv. The audit plan is scheduled and submitted on time.
v. The auditor's role is to identify opportunities, including benefits in adhering to coordination and process control.
vi. A function that is clear and can show a positive cost return.

This study aims at developing a prototype on a leanness assessment diagnostic tool or known as lean audit system. This system is expected to be implemented periodically.

## II. THE MATERIAL AND METHOD

This study adopts the Model of Implementation of Assessment Implementation Development (ADDIE) design. There are four main phases of this study: planning, analysis and design, development, and prototype evaluation. However, this article will only focus on the planning phase. Planning phase involving the criterion of audit prototype development. This phase consists of the identification of critical audit prototype development criteria. The prototype development criteria are guided by a conceptual framework developed in [26] to form one of the modules in the prototype, namely, dimensional and waste modules. User and research needs are integrated to achieve the objectives of the study. The purpose of the development of this application is to provide guidelines to users for the following:

i. Identify the types of waste based on symptoms that occur in the operations of the organization.
ii. Propose types of waste that can be eliminated within the operating dimensions of the organization.
iii. Propose types of techniques or tools of production of waste based on the type of waste.
iv. Generate charts that report symptoms of waste, waste in organizational activities, and use techniques or tools.

An initial prototype was built to see the suitability and usefulness of the prototype in helping the organization plan and review the achievement of the leanness qualitatively and periodically. A prototype is known, as a leanness manufacturing audit system is a simple application built based on Excel software.

## III. DEVELOPMENT OF THE AUDIT SYSTEM

Previous studies used different approaches to measure leanness. This study focuses on the assessment of leanness based on the level of use of lean practices, techniques, or tools in an organization. Thirty-three articles specializing in the lean evaluation were analyzed in detail. Therefore, the central question of this study is answered by identifying the most common or frequently used practices, techniques, or tools to address waste problems in the company's operations. According to Kuruppalil (2007), the determination of such criteria aims to identify critical indicators for the assessment of malformations [27]. A brief analysis is done to determine the level of use of practices, techniques, or tools in the past study. The frequency of each practice, technique, or tool mentioned by previous researchers was assessed. The results of the frequency analysis are shown in Table 1.

