

An Analysis of Incorporation of Lean Tools inside Quality Control Tools

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Abstract: *In the present competitive world, with an expansion in populace and subsequently the requests, to satisfy those needs a ton of enterprises that give a similar sort of merchandise and ventures have come up from little scope to huge scope which has inevitably prompted a great deal of rivalry among them. So as to build deals and arrive at the benefit desires to make due in this serious condition, an organization needs to follow and place in the application OF various devices and strategies. Executing legitimate procedures and applying the right tool at a right spot at the right time can most likely assistance an organization in revising the escape clauses in their framework and henceforth exceeding expectations in the business. This paper deals with various tools and techniques which, when incorporated in the system of an organization in a proper way can make it achieve its sales and profit goals.*

Keywords: Industrial Sustainability, Lean Manufacturing, Quality Control

1. Introduction

Sustainable development is basically referred to as developing and moving forward in such a way that no compromise is made with the environment which basically implies the usage of techniques which not only reduces the exploitation of available resources but also decrease the pollution and wastes. But these practices are more labour intensive although the resource usage is less [1]. More people are required to do the same which increases the cost to the company and the profit expectations are not reached. So, to counter this issue the system has to be developed in such a way that in protecting the resources for the future generations, the profit margins and consumer satisfaction is not compromised [2]. To make a balance between Green Manufacturing and making profit various tools and techniques have to be applied in a complex manner [3].

Quality control is a methodology which contains a set of tools and methods which serve the purpose of maintaining a standard of the quality, life-cycle, damage proneness upon harsh conditions etc [4]. Basically, the only motive of Quality control is to do internal and external improvements just to make it perfect without laying any emphasis on the costs incurred. Applying these, in a product, increases the processing cost, material cost, labour cost, as well as a lot of time is used up, hence value of the product increases to maintain the profit margin [4,5]. But, although the quality is high, the high costs eventually decreases the sales and the product life cycle ends causing an overall loss to the manufacturer [6]. Now, Lean Manufacturing is a methodology which contains a set of tools that is only concerned in saving costs wherever possible even if, sometimes, the quality is compromised, although a few of its tools lay emphasis on quality but still it is less than what we get on solely apply in h Quality Control [7]. Lean focuses on removing all the factors that do not leave any impact on the customer, for example, a customer couldn't care less about the inner highlights of an item, so utilization of generally excellent quality isn't done, along these lines the expense on the material is spared yet the item turns out to be somewhat less dependable. Because of the low manufacturing costs in Lean Manufacturing, the sales tend to increase. The general

objective is to benefit the sellers, so legitimate synchronous execution of these tools is extremely hard to be in place of conventional strategies in an organization [8,9].

The actual problem is to implement Lean Manufacturing and Quality Control in such a way that a balance is maintained between the two and the customers obtain a high-quality product with a low manufacturing cost and hence higher net profit to the manufacturers. Lean tools already deal in increasing the quality of the product i.e. Total quality management already incorporated in implementing lean tools [10], but there is another way around, like, what if we incorporate lean tools into quality control methods? Would that be more profitable and satisfactory than before or not?

Womack and Jones, in their book Lean Thinking, characterize lean assembling as "an orderly way to deal with recognizing and disposing of waste." When appropriately actualized, lean assembling gives numerous focal points, which incorporate improving stream (material, individuals, data, and work) and taking out waste. These advantages can be acknowledged utilizing an assortment of lean assembling devices, similar to 5S, Kaizen, and Total Productive Maintenance (TPM) [11].

(a) Create Flow

Lean assembling can help make course through procedure and visual plan. Each factor (structures, individuals, gear, materials, and procedures) must be painstakingly inspected with the goal that work process can be upgraded. 5S can help improve work process by Removing pointless tools, supplies, and hardware to build the accessible work zone and extra room (Sort)

- Organizing devices, supplies, and workstations in a way that will improve productivity and make it simpler to move starting with one errand then onto the next (Set all together)
- Cleaning the working environment to make it simpler to spot releases, material development (metal shavings and dust), and different signs that gear may not be working appropriately (Shine)

- Applying predictable enhancements from Sort and Set all together all through the working environment (Standardize)
- Continuing to audit and improve work process by rehearsing each progression in 5S (from Sort to Sustain) every day (Sustain)

All through the procedure, visual structure (signs, names, wayfinding, and floor checking) can bolster 5S:

- Mark tools with division data, numbers, and scanner tags to improve following and remind laborers where things have a place.
- Use shading coding to recognize one office from another. This will help guarantee that workers can rapidly explore their work environment and distinguish their zone of obligation.
- Use floor stamping items to distinguish places for gear, mark traffic paths (controlled vehicle versus passerby paths), and assist individuals with distinguishing offices and work zones.
- Place signs in key areas to convey normal upkeep rehearses also the tools expected to perform support or get together. This will make it simpler for laborers to follow principles and guarantee that they have the tools they have to play out their work.

