KAUNAS UNIVERSITY OF TECHNOLOGY

MECHANICAL ENGINEERING AND DESIGN FACULTY

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IMPROVEMENT OF BRAND CHANGE PROCESS IN COMPANY X BY USING SINGLE MINUTE EXCHANGE OF DYE TECHNIQUE

Final project for Master degree

Supervisor
Assoc. Prof. Dr. Kazimieras Juzėnas

KAUNAS, 2015

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Industrial Engineering and Management (621H77003)

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"Improvement of brand change process in company X by using single minute exchange of dye technique"

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SANTRAUKA

Pagrindinis darbui iškeltas tikslas - pritaikyti greitojo perėjimo metodą "SMED" rūšies keitimo procese, analizuojant proceso trūkumus. Tam tikslui tyrimo objektu buvo pasirinktas cigarečių gamybos rūšies keitimo procesas, kuris susideda iš dviejų atskirų rūšies keitimų - cigarečių gamybos mašinoje ir cigarečių pakavimo mašinoje. Rūšies keitimo specifinių sąlygų bei SMED taikymo galimybių bei galimų rezultatų analizė buvo atlikta, remiantis literatūrine analize ir atlikta SMED sesija cigarečių gamybos ceche. Analizė parodė, kad ne tik rūšies keitimo laiko valdymo modelis neatitinka esamos situacijos, bet, taip pat, ir keletas proceso atnaujinimų yra reikalingi tam, kad būtų galima prailginti mašinos darbo laiką, sumažinti broko kiekį bei padidinti gaminamo produkto kokybinius reikalavimus.

Rūšies keitimas yra gana sudėtingas procesas, trigdantis gamybos vientisumą, generuojantis faktorius, didinančius brokuotos produkcijos kiekį, kurie turi būti išgryninti ir eliminuoti. Taip pat, buvo organizuotos dar dvi papildomos sesijos, įskaitant SMED sesija planuoto pamaininio valymo procesui bei sesiją, skirtą susikurti naujo dizaino operatoriaus stalą.

Buvo atlikti ekonominiai skaičiavimai, įvertinant pagerėjusius gamybos mašinų parametrus, sumažėjusį broko kiekį bei išaugusius gamybos kiekius. Tai parodė, kad idėja yra verta realizuoti, remiantis keletu veiksnių. Pirmiausia, darbinės sesijos metu buvo surasta, kad nustatyti rūšies keitimo operacijų laikai neatitinka dabartinio rūšies keitimo greičio. Antra, buvo inicijuoti bent trys rūšies keitimo proceso atnaujinimai, įskaitiant pakelio detektorių, pakaitinimo plokštelę bei operatoriaus stalą. Trečia, buvo įvertintas filtrų padavimo sistemos atnaujinimas, remiantis didžiausia įtaka mašinos generuojamam broko kiekiui. Apibendrinant galima teigti, kad bendri generuojami sutaupymai turėtų padengti investicinias išlaidas vienerių metų laikotarpyje, kas yra priimtina, remiantis tiek kompanijos, tiek bendrais investavimo principais

Buvo sukurti modernizacijas paremiantys techniniai brėžiniai, įskaitant filtrų padavimo sistemos, pakaitinimo plokštelės, pakelių patikros detektoriaus bei operatoriaus stalo brėžinius. Buvo atlikti pagrįsti detalių dydžių bei kitų faktorių skaičiavimai. Matomai, nėra jokių kliūčių modernizacijos įgyvendinimui.

Raktiniai žodžiai: *SMED, gamybos optimizavimas, rūšies keitimas.*

Balnasovas, N. Improvement of brand change process in company X by using single minute exchange of dye technique. *Master's degree* final project / supervisor Assoc. Prof. Dr. Kazimieras Juzėnas; Kaunas University of Technology, Mechanical Engineering and Design faculty, Production Engineering department.

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SUMMARY

The main objective raised to this project - employ Single Minute Exchange of Dye (SMED) technique in brand change process examining the shortcomings of the mentioned process. For that purpose as an object of investigation cigarettes brand change process was selected, which consists of two partial brand changes - cigarettes making machine and cigarettes packing machine. Evaluation of brand change peculiarities and SMED application possibilities, possible outcomes, was made based on literature review and actually performed SMED session on the brand change process within company premises. It revealed that not only the time pattern of the current band change is no longer up to date but several of process upgrades are essential in order to increase machine running time, reduce rejects and increase brand security.

Brand change process is rather intricate process that includes disturbance in continuous production flow, generates production wastes which need to be purified and eliminated. Next to it, two more sessions were performed including SMED session on planned shift cleaning with aim to connect the two processes planned shift cleaning and brand change. Moreover, one session dedicated to create new design of operators table took place.

Economical calculations were done evaluating savings on increased uptime, reduced rejects rate and increased production volume. It proved that the idea was worth implementing owing to several factors. First of all, it was identified during the session that former time frame of the brand change is out of date and no longer comply with current brand change speed. Next, at least three major improvements on process upgrade were initiated including pack pocket sensor, heating plate, and operator's table. Last, current filter feeding system was identified as the one adding up the most to the total machine rejects. Sequentially, an upgrade of the system was initiated. Generalizing, total generated savings would pay the investment of in less than one year time, which is acceptable based on company's practice and general investment principles.

A technical drawings supporting modernization were developed including the upgraded filter feeding system, heating plate, inspection pocket and operator's table. Reasonable calculations on parts size, modification pay-offs were made. Presumably, there are no obstacles to, actually, implement the defined modernizations.

Key words: *SMED, production optimization, brand change.*

Abbreviations

SMED	Single Minute Exchange of Dye
VSM	Value Stream Mapping
KPI	Key Performance Indicator
JIT	Just In Time
SCM	Supply Chain Management
QCD	Quality Cost Delivery
TWI	Training Within Industry
TPM	Total Productive Maintenance
OEE	Overall Equipment Effectiveness
CFFS	Current Filter Feeding System
NFFS	New Filter Feeding System
PIF	Project Initiation Form
PSC	Planned Shift Cleaning
BC	Brand Change

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Introduction

"Change is not an obligation if survival is not mandatory" - there were the words, said by Samuel Obara, "Honsha" executive director of "Lean Enterprise Institute", that started conference Lean 2015: business strategy - effectiveness [1]. Either it is service or industrial company one could feel safe anymore in terms of the fast growing businesses and cutting edge technologies that come in the market beforehand one could decide what's the best for one's company. Loss in time or decision making uncertainties make trending companies move over and the rest move under i.e. got bankrupted. The changes must be implemented from the bottom (the roots) to feel the pleasure of success (the fruits) some day after. This is a continuous process and that have to start immediately.

The booming trend across the world and already several of years in Lithuania, lean production model serves as a key to success for those companies that are able and willing to apply this methodology in the right way. Fast track or just in time production model is the most attractive solution to convert raw materials into finished goods but that requires most of the current company processes to be re-evaluated applying variety of lean tools. This is especially essential for companies that utilizes complex production models in terms of intricate brand change processes that usually inefficient. With that being said, in this thesis it is analyzed on the most commonly applied lean technique - single minute exchange of die (SMED), to serve a purpose of leaning brand change activity in cigarettes production.

It all implies, that the main object of research of this thesis is chosen to be brand change process in company X.

The main objective of the thesis - to employ SMED technique analyzing shortcomings of brand change process.

The objective of the thesis is followed by the several of tasks:

1. To compare several of lean tools versus SMED technique application in brand change activity: purpose of application and possible outcomes;
2. To analyze SMED method implementation in cigarettes brand change process;
3. To make analysis and presumptions on obtained results:
4. To disclose obtained process upgrades and variations;
5. To give further recommendations for process development.

1. ANALYSIS AND COMPARISON OF LEAN TOOLS

Brand change process is a very demanding process in terms of intensity of steps, coordination of movement of materials, cleaning up of production line and many other activities that have to be performed in several of minutes. Moreover, this is a teamwork activity that requires unanimous and well coordinated work pattern of all team members. For optimizing this kind of activity it could be applied many of lean tools but in this thesis it is thought that SMED technique is the right one. The purpose of this analysis below is to compare the main lean tools with SMED to show, what are the pros and cons of application of one method in regards to another, and find proves SMED tool is the right one to apply in brand change process under investigation.

1.1. Principles of lean

Globalization has made an impact to the world's economy by many different ways but when it comes to industry we can compress it in one single word - Toyota. When Toyota company started their management system dating back more than 50 years ago, there was no clear signs this could become a booming trend in most of the industries around the globe at the start of 21st century. Back at a time, so called father of Toyota management system - Taiichi Ohno [2] commenced to define processes into a value and non-value added activities, which resulted in a seven wastes concept. The wastes were organized in a sense to have a full process concept covered with a purpose of finding a golden nuggets in any activity performed by a company. Total Toyota system concept separates the lean theory into two concepts: automation and just in time (JIT) production. The first corresponds to a general idea that no production is possible if there is no continuity in processes. Production has to be stopped. The later then says that one must only start the production when several variables, including what, when and how much are known [3]. Then, a pretty simple set methods connected to a holistic unity was created and developed, making changes throughout the industries allowing companies to reach their goals on processes optimization, increase in savings or reduced safety issues. These methods are, in other words, called the lean tools or a self-assessment instruments [4]. The self-assessment instruments helps companies identify their current state and define a roadmap toward lean thinking using qualitative and quantitative key performance indicators e.g. a value identification and waste elimination tool, focuses on value creation and waste minimization. This is achieved by capturing the time, cost and resources of current and mapped processes to improve them according to lean principles.

Now when lean tools have been thoroughly investigated for more than two decades, one can state that one of the most versatile tools which is widely applicable is titled as SMED (or Single

Minute Exchange of Die). Even though it was first extensively applied in car industry for moulding process (that is where the name comes from) [5], it later found place in almost every sphere of everyday process management including office area, sales activities etc. With a challenges that most of industrial companies battle, lean methods are the one and only option they can use to remain positive of a balance sheet or otherwise be defeated by competitors in severe business conditions some of which include growing customer requirements for quality and product variety, poor economic conditions and increasing competition [6].

1.2. Analysis of SMED application

Going back to the essence, the very purpose of these methods allows users to understand where they must concentrate on to get any kind of process lean. Toyota company back in 1950s faced issues with excessive waste handling especially in terms of time during brand change. It's all about being efficient while doing the brand change since machinery is not running [7]. The more you delay a start of a new brand, the more money idle time will cost for organization. Generally speaking, the word "single" does not mean brand change has to be performed in a single minute time frame. That serves more like a reference point to organizations that would like to resemble Toyota company. What one actually needs to conceive is that there is no clear limit to any kind of process improvement. One first starts with obvious and most easy to define and upgrade areas and then move forward looking for a more sophisticated solutions. The target limit is more likely to reduce the changeover between processes to a single digit time, which means less than ten minutes. The main purpose of the theoretical analysis below is to analyze how did the lean production model representative technology - SMED was implemented in variety of industries and what is the relation that can be applied pursuing with SMED activities in tobacco industry.

Transfer of information to suppliers, customers and consumers, gathering of information from the same environment is defined in many standard Lean methods - Supply Chain Management (SCM), Value Stream Mapping (VSM), Kaizen, Key Performance Indicators (KPI) [8, 9] where lean emphasizes the importance of a long term relationship establishment with suppliers (Fig. 1.1). The SMED on its own is more of a process and product improvement kind of tool that tries to find a discipline and connection between the customer service, suppliers and total value that end customer gets afterwards. Moreover, this and other lean tools like Just In Time (JIT) production model, Quality Cost Delivery (QCD), which is part of continuous improvement activities [10],

create a need and, so to declare, necessity for organization to align a fluent communication and work coordination with the customers, and also to well handle internal processes management.

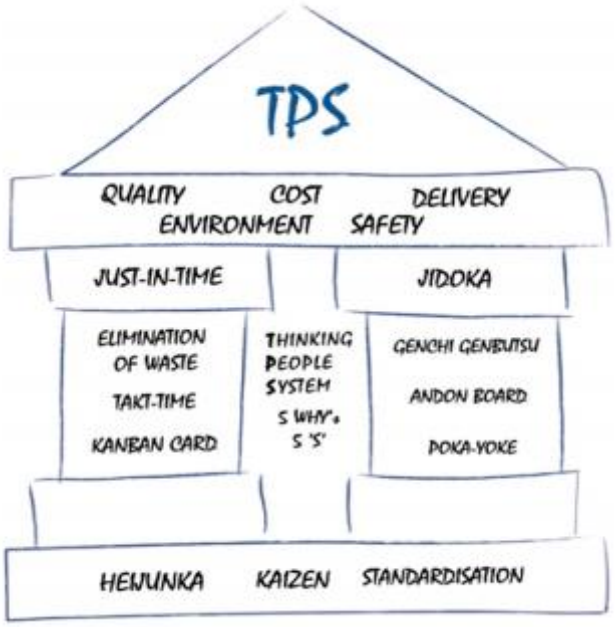


Fig. 1.1 Total Production System by Toyota [11]

SMED is a three phase process that firstly consists of identification of internal and external time activity that are directed towards "eliminate the internal time" time management, which is the second step in chain [12]. That is done by using Yamazumi chart [13]. The Yamazumi (or in Japanese - "to stack up") is a workload balance chart that counts the time driven work pattern of individual task of a team, performing a brand change or any other type of task. This is either applied with SMED or Kaizen activities. It connects a TWI (Training Within Industry) job instruction tool and allows defining actual time table and pattern for any kind of task related activities. The third step is linked with upgrade of the status quo activities, which seemed to be unchangeable from the start and are, actually, hard to be leaner.

