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The Process Model for Shop Floor Management Implementation

Dr. Nico Hanenkamp*

*Vice President Operational Excellence
Freudenberg NOK Sealing Technologies,
47690 East Anchor Court, 48170 Plymouth/Michigan/USA
Fon: +1 734 395 4771
nico.hanenkamp@fnst.com*

Abstract: During the early 1990s, the Toyota Production System (TPS) became widely accepted across the industrialized world. Companies from different industries gained in experience by applying lean principles as well as by developing and refining customized approaches to optimize products and processes. From a practical standpoint, the implementation of TPS-elements such as one-piece-flow, visual standards or U-shaped layouts, can easily be identified on the shop floor. Meanwhile, most of the underlying management processes and structures remain hidden to the outside observer. Closing this major gap is the objective of shop floor management. It provides and formalizes an integrated framework of processes with defined roles, responsibilities and competencies to sustain and improve efficiency. Its fundamental principles include a focus on prevention, frequent high decision making and empowered teams consisting of experts, managers and operators. The objective of this article is to define the scope of shop floor management, to sketch a generic structure in terms of an overall process reference model as well as to detail new and modified sub processes, roles and responsibilities to enhance its implementation.

Keywords: Continuous Improvement, Shopfloor Management, Lean Management, Toyota Production System

Introduction

Scientific research has focused mostly on lean principles, behavior and rules rather than on describing management processes in more detail [1,2]. Due to the abstract nature of these rules, their interpretation and implementation still represents a major challenge for practitioners [3]. Jeffrey Liker notes in his 4P Lean Enterprise Model that most companies are on the “process” layer, i.e. they focus their effort on reducing the seven types of waste while not substantially addressing their philosophy, people and external partners, (see figure 1 [4].) The concept of shop floor management emerged from recognizing the need for efficient, on-site problem solving and therefore contributes to the highest layer in the 4P-model. In practice, problem solving or performance tracking have not been necessarily set up as supporting processes to address the real needs of the production floor but rather for satisfying external requirements such as management reporting. Moreover, while it is essential for managers to be present on the shop floor, there is often a lack of structures and standards to efficiently improve decision making aligned with operational implementation. Therefore, the objective of SFM described here is to close, as much as possible, the gap between individual behavior and organizational guiding principles and their

application in a systematic, process-oriented industrial approach. To do so, the following literature review takes into account existing definitions for shop floor management supporting a pragmatic and process-oriented implementation.

Suzaki defines shop floor management as practicing the three reals: genba (real place), genbutsu (real thing) and genjitsu (real fact) [5]. First, genba refers to the location where the value is created which can be either the factory floor or a business process in case the final product is a specific service or information. The second focus, genbutsu, requires all associates to understand the nature of problems rather than relying on documented information. Finally, genjitsu implies that the connections between the current problems and their final root causes have been mapped based on valid and consistent data. Thus Suzaki defines shop floor management as a closed loop process to observe the problems on site as well as to understand and eliminate their underlying root causes. Slightly different but with a broader scope, Spear identified four main TPS rules to design, operate and improve process efficiency in 33 Toyota plants through embedded research [6]. While not specifically limited to shop floor management, these rules imply that any improvement has to be performed using a systematic

