Investigating the level of involvement of lean manufacturing tools in Hail Industrial City

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Abstract: Lean Manufacturing is a strategy of eliminating waste in organisations intended for expediting the flow of the manufacturing process. The extent to which Lean manufacturing is applied in various types of industries is partially related to the lean manufacturing tools that are used. However, not all organisations are aware of the exact impact of each Lean manufacturing tool on their business value and productivity. The purpose of this study is to investigate the level of involvement of selected lean manufacturing tools in Hail Industrial City (HIC). The study categorised the HIC industries into ten sectors based on their business focus. It was found that lean manufacturing tools are extensively used in automotive parts companies with 90% occurrence, plastic products companies and steel structures companies with 80% occurrence. The study also found that TPM is the most common used lean manufacturing tool in HIC, while SMED and Heijunka are the least.

Keywords: lean manufacturing tools; level of involvement; Hail industrial city; manufacturing waste.

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1 Introduction

The reduction in crude oil prices associated with reduction of transport business has forced many formerly protected economies to open up to global competition and to confront the challenge of achieving global competitiveness. This has implications for a wide range of firm-level practices, including the effectiveness of industrial manufacturing performance. The Saudi Arabia Economic Cities shape a general strategy that seeks to accommodate the changing needs of a growing non-oil economy embracing new knowledge based industries and, at the same time, ensuring adequate employment opportunities, educational facilities, and housing for a young and growing Saudi population. Three New Economic Cities lay along the Red Sea coast of Saudi Arabia, while the fourth one is located in the hinterland near the city of Hail. The Hail Industrial City (HIC) is focused on transport, logistics, and food-related industries. Designed as a new city clustered around the international airport of Hail, aims to be a state-of-the-art transport hub with corresponding logistical arrangements. The city of Hail is approximately 600 km northwest of Riyadh and its population of 230.000 inhabitants is growing at a rate of 2.8% per year. The Hail region, rich in natural resources, is one of the key agricultural areas accounting for 10% of the Kingdom's agricultural land. HIC has been planned by the Saudi Arabian General Investment Authority to leverage the technological capabilities of Saudi Arabia. HIC include a number of land zones with specific uses such as: Logistics and Supply Chain, Education, Agriculture and Food Processing, Mining and Industry, Entertainment, and Housing. The planning of the City aims to redesign and improve the Hail Airport area, offering a high quality urban environment, with its major characteristic being the extended green spaces. The planning concept has been conceived in such a manner as to facilitate investment opportunities without compromising physical planning standards. HIC represents one of the high technology poles to develop the Kingdom's economy through private sector investment. HIC was established on an area of 2.56 million square metres. The region has been establishment, rehabilitated with infrastructure, and integrated services according to the international quality standards. The city is home to nearly 94 productive, existing, under construction and under formation factories of a variety of products, the most important are support factories, and these are chemical and national industrialisation. Hail is strategically located as it is close to the raw materials used in many industries such as metallurgy; especially bauxite, silica, gypsum, Zinc and magnesium. Railway track also passes through it to facilitate the movement process for industrial investors and allows them options to work in other multiple industries. HIC industries are consisted of refined petroleum products, chemical materials and products, service (electricity services, road services, telecommunication network), medical industries, wood and furniture industry, electricity and electrical appliances industry, nonferrous metals and building materials industry, manufacture of food products and beverages, metal industry, manufacture of rubber and plastic products, equipment and machinery, paper and its products, and other manufacturing industries.

2 Lean manufacturing

The Term 'Lean' has brighten up repeatedly the Quality terminology in the same way that it has envisaged waste elimination within a production systems and manufacturing processes. Lean is focused on speeding the delivery of value, and value is defined as to the customer through the elimination of waste – anything that is non-value added from the customer's perspective. Khan and Dalu suggested that lean can be implemented in all the functional areas (departments) of an organisation because waste can be present in any department (Khan and Dalu, 2016).