In 1945, Mr. H. L. Austin wrote [14] that a poor performance of his food machinery corporation was a result of low morale of workers that did not have a clue of what either a continuous improvement or training within industry meant. But then the lean came, which separated low morale workers from under-skilled ones [15]. An overall view of SMED application in various industries seems significantly increased throughout years of learning. A modern car user search for quick and efficient solutions while organizations have to act back quickly to that. It facilitates organization of a mixed production of several types with high frequency of changeovers. In example, automobile industry have just gone through the most severe crisis since decades, which led to a huge changes in terms of reorganization, process optimization and even factories shut-down

[16] e.g. the city of Detroit, which became an epicenter of American decline. It all happened starting with 1960s when Japanese cars companies were given a "green light" to enter American markets. Japan as a strong global player and already proficient lean user came well prepared and equipped with a plan: become number one car selling company in United States of America and defeat American auto companies making them leave the business. The highest governmental institutions seemed to welcome Toyota company thinking of it more as a foreign capital investment and not a potential threat. What happened next is that most of American auto giants like Ford, GM and Chrysler were pushed out of the country due to the very same government policies [17]. Even further steps were taken by world widely known alliance of trade called NAFTA [18], which made the territories of North America globalized in terms of cheaper work force and goods movement. Since Toyota was already a lean company and had optimized its processes, and American companies were way out of the lean league. American automobile industries became too expensive to produce their cars in local lands and they shift towards Canada and Mexico for cheaper workforce etc.

Another comparison comes from electric power industry, where SMED is applied in production process of plastic and metal components required for assembly of several types of circuit breakers [19]. A mass production, which was set to be a dominant factor is now gone years ago. The goal here seems to have the same roots which are cost reduction, growing competition and elaborate customer needs. Since production processes are pretty much the same all around the globe competition is no longer caused by technological advancement. In the 21st century, being competitive means your "know how" and not possessing a cutting edge equipment only. Company that serves customer in terms of high product variety pick lean tools, that would help them to concentrate on the most obvious losses first, which of course could be classified as idle time versus production time [20].

Summing up, it could be stated that SMED technique is a powerful tool that increases speed of operation, reduces complexity of task and introduces competitive advantage over rivals in most of industries. Process organization that is proposed by SMED suits well brand change process of possibly all the indutries, which makes sense to apply it in the current situation improving brand change process.

1.3. Comparison of SMED with Kaizen

Regarding the tools that could have been selected to solve some certain process issues SMED serves as the one that usually puts focus on the whole but smaller process or some part of the process that makes sense to be treated and upgraded this way. The key function of SMED is to

find gaps of the processes like brand change, cleaning activities, and make them disappear or to be diminished to the very limit while giving the right orders to each and every participant in the activity.

Evaluating the other inexpensive choices of management emphasizing reduction of wasted materials and activities in variety of organizations one can take out the Kaizen technique. The word "Kaizen" means a "continuous improvement" in Japanese language and is broadly defined as a "process of improvement of the standard way of work" [21]. With the situation that most of the companies face at no matter type of business they participate in is always performing at the edge of being shut down and not making their budget to the next month [22]. What was revealed by the researchers in Nairobi, where the research project was dedicated towards analysis of local enterprises performance issues, is that surprisingly the same problems occurred comparing many different companies in terms of materials mishandling, injuries, some machinery breakdowns with an incredibly high rate of occurrence. Of course these were the major factors that stagnated their performance but also the other issues, in general, was that people that worked in those companies had a lack of motivation. While it is no way considered applying SMED technique, motivation is a force that can bring teams together for common purpose and make grounds for activities like SMED of daily management system (DMS). A motivation is that engine to drive a group of people look after their results and work as a team. If there is no team, it becomes rather hard task to do keeping even the most common and easy work standards like housekeeping, daily management systems or improving the productivity, safety etc. On the one hand, this is where Kaizen technique could be successfully applied in terms of bringing the team together as one "for continuous improvement, to develop products with higher quality, lower cost, and higher productivity in meeting the customer requirements" [23]. SMED on the other hand with quick changeovers allows manufacturers to keep less inventory while supporting customer demand for products with even slight variations. It also allows manufacturers to keep expensive equipment running because it can produce a variety of products. Moreover, this only requires a certain process conditions to be fulfilled during SMED workshop like special production type or a brand change at a certain moment and Kaizen would require a total production stop and people away from work solving more general issues such as quality improvement.

Kaizen as a philosophy is mostly utilized by huge industrial companies to reach an excellence in performance indicators [24]. In other words, Kaizen philosophy refers to people as a matter of experts, which only need to have a right set of tools and an adequately selected management to guide them throughout the problem solving [25]. Therefore, this model ensures that any kind of personal, team or process issue will be solved step by step with supervision of group leader. Even though Kaizen sessions could have totally different issues to be solved, the goal, that

links all of them is to increase self - awareness of team members step by step. The main of purpose of management team of a company applying lean tools is to be behind their people, to stimulate them, to keep up with continous improvement acitivites. Kaizen is more a cultural change requiring technique than a simple set of rules to be implemented. One has to be dedicated to the process motivating one's team, explaining the benefits that are given by team work and systematic and structured movement towards objectives.

When it comes to SMED, it is not that cultural breakthrought that is required to execute the process like brand change in cigarettes production. This is more of a standard procedure that is performed in steps and one is certain to bring the desired outcomes everytime it is applied. People here has to believe they will be given a way to change their own status - quo, current time pattern, workplace organization, when in Kaizen activities, people have to make their own ways to solve issues.

1.3. Comparison of SMED with VSM

This is one of the most aligned two techniques that could be compared when speaking about the process optimization. While SMED concentrates on smaller processes to get the value stream as smooth as possible the VSM on its own strives to encompass the whole. By stating the whole one could imagine a process like, for instance, building a new production line that must have supply of machinery parts, materials, contractors working around, building areas, exits, other complex stuff etc. [26, 27]. Managing this kind of process project manager must be aware of hundreds of activities that take part on site as well as handle well the financial part of the project and the timings which may take up to several years [28].

The lean methods have rather high influence to production parameters either this is job-shop production model or a flow shop especially at the very start of building of production line (Fig. 1.2, [29]) [30]. Having this in mind, lean thinking concepts gave an outstanding impetus into entrepreneur thinking during the past decade in terms of identifying and removing wastes from the site of manufacturing facilities or the service industries [31]. Even a smaller manufacturing companies today face increasingly high challenges that requires certain measures to remain cost-effective, retain high confidence on agreed lead time and quality standards. These seems to be nearly impossible to deal with such a contradictory terms in business but this is the point where the easily applicable value stream mapping technique steps in to make it happen e.g. Malaysia – Japan Automotive Industries Cooperation (MAJAICO) [32]. It even used a combination of VSM and Kanban for immediate countermeasures to process flaws.

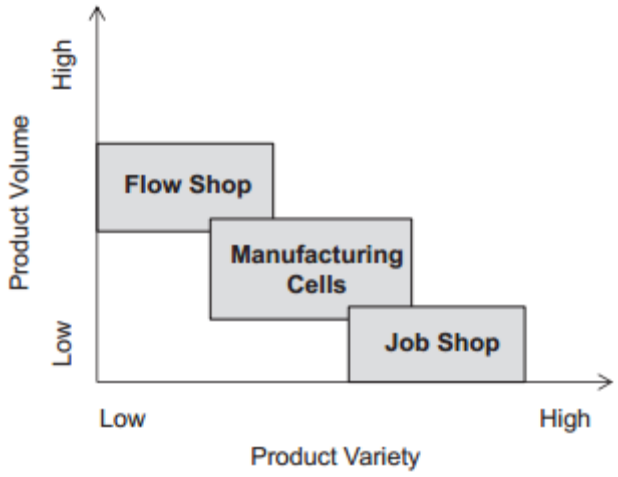


Fig. 1.2 Manufacturing system classification based on product volume and variety

This tool allows to make clear visual aids and make the right grounds for analysis and process design taking into account people that currently take part in or will make an impact to the process in the further stages [33]. So, basically, it serves as a mother-tool to view the process accurately and make grounds for other lean tools to be applied later on, among which we could find the SMED tool. The VSM and SMED has the same approach in terms of situational visualization. The two techniques encompasses all the process steps, both value added and non-value added, which are later on inspected one by one and help to find hidden things like process steps that doubles, which make them redundant, so it is waste. The current state map is compare with a future state map in both cases (the small map version is called *Yamazumi* chart). All the place that general wastes must be treated with lean attitude to look for solutions.

To round up, Value Stream Mapping process for brand change in cigarettes production is too overwheming process, when the situation dictates that only a small part of total chain needs to be examined. One should concentrate on the brand change process itself not considering supply chain's material delivery or ensurance of informational technologies, communications etc. SMED offers set of tools that divides cigarettes brand change process into steps small enough to find out process flaws and areas for improvements, and big enough not to get lost into the whole work of cigarettes production.

1.4. Comparison of SMED with 5s

One would suggest 5S is a tool that when fully incorporated into the companies daily management system can serve a powerful technique setting workplace environment in order either it is a tobacco industry, automobile industry [34, 35] or others. 5S makes a background for all the other process within organization to exist. If one could not adhere to the processes proposed by 5S

technique there a very small possibility other more sophisticated processes could ever be applied on top of that [36]. Workplace organization in terms of production processes could help one out giving an outstanding advantage to perform industrial activities clearly knowing where to look for and what is needed. The principle says that once 5S order standard in in place and maintained properly all the players in the zone should be able to act comfortably since every part around the workplace is either marked with special signs, which is usually for places that are being utilized, or places are left empty removing all the unnecessary stuff. In that manner people are no longer keen on using many different and in most cases unsafe tools to support their daily work activities. But when we talk about the benefits that SMED tool can propose we get to another level of characteristics we are able to extract from any kind of process.

SMED searches for process bugs or shortcomings that can result in poor time management, redundant team mates activities and the very same workplace order. It means, and based on scenarios proposed by the literature, one of the outcomes of SMED session is to perform an audit on 5S order in the workplace or at least introduce one. It is clear, that both tools tend to give time savings and increase workplace order. SMED may bring out the only changes that are related to the process at stake. In example, if one only analyses brand change process the things that one would see must only be related to that certain machine unit which would not lead to a general 5S order improvement in the workplace. Nevertheless, 5S would automatically lead to a review of places of tools and materials and debris sources in the area, which would definitely upgrade a level of brand change activities, no matter what kind of industry encompasses the process [37]. One of the examples in the literature even reveals [38], that process should be modified so and upgraded as many times as needed to serve the operator in the best way. That is what one of the first critiques on Toyota system – Sugimori – declaired: "It is not a conveyor that operates men, while it is men that operates a conveyor, which is the first step to respect human independence" [39]. This rather makes sense in terms of lean tools application. While 5S is the one to apply and maintain forever with usually slight changes in workplace order that could result from production line or upgrades of internal procedures (e.g. cleaning standard or general allowable materials list), SMED works differently.

SMED activity works in circles which combines a small process upgrades like creating a right order, giving right tolls, setting everything in place and then moving forwards with machine modifications, improving quality of materials and other standards to further reduce activity time, which is crucial for process like brand change. 5S could only serve as a part of brand chnage process and may have a significant influence to the whole process what so ever, but it may never be applied in brand change process for purpose of finding process quality issues.

1.5. Comparison of SMED with total productive maintenance

The 21st century brings us understanding that customer is the one that drives markets as well as manufacturers in the most dynamic way. Either one takes pledge to buy new cutting-edge technologies or invests into lifecycle extension of current equipment by not only maintaining its function but even adding up to value, quality and performance indices. Since there is no better way to do this than simply identify what part of process is lagging, what part of equipment needs to be upgraded, companies that strive for excellence apply total productive maintenance lean tool.