methodology, supported by a qualified coach and executed at the lowest possible level in the organization. A cross-functional rule requires the equipment and process design to meet first time right quality. As a consequence, the organization is able to address continuous, systematic, highly frequent deviations from standards indicating potential risks or current problems. Following Peters definition, SFM consists of recognizing visual deviations from standards and initiating effective countermeasures [7]. In addition to that, he differentiates three maturity levels. The focus on the lowest level is to react quickly to process failures, i.e. the problems have already occurred. A typical example might be the breakdown of a single machine or a section of the production line. The second level emphasizes preventative problem avoidance, i.e. potential sources of risks are systematically monitored and actions are put in place as necessary. On the highest level, deviations from standards have to be closely monitored to prevent the occurrence of problems, implying that root cause and effect is well understood. More advanced levels can only be achieved through a better understanding of system behavior and standardization of prevention rules and the corresponding action plans. Finally, managing closed loop control systems to reduce variation in production processes constitutes the concept of daily management [8,9]. In addition to sustaining standards, daily management also focuses on improvement in current conditions as well as managing change points. Because deviations from standards refer to the process output, change point management is instead used to control input parameters when reaching critical thresholds. It thus anticipates severe impacts on product quality. A strong focus on systematic change point management (CPM) contributes to plan and executes preventative counter measures in a scheduled way with positive impact on process variation and overall efficiency. The brief discussion of the various approaches will be concluded with the formal definition. In general, shop floor management is a precondition for the implementation of lean systems. It defines an organizational framework with standardized processes and activities taking place on the shop floor. Empowered, multi-skilled teams with a profound understanding of system behavior decide and facilitate the sustainable implementation of effective and efficient counter measures. Abnormality control, attainment of change points, deviations from standards, current problems and the continual efficiency improvement along the value stream are the major drivers for activities and counter measures.

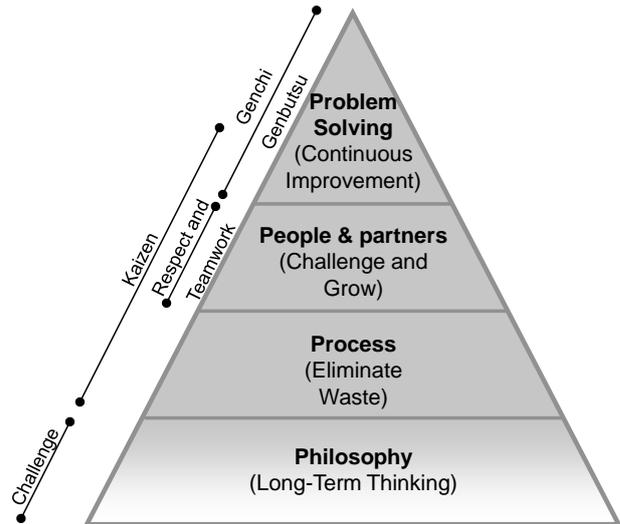


Fig. 1. 4P model

Shop Floor Management Process Model

Figure 2 shows the extended SFM process model based on the previous definition. The display of the hexagon has been chosen to express that the elements complement and interface with each other while the six step process illustrates the rigid, cycle-by-cycle structure leading to its implementation.

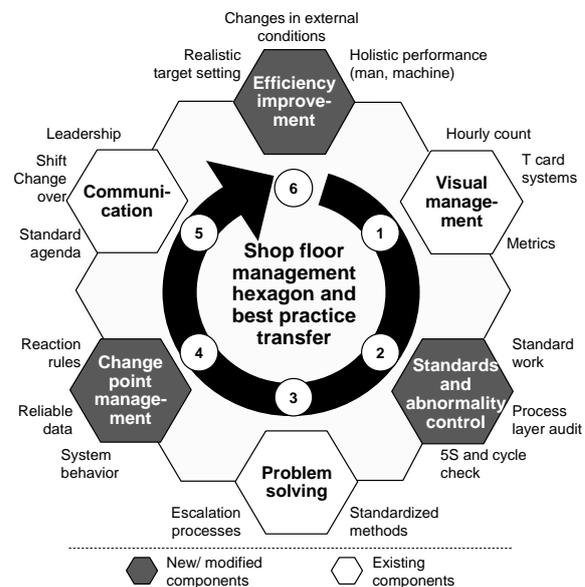


Fig. 2. Hexagon of shop floor management

The tools next to the elements have to be interpreted as enablers of the process. Changing the perspective from a tool-oriented implementation view, e.g. the introduction of standard work combination sheets or 5S standards, to the process perspective helps team and management to understand their “real” contribution to efficiency improvement. Thus the benefit of SFM relies not on the presence of tools but rather on their consistent, process-driven application. Although there is no contradiction between the proposed model and Peters’ concept, three major differences must be acknowledged. First, the

elements change point management and efficiency improvement have been added. Managing change points systematically emphasizes prevention and thus reduces effort required for reactive problem solving. The objective of efficiency improvement is to break down changed external or internal conditions in a standardized way into realistic targets on the operational level by looking holistically at performance (man, machine, organization). The second difference is the change in mind from an element or even tool implementation perspective to a process orientation as stated above. Finally, systematic, best-practice transfer is an integral part of SFM. It ensures knowledge exchange across teams, increases efficiency in problem solving and leads to a focus on prevention rather than on reacting to problems in the long term.