Lean manufacturing is a generic term that is used to imply a particular way of going about the manufacture of a particular product. Henry Ford's insight of lowering the expense associated with making a product by shorting the production cycle times is similar to that of lean production. Lean Manufacturing is a production practice that considers the expenditure of resources for any goal other than the creation of value for the end customer to be wasteful, and thus a target for elimination. In 1990, James Womack, Dan Jones and Dan Roos wrote a book entitled "The Machine that Changed the World" (Womack et al., 1990), based on a three-year MIT study in the automotive industry. The study showed that Toyota outperformed the large US car manufacturers by a factor of 2 : 1 on quality, cost and time to market. They coined the term "LEAN" to describe the way the Toyota Production System sought to continually identify and eliminate waste. They described it as a fundamentally different system "of thinking about how humans work together to add value" (Kessar, 1999).

Today Lean is being used all over the world virtually in every industry such as health, fashion, grocers, government, education, mining, accommodation services, construction, etc. Lean manufacturing is a near perfection activity of continuous improvement which requires effective strategies to successfully implement. Bayat and Dadashzadeh found that implementation of lean manufacturing is very beneficial in terms of the safety of the work environment, ease of access to the necessary equipment, and the procedures of disposing wastes in Healthcare(Bayat and Dadashzadeh, 2017; Weiss et al., 2017).

Lean Manufacturing is an optimisation method of production activities focusing at most on speeding up the flow of the value in the product lifecycle. Lean manufacturing approach does not only simply alter the organisation of enterprises activities; but it creates new culture and institutes a well-defined management philosophy. Lean Manufacturing means maximum focus on the identification of market needs in order to create the maximum possible value to the customer at the lowest costs of resources. Dennis identified lean manufacturing as a philosophy of continuous improvement that is synonymous with Kaizen or the Toyota Production System (Dennis, 2016; Drew et al., 2016).

3 Lean manufacturing principle steps

Lean manufacturing focuses on developing high-quality, low-cost products using less time, less space, fewer workers, and fewer tools. It is a system of organising and managing of the product lifecycle processes in the enterprise based on a constant drive for elimination of all kinds of wastes. A lean production facilitator is challenged to find new ways to increase the productivity and efficiency of their business. Because manufacturing environments vary due to differences in their purpose, design and control, there is no single set of management procedures that can be universally adopted to govern them. However, lean manufacturing provides us with a beginning step for sighting a company's operating practices with the final goal of aiming operational improvement. Lean Manufacturing facilitator is responsible for elucidating a sound understanding of their manufacturing systems, in order to create work environments that are competitive, creative, and continuously improving (Hayes et al., 2005). The process used to implement lean manufacturing is a straightforward one. However it is critical that lean is implemented in a logical manner. The following steps are consisting the five principles for lean manufacturing implementation: Step 1; Specify Value; Define value from the perspective of the final customer. Express value in terms of a specific product, which meets the customer's needs at a specific price and at a specific time. Identification of what is most important from the consumer's point of view and makes the product worth. It is necessary to clearly understand which processes in the organisation are important to the consumer and which are not. Step 2; Map Identify the value stream; this step visualises the stream of the value in a pictorial format to create products or service. Due to its clarity and precision this tool allows you to set all specific actions required to bring a specific product through the three critical management tasks of any business: the problem-solving task, the information management task, and the physical transformation task. Create a map of the Current State and the Future State of the value stream. Identify and categorise waste in the Current State, and eliminate it. The identification of all the interrelated sequential processes in the production map, which creates transparency of the organisation activity and enables to see the opportunities for improvement. Step 3; Flow Make the remaining steps in the value stream flow. Eliminate functional barriers and develop a product-focused organisation that dramatically improves lead-time. Arrangement of manufacturing processes as a continuous flow of interrelated activities which add to the product value. According to this step, most often a complete rearrangement of the manufacturing activity or an update of it must be conducted. This is due to the fact that the location of the equipment in most enterprises with conventional production prolongs the interoperation movement. An ideal explanation of this principle is the usage of the multiple stages of conveyor systems in the assembly line to feed several sectors which performs their own operations adding to the product value. Step 4; Utilising Pull System, let the customer pull products as needed, eliminating the need for a sales forecast. Creation of only one product being essential to the consumer. In organisations producing a large range of products manufacturing activity is most often focused on the even creation of all types of products resulting in formation of stocks of one type and lack of another. According to the ideology of Lean Manufacturing, it is necessary to create a certain number of each type of product when it is required the products of different nomenclature move on the conveyor depending on needs and time constraints. This is achieved by the principle of production alignment when cycle time of each product type is calculated, which allows of even distribution of the products on the production line. Step 5; Striving for Perfection, There is no end to the process of reducing effort, time, space, cost, and mistakes. Return to the first step and begin the next lean transformation, offering a product that is ever more nearly what the customer wants. Continual improvement of the organisation activity by continuously reducing unnecessary losses. It is really important to develop systematic actions that make up the Lean Manufacturing; it is also necessary to be constantly engaged in monitoring, analysis and improvement of production activities to achieve the desired result. It should be understood that what was perfect today, tomorrow may not fully reflect the needs of the enterprise, therefore continuous improvement not only leads to an increase in the competitiveness and stability of the organisation, but also bears a preventive character.