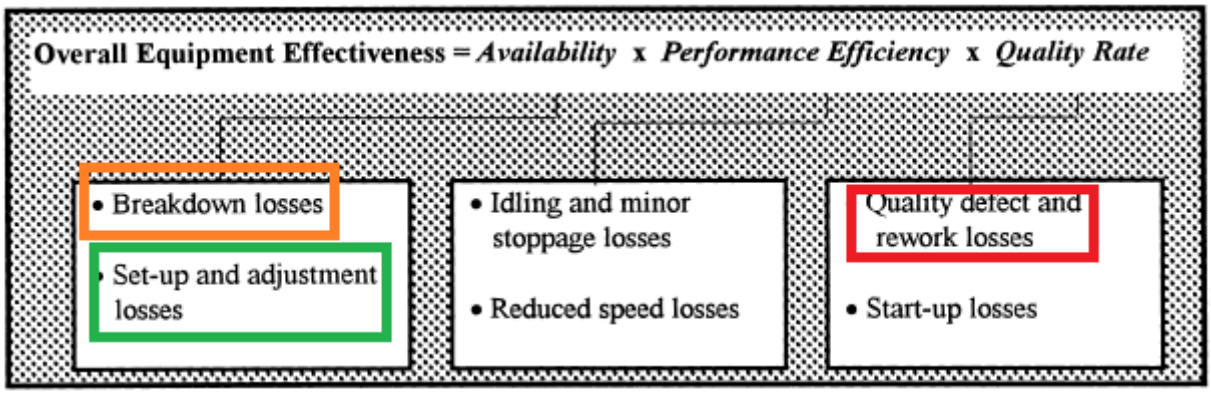


Fig. 1.3 Comparison Total Productive Maintenance (TPM) scope versus SMED scope [42]

What could be found analyzing literature is that industries, varying from automobile production to concrete mills [40, 41] is that first of all companies that try to encompass continuous improvement processes, tend to look for fast track return in reducing wastes and increasing profits throughout the organization. SMED, on the opposite, concentrates on smaller standardized process affects one certain performance element e.g. brand change activity. The general TPM process explanation is revealed above (Fig. 1.3) that discloses how complex TPM analysis of company processes could be. The colored boxes in the figure remark the possible SMED session targets – smaller processes that tend to have a standard set of step, procedures, that could be made leaner. So it could be stated this is the other way round approach to other conventional lean tools that strive to make processes simpler by reducing their time frame and steps redundancy. Here, the main focus is put on how to decrease process steps in that manner keeping the machinery under maximum working conditions and with maximum output and lowest possible cost per unit of production. So TPM attacks hidden losses and usually results in dramatic benefits [43]. Moreover, taking into account the time frame of process implementation, it may take up to four years for company to launch TPM process and reach the desired result (overall equipment effectiveness (OEE)) working in small groups and giving the right amount of attention at all times continuously. [44, 45]. In case

of implementing SMED, session itself may take a few days but the results are coming only by maintaining the upgraded standard and that is not embraced with time frame. In other words, the process is small enough to control but may be continuously improved and remain rather silent in terms of size of the company, which is not the case for TPM, which is applied for the whole entity.

To sum up, the scope of TPM activities is rather wide and demanding a more holistic approach to equipment maintenance. Brand change acitivity in cigarette production is simplier process that mostly involves labour skill and process continuity issues and only marginally relies on, for instance, material flow within the machine issue. For that purpose, it would make sence not to concentrate on general machine issues, and it is stated general because there are almost no certain machine areas that would only be linked with brand change activity, and concentrate better on the brand change process management itself. SMED tool allows to find both equipment insufficiences, that needs to be solved to perform brand change smoothly, and team work issues, where simply some kind of standardized work is required.

2. APPLICATION OF SMED METHOD INTO BRAND CHANGE ACTIVITY

SMED session for cigarettes brand change process was performed in factory premises. The aim of the SMED session was to share experience with cigarettes production department, with the support of the continuous improvement department according to a prepared an agenda for three days practical workshop. As a result, a team of twelve people had a chance to go through the comprehensive SMED training. The main area of the workshop (in boxes) as well as several photos of the workshop that relates to brand change activity is designated in the figures below (Fig. 2.1, Fig. 2.2, Fig. 2.3). Machine consists of two main parts - cigarettes making machine and cigarettes packing machine. Cigarette production starts in cigarettes making machine (Fig. 2.1, right side).

Cigarette manufacturing is highly automated process which generates extremely high production output. Cigarettes making machines have an output up to 10 000 cigarette sticks per minute. Every machine has its own mechanism of tobacco feeding, which regulates the flow, separates unwanted particles, like heavy stems, and removes tobacco dust. The process begins when blend reaches "maker" and one long cigarette, known as "rod" is created. To produce the rod, a reel of cigarette paper ranging from 3 000 to 7 000 meters long is unrolled and a defined amount of tobacco is put on it constantly. The cigarette paper then wraps tobacco blend and is glued, forming circular shape rod. The supersized rod is then divided into pieces of required length. Those are of double cigarette length to insert filters at both ends and double the efficiency. Tipping paper (or plug wrap) is then wrapped around the filter, which is mostly of a well known cork color. Some laser on printing can be performed, imprinting brand name on the cigarette paper. At the end, each rod is cut to a half through a filter centre obtaining two filtered cigarettes. There are three on line check points, located at different stages for visual quality assurance.

Packing of cigarettes starts in packing part (Fig. 2.1, left side) sticks into packs of 20 (sometimes 19 or 21). The foil is wrapped around the prepared cigarette number to preserve fresh taste and quality. Inner frame is then mounted to increase stability of the final pack. When the pack form is shaped around an assembled pack is wrapped with a preheated shrink film in order to double secure freshness and perfect look. Furthermore, packs in batches of ten are either put in carton box or wrapped with film one more time, and, finally, packed into shipping case (SC), which is the biggest production volume that a cigarette machine can pack. SCs are palletized by various schemes depending on the market and are ready to be transported.

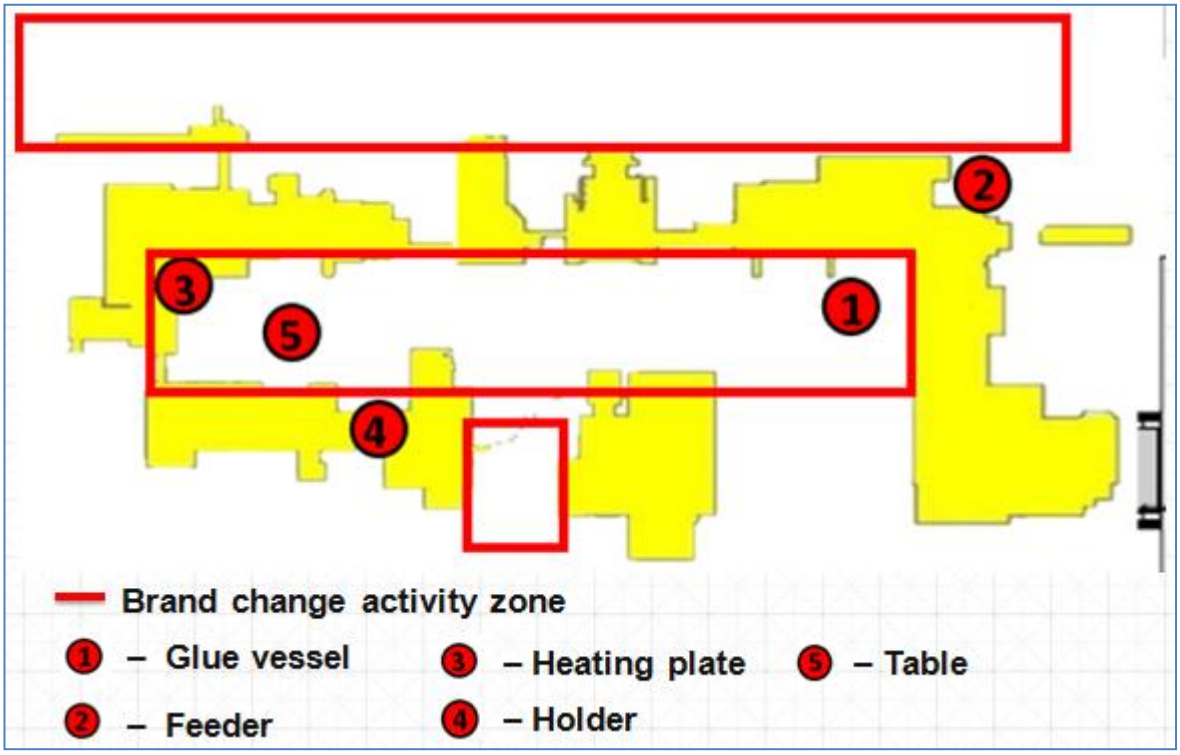


Fig. 2.1 Machine area impacted by brand change process

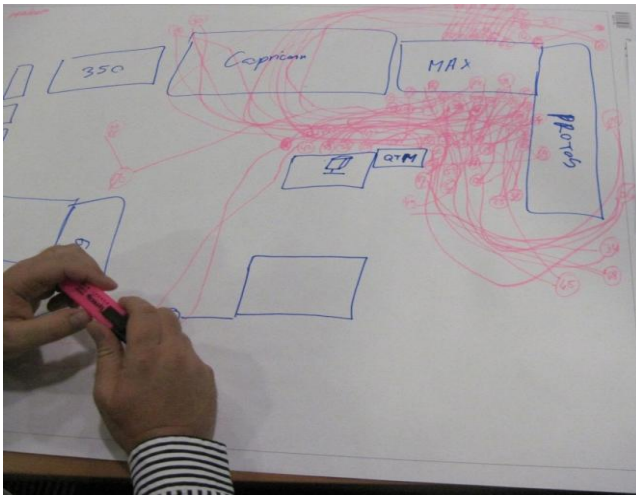


Fig. 2.2 Spaghetti diagram

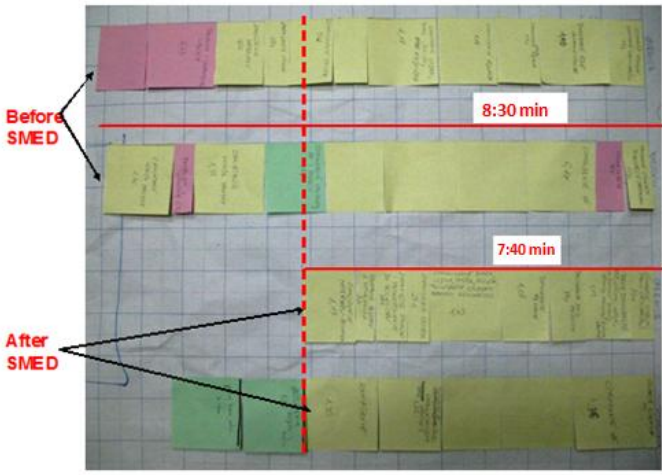


Fig. 2.3 Yamazumi diagram of the brand change

Human factor is also very important during whole production. Supervision of the process is highly required as various faults can occur. Operators have to secure quality of blending, incoming tobacco flow and assure the required quality of finished goods. Especially with this complexity factory maintains, adjustments during the process are constant and machines can't be left unwatched.

Brand change process is a complex activity that involves participation of several of departments, changes of materials, machinery regulations and doing it under current standards. For that purpose a table, that generalizes the main areas of improvement was collected below (Table

2.1). It discloses the main issue one faces performing brand change in company x and effect they do on standard processes.

Table 2.1 Brand change (BC) related issues and effect on standard processes

Issue	Effect on brand change
1. No defined time frame under current BC standard.	1.Variations in BC time distort production planning; 2. Unplanned machine stoppages; 3. Excess of materials at machine area; 4. Increase in movement of transporters - safety issues.
2. Excess of materials.	1. No clear timetable of materials delivery; 2. Burdened machine area.
3. Idle time of some teammates.	1. Complexity increases, teamwork standard during BC remains unchanged; 2. No clear distribution of roles under current working conditions.
4. Poor preparation for BC.	1. Low quality of tools; 2. Imprecise positions of tools, materials, teamgoals; 3. Poor time management.
5. Several process related issues.	1. Loss on materials during BC; 1.1. Filter losses; 1.2. Increasingly high amount of rejects; 2. Poor brand security; 2.1.Several of potentially high risk places.

2.1. Time savings: glue vessels

One of the most apparent issues that appeared in the planned shift cleaning process and as well as in brand change activity is washing of the glue vessels for cigarettes making machine (Fig. 2.4, Fig. 2.5). It turned out that operator or his/her teammate is obliged to clean the glue vessel once per day during specific time. Overall on average it takes around ten minutes of internal time, which seems crucial to save, since it takes around one third of allowed cleaning duration. For that purpose, it was decided to estimate price of purchase of nine additional glue vessels. These vessels would

serve as a spare ones to do a quick change during cleaning procedure. More information on the vessels is given in Table 2.2 below.