At the point when utilized together, these visuals structure a complete framework that empowers individuals to rapidly travel through the working environment, distinguish strategies, find hardware, and supplant gear toward the day's end. Become familiar with 5S and how it can improve work process, increment productivity, and lessen costs with the top to bottom Best Practice Guide to 5S by Graphic Products.

(b) Expel Waste

Diminishing waste is one of the key parts of lean assembling, and devices like Kaizen and TPM can assist organizations with finding and dispense with squander all through the work environment. Squander takes numerous structures including:

- Time spent pausing
- Overly confused techniques
- Defects or blunders made by procedures or gear

Inert and breaking down gear is a huge wellspring of waste for some organizations. Insufficient upkeep makes hardware separate, bringing about inefficient times of personal time. TPM assists with diminishing gear breakdowns through its Eight Pillars. Administrators perform day by day upkeep on the gear they work with and report issues to the support office. The support division, thusly, addresses issues before they cause hardware to separate. At the point when the gear separates or produce imperfect items, the reason is dispensed with by refreshing preventive support programs, putting resources into new hardware, and by giving extra preparing varying. Regardless of which lean assembling tool is utilized (5S, Kaizen, or TPM) organizations will expand benefit by improving stream and decreasing waste.

2. Lean Manufacturing Tools

Now the question arises that what are actually Lean tools and how they work.

Kaizen - Kaizen is a framework that takes a stab at constant improvement in regions of value, innovation, forms, organization culture, profitability, wellbeing, and authority. The thought is that each worker and each degree of the association can make recommendations for development. While these recommendations regularly don't prompt significant change, after some time, little upgrades can include and prompt noteworthy decreases in squandered assets. In Japanese, Kaizen implies nonstop improvement or great change. In genuinely lean organizations, it is a way of thinking that pervades each part of the organization's way of life. It is the determined quest for wiping out waste [12].

Kanban - Kanban is pull creation framework intended to take out stock waste and overproduction. At the point when a get together thing or loaded thing starts to come up short, a representative excursions a visual reorder device that triggers a programmed reorder of stock. The stock is sufficiently only to recharge the sum devoured and forestalls the unnecessary amassing of stock. This occurs with negligible human mediation, and guarantees that creation proceeds with no deterrents or hiccups. This encourages producers to keep stock low by responding to needs, as opposed to making incorrectly surmises about request amounts [13].

Value Stream Mapping (VSM) - Value stream mapping (in some cases called VSM) is a lean assembling strategy to break down, structure, and deal with the progression of materials and data required to carry an item to a client. Otherwise called "material and data stream mapping", it utilizes an arrangement of standard images to portray different work streams and data streams. Things are planned as including value or not including value from the client's point of view, to uncover things that don't include value. Value stream mapping can be utilized to improve any procedure where there are repeatable advances – and particularly when there are various handoffs. In assembling, handoffs are simpler to picture since they normally include the handoff of an unmistakable deliverable through stations. On the off chance that, for instance, an issue emerges when collecting a vehicle, line laborers can see the physical parts amassing and sticking up a specific piece of the sequential construction system. They would then be able to stop the line to take care of that issue and get the procedure streaming once more. The use of value stream mapping – additionally alluded to as "imagining" or "mapping" a procedure – isn't constrained to the mechanical production system. Lean value stream mapping has picked up energy in information work since it brings about better group correspondence and increasingly powerful joint effort [14].

Jidoka - The idea of Jidoka first picked up footing in the nineteenth century. The thought is to structure hardware that is incompletely computerized and will stop at whatever point an imperfection is distinguished. Essentially, a human specialist directs a robotized procedure and, when the procedure is halted, the laborer will intercede to explain the problem. Not just does Jidoka lessen costs and improve profitability by just requiring a solitary laborer on location, it eventually decreases the quantity of imperfections that are delivered; which prompts expanded consumer loyalty. Jidoka is the idea of "don't pass deserts down-stream", you own the issue. We should diminish surrenders by forestalling

mistakes, and so forth. It is frequently contrasted with job burdens, the idea of "mistake sealing" an activity [15].

Total Quality Management (TQM) - First executed by Western Electric Company, TQM is a far reaching, association wide methodology that looks to improve the nature of items and administrations an association produces. The objective of TQM is to ceaselessly refine and tweak forms through the periods of the Deming Cycle: Plan, Do, Check, and Act (PDCA). TQM puts a solid accentuation on consumer loyalty and has the capacity to totally streamline change the manner in which an association works [16].