4 Lean manufacturing waste

To better understand how to deal with lean manufacturing waste, it is very important to identify the waste from a lean manufacturing perspective. Taiichi Ohno the co-developer of Toyota Production System (TPS) defined waste, or (MUDA), as any non-value added activity in the manufacturing processing and production (Ohno, 1988). Ohno categorised waste into the following seven types:

- *Unnecessary transportation*: Moving parts and products unnecessarily, such as from a processing step to a warehouse to a subsequent processing step when the second step instead could be located immediately adjacent to the first step. This leads to an additional use of vehicles, creation of infrastructure for them and additional item of expenses on infrastructure maintenance. Unnecessary transportation imposes additional requirements concerning the handling of the equipment in the enterprise and the use of their resources.
- *Extra inventory*: Having more than the minimum stocks necessary for a precisely controlled pull system. Extra production required to buffer process variability through excess unused inventories of raw materials, work-in-process, and finished goods for quite a long time. This type of losses is characterised by clutter of production areas and warehouses with materials, components and finished products in store, which carries additional expenses for maintenance of the area and the staff. In some cases, traumatic situations can occur due to these stocks; therefore the elimination of this type of losses contributes to the compliance with laws on labour protection.
- *Overproduction*: Producing too much ahead of what's actually needed by the next process or customer. For many manufacturers this is the most serious type of losses because it includes a lot of negative factors and significant costs. In general terms it is primarily the costs of production itself, the movement of products, recording and storage; in addition products in the warehouse lose their relevance, demand on the market and cost over time, they are simply outdated.
- *Over processing*: Performing unnecessary or incorrect processing, typically from poor tool or product design. This type of losses is the fulfilment of actions over the products being unnecessary to the consumer, or rework of defective products. An example of such measures is a complete control when there is no need in this according to statistical indicators, or rework instead of prevention. In addition there can be attributed not ergonomic workplace or working space when even in the order the employee needs to make a lot of unnecessary movements. This factor in production activities is levelled by U-shaped cells that provide the workplace with necessary clear sequence of operations arranged one by one. Where it is impossible to implement such a principle, the card of staff movement over manufacturing area is used for subsequent analysis of it and organisation of activities to minimise these movements.

- *Waiting*: Operators standing idle as machines cycle, equipment fails, needed parts fail to arrive, etc. in this case it refers to the process waiting for another one. Similar losses occur when the uniformity of the production activity flow is violated, where there are highly loaded sections of the path (the so-called bottlenecks), which can result in disruption of all activities of the production line.
- *Motion*: Operators making movements that are straining or unnecessary, such as looking for parts, tools, documents, etc. This type of waste is more common for the enterprises that do not keep order in the manufacturing areas, which makes employees search for the necessary materials, tools, and the right information.
- *Defect rework, and scrap*. This type of losses includes a variety of negative factors including customer's dissatisfaction, negative attitude to the manufacturer, the additional costs on rejection rework or recycling, while to remanufacture this rejection certain resources had been spent and ultimately did not pay off themselves.

Over time seven main types of losses have been added to by new losses associated with unused human potential of employees or false economy consisting in the use of low-quality feedstock and materials. The *eighth type* of waste was added and defined by James Womack who considered under-utilised skills or talent as a source of waste which has to be eliminated through elevating the level of the workers' productivity and efficiency through task scheduling and planning (Womack et al., 1996).

The realisation of each of the above types of waste is a very important factor to achieve success in the implementation of Lean Manufacturing in the organisation. Of course, for the best applicability of this approach in its own activities every organisation can add, exclude or change certain principles of Lean Manufacturing; however, the essence is always the same; elimination of all kinds of losses and maximum consumer's satisfaction.

