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Reliability of Lean Tools

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ABSTRACT: Lean production symbolizes an alternative to the traditional Western production organizations. It is much more than only the outsourcing of vertical range of manufacture to the suppliers. In fact, the lean philosophy is based on a continuous improvement process, which is supported by the employees and the suppliers in order to achieve an increase of productivity. The relationships between employer and employees, suppliers and consumers are totally new defined by implementing the Lean tools like Just-in-Time concept, the Kanban principle and cellular manufacturing. These changes of production management are necessary in order to produce a variety of high quality parts at competitive prices considering the significant changes of a more intense international competition and the increasing globalization. Since the late 1980's "lean production has taken manufacturing industry by storm" [9]. The system, which was developed by Japan after the Second World War in order to overcome the shortage of Japan's resources and the limited means, was first implemented at Toyota Motor Corporation. Toyota is still the prime example of a perfect lean implementation

KEYWORDS: Kanban, cellular manufacturing

I. INTRODUCTION

The outstanding success of several companies and the significant advantages, which the lean production undoubtedly has, cannot cover the problems and risks, which are involved. Managers, who want to change their companies according to the lean philosophy, have to face serious issues. Initially, the partial implementations of the Toyota Production System resulted to failures and misunderstandings causing deceptive myths and prejudices of the function of a lean system - even today [1]. Besides the significant problems of its implementation lean production itself contains weaknesses and drawbacks, which are predominantly linked to a lack of reliability and robustness. This paper shows the main negative factors of this issue and their effects, discusses appropriate reliability tools and provides a methodology, which helps companies to make their systems more reliable and stable.

II. FACTORS CAUSING A DECREASE OF THE SYSTEM RELIABILITY

The implementation and use of a lean production system are challenging tasks. The difficulty is caused by the complexity of this project. For a successful realization every part of a company has to be changed. Therefore, both the incentive of the entire workforce and the support of the management by defending unwelcome decisions are needed. Nevertheless, the fragility and the lack of flexibility are still the main problems of the lean production system [21]. Up to know the system of lean production did not prove its stability in the face of a crisis [1]. In order to make the system more reliable a comprehensive insight of the factors, which negatively affect the system's stability, is required. Therefore, it is important to understand how a lean system reacts if the input and the variables of the system do not meet the expectations or requirements but real conditions with fluctuations and unplanned events based on the today's more and more challenging and fast moving market

2.1 Elimination of buffers (JIT)
Buffers are usually used to establish a certain level of 'redundancy.' They can appear in different forms like extra capacity, lead time or inventory [21]. By using buffers, material is always available at the work stations to ensure a

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high usage and less idle time. WIP-inventory covers the risk of unscheduled downtime and indeterminable failures [1]. Buffers will also compensate an unbalanced line to a certain level or the frequently occurring abyss between the target and the actual state. The coverage of production problems is one of the reasons, why the lean production system criticizes any kind of buffers and tries to eliminate them. The philosophy of lean interprets buffers as a sign of mismanagement, where buffers are only established to protect the system against problems, which are on the other hand occurred by a bad production management. In other words, buffers only cover problems – they do not solve them. By eliminating them, the management is forced to face these failures [1]. A well implemented lean system does not need WIP-inventory (except the 'supermarkets'[1]) – all processes from the supplier to the production and customers are coordinated. Material is provided just on time when the respective workstation needs it. However, the JIT concept is based on many assumptions and conditions, which have to be established, like:

- reliable and stable processes,
- no quality problems,
- punctual and correct replenishments,
- reliable forecasts, or
- totally balanced lines.

A system, which is based on so many requirements and limitations, can easily fail if unpredictable problems arise. This lack of robustness makes the production system fragile and can affect the whole supply chain. "Such supply chains lack then the extra resources needed to cope with unplanned events" [21].

2.2 JIT CONCEPT – THE CONCENTRATION ON MINIMAL RESOURCES

There are three main factors of the JIT concept, which weaken the system reliability [1]. One is the concentration of only one main supplier. JIT production prefers this strategy, because of the significant reductions of time and effort (e.g. data handling), the simplification of part scheduling and quality control, and finally because of the cost-cuttings caused by the reduced amount of required resources. However, there is a high risk involved with this strategy. Uncontrolled events like strikes, natural disasters or mismanagement at the supplier's plant can occur at anytime. The negative effects will then be transferred to every link of that supply chain caused by missing back-ups and a too small pool of suppliers (alternatives). The elimination of material, personnel and machines for rework purposes is the second factor making the system unstable. The philosophy of minimal resources propagates that rework resources are not required, if quality tools and preventive measures are in place. Such a no zero-defect production is a challenging task, which needs a highly developed infrastructure. Smaller enterprises for instance can hardly meet these requirements. Therefore, there will be defective parts requiring rework in order to avoid scrapping. If there are no resources or capacities for rework processes, the goal of reducing costs by eliminating these kinds of capacities can be counteracted by the increasing amount of scrap.