An overview of the nine basic functions of visual management is given in [10]. The authors point out that visualization enables organizations to effectively communicate, focus teams on common goals and facilitate decision making on the shop floor. For implementation purposes, shop floor displays and t-card systems are simple but effective tools. This concept does not specify methods for problem solving. Nevertheless as a general condition, a systematic approach based on reliable standards, for example, 8D, Kepner-Tregoe, Six Sigma, is mandatory to avoid trial-and-error problem solving and leads to significant better results [11, 12]. Depending on the market environment and product specifications, industry guidelines have to be adopted [13]. In addition to the problem solving approach itself, a suitable escalation process has to be defined and aligned with the management levels of the organization. Finally communication refers to standardized and scheduled exchange of information within the team.

Abnormality Control

The objective of this sub process is to enhance the ability to see and correct abnormalities in the short-term that can contribute to poor quality and customer complaints. Based on project experience and scientific research, the importance of abnormality control is often understated [14,15]. The perception of many western managers is that 5S – sort, set in order, shine, standardize and sustain – simply describe basic housekeeping elements rather than a means for managing continuous improvement [16]. Thus implementing stable 5S initially relies upon a strong belief in its importance since the relationship between poor 5S status and its impact on key performance metrics is not directly transparent. This approach thus requires establishment of abnormality control as a consistent process within the shop floor management concept. Finally the process scope should not only encompass 5S, but also incorporate safety related and equipment abnormalities. Some practitioners call this combination of 5S levels and safety the 6S concept.

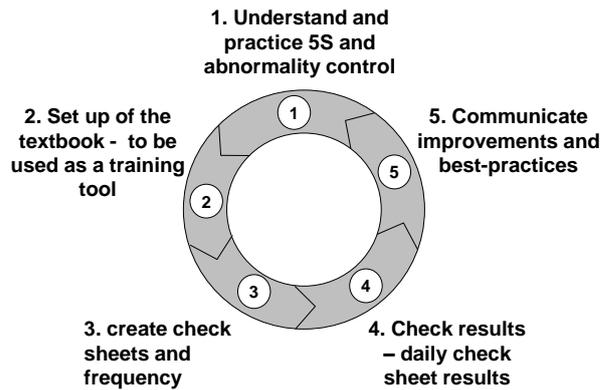


Fig. 3. Abnormality control cycle

Figure 3 displays the continuous process to start and stabilize abnormality control. In the first step, a common understanding of each of the 5S levels has to be developed within the shop floor management team. In addition to that, abnormalities have to be analyzed in a holistic way rather than scattered around the production cell. In addition to observations on the shop floor, external data in terms of process parameters should be taken into account for example, applied pressure or temperatures of a molding press. Sources for this kind of data could be shop floor data based on manufacturing execution (MES) systems.

In the second step, the textbook consolidates these findings and describes their target situation (see figure 4.) Each abnormality found is classified (5S, safety, equipment), assessed regarding its possible nonconformity and assigned to a shop floor team member to be solved. Once completed, the problem-solving steps and responsible team member must be tracked in the third step. As abnormality control is considered a continuous process, existing check sheets are updated incorporating new or modified standards and their check frequencies. Step 4 encompasses the regular monitoring and documentation of the implementation status with visual tracking sheets in the production area. The abnormality control process cycle is concluded with presentation of findings and best-practice solutions to other shop floor management teams before restarting the same activity in a different cell. The conduction of these events is based on a continuous schedule.