5 Lean manufacturing tools

The objective of Lean Manufacturing is a to eliminate any types of waste and to minimise all kinds of losses. Lean Manufacturing tools are a set of variety standalone and interrelated procedures that are mutually complementing each other to achieve the objective of eliminating waste and minimising waste. Some of these tools are described below

- *Kanban* is a Japanese word invented by Taiichi Ohno. It has two parts: The word Kan means card, and the word ban means signal. It is pronounced as 'Kahn-Bahn'. Kanban refers to 'signal cards'; this is a card-based system that lets workers have what they need, where they need it, and when they need it (Berekely, 1992). Kanban is a single printed card that contains specific information such as part number and description. It is used to implement pull systems in production process to reduce costs by minimising the inventory, which provides the ability to adjust production more quickly in response to changes in demand. Kanban systems are inventory delivery control techniques used to re-enforce constant work flow throughout the assembly line. Kanban cards are divided into several types: cards triggering the previous process and cards required for direct movement. The movement of products over the manufacturing area is carried out in special containers, boxes or carriages, and Kanban cards are attached to them. Kanban is highly responsive to customer demand. The external customers can have the products available when they need them, which implies continuous product availability, and for any extraction of the product there is an impulse to refill (Lee and Ebrahimpour, 1984).

- 5S is a house keeping methodology that focuses on having visual order, organisation, cleanliness, and standardisation. 5S is a system of an effective organisation of the working space, making cleanness and order as well as strengthening discipline. This tool is characterised by its applicability to almost any space from storage facilities to the workplace of employee and even the order of files on a person- al computer. This system consists of five consecutive Japanese words: (Seiri, Seiton, Seiso, Seiketsu, and Shitsuke).

  (Seiri) means *sort*: A process of identifying all items in a work area and the appropriate disposition of those items.

  (Seiton) means *set in order*: A process of assigning a storage space for all items remaining in the work area: "a place for everything and everything in its place" (Shingo and Dillon, 2003).

  (Seiso) means *shine*: A process of thoroughly cleaning the work area. Workers take pride in a clean work area and create ownership in the equipment and facility. Workers also begin to notice changes in equipment and facility location such as broken or misaligned machines.

  (Seiketsu) means standardise: A process of changing employee value by practicing clear workplace standards throughout the organisation.

  (Shitsuke) means sustain, this step is considered the most difficult step of the 5S to implement. Human nature resists change, and tends to return to the status quo and the comfort zone of the old way of doing things. Sustain focuses on defining a new status quo and standard for the workplace (Carl, 1984).

- *Cellular layouts,* is an arrangement and coordination of the physical cell to allow greatest efficiency in the combination of men, materials, and machines. Cell layout reduces the time between operations and increases productivity by balancing the process and enabling flow to be continuous. Cell layout refers to the arrangement of assembly line operations into small such as S-shaped, I-shaped, and U-shaped cells.

- *Total productive maintenance* (*TPM*) is aimed to increase equipment reliability and availability through well-defined maintenance control. TPM is primarily intended for preventing possible malfunctions of equipment resulting in manufacturing of defective products. The concept of TPM was first put forward by Seiichi Nakajima, who pioneered the approach in Japan and exerted a major influence over the economic progress made by Japanese manufacturers from the late 1970s. TPM is a successful strategy toward zero breakdowns, zero defects, and lower costs, which can be achieved by observing the equipment's life span. The most popular performance measure in the TPM is the Overall Equipment Efficiency (OEE), which is defined as follows (Smith and Hawkins, 2004):

$$OEE = E \times P \times Q$$

Equipment availability: E

Performance efficiency: P

Quality rate: Q

The world-class level of OEE starts at 85% based on the following values: 90% equipment availability,

95% performance efficiency, and 99% quality rate (Evan and Lindsay, 2004).