TABLE I FREQUENCY ANALYSIS

| | Dimension | Author | Total |
|---|---|---|---|
| 1 | supplier relations | (Ahrens 2006; Anand & Kodali 2010; Anisur & Azharul 2013; Doolen & Hacker 2005; Herzog & Tonchia 2014; Krajewski et al. 2013; Lewis 2000; Norani et al. 2010; Nurul Syuhadah et al. 2014; Panizzolo 1998; Sanchez & Perez 2001; Shah & Ward 2007; Sohal & Egglestone 1994; Sternberg et al. 2013; Saetta, S., & Caldarelli, V. 2020; Wan & Chen 2008; Wong & Wong 2010; Wong et al. 2009) | 18 |
| 2 | customer relations | (Ahrens 2006; Anand & Kodali 2010; Anisur & Azharul 2013; Doolen & Hacker 2005; Herzog & Tonchia 2014; Hooi, C. C., & Rahim, S. A. 2020; Krajewski et al. 2013; Lewis 2000; Norani et al. 2010; Nurul Syuhadah et al. 2014; Panizzolo 1998; Sanchez & Perez 2001; Shah & Ward 2007; Sohal & Egglestone 1994; Sternberg et al. 2013; Saetta, S., & Caldarelli, V. 2020; Wan & Chen 2008; Wong & Wong 2010; Wong et al. 2009) | 17 |
| 3 | human resource | (Ahrens 2006; Anand & Kodali 2010; Anisur & Azharul 2013; Doolen & Hacker 2005; Herzog & Tonchia 2014; Krajewski et al. 2013; Lewis 2000; Norani et al. 2010; Nurul Syuhadah et al. 2014; Panizzolo 1998; Sanchez & Perez 2001; Shah & Ward 2007; Sohal & Egglestone 1994; Sternberg et al. 2013; Saetta, S., & Caldarelli, V. 2020; Taj 2005; Wan & Chen 2008; Wong & Wong 2010; Wong et al. 2009) | 15 |
| 4 | manufacturing processes and equipment | (Ahrens 2006; Anand & Kodali 2010; Anisur & Azharul 2013; Bayou & De Korvin 2008; Cai, W., et al. 2019; Doolen & Hacker 2005; Herzog & Tonchia 2014; Krajewski et al. 2013; Lewis 2000; Moshood, T. 2020; Norani et al. 2010; Nurul Syuhadah et al. 2014; Panizzolo 1998; Sanchez & Perez 2001; Shah & Ward 2007; Sohal & Egglestone 1994; Sternberg et al. 2013; Saetta, S., & Caldarelli, V. 2020; Taj 2005; Wan & Chen 2008; Wong & Wong 2010; Wong et al. 2009) | 20 |
| 5 | manufacturing planning and scheduling | (Ahrens 2006; Anand & Kodali 2010; Anisur & Azharul 2013; Bayou & De Korvin 2008; Cai, W., et al. 2019; Doolen & Hacker 2005; Herzog & Tonchia 2014; Krajewski et al. 2013; Lewis 2000; Moshood, T. 2020; Norani et al. 2010; Nurul Syuhadah et al. 2014; Panizzolo 1998; Sanchez & Perez 2001; Shah & Ward 2007; Sohal & Egglestone 1994; Sternberg et al. 2013; Saetta, S., & Caldarelli, V. 2020; Taj 2005; Wan & Chen 2008; Wong & Wong 2010; Wong et al. 2009) | 13 |
| 6 | product and technology development | (Ahrens 2006; Anand & Kodali 2010; Anisur & Azharul 2013; Bayou & De Korvin 2008; Doolen & Hacker 2005; Herzog & Tonchia 2014; Krajewski et al. 2013; Lewis 2000; Norani et al. 2010; Nurul Syuhadah et al. 2014; Panizzolo 1998; Sanchez & Perez 2001; Shah & Ward 2007; Sohal & Egglestone 1994; Sternberg et al. 2013; Taj 2005; Wan & Chen 2008; Wong & Wong 2010; Wong et al. 2009) | 7 |
| 7 | visual information systems | (Ahrens 2006; Anand & Kodali 2010; Anisur & Azharul 2013; Bayou & De Korvin 2008; Doolen & Hacker 2005; Herzog & Tonchia 2014; Karlsson & Ahlstrom 1996; Krajewski et al. 2013; Lewis 2000; Machado & Pereira 2008; Nicholas & Soni 2005; Norani et al. 2010; Nurul Syuhadah et al. 2014; Panizzolo 1998; Sanchez & Perez 2001; Shah & Ward 2007; Sohal & Egglestone 1994; Sternberg et al. 2013; Taj 2005; Wan & Chen 2008; Wong & Wong 2010; Wong et al. 2009) | 10 |

The results of the analysis produce seven critical dimensions of lean assessment: supplier relations, customer relations, product, and technology development, manufacturing planning and scheduling, visual information systems, human resource, and manufacturing processes and equipment. Each dimension of the study is formed from factors consisting of related practices, techniques, or tools. Generally, the manufacturing system is an input-output model. Amelia et al. (2017) show the relationship and waste's position of the seven dimensions of leanness through an input-output model. The system receives the input elements and later undergoes a few processes in the transformation stage. Finally, the desired product is produced in the output stage. The quality and cost of the final output depend heavily on the factors that affect or control the system during the transformation process. The dimension and wastes modules dimension and waste modules are developed to identify the location and type of waste. Table 2 shows and describes the four main modules that are considered in the development of lean audit applications, i.e., employee module, waste module, dimension and waste module, and tools analysis.

TABLE II MAIN MODULES

| Module | Description |
|---|---|
| Employee | • Employee name information, username, deadline to use the application.<br>• Three types of analysis charts from modules waste, dimensions and waste, and tool analysis |
| Waste | • List 45 types of symptoms<br>• Wastes analysis based on symptoms |
| Dimension and Waste | • List seven types of dimensions<br>• List the types of waste based on Dimensions (location). |
| Tool Analysis | • List 36 types of lean techniques/tools based on phases<br>• List the right techniques/tools for wastes |

Organizations began to identify tools or techniques to eliminate waste after identifying the organization's types of wastes and goals. After a few weeks, users can perform audits based on the current symptoms that occur in the user's dimension of the study. The application will identify the problems that arise, and the user may choose the appropriate tool or technique as necessary. The selection of tools or techniques by users is based on the types of wastes based on the company's vision, stability, continuous flow, synchronous production, pull system, and production levelling. In the event of poorly-propelled tools or techniques that are less effective, then users may choose another technique as suggested.

## IV. CONCLUSIONS

This study is undertaken to discover the different approaches used in the company to measure leanness. As a conclusion, the four main modules that are essential in the development of lean audit application to identify and overcome the problems that arise with a proper technique based on the specific criteria regarding each company.

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