TQM is really the Lean tools which manages Quality improvement. Total quality administration (TQM) is an organized way to deal with by and large authoritative administration. The focal point of the procedure is to improve the nature of an association's yields, including products and enterprises, through ceaseless improvement of inside practices. The norms set as a component of the TQM approach can reflect both inner needs and any industry guidelines as of now set up.

Industry measures can be characterized at different levels and may incorporate adherence to different laws and guidelines overseeing the activity of the specific business. Industry measures can likewise incorporate the creation of things to a got standard, regardless of whether the standard isn't sponsored by authentic guidelines. TQM is viewed as a client centered procedure and focuses on persistent improvement of business tasks. It endeavors to guarantee all related representatives progress in the direction of the shared objectives of improving item or administration quality, just as improving the strategies that are set up for production [17].

3. Quality Control

The quality control tools that are used in the industries are:

- 1) **Advanced Product Quality Planning (APQP)**: APQP is a group of different strategies and procedures utilized for item quality confirmation by conveying different prerequisites, particulars, and dangers. It is like the idea of Design for Six Sigma (DFSS). Five phases of APQP are Pre-planning and input, Planning and defining, Product assignment and development, product designing and development, and Product process validation [18].
- 2) **Failure Mode and effect analysis (FMEA)**: In FMEA, all the potential methods of disappointment which can come to pass are resolved, trailed by the assurance of their root and the outcome issues. A specialized hazard level of the outcome is doled out. On the off chance that the hazard level is seen as much raised, steps are taken to lessen the hazard by fixing the deformity. A few elements used in FMEA improvement are Severity, Occurrence, Detection, and Risk Priority Number (RPN), Criticality. Subject matter experts (SME) use their experience to determine potential failure modes [18].
- 3) **Measurement Systems Analysis (MSA)**: MSA is a trial and a numerical technique that is utilized for computation of variety inside the estimation procedure, which adds to generally speaking procedure changeability. MSA searches for five unmistakable boundaries i.e., Bias,

Linearity, Stability, Repeatability, and Reproducibility. Acceptance is based on two parameters: (a) percent error in tolerance limit and (b) percent error in variation [18].

- 4) **Statistical Process Control (SPC)**: SPC is an assortment of factual procedures planned to comprehend the adventures of a framework. SPC uses central tendency i.e., Mean, Median, and Mode, as well as Variation and Standard deviation to control the quality and determine errors [18].
- 5) **Product Part Approval Process (PPAP)**: PPAP is a normalized procedure in the car and aviation enterprises. It is the business standard that guarantees that building plan and item detail prerequisites are with no defect. It additionally assists with guaranteeing that the procedure chose to fabricate parts can reliably recreate parts at arranged creation volumes immediately. A Cross Function group (CFT) is expected to finish PPAP documentation. The elements require input from (a) Supplier procurement and subcontracts (b) Design engineering (c) Processing and Manufacturing engineering (d) Quality Assurance and control (e) Manufacturing Operations (f) Lab Activities [18].

4. TQM vs Quality Control

All out Quality administration is the act of drawing up plans that decide the gauges that need to apply to the undertaking, figuring out who might be engaged with overseeing quality and their particular obligations, gatherings to decide whether the task is adjusting to the quality details spread out in the quality administration plan and spreading out the measurements that are utilized to quantify quality. As characterized by the PMBOK, Project Quality Management is the far reaching plan that incorporates all the parts of the quality arranging process. Quality control, then again, is the arrangement of procedures that measure the measurements of value by evaluating the particular undertaking results against guidelines. Quality control forms are finished during venture checking and controlling capacities while quality administration is finished during the starting and arranging stage (PMBOK, 2009). Subsequently, quality control is the subset of value the board and is the last period of the undertaking the executives cycle. Quality administration is widely inclusive and comprise of setting down principles against which the task quality measurements are characterized and should be estimated against. Quality administration considers the lower level subtleties of how the yield of the venture is to be followed and estimated [19]. Quality control is the way toward guaranteeing that the quality measurements are met. Consequently, while quality administration is the way toward arranging and dealing with the necessities of the task from the point of view of value, quality control is the way toward estimating the degree of yield and the nature of the yield and normally comprises of estimating the yield against the quality measurements that were chosen in the quality administration plan. The explanation that quality administration and quality control are utilized reciprocally is because of the recognition that quality control incorporates the arranging viewpoint too. This is absolutely obvious in associations that don't have a different quality office and quality arranging and quality control is the space of the task the executives forms. In associations that have separate quality offices and where

there is an all around considered quality arrangement, quality administration and quality control are isolated and are taken care of by various individuals. Taking everything into account, quality administration commonly creates as its expectations a thorough quality administration plan that incorporates the quality control part of it. Quality control for this situation is taken care of by an alternate arrangement of individuals who do the following and estimating of measurements in a committed way. Commonly, the procedure of value the board incorporates the agents from the quality division and the quality control forms are the converse with the quality office taking care of the following of measurements and answering to the venture supervisory crew. Quality control is an autonomous review of the nature of expectations and is vital for the close down of the task [19,20].