Table 2.2 General characteristics of glue vessel

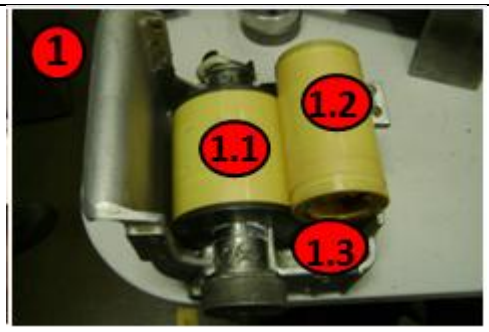
<table>
<tr><td>Element</td><td>Function</td><td colspan="6" rowspan="2"> 

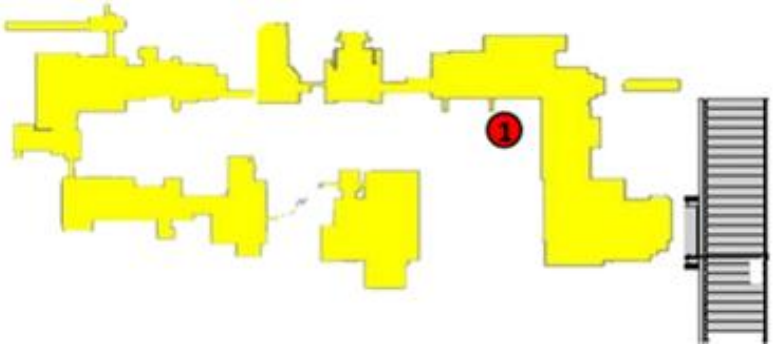
Fig. 2.4 Elements of glue vessel. General view</td></tr>
<tr><td>1.Glue vessel</td><td>Ensures glue is propelled under tipping paper.</td></tr>
<tr><td>1.1.Feeding roller</td><td>Ensures glue is distributed evenly under tipping paper.</td><td colspan="6"></td></tr>
<tr><td>1.2. Skimming edge</td><td>Ensures elimination of glue surpass.</td><td colspan="6">Main parameters:</td></tr>
<tr><td rowspan="2">1.3. Glue bed</td><td rowspan="2">Ensures optimal level of glue is filled before use.</td><td>Speed of rotation, rev/min</td><td>Lenght, mm</td><td>Height, mm</td><td>Width, mm</td><td>Volu-me, l</td><td>Weight, kg</td></tr>
<tr><td>10 000</td><td>250</td><td>170</td><td>200</td><td>1,2</td><td>1,7</td></tr>
<tr><td colspan="8"> 

Fig. 2.5 Glue vessel position in machinery. General view</td></tr>
</table>

The total time saved per one machine per day t_{tot} is calculated as shown in formula (2.1):

$$t_{tot} = \mathrm{t} \cdot \mathrm{n} \tag{2.1}$$

where,

t – time saved per machine, s;

n – number of machines.

Then we have the time per all impacted machines per day t_{tot1} and the total sum-up of one year production t_{tot365} as follows:

$$t_{tot1} = 600 \cdot 9 = 5'400 \text{ s} = 1{,}5 \text{ h}.$$
$$t_{tot365} = 5'400 \cdot 356 = 1'922'400 \text{ s} = 534 \text{ h}.$$

It could be stated that during one day of planned shift cleaning, 1,5 hours of time is saved. In terms of annual production rates, 534 working hours are saved, thus converting it to uptime - Formula (2.2), we have:

$$U = \frac{\mathrm{v_n} \cdot \mathrm{T}}{\mathrm{v_{act}} \cdot \mathrm{t_{act}}} \cdot 100\%: \tag{2.2}$$

where

v_n – is nominal machine speed, $\frac{\text{packs}}{\text{min}}$;

T – total possible running time, s;

v_{act} – actual machine speed, $\frac{\text{packs}}{\text{min}}$;

t_{act} - actual running time, s.

If it is stated that each of link-ups saves 10 additional minutes of running time and all of them are going full speed, then the formula (2.2) is simplified as follows:

$$U_{9LUs} = \frac{\mathrm{t_{tot1}} \cdot 100\%}{720 \cdot 60 \cdot \mathrm{n}}$$

where,

720 - number of minutes per twelve hours shift;

60 - number of seconds in a minute;

n - number of link-ups running.

Then the following is true:

$$U_{9LUs} = \frac{\mathrm{t_{tot1}} \cdot 100\%}{720 \cdot 60 \cdot \mathrm{n}} = \frac{5400 \cdot 100}{720 \cdot 60 \cdot 9} = 1.39\%$$

It thus could be stated that impact to total uptime of factory is 1.39 per cent with 9 link-ups running i.e. machines save that much of time to increase production output. If it would be taken that

1 per cent of uptime per machine costs p = 15 EUR for the factory, then the following calculations on savings on price P_1 are driven:

$$P_1 = \mathrm{U_{1LU}} \cdot \mathrm{n} \cdot \mathrm{p} = 1.39 \cdot 9 \cdot 15 = 187{,}65 \text{ EUR}$$

where,

P_1 - price saved for having an additional glue vessel for each link-up, EUR;

U_{1LU} - uptime value of one link-up, %.

p - price of one per cent of uptime.

It means, during 24 hours of production, 375.3 EUR of money is saved making a product instead of machine idle time. Recalculating everything in terms of yearly volumes, price saved P_{356} shows:

$$P_{356} = \mathrm{P_1} \cdot 356 \cdot 2 = 133\,606{,}8 \text{ EUR}$$

Project evaluation chart shows, that IRR - internal rate of return, (formula (2.2)) is less than three years, which makes it useful to execute such purchase:

$$PV = \frac{\mathrm{FV}}{(1+\mathrm{r})^{\mathrm{n}}}, \tag{2.3}$$

where,

PV – present value;

FV – future value;

r – interest rate;

n – number of years.

Formula (2.3) is converted for interest rate, which reflect a positive index:

$$PV = \frac{FV}{(1+r)^n} \Rightarrow \mathrm{r} = \sqrt[\mathrm{n}]{\frac{\mathrm{FV}}{\mathrm{PV}}} - 1 = 1\sqrt{\frac{133\,606{,}8}{58\,500}} - 1 = 2{,}29 - 1 = 1{,}29 \text{ or it is equal to } 129\%$$

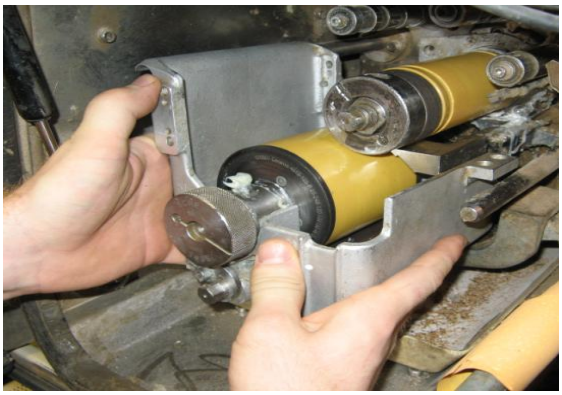


Fig. 2.6 Place of glue vessel on machinery

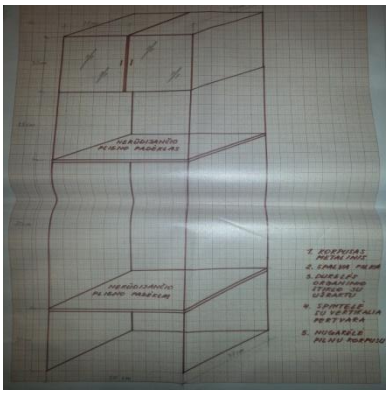


Fig. 2.7 Glue vessels storage system

The glue vessel's position and mounting on machinery is additionally showed above (Fig. 2.5, Fig. 2.6). Having in mind an increased number of glue vessels per factory a need to have glue vessels maintenance system (Fig. 2.7) was raised. In light of that, one was created and will become functioning as per given view. It must be evaluated that labour people must be well trained to adhere to the standard brand change and planned shift cleaning processes to back up theoretical calculations above.

2.2. Reduction of material losses: filter feeding system

The second field to upgrade is filter loading (Annex A - 3.Feeder). Currently, during brand change a labourer is responsible for collecting filters from the former brand right before a new brad filters are put on filter path, using tray system. The following characteritics of the tray system are defined in Table 2.3.

Table 2.3 General characteristics on filter loss

k - Filter loss at machine area on avg. , %	*v* - Monthly usage of filters on avg., mio	*p* - Filter price on avg., EUR/mio	Number of filters in tray, pc	Number of machines generating losses, pc
0,25	525,6	5 400	4 500	12

It follows that price on filter loss P_{FL} is calculated using formula (2.4):

$$P_{FL} = \mathrm{k} \cdot \mathrm{v} \cdot \mathrm{p}: \tag{2.4}$$

where,

P_{FL} - price of rejected filters, EUR;

k - filter loss at machine area;

v - monthly usage of filters;

p - price of filters.

Then the following is true:

$$P_{FL} = 0.25 \cdot 525{,}6 \cdot 5400 = 709\ 560 \text{ EUR}$$

The total loss on filters P_{FL} that is covered by factory is turned out to be 709 560 EUR. If we would assume, that no more than 1,5 tray of filters is lost on one machine during one shift period of time, the calculations for full year time, two shifts within 24 hours, it would follow:

$$P_{FL1} = \frac{\mathrm{P_{FL}}}{12 \cdot 356 \cdot 2} \sim 83 \text{ EUR/shift}$$

where,

P_{FL1}- is price of lost filters using current filter feeding system, EUR.

The solution to the problem came as it is shown in the figures (Fig. 2.9) and (Fig. 2.11) below. Currently filters are put on machine as it is shown in the figure (Fig. 2.8, Fig. 2.10), whereas a new design of filter loading must ensure entirely different approach to filter feeding system.

Table 2.4 Comparison of filter feeding systems

<table>
<tr><td colspan="3">Current filter feeding system (CFFS)</td><td colspan="3">New filter feeding system (NFFS)</td></tr>
<tr><td colspan="3">1. Manual filter loading in trays.</td><td colspan="3" rowspan="4">1. Manual filter loading on filter shooter.
2. Automated process throughout.</td></tr>
<tr><td colspan="3">2. Manual filter tray loading on conveyor.</td></tr>
<tr><td colspan="3">3. Manual filter tray pushing towards unloading point.</td></tr>
<tr><td colspan="3">4. Manual filter tray unloading from conveyor.</td></tr>
<tr><td colspan="6">Main parameters:</td></tr>
<tr><td></td><td>Lost filter trays, pc/machine/shift</td><td>Tray loading speed, pc/min</td><td>Buffer of trays, pc</td><td>Material</td><td>Height of loading, m</td></tr>
<tr><td>CFFS</td><td>1,7</td><td>~0,9</td><td>6</td><td>Plastic</td><td>1,65</td></tr>
<tr><td>NFFS</td><td>0,5</td><td>0,3</td><td>18</td><td>Metal</td><td>Adjustable</td></tr>
<tr><td colspan="6">*Filter propulsion flow - arrows</td></tr>
</table>

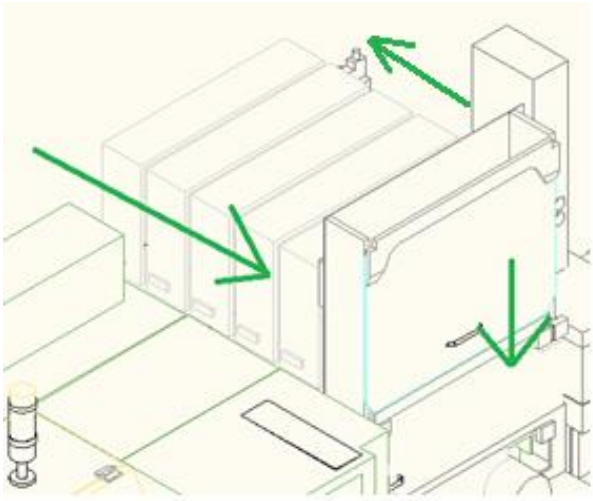


Fig. 2.8 Current Filter Feeding System (CFFS)

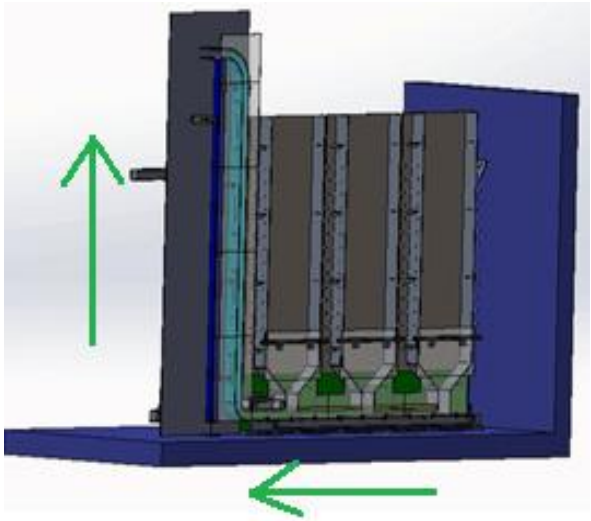


Fig. 2.9 New Filter Feeding System (NFFS)

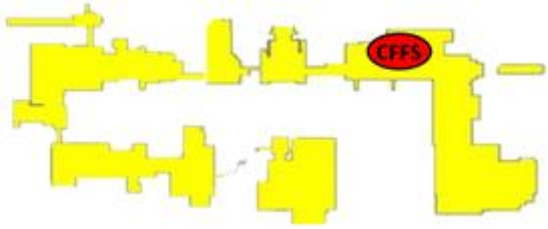


Fig. 2.10 CFFS position at machine area. General view

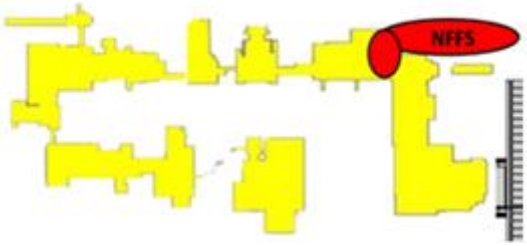


Fig. 2.11 NFFS position at machine area. General view

Financial benefits are calculated as follows:

$$P_{FL2} = \frac{P_{FL1} \cdot 0{,}5}{1{,}7} = \frac{83}{1{,}7} \sim 24 \text{ EUR/shift},$$

where,

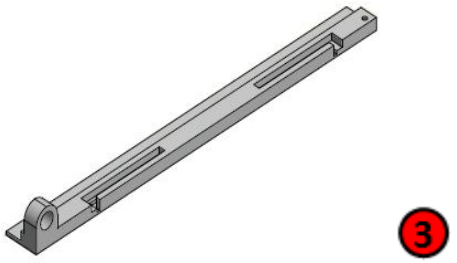
P_{FL2} - is price of lost filters using new filter feeding system, EUR.