- *Heijunka* is a Japanese word means levelling out production schedule for both volume and variety. It refers to the way in which jobs are scheduled. A levelled production is necessary to keep the system stable and to allow for minimum inventory. By keeping the production constant, variability that is due to sporadic customer demand does not force the assembly line to have a work-in-process (WIP) when demand is low and too little when demand is high. Big spikes in the production of certain variety while excluding others will create part shortages unless huge inventory is maintained.
- *Poke Yoke* (Poh-kah Yoh-kay) is a mistake-proofing technique that makes it difficult or impossible for the workers to perform the job incorrectly. Poke Yoke was invented by Shigeo Shingo in the 1960s (Shingo and Dillon, 2003). Shingo made a crucial distinction between a mistake and a defect. Mistakes are inevitable; workers are human and cannot be expected to concentrate all the time on the work in front of them or to understand completely the instructions they are given. Whereas defect is a result from allowing avoiding mistakes. Therefore, defects are entirely avoidable (Bayers, 1994).
- *Jidoka* means it is authority to stop the production system if there is a mistake or defect. The Japanese practiced this tool to stop the defect propagation in the production process.
- *Fast Changeovers* is simply the time required to change between machine to machine, shift to shift, piece to piece, stage to stage. It could be a matter of changing size, style, colour, materials, tools, or instructions (Smith and Hawkins, 2004). This system developed by Shigeo Shingo has made a major break- through in the processes of equipment changeover and refitting. The main essence of this tool of is the drive for the changeover under the principle of 'in a wink'. According to this system, all processes related to changeover or refitting are divided into internal ones performed when the equipment is turned off, and external ones carried out directly in the course of work. And the idea is to transfer the maximum number of changeover processes from the inner part to the outer one, which will enable to minimise the losses of time and increasing the mobility of production lines.
- *Single minute exchange of die* (*SMED*) is a technique used to reduce lot sizes in a manufacturing operation that typically makes products in batches. The lean idea is that less money will be wrapped up in work-in-progress inventories, so that if a product becomes obsolete during production not much money is lost. For example, in the production with the implemented SMED system functional clamps are used that allow of secure fitment in one motion, thus this upgrade makes it possible to

get rid of the screws that take a lot of time to work with them, though the result is the same parts are fixed. Such methods and principles constitute the SMED system and guarantee the acceleration of work of the enterprises producing a broad range of products.

- *Andon* boards are signal systems that are employed to notify operators about the status of the system they are working in. It is the tool that facilitates the system operations visualisation. It includes various kinds of visual tools and techniques to ensure the availability of information on how the work must be carried out. In other words, the implementation of this tool by using visual aids allows for faster understanding of the system status.

These are not all the tools of Lean Manufacturing. There are many of their analogues or combined together concepts of the different instruments that form new ones. The industries that follow the way of implementation of Lean Manufacturing tools at the lowest costs achieve more results, these are: an increase in labour productivity, improvement of product quality, reducing nonconformities, decrease of investment needs and so on, and so forth; the amount and quality of improvements speaks for itself.

6 Lean manufacturing tools in HIC

The study investigated the list of registered companies in HIC through the administration office in Hail Chamber. Besides, the researcher visited each company and collected the data though semi-interview with main office personnel of each company. The researcher asked them to rate their level of involvement in applying a list of 10 lean manufacturing tools. Each tool could be rated 'Strong' (S), 'Medium' (M), or 'Weak' (W) in term of its utilisation. The researcher focused the study on the lean manufacturing tools that are illustrated in the previous section; Andon, SMED, Fast Changeover, Jidoka, Poke Yoke, Heijunka, TPM, Cellular Layout, 5S, and Kanban.

After collecting and organising the data, the researcher categorised the companies in HIC into 10 sectors; pharmaceuticals, automotive parts assemblies, construction materials and tools, steel structures, wood and kitchen parts, distilled water, grains, food, chemicals and solvent solutions, and plastic products. Table 1 shows the HIC sectors categories and whether the company use the lean manufacturing tools or not.