5. Lean and Quality Analysis

Presently the inquiry emerges on the off chance that we should adopt the Lean strategy all things considered or, we should accept quality control as the primary methodology and make lean a piece of it. This should be possible on the off chance that we expel TQM from the Lean system and join Kaizen, Kanban, VSM and Jidoka in APQM, FMEA, MSI, SPC and PPAP individually. This would guarantee that now the fundamental point of the association would become to concentrate on the Quality of items, fusing inside them, the settled lean apparatuses in that.

Now, if we take a theoretical consideration:

Let m be the base manufacturing cost of the product without Lean implementation or Quality Control implementation
Let x be the profit margin that is fixed by the manufacturer as per his expectations of profit, L is the cost of lean implementation

$$\text{So, Selling price} = m+L+x \dots\dots(i)$$

Now, on Applying the Lean tools except TQM let the manufacturing cost decreases by 'p' ($p>L$)

$$\text{Selling price now } S1(\text{without TQM})=m+L+x-p = (m-p)+L+x \dots\dots(ii)$$

From equations (i) and (ii), the decreases in manufacturing cost is by a factor of $\frac{m-p}{m}$

On including TQM let the manufacturing cost decreases further by an amount 'q', and Q is the implementation cost
Selling price now, $S2= m+L+x-p+Q-q = (m-p-q)+(L+Q)+x \dots\dots(iii)$

From equations (i) and (iii), the decrease in manufacturing cost due to application of only TQM is by a factor of $\frac{m-p-q}{m-p}$

Now, instead of applying Lean Tools, we apply the quality control tools in the process, Let n is the implementation cost and y is the profit increased to balance the manufacturing costs such that $\frac{x}{m} = \frac{y}{n}$

Selling price of the product with only Quality control Tools= $m+n+x+y$

[y is increased profit margin to keep the profits balance with manufacturing costs, such that $\frac{x}{m} = \frac{y}{n}$

$$\text{S.P. on applying Lean tools except TQM} = \frac{(m+n)(m-p)}{m} + L + x + y$$

[Application cost is L and decrease in manufacturing cost is by a factor of $\frac{m-p}{m}$]

Now 'Q-n' is the cost of TQM application excluding Quality control tools

So, now applying all techniques of TQM without Quality control tool, decrease in existing manufacturing cost due to is by a factor of $\frac{m-p-q}{m-p}$, because decrease in manufacturing cost in TQM is not dependant on quality control tools application, they are just responsible to make products defect free and enable the manufacturer to increase the price due to a better quality.

$$\begin{aligned} \text{Selling price, } S3 &= \frac{(m+n)(m-p)(m-p-q)}{m(m-p)} + L + x+y+(Q-n) \\ &= \frac{(m+n)(m-p)(m-p-q)}{m(m-p)} + L + Q + x+y-n \end{aligned}$$

Now for this to be successful this selling prize must be less than $S2$

So, $S3<S2$

$$\begin{aligned} \Rightarrow \frac{(m+n)(m-p)(m-p-q)}{m(m-p)} + L + Q + x + y-n &< (m-p-q)+(L+Q)+x \\ \Rightarrow y &< \frac{pn}{m} + \frac{qn}{m} \\ \Rightarrow \frac{nx}{m} &< \frac{pn}{m} + \frac{qn}{m} \\ \Rightarrow x &< p+q \end{aligned}$$

Therefore, in this case the profit margin must be kept less than or almost equal to the amount reduced due to basic lean implementation for this case to be successful.

Keeping much higher profit margin can also have a bad effect sometimes, hence if it is kept under a certain limit can prove much beneficial for an organization

6. Conclusions

Quality Control and Lean Manufacturing both have a Herculean arrangement of devices, strategies and rules that when appropriately applied all the while, can achieve unrivaled hierarchical administration and furthermore money related objectives. Its usage standards must be related in the exhaustive mechanical framework to get all the more altogether the impacts in work environments and successful creation frameworks. Makers who have effectively actualized Quality Control are bringing down assistance costs, improving efficiency, and improving quality. At last, makers following Quality Control and Lean tools adequately will develop, motivating new makers for grasping these methods. Accomplishing these outcomes requires an organization to get a great deal of exertion and changes, which is exhausting, however over the long haul, can give the most excellent outcomes. The most vital element for progress is that steady improvement which must be taken very much seriously.

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