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## Lean assessment tool for workstation design of assembly lines

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### Abstract

Efficiently designed workstations are essential to provide both flexibility and mass production in an effective way. Unfortunately, it is common to find industrial workstations built without a purposeful design. The design of the workstation, oriented to both users and tasks requirements, allows organisations to increase their production indicators (less time, space and cost) and quality levels. Within the present paper, an assessment tool was developed to address a literature gap regarding the lack of tools to evaluate Workstation Design, particularly in assembly lines. The concept of “Hierarchy of Workstation needs” is introduced for prioritising the requirements to achieve full performance in workstations. The concept is visualised as a pyramid split in four levels to achieve excellence: functionality, effectiveness, efficiency and satisfaction. Seven requirements were identified for Workstation Design, namely: “Health and Safety”, “Work environment, cleanliness and orderliness”, “Waste elimination”, “Inventory and material logistics”, “Flexibility”, “Visual Management” and, lastly, “Quality”. An evaluation model and a tool to assess each requirement was developed based on lean and ergonomic aspects and specific for workstation design, which it is difficult to find in other assessment tools. This model has the form of a checklist that is based on the current best practices in Workstation Design of assembly lines. The assessment tool was validated in an automotive assembly line and based on the results obtained, improvements in the associate working zones, workstation dimensions, storage areas or parts feeding system are introduced to improve “Waste elimination” and “Inventory and material logistics”.

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### 1. Introduction

Manufacturing organisations need to exhibit flexibility and mass production capabilities for individual customisation in a hyper-efficient way. The development of an effective and efficient manufacturing system is crucial to deal with the market competition. A workstation is among the most important places in a manufacturing environment. Several lean based tools have been developed for the optimization of workstation design. 5S is probably the most widely used one to support continuous improvement. Well-organised working areas are essential for standardised work procedures, which are needed to control the workplace. To perform the required tasks, operators must use different types of equipment, tools and materials. If the necessary resources are not clearly and properly stored, operators lose precious time to find them, increasing thus the non-value added time (waste) [1].

Workstation design thus is a crucial process to ensure effectiveness, customisation, automation and competitiveness in high volume environments, using less time, space, cost and inventory. Taking that into account, workstations play a critical role in manufacturing processes. Lean workstations should be designed with a focus to minimise waste and concentrate operators to critical issues. Unfortunately, it is common to find that industrial workstations have been built ad-hoc without investing effort to achieve a purposeful configuration. It is important that the design of the workstation is done from the inside out and optimise the workstation from the operators’ perspective.

In the current paper, the key aspects to be considered to design an assembly line workstation are proposed, following both lean and ergonomic principles. In order to design leaner and safer workstations, a tool to measure and evaluate them objectively is proposed.

## 2. Literature review

Studies on lean manufacturing principles and workstation assessment methods have been reviewed and critically analysed to present the importance of an efficient workstation design in a manufacturing plant.

### 2.1. Workstation Design

Workstation design is responsible for placing materials, tools, equipment, etc., and routing operator movements in the most suitable form. That way, operators can perform their work in an efficient manner [1]. It is essential to ensure effectiveness in an environment of high customisation, automation and competitiveness.

Traditional workstations and lean workstations are inherently different. Traditional workplaces are designed to facilitate the work of material handler, not increase value added by the operator. A lean workstation is designed focused on operator concerns, such as safety and ergonomics, and minimal wasted motion, with the goal to get parts efficiently and find tools quickly. Assembly materials, tools or parts should be strategically positioned to allow the operator to reach it instantaneously, without interfering with operators' safety and comfortability [2].

### 2.2. Workstation Assessment Tools

There are uncountable lean tools (Strategos Lean Assessment Questionnaire [3], Rapid Plant Assessment [4], etc.) and workstation assessment tools (Kobayashi's 20 Keys [6], Ergonomic Workstation Analysis [7], etc.). However, it is evident that gap in instruments to evaluate the performance of the workstation design in assembly lines exists.

Strategos LAT [3], developed by Quarterman Lee, is used to evaluate nine areas of manufacturing using a Microsoft Excel-based self-assessment questionnaire. Goodson [4] created one of the most well-known and useful plant assessment tools which aims to evaluate if a factory is truly lean in as little as 30 minutes - "Rapid Plant Assessment". Then, this information should influence decisions related to benchmarking, continuous improvement, competitor analysis, and acquisitions. Lean Enterprise Self-Assessment Tool (LESAT) is a questionnaire developed by a team of industry, government and academic members. It is a simple and easy to use guide focused on lean attributes and aligned with business performance planning, which forms the basis for most other lean assessment tools [5]. These lean tools are well-known in the industry but they focus on assessing where the companies are along their lean journey, and not in the evaluation of specific aspects of the workstation.

Kobayashi's 20 Keys [6] is also one of the most used implementation guides to lean manufacturing at shop floor level. Probably because it allows to evaluate particular aspects in the workplace. It is not a model to achieve success, but a pragmatic approach or roadmap based on several years of experience of the author. The main objective of this practical method is to create "a way to make footholds all the way to the top of the manufacturing mountain". Despite of being a

fantastic learning tool, it does not take in consideration the safety and comfort of the employees. On the other hand, workstations tools mostly focus on employee safety and ergonomics aspects. Ergonomic Workplace Method (EWM) [7] is one of the most used ergonomic tools in workstations. It assesses health risks of working conditions of a workplace.

These tools are powerful but they do not take into consideration the relations between the operator and his work space [1], [8]. The assessment of workstation design must focus on both lean and ergonomic aspects. Lean assessment tends to reduce the waste in the workstations and ergonomic assessment safeguards employee safety and comfort. This relationship is essential to ensure success, mainly in a long-term period [9].

A good example is the "Workstation Design Navigator", developed by Bergman et al. [9]. The evaluation method used is based on AB Volvo Assessment Tool, inspired by Toyota Production System, and it results in a combination of human factors, materials supply and personnel strategies. This proactive approach assumes that losses should be reduced by solving problems before they occur, which means, supporting design of workplaces. Other tools have been also published, mainly in the automotive industry. Good examples are the "Process Diagnostic Standards Tolls", inspired again by Toyota Production System. They allow an objective evaluation, but they are often very restrictive, making them only usable in specific contexts.

## 3. Hierarchy of workstation needs

To understand what motivates people, Maslow [10] identified five different motivation needs which are often depicted within a pyramid. One of the biggest principles of his theory is that lower level needs should be satisfied to be able to reach higher levels. In the present study, the same principles were applied in workplace environments, and based on that the "Hierarchy of workstations needs" was developed to understand and prioritise the requirements to achieve full performance in workstations.

Functionality, effectiveness, efficiency and satisfaction are the levels before reaching excellence, which are closely related with the tiers of motivation needs proposed by Maslow (Fig. 1). Functionality ensure physical and safety needs of the operators. Effectiveness fulfil their social and relationship needs, such as friendship, love and belonging. Efficiency reflects how the workstation and their associates are seen in the whole facility and if their value is recognised and respected by others – esteem. Finally, satisfaction refers to the achievement of higher goals and full levels of satisfaction – self-actualisation and self-transcendence. Once all levels have been fulfilled, the company and its workstation can achieve the desired level of excellence

According to Granath et al. [11], two main dimensions in workplaces should be distinguished: functionality and usability. *Functionality* refers to the ability to perform a regular function and it is more concerned about features of the workstation (which individually do not make the workstation usable). For improving the functionality dimension, workstations need to be designed based on lean and

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