Kaizen sheet						
No.	Classification	Process	Abnormality	Possible nonconformity	Date checked	Date complete
20	45	Tech tool box	Unorganized	Waste of time looking for tools needed	10/27/2010	12/9/2010
Before Kaizen				The state of the abnormality: Unorganized		
Checked by: MY, ZV, RJ				Possible Nonconformity: Waste of time looking for tools needed		
After Kaizen				Evaluation of the results: Clean, neat and organized. Less time wasted looking for tools. Tools are less likely to be damaged		
Checked by: MY						

Fig. 4. Textbook

Change Point Management

In general, issues regarding product quality are the result of a change. In its introduction, the Toyota handbook for CPM links quality problems with the corresponding nature of a change [17]. According to that, about half of all issues stem from so called programmed changes such as new part numbers, product models or new production process introductions. Considering that these processes are managed by other major business units prior to start of production and thus not primarily owned by the shop floor – for example the product development process – other quality issues that erupt can be considered systemic. Their main drivers are setup and changeover processes, operator changes and abnormal conditions in terms of machine or tool malfunction.

Therefore, CPM always starts with a holistic analysis of potential change points (see figure 5.) Change points in each of the four categories have to be discussed regarding root causes impacted by man, machine, material and methods using Ishikawa diagrams. Past experiences, current problems and future potential risks have to be taken into account in this brainstorming stage. While the challenge for planned changes is to minimize disruption of current production, the focus of the second and third category is to define suitable reaction rules for personnel facing clearly described abnormal situations. Finally, visualization is the key to manage gradual changes. Upper and lower control limits combined with real-time process data, for example, sharpness of tools, indicate whether change points have been approached or already reached. Six Sigma tools can be used to model the system behavior in case process data cannot be directly measured.

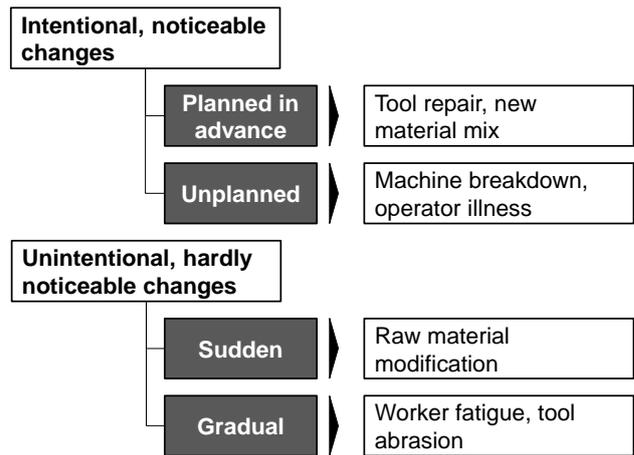


Fig. 5. Change point analysis

Once the analysis is complete, standard reaction rules have to be agreed upon and described in abnormality reaction rule displays, (see figure 6.) They connect the change points on the left with the corresponding escalation levels to the right, commencing with the operator at the machine and moving up the chain to the operations manager. They describe specific actions to be taken according to the competencies of each role. The levels have to be aligned to other escalation processes such as layered process audits. The standard agenda on each level starts off with an evaluation and assist phase to agree on the same problem and root cause understanding, followed by recording and reporting the change point event. The record history facilitates internal or external tracking specifications and also helps to understand in detail the impact of the change point to the process output. If the directly initiated counter measure has been effective, regular operations will be resumed and an escalation to the subsequent level is not required. To ensure a quick response and information tracking, standard lead times can be defined for each level after automatically being forwarded to the next layer. Nevertheless this automated flow must not be designed too aggressively, ending up potentially with either with too much detail on higher escalation levels or overloading the process. Even with a highly skilled and trained workforce, these displays serve as a guideline and check list of necessary actions. They are not a substitute for more detailed process descriptions such as quality control plans. Finally, they illustrate standard reaction rules to outside observers and thus explicitly describe the dynamic behavior of the production system.