This means 59 EUR could be saved during period of one shift in terms of filter wastage at link-up. Since the new filter feeding concept would not be an original equipment manufacturer (OEM) product, the price is currently unknown. Possibly price of 7 000EUR with linkage to machinery using company's workforce seems optimal. All the theoretical calculations above are based on process which includes already standard - trained machine crew.

2.3. Reduction of material losses: pack heating components

It was identified during the session that prodution line has several of places that generates additional amount of rejects in form of packs. This mainly happens during machine start – stop times when speed variations occur. At that moment, packs that are in a certain position (e.g. partially formed, without proper gluing or even fully formed packs) are rejected out of line to keep finished goods flawless. For that purpose modification to the current process was introduced, upgarding one of the line elements, namely, pack transition point. The Table 2.5 below reveals main characteristics of the plate (Annex A - 1. Heating plate), which is displayed below (Fig. 2.12) with its position in machinery (Fig. 2.13).

Table 2.5 Heating plate characteristics

<table>
<tr><th>Current situation</th><th colspan="5">Future situation</th></tr>
<tr><td>1. Open upper pack flap (1 of 5packs - machine running full speed 500 packs/min, zero packs - machine running 400 packs/min).</td><td colspan="5">1. Open flap issue is solved (zero packs machine running full speed 500 packs/min.</td></tr>
<tr><td>2. Glue injection is sufficient but not efficient. Glue does not adhere to carton due to several layers of lacquer applied.</td><td colspan="5">2. Change in pack desing is almost impossible due to technology of production.</td></tr>
<tr><td>3. Surplus of rejected production (5 packs rejected every short stop. On average 2300 packs/shift).</td><td colspan="5" rowspan="2">3. Reduce amount of short stops 5 times i.e. 460 rejected packs per shift.</td></tr>
<tr><td>4. Additional machine stops.</td></tr>
<tr><td>5. Low brand security.</td><td colspan="5">4. Reduce brand mix possibility to 0.</td></tr>
<tr><td rowspan="3"> 
Fig. 2.12 Heating plate</td><td colspan="5">Main parameters:</td></tr>
<tr><td>Length, mm</td><td>Height, mm</td><td>Width, mm</td><td>Weight, kg</td><td>Heating temp., °C</td></tr>
<tr><td>400</td><td>11,5</td><td>35</td><td>1,0</td><td>130</td></tr>
</table>

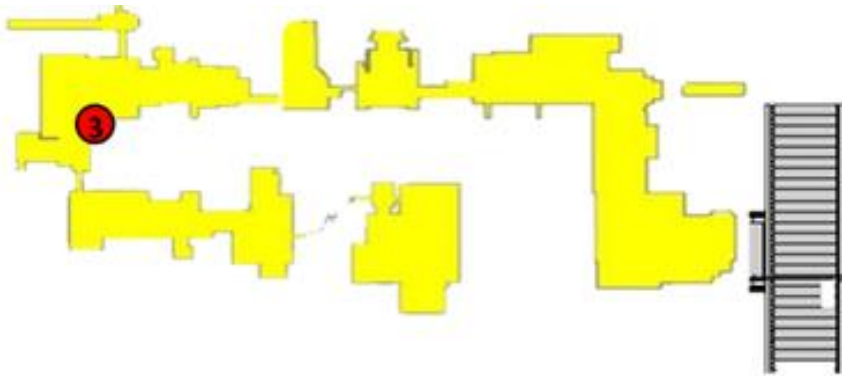


Fig. 2.13 Heating plate's position in machinery. General view

The Table 2.5 above discloses several of purposes plate was created for. Calculation on the above is started with rejected packs issue (formula 2.5). The main parameters of rejected production are displayed in Table 2.6:

Table 2.6 Characteristics of rejected production

r_p – rejected packs/shift/machine on avg., pc	Short stops/shift/machine on avg., times	Sum of short stops/shift/machine on avg., s	p_r - price of rejected pack on average, EUR
2 300	300	7 200	0,15

$$P_{rp} = \mathrm{r_p} \cdot \mathrm{p_r} \qquad (2.5)$$

Then the following is true:

$$P_{rp1} = 2\,300 \cdot 0{,}15 = 345 \text{ EUR}$$

where,

P_{rp1} - price of rejected packs per shift before installation of heating plate, EUR.

It could be stated that on average during on shift of production with laminated board packs, it is generated around 345 EUR of rejected production due to unsuccessful application of heating at pack side gluig spots. Once heating place is installed the following numbers must be valid:

$$P_{rp2} = 460 \cdot 0{,}15 = 69 \text{ EUR}$$

where,

P_{rp2} - price of rejected packs per shift after installation of heating plate, EUR.

It means, generated savings grow to as much as 276 EUR per shift per machine. Time saving play as much important part in the process as reduced rejects. Each and every short stop generates time losses. When the heating plate is installed, short stops must be reduced significantly thus increasing the uptime. Calculation on increase in uptime are made as follows. First it is important to know the time of one short stop on average:

$$t_{st1} = \frac{7\,200}{300} = 24 \text{ s},$$

where,

t_{st1} - time span of one short stop on average, s;

7200 - sum of short stops, s;

300 - number of short stops, times.

If it is interpreted that after installation of heating plate number of short stops must be reduced five times, then the calucations using formula 2.6 are as follows:

$$t_{st60} = \mathrm{t_{st1}} \cdot \mathrm{n_{sts}} \tag{2.6}$$

where,

t_{st1} - time span of one short stop on average, s;

n_{sts} - number of short stops per shift.

Time of short stops per shift after installation is calculated this way:

$$t_{st60} = 24 \cdot \frac{300}{5} = 1440 \text{ s}$$

An impact to uptime of one link-up is 3,33% as it is calculated using formula (2.2) below.

$$U_{1LUbi} = \frac{\mathrm{t_{tot1}} \cdot 100\%}{720 \cdot 60 \cdot \mathrm{n}} = \frac{7\,200 \cdot 100}{720 \cdot 60 \cdot 1} = 16{,}67\%$$

where,

U_{1LUbi} - impact in uptime due to short stops before installation of heating plate, %;

720 - number of minutes per twelve hours shift;

60 - number of seconds in a minute;

n - number of link-ups running.

Then the following is true:

$$U_{1LUai} = \frac{\mathrm{t_{tot1}} \cdot 100\%}{720 \cdot 60 \cdot \mathrm{n}} = \frac{1\,440 \cdot 100}{720 \cdot 60 \cdot 1} = 3{,}33\%$$

where,

U_{1LUai} - impact in uptime due to short stops after installation of heating plate, (%)

$$P_1 = \mathrm{U_{1LU}} * \mathrm{p} = 3{,}33 * 15 = 49{,}5 \text{ EUR}$$

It could then be stated that, the final impact into uptime is reduced to 35 244, which is 5 times lesser number than the former yearly impact P_{356}:

$$P_{356} = \mathrm{P_1} \cdot 356 \cdot 2 = 49{,}5 \cdot 356 \cdot 2 = 35\,244 \text{ EUR}$$

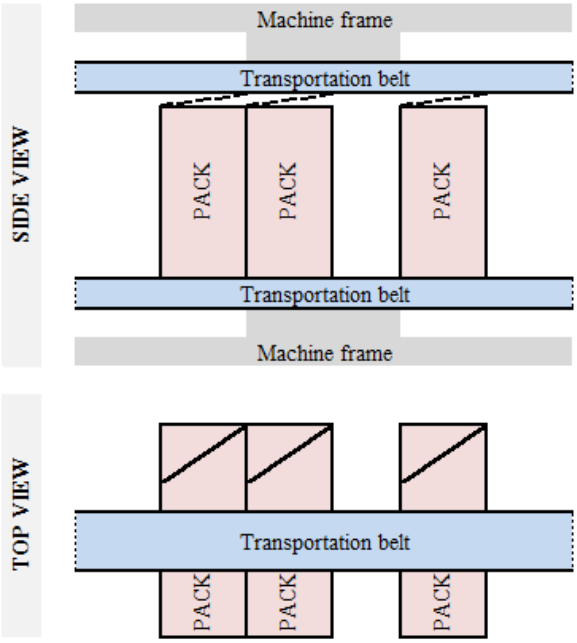


Fig. 2.14 Systematic view of current pack transporter system

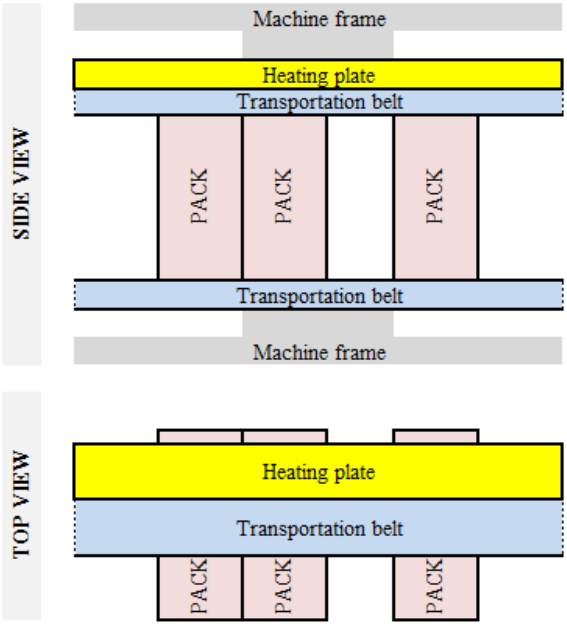


Fig. 2.15 Systematic view of upgraded pack transporter system

Now regarding the brand security (quality), analysis was made on the impact of the heating plate to the operators daily activities. In figure (Fig. 2.14) it could be observed that flap on pack side

is shown in dashed line, which symbolizes possible non-adherence. This non-adherence make packs fall on side, incline in both direction, that make machine stop. Operator may not even see fell-down packs during brand change, if packs are in position, covered by machine parts. Now the other figure (Fig. 2.15). reveals a new desing looks of upgraded packs transportation system. The heating place is attached to machine housing in a way to have it 1-2 mm upper the pack lid. That makes the flap being heated and pushed towards pack side to adhere better at the same time. Moreover, packs must almost never fall or get inclined since no other option remain.

During brand change, packs always remain steady in one position after machine is stopped and prepared for being emptied or are simply slided towards further packing. Machine start-stop procedure does not affect packs forming. If one would also evaluate the speed increase from 400 packs/min which is normal speed in a current packing situation to 500 packs/min which is sought situation including 15 per cent of downtimes, then it could be displayed that:

$$V_{1LU} = (500 - 400) \cdot 60 \cdot 12 \cdot 0{,}85 = 61\,200 \text{ packs}$$

If 500 packs constitute one box of finished goods, then:

$$V_{1LU} = \frac{61'200}{500} = 122{,}4 \text{ pc}$$

where,

V_{1LU}- volume of finished goods, pc;

500 - number of packs in one shipping case, pc.

Assumption implies, that more than 122 boxes of finished goods could be made during 12 hours of one shift time, when an increase of speed is possible due to solved pack forming issue.

2.4. Increase in brand security: pack position inspection pocket

Brand security (quality) is one of the most important issues that one currently undergoes and needs to sustain. In this kind of production system it is always important to ensure the right amount of product per production unit, for instance, one pack must contain the number of constituents as it is declaired on pack. It not only company's policy but also a legal issue. During the session it was identified that among the highest risks to produce safely the right amounts

modification of the current pack inspection pocket (holder) (Table 2.7) is necessary (Fig. 2.16, Fig. 2.17). Detailed view is revealed in annexes section (Annex A - 2. Holder).