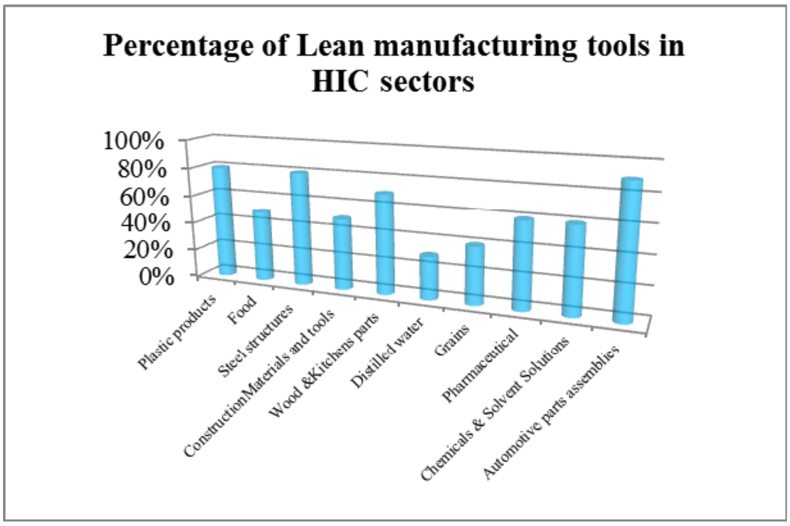
Figure 1 shows that 90% of the listed tools are used in automotive parts assemblies, 80% in plastic products and steel structure, 70% in Wood and kitchen parts, 60% in pharmaceuticals and chemicals and solvent solutions, 50% in Food and construction materials, 40% in grains, and 30% in distilled Water.

Figure 2 shows the percentage of times of occurrence of each lean manufacturing tool in various HIC companies. 90% of the companies are using Kanban and TPM, 80% are using 5S and cellular layout, 60% are using Andon and Jidoka, 40% are using Poke Yoke, and 30% are using SMED and Heijunka.

Table 1 Scope of industrial organisation

Tools	*Scope of industrial organisation*										
	Plastic products	*Food*	*Steel Structures*	*Construction Materials and tools*	*Wood and kitchens parts*	*Distilled water*	*Grains*	*Pharmaceutical*	*Chemicals and Solvent Solutions*	*Automotive parts assemblies*	*Times of occurrence*
Andon	✓		✓	✓	✓			✓	✓		6
SMED				✓	✓					✓	3
Fast Changeover		✓	✓			✓		✓	✓	✓	6
Jidoka	✓		✓		✓			✓	✓	✓	6
Poke Yoke	✓		✓				✓			✓	4
Heijunka	✓		✓							✓	3
(TPM)	✓	✓	✓		✓	✓	✓	✓	✓	✓	9
Cellular Layout	✓	✓	✓	✓	✓		✓	✓		✓	8
5S	✓	✓		✓	✓			✓	✓	✓	8
Kanban	✓	✓	✓	✓	✓	✓	✓		✓	✓	9
Percentage of involvement	80%	50%	80%	50%	70%	30%	40%	60%	60%	90%	

Figure 1 Percentage of lean manufacturing tools in HIC sectors (see online version for colours)



To measure the level of involvement of each lean manufacturing tool in HIC sectors, the researcher assigned a colour code and numerical value for each level of utilisation as shown in Table 2.

Figure 2 Times of occurrence of lean manufacturing tools (see online version for colours)

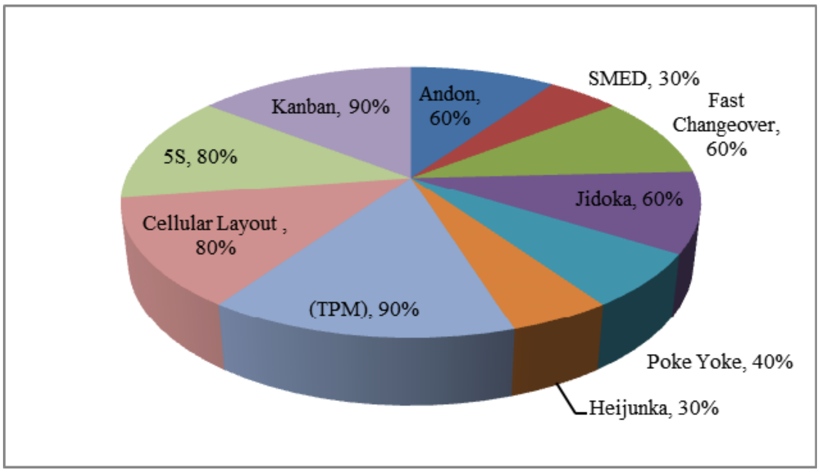


Table 2 Scale of level of utilisation (see online version for colours)

	Level of relevance		
Utilisation level	*Strong*	*Medium*	*Weak*
Utilisation level weight	9	5	1
Interpretation of the weight	Fully used	Partially used	Not used
Utilisation level colour code			

To illustrate the method of calculating the level of involvement for each lean manufacturing tool in HIC the researcher used the following:

$$LI = \sum (R \times W)$$

where

LI: Level of involvement

R: Recurrence of HIC sector rate

W: Weight of the utilisation level.