Change points categories	Escalation levels			
	Operator	Set up	Group leader	Operations manager
Equipment	Stop and suspend	1. Evaluate and assist	1. Evaluate and assist	1. Evaluate and assist
Raw material	Call	2. Record and Report	2. Record and Report	2. Record and Report
Tool		3. Counter measure	3. Counter measure	3. Counter measure
Finished product	Wait	Decision: Resume or escalate	Decision: Resume or escalate	Decision: Resume or escalate
Inspection, packaging		Decision: Resume or escalate	Decision: Resume or escalate	Decision: Resume or escalate

Fig. 6. Reaction rules

Efficiency Improvement

In addition to maintaining existing standards, SFM has to provide a consistent approach and methodology to facilitate sustainable efficiency improvement. External conditions and performance targets are may continuously change and the TPS also specifies ongoing waste reduction [18]. The following standardized five step process satisfies these exogenous and endogenous specifications.

The first step consists of defining the current needs and focus of the improvement. It can be either induced by modified external conditions, for example, production volume increases requested by the customer, or strategic decisions such as internal product transfers. Key performance indicators that will be impacted have to be selected and top down targets formulated. Following the guidelines of the TPS, the balance of quality, lead time, productivity and safety related targets has to be ensured. Additionally general conditions in terms of constraints must be defined.

The second step incorporates an in-depth analysis of the current performance of the production cell or line. To do so, the limits of the production area have to be grasped using schematic layouts of equipment. Before starting detailed time studies, standard operator movements have to be observed and mapped. The quantity of current production (articles and volume) and resources in terms of operator staffing (shifts or allocated hours) in a representative time period have to be analyzed. Supporting resources such as set up associates have also to be taken into account and if needed, allocated using suitable key factors to the respective production area..

This phase is followed by detailed time studies on the shop floor focusing on standard work as well as non-standard activities (changeover, machine breakdowns etc.). For both types of analyses, the accuracy of time measurement units depends on the observer's choice and the current degree of standardization. For standard work analysis purposes, figure 7 outlines a potential guideline to derive the right detail for the measurement units.

In general, their choice should be based upon the ability to distinguish between activities that add value and those that result in waste. The same concept can be applied to benchmark similar machines against each other on a process step level. Precise time durations to open or close a press, vertical or horizontal movements or the pressure build up phase can be compared among similar types of equipment and the root causes for deviations can be identified. As a final step, a virtual good-practice machine cycle based on the lowest time for each process step should be determined. The final results of the standard work analysis are documented using standard work combination sheets (SWCS) as well as standard work layouts (SWL). In addition to that, the intention of work content studies (WCS) is to get a deeper performance understanding over a longer period of time, typically on a 24-hour basis in a three shift operation. During this period, each associate in the area under consideration is observed separately without interruption. The WCS also encompasses non-standard work such as

shift change activities, changeover processes or response to machine failures.

The production index has three main tasks in the third process step. First, it consolidates the current performance data and therefore determines the baseline for efficiency improvement. Second, it serves as a model to break down overall efficiency targets to specific performance parameters of the production cell as shown in figure 8. For example, reduction in cycle time, increase in overall equipment efficiency or scrap reduction positively contribute to a top-down productivity target of +20 percent. Third, it is able to quickly compare different scenarios with each other before final targets are set.

Line items 1 through 5 usually incorporate external conditions such as the shift pattern and production volumes. Items 6 through 8 represent current resource consumption (personnel, machines and tools), while line items 9 and 10 reflect the major results of the previous time studies. The productive time ratio (11) expresses the percentage of time being spent with production of parts and constitutes the first major performance parameter. This ratio also tracks the current efficiency level of the cell by measuring associate productivity in terms of pieces.. After defining the baseline, the production index is applied to derive sub targets. To do so, external conditions which are not subject to change such as production volume and scrap rate are kept stable.. Here, a challenging top down target of more than 25percent operator efficiency improvement has been given upfront. The production index is now the vehicle to indicate the right levers and derive the corresponding sub targets: integration of an additional machine in the operator cycle (item 7), more efficient use of tool cavities (line 8) and an increase of +3 percent of the productive time ratio (item 11). If achieved, these levers increase efficiency by 36 percent (item 13).