Table 2.7 Main characteristics of pack inspection pocket

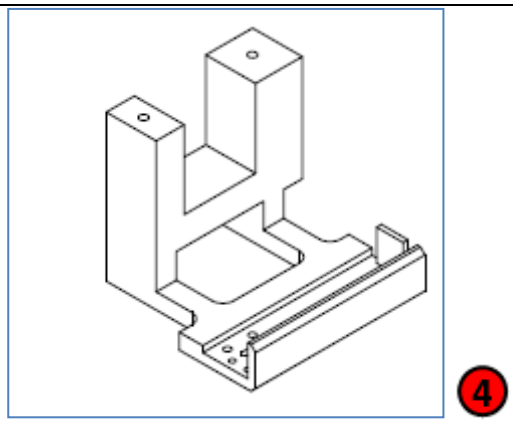
<table>
<tr><td>Current situation</td><td>Future situation</td></tr>
<tr><td>1. During start-stop processes, packs remain unstable while in pocket. On avg. 12 stops/shift.</td><td rowspan="4">No stoppages due to unstable packs going full speed.</td></tr>
<tr><td>2. Loose packs position fixing in pocket causes packs being ejected and curved during operational time.</td></tr>
<tr><td>3. Additional machine stoppages to removed impacted packs and clean up unit area. On avg. 1 stop - 360 s.</td></tr>
<tr><td>4. Unplanned machine stops - surplus of rejects.</td></tr>
<tr><td rowspan="3"> 

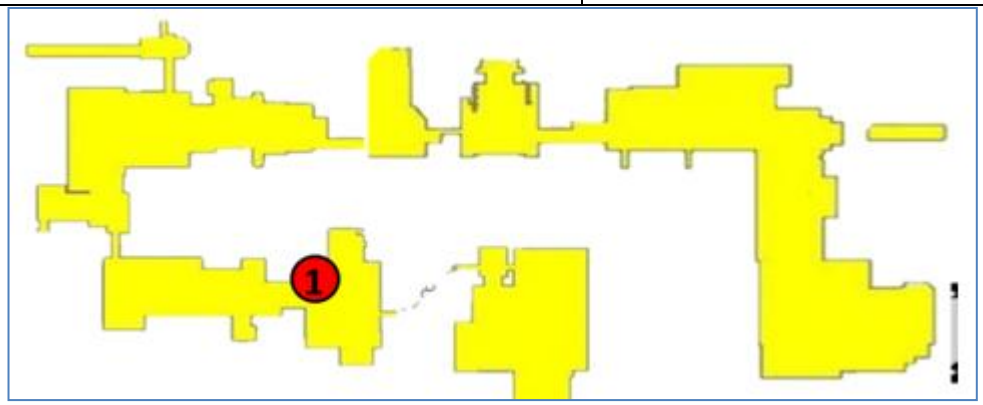
Fig. 2.16 Pack position inspection pocket</td><td>Main parameters:
<table>
<tr><td>Lenght, mm</td><td>Height, mm</td><td>Width, mm</td><td>Weight, kg</td></tr>
<tr><td>111</td><td>94</td><td>32</td><td>0,45</td></tr>
</table></td></tr>
<tr><td colspan="2"> 

Fig. 2.17 Pocket's position in machinery. General view</td></tr>
</table>

Here we observe an identical situation in terms of rejected production that was observed in the previous case installing the heating plate. Table 2.8 reveals the following:

Table 2.8 Characteristics of rejected production

r_p – rejected packs/shift on avg., pc	Short stops/shift on avg., times	Sum of short stops/shift on avg., s	p_r - price of rejected pack on avg., EUR
46	6	2 160	0,15

If it would be assumed that, on average, we observe a twelve times of stoppages due to incorrectly possitioned pack in the pocket then, based on the formula (2.5) the following becomes valid:

$$P_{rp3} = 46 \cdot 0{,}15 = 6{,}9 \text{ EUR}$$

where, P_{rp3} - price of rejected packs per shift before installation of pack inspection pocket, EUR.

It is assumed, after the installation of this new upgraded pocket is done, no further phenomenon is observed. Now regarding the time constituent, when inspection pocket is installed, short stops must be reduced to zero thus increasing the uptime. Calculation on increase in uptime are made as follows. Firstly, again, it is important to know the time of one short stop on average:

$$t_{st1} = \frac{2\ 160}{6} = 360 \text{ s}$$

where,

t_{st1} - time span of one short stop on average, s;

2'160 - sum of short stops, s.

If it is interpreted that after installation of upgraded inspection pocket number of short stops must be reduced to zero. The former short stops per shift impact to uptime of one link-up is 5% as it is calculated using formula below.

$$U_{1LUbi} = \frac{\mathrm{t_{st1}} \cdot 100\%}{720 \cdot 60 \cdot \mathrm{n}} = \frac{2\ 160 \cdot 100}{720 \cdot 60 \cdot 1} = 5\%$$

where,

U_{1LUbi} - impact in uptime due to short stops before installation of heating plate, %.

720 - number of minutes per twelve hours shift;

60 - number of seconds in a minute;

n - number of link-ups running.

The following is true:

$$P_1 = \mathrm{U}_{1\mathrm{LU}} \cdot \mathrm{p} = 5 \cdot 15 = 75 \text{ EUR}$$

where,

P_1 - price saved for installing upgraded holder, EUR;

p - price of one percent of uptime, EUR.

It could then be stated that the yearly impact to the uptime P_{356} is evaluated as much as:

$$P_{356} = \mathrm{P}_1 \cdot 356 = 75 \cdot 356 \cdot 2 = 53'400 \text{ EUR}$$

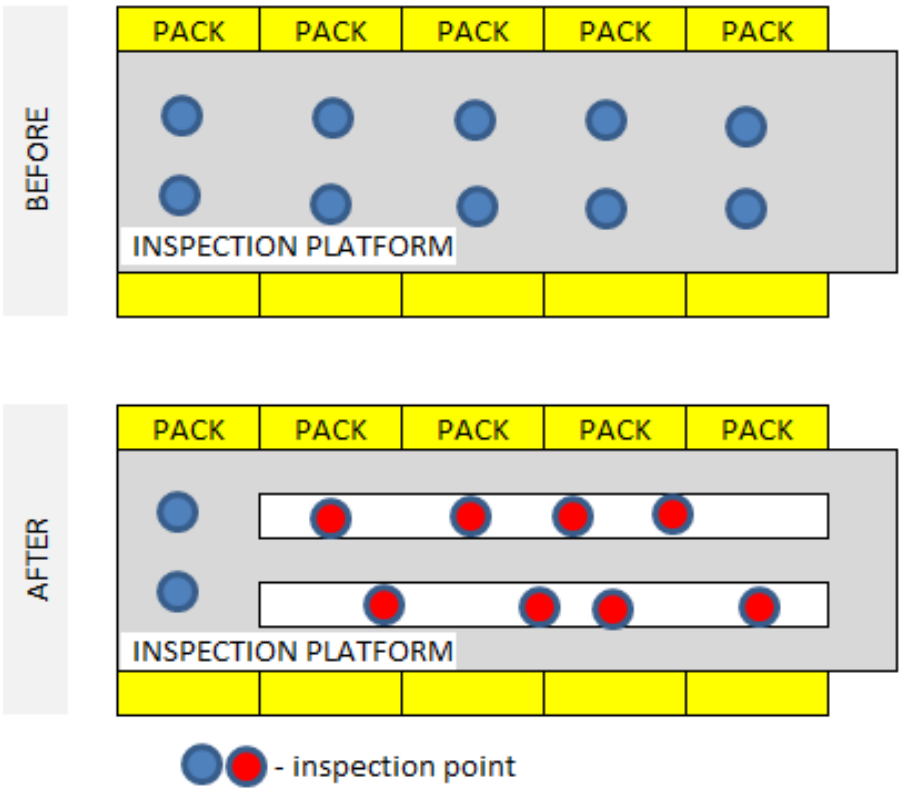


Fig. 2.18 Scheme of inspection points before vs after states

The scheme above (Fig. 2.18)defines the major improvement that was done with this installation. In the upper view it is seen an inspection platform, that gave a stable inspection points. Due to this constraint it was only possible to ensure amount of five packs pushed towards packing side when packs came perpendicularly to the belt. If pack was inclined or laying on the back, sensor

would still fix pocket as full. Now the second half of the figure shows the change that was made in terms of free positioning of sensors. A groove throughout the pocket was made so that sensors could be placed where mecessary depending on production type.

2.5. Reduction of material losses: operator's table

One of the most important part of workplace to any kind operator performing daily activities is a table (Annex A - 4.Table). It has to be convenient in many ways including brand change, quality inspection, material separation, data management etc. It was identified that evaluating current condition it rather complicated to be a hundred percent satisfied with the workplace culture, safety and brand security if operator's table does not fully fit one's needs. With that being said, another session with operators was performed to develop totally new table which is displayed in figures below (Fig. 2.19, Fig. 2.20) and feed them with empowerment to change a current standards. Table's position in machine ares is defined by the last figure of Table 2.9 (Fig. 2.22). Details of sessions are displayed below in Table 2.9:

Table. 2.9 Operator's table characteristics

Table data. Former version					Table data. New design version				
Heigth, mm	Width, mm	Length, mm	Main material	Additional materials	Heigth, mm	Width, mm	Length, mm	Main material	Additional materials
1 350	950	1 830	Wood	Stainless steel	1 400	1 290	2 000	Wood	Glass, stainless steel
1. No dedicated place for quality inspection.					1. Extra place for quality inspection, important infotmation, production sampling.				
2. Too small in size.					2. Optimal size, with necessary elements to get satisfactory daily activities.				
3. No place for brand change formats.					3. Place for inner frame knifes, embossing rollers, cleaning equipment.				
4. Data insertion monitor is not in place.					4. Monitor, telephone, lamp became a part of table.				

Fig. 2.19 A mockup made during session

Fig. 2.20 A real-life version mock-up made by supplier

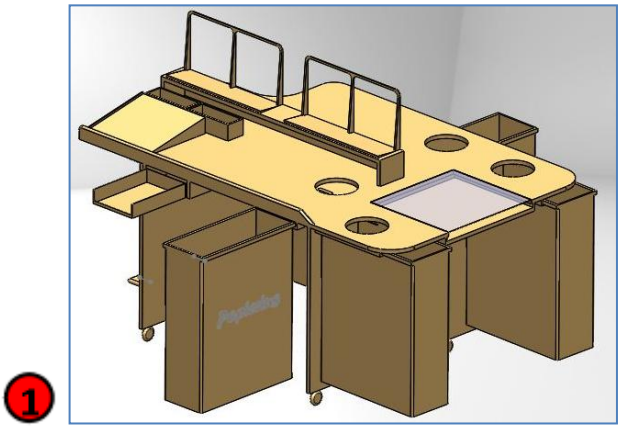


Fig. 2.21 New design table

Fig. 2.22 Gauge position in machinery. General view

After a real-life mockup was made by participant of session, table was presented to the rest of population for further evaluation. It took some several of weeks to evaluate all pecualiarities of the mockup, since population to use the table is rather high.

A list of disadvantages (Fig. 2.23) was made during one month of usage of the table, which was later included into development of the final new design version (Fig. 2.21). A new table is not being produced by supplier. This new version of table will not only embrace people's empowerment to change the status quo but also let company to increase safety in that certain area as well as significantly increase workplace order.

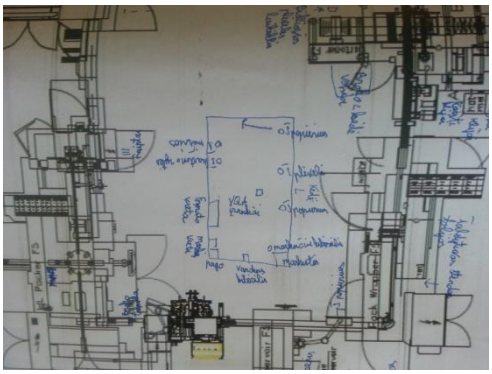


Fig. 2.23 List of cons

2.6. Reduction of time losses: improvement of operations time frame

During SMED session it was identified that the current brand change standard (Annex A-5. Example of standard after SMED session) is no longer valid and satisfying users in terms of timings. Machine crew have proved they become much more skilled and they practices that have been applied so far were implemented and sustained as per standard. For that purpose, as new updated time standards were placed as it is shown in Table 2.10:

Table 2.10 Timings of current vs updated brand changes

BRAND CHANGE					
Former time standard	New time standard	Former time standard	New time standard	Former time standard	New time standard
Making operator		Packing operator		Labourer	
STOP					
0:35	0:30	2:00	1:51	1:30	1:22
5:00	4:23	2:30	2:32	1:30	1:25
1:00	0:45	3:00	2:45	3:30	3:00
6:00	6:19	2:30	2:39	0:25	0:25
3:00	3:11	0:15	0:15	0:45	0:51
2:50	2:24	10:15	10:02	0:50	0:37
0:15	0:17	START		8:30	7:40
18:40	17:49	SAVED	0:13	START	
START				SAVED	0:50
SAVED	0:51				
Format change - 15 to 45 min.					