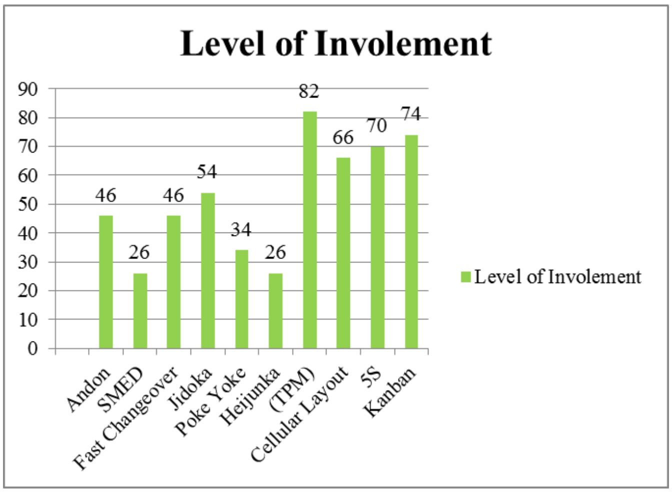
Table 3 summarises the calculation of the involvement level of the 10 lean manufacturing tool.

Figure 3 shows that TPM is the highest common used lean manufacturing tool in HIC, while SMED and Heijunka are the least and.

Table 3 Lean manufacturing tool involvement levels and ranks (see online version for colours)

Lean manufacturing tool	*Scope of industrial organisation*										*Involvement*		
	Plastic products	*Food*	*Steel Structures*	*Construction Materials and tools*	*Wood and kitchens parts*	*Distilled water*	*Grains*	*Pharmaceutical*	*Chemicals & Solvent Solutio*	*Automotive parts assemblies*	*Weight (S = 9, M = 5, W = 1)*	*Level*	*Rank*
Andon	M	W	S	M	M	W	W	S	S	W	3S + 3M + 4W	46	6
SMED	W	W	W	M	M	W	W	W	W	S	1S + 2M + 7W	26	8
Fast Changeover	W	M	M	W	W	S	W	M	S	S	3S + 3M + 4W	46	6
Jidoka	M	W	S	W	S	W	W	S	S	S	5S + 1M + 4W	54	5
Poke Yoke	S	W	M	W	W	W	M	W	W	S	2S + 2M + 6W	34	7
Heijunka	M	W	M	W	W	W	W	W	W	S	1S + 2M + 7W	26	8
(TPM)	S	S	S	W	S	S	S	S	S	S	9S + 1W	82	1
Cellular Layout	S	S	M	M	S	W	S	S	W	S	6S + 2M + 2W	66	4
5S	S	M	W	S	S	W	W	S	S	S	7S + 1M + 2W	70	3
Kanban	S	S	S	M	S	S	S	M	S	S	7S + 2M + 1W	74	2

Figure 3 Lean manufcturing tools levels and ranks (see online version for colours)



7 Conclusion

The most difficult constraint faced the researcher during the investigation of the level of applying lean manufacturing tools in HIC is the management attitude. They were afraid of finding mistakes in their firms, and they were concerned about proposing any type of operational routine change. Indeed, lean manufacturing requires a full commitment from the management team especially the top management, and every tool of lean manufacturing is intended to solve one or more constraints or type of waste in the organisation. The integration of several tools of lean manufacturing would enhance waste elimination. The study found that lean manufacturing tools are intensively used in automotive parts companies with 90% occurrence, plastics products companies and steel structures companies with 80% occurrence.

The study investigated the level of involvement of 10 tools of lean manufacturing and found that 90% of the companies are using Kanban and TPM, 80% are using 5S and cellular layout, 60% are using Andon and Jidoka, 40% are using Poke Yoke, and 30% are using SMED and Heijunka. In addition, the study found that TPM is the highest common used lean manufacturing tool in HIC, while SMED and Heijunka are the least.

Finally, the study found that implementation of Lean Manufacturing is needed to eliminate waste and decrease losses and make the processes activity optimised at HIC industries. The researcher recommend that the HIC leaders must be aware of the importance of applying lean manufacturing tools in HIC to eliminate any non-value added operation that would stand against HIC local and national competitiveness.

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