The fourth step defines implementation items to satisfy the above mentioned sub targets and benefits from the detailed time studies and data analysis in earlier steps. For instance, the SWCS represents the simplest simulation tool to check the plausibility of integrating the additional machine in the standard work. It also quantifies how much process steps have to be optimized through waste reduction. If possible, each improvement has to be time studied separately on the shop floor and its impact has to be verified *ceteris paribus*. This best-practice approach ensures an easy transfer of optimization ideas to equipment with slight modifications outside the respective area. Non-standard work activities usually cause disruption of regular operation, thus their main levers for optimization are to perform these tasks in a scheduled and standardized way. Similarly, tool efficiency benefits from preventative maintenance activities that are provided by dedicated expert support teams with fast and reliable response times.

Once all improvement items are chosen and their time-related impact verified, the fifth step encompasses their sustainable implementation. Technical changes of equipment, training of employees and updating of standards is being conducted step-by-step. Until the targeted efficiency has been achieved and stabilized, the production index is being tracked on a shift-by-shift basis.

The implementation is managed by the dedicated shop floor management resources.

Conclusion

Until now, there has been limited research regarding SFM approaches and the explicit formulation of its processes. Information presented in this article will help close this gap.

By discussing related scientific research, the formal definition for SFM has been expanded to represent the foundation for the developed model. The process model is designed to prevent abnormalities, to ensure highly reactive decision making and to facilitate continuous efficiency improvement. Due to their novelty, abnormality control, change point management and efficiency improvement have been described more in detail.

It is important to understand this approach as a consistent guideline rather than a catalogue of tools to be implemented. Involved associates will not only experience a steep learning curve but also a higher motivation as a team. Following this approach, organizations will benefit from more stable processes and aligned decision making rather than reactive problem solving.

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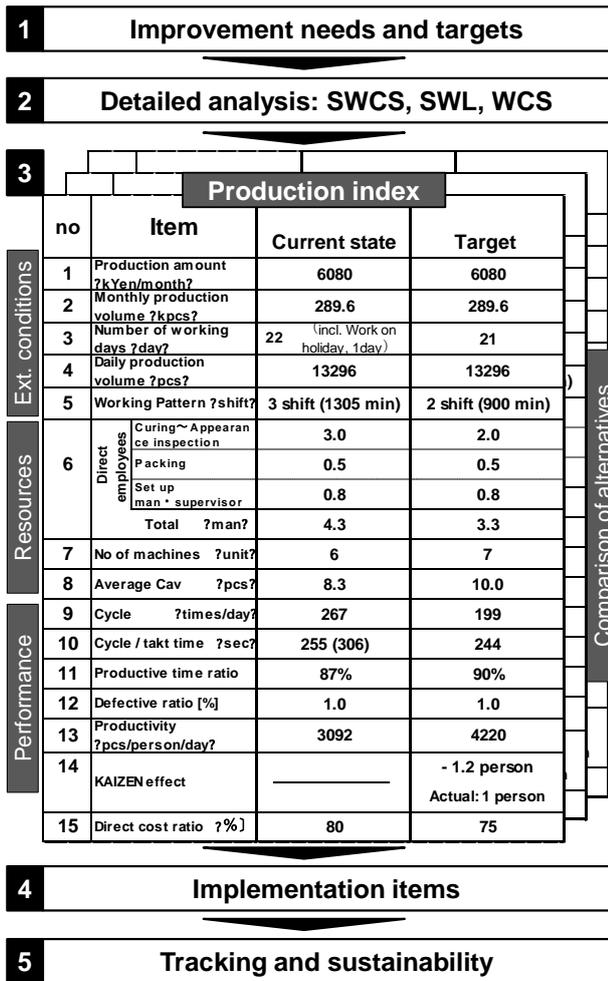


Fig. 7. Production index