The Table 2.10 above reveals that former steps, that were identified some time ago during creation of the firts brand change standards remain unchanged. What changes is the time constituent. As it is seen, most of the timings in columns named *"New time standard"* are marked as green, which highlights the improvement on time versus former time frame. Several of steps were identified as red due to extended activity time. This mostly happens due to either unskilled labour force or due to obstacles operator met while performing the task e.g. fracture in pocket of rotary drum causes extra time to remove surplus of glue, that under normal conditions must not be there. The yellow color indicates no change throughout the operation. Generally speaking, new standard saves around two minutes of time.

Table 2.11 Timings of current vs updated planned shift cleaning

PLANNED SHIFT CLEANING					
Former time standard	New time standard	Former time standard	New time standard	Former time standard	New time standard
Making operator		Packing operator		Labourer	
STOP					
1:00	1:00	3:25	3:20	1:30	1:22
1:00	0:55	7:30	7:21	1:30	1:38
2:10	2:00	5:10	5:00	0:30	0:30
3:15	3:25	1:10	1:02	1:00	0:45
0:10	0:10	1:00	1:14	2:25	2:00
1:05	0:55	4:20	4:00	1:00	0:47
2:00	2:00	0:20	0:19	2:00	1:49
0:15	0:15	2:00	1:34	2:00	2:09
0:10	0:10	1:20	1:22	4:00	4:00
3:00	2:50	1:00	0:55	1:00	1:11
0:10	0:10	2:30	2:39	27:00	16:11
0:20	0:17	0:40	0:32	START	
0:40	0:30	30:45	28:18	SAVED	10:49
0:10	0:10	START			
0:30	0:26	SAVED	2:27		
1:05	0:53				
2:00	1:30			-total time	
19:00	17:36			-improved	
START				-missed the target	
SAVED	1:24			-remain steady	

An additional idea was evaluated that involved planned shift cleaning activity. It is rather obvious that some steps performed in brand change process resemble the ones performed in planned shift cleanig process. With that being said, another SMED session was set up to investigate opportunities of leaning the mentioned process. Table 2.11 below reveals results in terms of process steps.

As it was defined in the brand change example (Table 2.10.) most of the steps turned green color due to optimized steps time. In general, around 15 minutes were saved evaluating the three persons that take part in the planned shift cleaning activity.

The important part of time that is included into calculations is the so called "Internal time", which means that machine must be stopped to perform certain kind of operations. As is it seen from the above table, evaluation on time pattern was successful since in reference to former time standards around 60 per cent of steps were improved. Moreover, in terms of steps and structural flow, one significant change was made - to remove cleaning of cigarettes making machine step out of internal time by approving a PIF (Project Initiation Form) o buy an extra glue vessels for all of the link-ups

Then we have an extra time for the operator to perform other tasks and help teammates to do their steps faster. The proposition for the future production process improvement is try to connect both the planned shift cleaning activity and the brand change activity so that the two processes combined would save some more time and be dedicated for making machine clean, free of trash, and save from brand mixes (Table 2.12).

Evaluating savings on uptime after the implementation of new standards after SMED session on planned shift cleaning it could then be stated using formula (2.7) that:

$$t_{ts} = t_{MAOPPSC} + t_{PAOPPSC} + t_{PagalbPSC} + t_{MAOPBC} + t_{PAOPBC} + t_{PagalbBC} \quad (2.7)$$

where,

t_{ts}- total saved time, s.

$t_{MAOPPSC}$ - time savings of maker operator during PSC activity, s;

$t_{PAOPPSC}$ - time savings of packer operator during PSC activity, s;

$t_{LabourerPSC}$ - time savings of labourer during PSC activity, s;

t_{MAOPBC} - time savings of maker operator during BC activity, s;

t_{PAOPBC} - time savings of packer operator during BC activity, s;

$t_{PagalbBC}$ - time savings of labourer during BC activity, s.

Then substituting the real time values it goes as follows and the total time saved is summed-up to 994 seconds:

$$t_{ts} = 84 + 147 + 649 + 51 + 13 + 50 = 994 \text{ s}$$

Table 2.12 Combined activities new time standard

New time standard	New time standard	New time standard
Making OP	Packing OP	Labourer
STOP		
0:30	1:51	1:22
4:23	2:32	1:25
0:45	2:45	3:00
6:19	2:39	0:25
3:11	0:15	0:51
2:24	10:02	0:37
0:17	3:20	7:40
17:49	7:21	1:22
1:00	5:00	1:38
0:55	1:02	0:30
2:00	1:14	0:45
3:25	4:00	2:00
0:10	0:19	0:47
0:55	1:34	1:49
2:00	1:22	2:09
0:15	0:55	4:00
0:10	2:39	1:11
2:50	0:32	16:11
0:10	28:18	23:51
0:17	38:20	
0:30		
0:10		
0:26		
0:53		-total new time
1:30		
17:36		
35:25		

Calculating the total impact on uptime that company may have using the new standards is as follows:

$$U_{9LUs} = \frac{\mathrm{t_{ts}} \cdot 9 \cdot 100\%}{720 \cdot 60 \cdot \mathrm{n}} = \frac{994 \cdot 100}{720 \cdot 60} = 2.30\%$$

where,

720 - number of minutes per twelve hours shift;

60 - number of seconds in a minute;

n - number of link-ups running.

Let it be noted, that several other conditions must be fulfilled including the fact that format change must take place at the same time; machine crew is supportive of the standard, well trained and duly performs daily activities; the type of brand is produced etc. The the total savings in euros becomes:

$$P_9 = U_{1LU} \cdot p \cdot n = 2{,}3 \cdot 30 \cdot 9 = 3726\ EUR,$$

where,

P_9 - price of saved uptime per 9 link-ups, EUR;

p - price of one percent of machine uptime, EUR.

n - number of link-ups.

Summing up, it could be stated that both technical improvement and general management solutions cotribute to the result of improved time standards. In this way, SMED technique ensured that process analysis was done in many different directions and what is the most important it all happened based on people's opinion. In this way a foundation for human attitude as well as room for further improvement was built. This time, people will know how they should act and what needs to be done to move forwards and concentrate on further solving of issues to improve timing.

3.RESULTS AND RECOMMENDATIONS

In this section all kinds of results of performed analysis of literature sources and real-life SMED sessions is discussed. The positive and negative impact of SMED application to brand change process in cigarettes production is given. Moreover, recommendations to further process development and general guidelines are given.

3.1. Positive results

1. Having in mind the complexity of brand change process company faces throughout production cycles it is rather apparent that the chosen direction of analysis and focus is amongst the key fields of optimization in the process. Tendency declares that under current conditions of continuous pressure from governmental institutions, social movement against tobacco industry and refreshing social opinion about the health issues of the product under discussion have a vivid negative influence resulting in reduction of production volumes, small and versatile brands and of course more idle time for producers that remain at stake.
2. Actual standard that serves for over four hundred people is, actually, available and running within organization. The former standard was no longer fitting continuously improving machine crews and time pattern that is dictated by markets. What so ever, former standard was continuously under risk to be violated, which was rather admitted by shop floor people since time management and variety of steps were no longer realistic in terms of constant machine modifications and change of staff.
3. Management of process of standardization was put adequately in reference to all users. Stating that being lean or adapting one of marginal lean tools (i.e. SMED) into corporate life means involving people into decision making and changing their mental state with new point of thinking. This is usually omitted as an option in some organizations and is more or less addressed as an obligation in form or standard created by management. People had chance to finally express their opinion on the process that they will later on manage themselves and make it as reliable and convenient to use as it could ever be. This is programmed for success, since people are fascinated and inspired by the idea to take over control of something that bothers them each and every day.
4. Bringing process owners together as a team - this rather challenging objective is completed. As it was framed by famous management expert and author of dozens of worldwide books Peter F. Drucker - "the best way to predict the future is to create it" [46]. What was chosen as a challenge at first became a force that drove the team for success throughout the process. The

team was selected randomly by volunteers targeted to address shift opinion. As mentioned previously, standards valid up till the SMED session were strongly questionable and thus disregarded by shifts. Each shift link-up team had their own specific rules on what must be done during certain period of time, which made so much discussion during the session.

5. The time management was improved. What was revealed during taping of the process is the total clutter. Since a new team of experts that have never worked together before were collected, they all knew what to do without even considering differences among teams between shifts which led to variety of misunderstandings and redundant steps. The aim of standard within organization is to keep it the same and make strict grounds for everyone to maintain it unless changed and communicated to population.
6. Combination of two SMED sessions led to intertwine two rather different processes planned shift cleaning and brand change. During the SMED session on brand change a thought was raised that some certain part of shift cleaning is actually performed during brand change. The brand change usually involves a complete change of applied materials that also includes cleaning of certain surfaces and machine area. Former cleaning standard dictated that cleaning of machinery is done during shift time by one labourer. To concentrate better on both processes proposition on time pattern reorganization for both of them was prepared. A new cleaning timetable with accurate tasks were also assigned.
7. Variety of process improvement were detected and several of solutions were initiated to eliminate them. These were rather simple improvements that could have been eliminated daily during continuous improvement analysis but, what so ever, it have never taken place. During the session, the focus was made not only on improvement of time pattern but also on several other machine issues including generation of rejected product, waste sources and possibilities to increase uptime.

3.1. Negative results

1. Culture is what forms a group of people as team. Regards to one another, mutual respect and status of team leader as an actual leader of that team are both the most complicated and the most important three variables to consider when it comes to team's compliance to standards. It is rather obvious that there should be one strategy and guidelines that serve within organization building common sense. This is declared loudly but still hard to implement since the lack of process continuity is apparent. People usually are forced to work in chaotic environment that complicates adherence to standards. It means, people are keen on doing things the way they

used to do it before than keeping the standards by learning steps and frequencies all over again if under pressure. The same approach is valid for the shop floor workers and team leaders, what so ever.

2. Lean leadership could be the missing link between toolbox lean and a sustainable continuously improving organization. The organization realize that it has so far basically focused on the visible parts of lean production systems. Although process optimization with various methods like Kanban, 5S, SMED, FIFO (First In, First Out) and many more is very effective to achieve short term improvements, but after a few years, the lean programs do not meet the expectations anymore if lean implementation is not ensured at all levels and mental state of the company.
3. Negativity is obvious. Statistics reveals that more than 60% of population that has to apply new standards are reluctant to obey due to unknown reasons or simply saying it is better to complaint that new process is wrong than comply with it and use the former one or do the process individually. This creates a barrier and challenge for team leaders to make people believe this comes from them, from colleagues, they delegated to create the process. It is not another rule that is delegated by management. Moreover, people are willing to study lean, they are willing to enrich the knowledge on variety of topics but once it comes to implementation, most of them reject invitation to change.
4. Complexity is what leads any kind of standard to exceptions. A most general brand change case was taken during workshop and situation was thoroughly analyzed but there are always some cases when one have to adjust process steps accordingly to fit the situation. Complying to lean methodology, standard work is one of the key measures of company's success and we need continuously strive for standardization and simplification. But it seems to cause most of the discussion since if management shares some information about new standards or other kind of activities, people's reaction to this could be defined as critical, which is either we go standard or we do it as we are used to.
5. Commitment to what is done is necessary. SMED session frames standards but people, that do the standard must feel free to speak up for it and try to do it while at work at no matter what comments are received from the rest. It is only a matter of time when other will believe. As it is shown in the figure (fig. 24), a group of people usually have different kind of awareness (red line in reference to blue line) about the same things even though they would be held in the same room for the same period of time and the same kind of information would be displayed and explained to them. Furthermore, information path and understanding comes differently for different people. Time frame is unconditional.