2.3 Optimization

The ultimate goal of the lean production system is the elimination of waste associated with the reduction of costs. Therefore, all utilities are optimized. The amount of used machines, materials and workers only correspond to the amount needed to carry out the production process. The reduction of costs comes along with a reduction of robustness and reliability. Considering the case that an unplanned event (e.g. machine downtime) occurs, the existing capacity will not be enough to fix the problem without a disregard of the current production [21]. The eliminated redundancies and back-ups were originally established to compensate exactly those types of issues.

A better effectiveness due to increased utilities' usage is another method to eliminate waste and cut costs. The weakness of this measure is that the equipment is running almost at its limit. This high load increases the risk to fail and does not longer allow for variability in production [10]. If the demand or the amount of scrap increases, there is no possibility left to compensate this gap. This kind of decreased robustness can result in an increasing delivery time associated with the loss of customers and finally of revenues.

Another critical aspect of the optimization are the shortened and more challenging production times [8], which are set up according to the takt time. This is an absolute requirement for the smoothing of the production. Nevertheless, it

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pressures the employees. This new pressure can cause simple mistakes due to a reduction of the concentration and a faster-growing exhaustion [3]. If finally such a failure occurs there is hardly time to fix it because of the highly optimized processes. In order to fix the problem the stop of the production line or at least the help of a coworker is needed. This is another example where the optimization and lean management increase the system fragility by cutting resources

2.4 The Pull system

The pull system is one of the core measures of a lean production system. It is necessary to ensure low or no buffers, a high level of customization and the reduction of costs by implementing the JIT concept. To be sure that the production does not exceed the demand, the production is set up according to the 'made per order' principle. The production starts only when an order is received. The critical point of this principle is the today's customer, who wants to make his decision on a short-term base and tries to avoid voluminous master agreements with purchase guarantees. The difficulty for a production manager is to correctly set up and schedule the production based on these short-term and uncertain information [23].

2.5 One-Piece-Flow

In order to decrease lead times and achieve the goal of inventory cutting the lean production system forces the companies to shift from the big lot production to a one-piece-flow. Even though a one-piece-flow is practically hardly achievable, the lean production program reduces at least significantly the lot sizes. A smaller lot size comes along with a higher variety of products. The higher form of product customization is mostly used in combination with the single-piece production [2]. Such a change of production operation requires a strict program of setup-time reduction and a redesign of the work floor including a relocation of the machines in order to compensate the higher setup efforts [24]. The increasing number of tool setups, fixture switches, etc. involve a higher risk to fail and a greater source of errors even with prevention and quality programs like 'poka yoke', simply because of the heightened number of setup operations.

2.6 KANBAN SYSTEM

The Kanban system represents only a compromise in the lean production system [1], because the one-piece-flow is not possible in practice and big lot productions have to be eliminated according to the philosophy of lean. Kanban is an important tool to "control the level of inventory, reduce lead times and synchronize the factory as well as vendors with the market" [23]. One of the conditions which are essential for a working Kanban system is the 'weakest link' with regard to stable processes: the concept only allows a limited usage of the capacities. If the demand exceeds this certain level (e.g. month's supply instead of a single container) the balance of the production process could be at risk. From this it follows that the lean production system is only applicable to a repetitive and stable environment. It lacks of flexibility and it is vulnerable in terms of fluctuations of demands and robustness [23].

2.7 Human Factor

The human factor is an example of a double-edged sword. On the one hand the lean production system assures that the workforce is the most important link of the entire system and therefore, the designs of the workstations are improved according ergonomic standards, the morale of the workers is increased by a variety of measures and the employees are involved in all important decisions. On the other hand many workers complain that the implementation of the lean production system comes along with a decline of the working conditions. The work becomes harder, more concentrated, monotone and standardized [3]. These factors create urgency, stress and discomfort among the workforce [8]. Mainly old workers are overstrained by these new conditions. If the stress factor is too high, the morale of the employees will adversely affected and failures will inevitably occur.

III.CONCLUSION

The main objective of a lean system is to achieve system effectiveness not only by reducing lead time and variation but also attaining changes through people. The analysis of the concept of lean shows that not only the

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problems within the implementation phase are potential causes for the failure of the lean system, but also the concept itself contains drawbacks, which is predominantly associated to a lack of reliability. The various components of lean system such as elimination of buffers, JIT, pull system, one piece flow and kanban system makes lean systems fragile. Therefore, the concept of lean has to be implemented in a manner that does not negatively affect system reliability, but also creates sustainable improvements. In this regard, it is important to understand how a lean system reacts if the inputs of the system do not meet the expectations or requirements. In reality the inputs are characterized by fluctuations and unplanned events based on today's more challenging and fast moving markets. The term inputs refer to factors such as incoming material and availability of people. The main components of lean system are defined as parts, material, equipment and scheduling. These components have to be considered and analyzed in more detail to achieve reliability

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