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A Proposal Simulation Method towards Continuous Improvement in Discrete Manufacturing

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Abstract

In kaizen improvement projects, the stages of analysis, and application of the proposed improvements are often a trial-and-error cycle carried out by direct experimentation. This feature is a major source of uncertainty in resource dimensioning. This paper presents the design and development of a sequence of activities that emphasizes the application of simulation capabilities as a tool to aid the continuous improvement process at discrete manufacturing, in the context of the Lean Manufacturing approach.

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Keywords: kaizen improvement projects; discrete manufacturing; discrete event simulation.

1. Introduction

This work seeks to systematize the analysis for layout modifications carried out during kaizen events in discrete manufacturing companies. A method is proposed to execute the process of discrete event simulation (DES) inserted into kaizen activities.

Discrete manufacturing companies need often a flexible manufacturing system that can develop quality and time-to-market according to product demand fluctuations. These requirements imply regular analyses in current production processes to generate improvements related to costs or operational practices, which can result in facility layout modifications. A lot of companies have chosen to apply changes in their shop floor by means of Kaizen events which are characterized, in part, by direct experimentation and trial-and-error cycles. Therefore, occasionally there are mistakes to predict the behavior of future states.

Traditionally, the use of kaizen has assisted improvements in production systems. However, when it is applied to more complex problems, with greater amount of data to be analyzed, some negative factors are highlighted [1.2]:

- Kaizen teams are not always knowledgeable about the process under study or are not prepared for analysis of complex processes;
- Variation must be addressed, both random and structural;
- Data must be fully analyzed to help understand the random nature of system behavior;
- The interaction between system components must be assessed;
- The future state must be validated before it is implemented to minimize or eliminate the period of trial and error adjustments;
- Alternatives to the future state must be systematically identified and considered.

The mentioned factors are substantially related to the knowledge of the process and precisely to the management and analysis of data associated with the behavior of a production system. This analysis can be done by means of collaborative tools for manufacturing environment simulation, since these tools are attached to the practices applied by the corporation. In this context, the main contribution of this

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paper is on the systematic merging of a traditional discrete event simulation method with the kaizen event method.

2. Related work

Some of difficulties regarding the use of Lean Manufacturing approach are related to the planning towards the effective implementation [3,4]. For this reason, simulation tools have been used to support systems specifications for manufacturing improvement in order to give greater effectiveness for analysis of resource utilization on production layout modifications.

Standridge & Marvel [1] approach the use of simulation in kaizen projects and claim that the future state layout must be validated through simulation before an improvement implementation plan, in order to minimize or eliminate periods of trial and error adjustments. Kumar & Phrommathed [5] have applied discrete events simulation by means of popular software tools to examine a paper sheet cutting operation. The re-designed operation has resulted in setup time reduction and productivity increased. Grimard et al. [6] describe the validation of a future state of a re-designed injector calibration work cell using a deterministic simulation. The simulation results were used to refine initial estimates of throughput and validate worker movement in the cell.

The works [1] [5] and [6] have used the method described by Banks et al. [7] and Kelton et al. [8], applied for analysis of future state in production systems. They report a better evaluation and increase in the effectiveness of planning for modifications by the use of DES. However, there is no formalized routine for the integration of processes improvement and simulation activities.

Khalil et al [9] proposed a routine for implementations of improvements by means of DES intended to increase the amount of potentials solutions generated towards the future state of a production system. Nevertheless, roles and activities were not assigned to kaizen team members, which have prominent importance in improvement process [10].

Although closely related to this paper, there are some important differences between these approaches and the problem approached herein. These works use simulation tools often under the domain of digital manufacturing experts, but without leverage the company´s collective knowledge, which is so emblematic in the process improvement approaches.

A common problem faced by many companies looking to employ simulation tools into manufacturing process is to obtain the information that their users really need. [11]. In this context, the effective use of these tools is related to standardization of procedures of own corporate system. The kaizen process is one of these procedures already applied in many discrete manufacturing corporations and establishes an opportunity of obtaining standard information needed by simulation tools users and, consequently, their joint use can help employers adhere to use of simulation tools.

Compared with [1], [5], [6] e [9], a differential approach in this article is the formalization and a detailed description of a method for more accurate diagnoses of future states during kaizen events. The proposed method inserts discrete event simulation routine into kaizen activities.

3. Simulation Process

Simulation is an experimental process which uses a detailed model of a real system to determine responses to changes caused in its structure, environments and boundary [12]. A simulation analysis changes according to the type of system analyzed and may be continuous or discrete. Discrete event simulation is suitable for problems in which variables change in discrete times and by discrete steps. On the other hand, continuous simulation is suitable for systems in which the variables can change continuously [8].

The automotive industries have increasingly used the simulation as a prominent decision support tool. Most makes use of discrete-event simulation (DES) to model manufacture systems and analyze issues related to factory layout, process flow, material handling systems, capacity planning, utilization of manpower, investment in new equipment, production and logistics scheduling [14].

The development of a computer program is just one of the many activities of a simulation process. For this to be successful, other activities should be followed. This set of activities or process is known in the literature as simulation methodology or lifecycle of a simulation model [7.8].

4. Simulation aided continuous improvement - MAPS

The term "kaizen event" is used to indicate a limited time period where are realized identification and implementation of improvements [15]. In a typical Kaizen Blitz project, a cross-functional multilevel team of 6 to 12 members works intensely, 12 to 14 hours a day, to rapidly develop, test, and refine solutions to problems and leave a new process in place in just a few days. [10].

The method developed in this work, called MAPS - Melhoria Auxiliada por Simulacão (Simulation Aided Improvement), has routines of a simulation process inserted in Kaizen activities, with the purpose of increasing the level of knowledge about the stages of Kaizen event process and improve the decision making for modifications of factory layout. The method MAPS contemplates the approach of continuous improvement when it is considering that at one point in the Future State becomes the Current State and emphasizes the application of simulation capabilities in the step to implement improvements, which traditionally occurs on the third day of the event kaizen .

The MAPS considers that the corporation has already defined the sector in which the project for improvement application will be made. It is also considered that the kaizen team is already formed and contains a simulation analyst, who is responsible for setting the measurement team and the model validation team within the team kaizen. The MAPS consists of four steps:

- Step 1 – Define the Project;
- Step 2 – Current-State Analysis;
- Step 3 – Computational Modeling;
- Step 4 – Future-State Analysis.