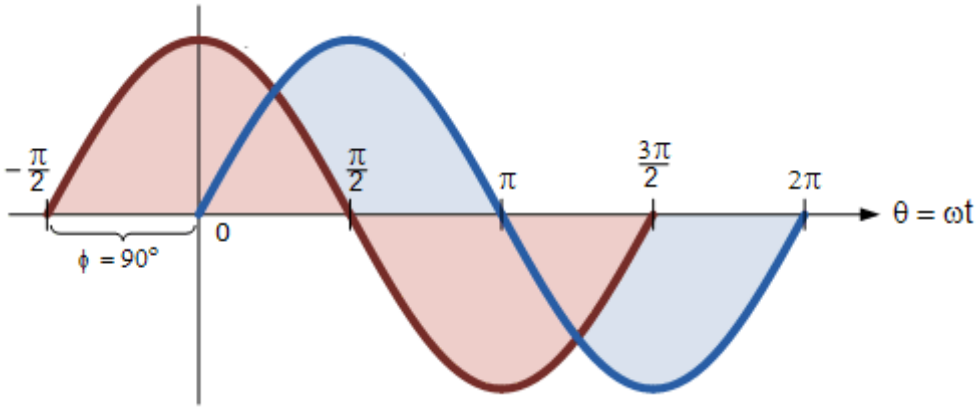


Fig. 24 Example of different kind of understanding [47]

6. Frequent change of workers generate stress. It still remains a problem even for a worldwide companies to keep their crew stable especially in terms of lower quality workers. Maintaining a clear standard makes it hard for other team members to take responsibility keeping, for instance, the cleanliness of area as required if labour people change every shift. It is not only hard technically but also morally to keep the same tutoring cycle every day. Furthermore, more decent planning is required if several of new standards are released live. How people will react to variety of changes and if something goes wrong who, how and when will take responsibility for failure and inspire people to believe the standards again? By saying "inspired" it is meant that when one tries to incept a new standard it makes some proactive steps with crew members that are most probably to buy in and take message to those more reluctant to change. If you break that brittle connection then it becomes harder to go further.
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9. It is hard to define the actual savings of any kind of process improvement when it has factor of work force that takes control of major part of the process control. In this case standard is created by people that are going to manage it but it is not always the case that it is followed and constant control (e.g. auditing) is obligatory to keep savings as promised. Moreover, there are no actual guarantee that any kind of process improvement will last or work as defined until proper amount of time passed to actually see it. Most often, operator is the one that will or will not obey certain rules or use machine upgrades properly.

3.3. Recommendations

1. The common lean levels are: philosophy or long-term thinking, process to eliminate waste, people and partner to respect, challenge and grow mutually, and problem solving. All these terms are well- known. However, most enterprises merely focus on process. Eliminating waste in all processes has been broadly adopted, whereas the other 3Ps, the "invisible" parts of lean, are less easy to adopt but equally important for the sustainable implementation. Lean leadership addresses all 4Ps and provides a methodical system for the sustainable implementation and continuous improvement of lean production systems. It describes the cooperation of employees and leaders in their mutual striving for perfection [48].
2. What makes lean process so special is the connection it builds among teams and team members. It seems plausible that team shares trust and confidence in each other's work. This is brilliance of team work. Any who, what may seem as victory over an old living status quo must be regarded with carefulness and taken seriously. To organize a team of members of pretty different working standards is a difficult task. It requires a lot of effort and vivid examples of how things could be done simpler but that actually works well later on once a team gets the idea. But there are many more team combinations, teams that could be assembled instantly due to various reasons and they still have to perform the same, under same set of rules without disobeying and having that trust. For an organization as huge as half of thousands of people this seems like a lot of work. One have to invest time and money to first of all prepare people to

meet the changes then again even more time and money for people to get involve into process and become a part of it. This must be a key target of an organization to make people responsible for what they are doing by giving them a chance to create whatever they want or in other words - "imagine please" state. People then become proud of where they work and even the most marginal process or a task that has to be performed transforms to a masterpiece.

3. One has to understand that only maintaining the required order will give an expected benefits. This is a rule applied to any kind of process. By saying order, one could declare importance for everyone participating in continuous improvement process about the rules that are semantically and sometimes directly retained. Rules imparts clarity, which means common understanding and the same level of awareness throughout organization. In example, safety. It is a common sense and booming trend to keep investment into safety growing for well-known reasons. No one ever asks what to do if it feels unsafe - one has to report and seek for fast measures. If a fire starts, everyone knows where to go, who to call. It is a protocol that has been given to people years ago and continuously repeated through variety of drills etc. The same is what one must seek while performing SMED, 5S and other activities. One must ensure people are involved into continuous improvement activities one hundred percent, people should become relaxed and willing to take part in that kind of activities sometimes dedicating even their free time. It is more of a Japan culture to seek for work of life, but for starters rules that are established by people must remain alive and everyone within organization must understand why the way they did something is not good enough, what is the purpose of new steps, etc.
4. Establishing process coordination within organization. It is crucial to think of a team that should coordinate SMED and other type of activities in terms of workshop planning, implementation and assistance, training of new leaders. Control is what should be felt during process implementation and maintenance. It is wise to have the whole area divided into zones that would have assigned supervisors. The roles of coordinators could be dedicated more to inspire other parties to use, in example, SMED activities in their area and sell the process for continuous improvement within organization. The area supervisors on their own would serve as catalysts that would coordinate the process inside and make sure people remain inspired.
5. The attitude is among the most important things ever during sessions and implementing the process online. The tone that one will set will destine one's success of implementation of that very process. In most of cases from current practice, people come to sessions already reluctant to change or they would like to change but the previous experiences tell them this will not last long, no one cares etc. A true leader, supervisor or coordinator must show trust in what is going one to support this new activity and show people that this is a new way of thinking and this suits new outlook of this organization. If one is a participant of this event, it means he/she has a

change to become one of the first to try something new, to change the current unsatisfying situation and master the process by simply creating it and becoming a true part of it.

6. Go for small improvements. Small usually means successful and these type of changes are easier to understand and accept. Moreover one can allure workers to follow the success of small improvements by inventing new ones and thus adding up to continuous improvement activities more and faster than if one would manage a grand plan of improvement that would cause a massive dissatisfactions, a lot more of money, and struggle. One should better select a pilot area that would get as much time as they need to redirect themselves to think leaner. This area could be somewhere in the easy to notice place, that bypassing people could feel the difference in what is going on with this area. The most important thing is to make others believe that these new things are good, that these are the ones that everyone needs. In other words, allure the crowd. And there is no trick there, since processes actually work no matter they would be applied in one or the other place. They only variable is attitude.
7. Separate zones and improvements in those zones. Do not mix and match unless necessary. One of the most common mistake when company strives to pave the lean path is do it in all directions and at the same time. SMED activity itself is rather not too complicated, since the steps are clear and procedure is standard. The most important thing is to manage a team that they would not get lost in the process and make the right decision. The hardest part is always sharing of standards to the rest of population. Experience shows, new type of activity in areas where continuous improvement was not abundant could have major issues in terms of reluctance of doing it the other way. Go with thorough trainings first, repeatedly if necessary. Do not try to cover all the population before going live with new standards. Follow Gauss distribution function that claims there will always be a part of team that refuses to change. Do not focus on them, they will get involved anyway when no other choice is left.
8. People are already reluctant to change or they would like to change but the previous experiences tell them this will not last long, no one cares etc. A true leader, supervisor or coordinator must show trust in what is going one to support this new activity and shown people that this is a new way of thinking and this suits a new outlook of this organization. If one is a participant of this event, it means he/she has a change to become one of the first to try something new, to change the current unsatisfying situation and master the process by simply creating it and becoming a true part of it.
9. It is much more important to put one's efforts on implementation of new program, new tools, that lead towards lean production. Even though the method was rather thoroughly analyzed and pertained to people during the session it could be stated that the method itself does not and will not bring desired outcomes if no thorough keep up will be done towards maintaining what have

already been achieved during the start-up application of the tool. Results revealed that once a group of people is engaged for a work, it most probably will not last longer than the end of session unless forced to go after what was discovered during the session. People tend to get back to the old habits, especially, when situation at workplace gets intense. In sequence, corrective measures needs to be taken to make sure it is always allowed to make mistake for a certain period of time after the session is over, to learn from what is not going well, to establish a culture, a habit, but not an assigned set of rules.

10. Being lean does not mean you only apply tools that are proposed by Toyota, randomly in no reference to what needs to be achieved. In case under discussion, SMED was chosen as a tool, that suits this situation the best and could most certainly bring the desired outcome - reduce time intervals, redundant steps, number of headcounts in the process etc. It was achieved a numerous improvements over period of time that includes clarification on process steps, picking the right time for each and every task, visualization of tasks, training of population to master the process according to these guidelines. Moreover, since these are a continuous improvement activities, people must understand the standards will always undergo changes but these changes next times will have to come from process owners and not from management arranged activities. This is the true cultural achievement of any company and it will require additional efforts to come.
11. Combination of two processes - planned shift cleaning and brand change - was an unexpected but very efficient decision. Once more, it could be referred to versatility of lean tools in terms of application. Separate SMED sessions were performed to stabilize the two processes and work pattern of associates which led to variety of process improvements, alignment and simplification of work patterns. It can be noted, that SMED can only be applied for tasks that have standard routine layout. To compare the two, planned shift cleaning was much easier to agree upon, since machinery across factory seem to remain the same. Talking about the brand change, certain approximations due to process limitations have to be made. It is not possible or almost not necessary to make it possible, when process under analysis is versatile and could have many forms. The key note is to make it as much usable as possible to be applied in most of the cases step by step but keep it rather clear and ensure at least partial compliance to the standard in terms of deviations e.g. if we talk about the standard brand change with format changes that were excluded during session analysis time.
12. SMED is a process of certain steps and pace. No matter what, one must ensure compliance to required order before, during and after the session. This is more a question of what message you care to deliver to a team. Since this is not a complicated process in terms of process steps, it makes look easy to get prepared and perform the session. Actually, standing alone time for a leader is the most crucial and transmitting the right message is what the whole SMED session is

all about, so preparation is the most important part of the process. In case under research, there were several issues of people getting understand of what they did during the session and what and when they have to start in tackling daily activities. The message to the team was communicated poorly and this allowed the team to make some presumptions that lead to unbalance during go-live stage.

13. Study revealed that genuinely selected target audience may not be the best suited for a case. Even the outcome of session and performance of session steps could be hard to implement in case people don't care or they are reluctant to changes. One may even waste lots of energy trying to persuade team members that this new approach could bring something beneficial in reference to current situation. It was decided to select people that belong to the same machine area from different shifts to manage difference of opinions and make people agree on the ground rules during the first SMED session on the brand change. The other approach, which was applied in the SMED session on planned shift cleaning was that people that are only interested to actually make the process improvement would participate. This way, it was much easier to communicate the message of the session and at the same time ensure implementation of results and training of population. Participant of the session spread across the facility which seemed natural process upgrade for many teams when process upgrade was acknowledged randomly.
14. SMED session it is not all about the numbers and people mindset. Combination of SMED tool with other lean tools like 5S works well and we were able to combine these two several of times to find new better places for tools, format parts and other important things. SMED allows to reveal the flaws of the process and make people to define them themselves looking for a solutions. First, one concentrates on the most obvious ones like missing tools or dirty areas that, in example, left after the cleaning. But then one discovers that the set of order of tools is not convenient since it takes more time to perform the task. Later, it goes even further and people strive for machine modifications or as Japanese refer to 'poka yoke', which means 'the only possible way'. Most certainly the tools may no longer be needed at all. The ground rule - let people imagine and do not neglect anything. Remember that owners of machine, i.e. machine crew, knows the best. Always test what's proposed.

Conclusions

1. In this very analysis of brand change process the most adequate lean tool to use was named SMED. The pros of the method over other lean tools were proven by logical explanations in literature analysis as well as tested several of times during two real-life SMED sessions, organized for the brand change process and planned shift cleaning processes in the factory premises.
2. Analysis of cigarettes production brand change revealed several of areas of improvement including time management of operations, specific process shortcomings, increasing risk of rejected product and potential risks of brand security and product quality.
3. Time table of operations of brand change process and planned shift cleaning were analysed and streamlined. Proposition to merge those two processes was given evaluating resemblance of certain operations and best utilization of time for whole team. Total time saved per both processes - 994 s or 1863 EUR/shift.
4. Upgrade on cigarettes making machine glue vessel system was proposed. To have a spare glue vessel for each machine would save 600 s/shift of time during each shift. Additional investment of 58’500 EUR is required. Theoretical pay-off – 187,65 EUR/shift.
5. To improve rejected production rate two process improvement were made including pack pocket sensor upgrade and installation of heating plate. In total, theoretically both of them should generate yearly savings of time – 407,4 EUR/shift.
6. Improvement of filter feeding reorganizes filter feeding process significantly. Filter loading speed is reduced 3 times to 0.3 trays/min while loss of filter trays is minimizes 3,4 times to 0.5 tray a shift. Possible cost of production is 7000EUR, theoretical pay back – 59 EUR/shift.
7. Operators table was revealed as centre tool for brand change and general daily chores. An upgrade of table was proposed, based on opinions of participant in session. Price of investment – 2000EUR.
8. Generalizing, total theoretical savings after the above discussed modernizations would be installed are 654,05 EUR/shift; time savings - 994s/shift or 1863 EUR/shift.
9. First focusing on low hanging fruits one should organize further sessions to proceed with PDCA cycle and continue developing brand change process to one digit time span. The most important is to make the buy-in for people to feel ownership of whatever process they have to manage.

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Annexes

A-1. Heating plate

A-2. Holder

A-3. Feeder

A-4. Table

A-5. Example of standard after SMED session

A-1. Heating plate

1-Filling element

2-Hiller element

3-Feeding element

A-5.Example of standard after SMED session