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Study of Parameters Influencing the Production and Improvement of the Launch System in a Production Department: Case Study in the Clothing Industry in Tunisia

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Abstract
This study was carried out in a clothing company to determine the parameters that influence the decline in production. The results showed that the parameter "Machine failures" had a 34.6% effect on production, and "lack of versatility" 19.7%, while the parameter "heavy launch" had an effect of 17.1%, "lack of supplies" 9%, touch-ups 3%, and "lack of cut parts" 2%. Indeed, the application of lean and six sigma tools and especially the D.M.A.I.C and TPM methods are two tools that improve efficiency and productivity in a production workshop. Thus, a grid was developed to monitor and maintain the effectiveness of improvement actions and for the continuity of the spirit of improvement within the production department without forgetting that teamwork makes it possible to improve the result.

Key words: *production, improvement, productivity, launch.*

Introduction

The textile clothing sector is a pillar of Tunisian industry and maintains a prominent position in the national economy as well as a strong contribution to the socio-economic balance of Tunisia. This sector represented 26.6% of the gross domestic product of Tunisia in 2015 [1]. In the clothing industry, the production phase remains essential for the success of the company while respecting the customer's requirements in terms of time, cost, and quality. However, in reality, several companies often find problems at the production stage, which has a major impact on deadlines and therefore on the predicted schedule. There are several methods for improving the production system and reducing wasted cycle time. The most recognszed is the Toyota Production System (TPS), which allows an improvement of the quality of the products manufactured as well as reduction of the costs and delays [2] (Kumbhar et al., 2014).

A lot of research has been done to study the parameters that influence production management. According to Fisher in 1996, new products introduced have a great influence on production management [3]. For the fashion industry, whose products have a short life cycle, improving the coordination of services and sharing information in the sales contract in a sliding plant framework make it possible to work with data in real time as much as possible and follow the customer's request, which is a random variable [4]. Market requirements and product characteristics influence the choice of the planning and production control system [5].

The textile and clothing industries are facing rapid changes in production technology and consumer preferences for greater variety, better quality and more fashionable products [6]. Clothing manufacturing is largely low-tech and labour-intensive, while the textile industry is more technology-intensive and requires less unskilled labour [7].

Improving productivity for the textile and clothing industries is an important condition for competitiveness on a global scale. During the period 1995-2004, productivity in the clothing industry increased on average by 0.3 and 1% per year, which was mainly due to technical progress [8]. In industry, the cycle time must be targeted to achieve a balance between labour, machines and materials depending on the management methods used. Business rivalry is a new approach to quickly respond to fluctuating consumer demand, which helps maintain global competitive advantage for the producer [9].

Indeed, research in the areas of improvement in production management is divided into two categories: The first uses simulation and the laws linking action parameters to performance indicators, helping the manager to better manage his production system [10], while the second proposes an approach for calculating action parameters to obtain a value for a performance indicator [11].

This study was done in a clothing company in Tunisia, whose objective was to investigate the parameters which have an influence on production using the tools of the two methodologies lean and six sigma, which are used for the improvement of the organisational and operational performance by large companies through their influence on productivity and quality [12]. The aim was also to resolve the problems that contributed to production weakness and to find solutions to minimise losses and improve productivity.

Material and method

The study was carried out in a clothing company specialising in the manufacture of knitted articles such as swimwear, panties, boxers, underpants and underclothing.

The study lasted 8 months in the production department, and it was started with an analysis based on the D.M.A.I.C tool

Table 1. *Summary table of parameters measured per month during the period.*

Parameters / Month	Number of working hours	Number of product chains	Number of model changes	Number of launches with 0 output	Lost quantity	Lost cost	% Retouch	% Efficiency
January	225	3	2	4	44406	72735 €	1.65%	57%
February	198	5	2	5	51760	62112 €	2.14%	60%
March	216	5	2	4	69896	83875 €	1.44%	62%
April	225	3	3	2	32302	38762 €	1.66%	67%
May	234	3	3	1	27047	32456 €	2.41%	61%
June	189	3	2	5	28518	25666 €	1.92%	77%
July	243	4	4	5	36427	43712 €	9.35%	66%
August	81	4	2	5	16623	19947 €	1.84%	64%

of the six sigma method [13]. The main steps of the method are as follows:

1. Define: in this first step, all the problems encountered in the production department identified by a daily follow-up, with a weekly summary, next classify the problems found according to priority and then reformulate them considering their weakness and the dissatisfaction of customers [14, 15].

In the production department of the company, which is its heart , many problems have a direct impact on planning, causing the delay of export and dissatisfaction of customers. The planning department was aware of this problem since the DOT (Delivery on Time) percentage was only 60%. The daily monitoring of problems encountered with respect to the KPIs represents the starting point of the project. The data tracked every day were the out production per line, number of defects, efficiency, number of lost parts, and the cause of the decrease in production in cases where the efficiency was lower than the target requested. Each instructor would insert all the data every hour. A recap was made at the end of each hour.

2. Measure: in this phase the relevant data in the production department must be measured to assess the current situation by means of the problems encountered [14, 15]. The five parameters to be measured in this case are as follows:

- the output of the production per day,
- the number of non-compliant parts recorded each hour by the control post, which are cumulated at the end of the day.
- the efficiency percentage, determined according to the actual quantity relative to the target requested,
- the quantity of parts lost each day, classified according to the problem encountered during production,
- the number of working days and production lines per month,
- the number of model changes per chain and per month,
- the number of launch days with zero output,
- the lost costs, calculated according to the quantity not produced and the unit selling price.

3. Determine the root causes of the problems encountered and make detailed analyses of each source [14, 15].

An analysis of the causes was done daily in order to make a corrective plan. The major causes of production losses are absenteeism, low versatility, machine breakdowns, low quality of cut, and lack of supplies or accessories at a new launch or during production. The causes are measured and arranged according to the Prometheus storage method: sort, order, describe and select [16].

4. A solution must be proposed to each problem in order to improve the production service [14, 15].

SPC (Statistical Process Control) brings a set of methods to monitor and improve a production process from a statistical point of view. SPC is the most appropriate method for monitoring a complex production process. It is defined as a set of actions for evaluating, regulating and maintaining a production process in a condition in accordance with the specifications adopted, with stable characteristics over time [14]. TPM is a methodology for increasing the availability of equipment by reducing investment needs and increasing the yield of human resources, with better quality of products and a reduction of labour costs [17].

5. Control: in this phase it is necessary to control the efficiency of the improvement system by evaluation according to a well-defined grid.

AMDEC is a method used as a reliability assessment technique to determine the effects of system failures. This method prevents potential failures of a product in a manufacturing process or organisation. It is based on a methodical analysis of potential risks which allows them to be prioritised in order to treat the most important risks in a preventive manner. AMDEC achieves quality through preventive action. The purpose of this tool is to detect product failures, define the actions to be taken to eliminate these failures, reduce their effects, prevent or detect their causes, and document the development process [18].

Results and discussion

The following table summarises the results found for the parameters measured over 8 months:

The ***Table 1*** shows that machine breakdowns decreased production by 34.6% and the versatility level by 19.70%, while absenteeism in the chain had an adverse effect of 14.60% on production. A heavy launch without any ideal preparation had an influence of 17.10% on production and the lack of supplies during a launch – 9% on the pace of production. The return pieces had an influence of 3% on production and missing cut pieces 2%.

The parameters studied have an influence on production between 2% and 19.7%. In total, we have a loss between 23% and 49% in terms of efficiency. This translates into a loss in turnover between 19947 € and 83875 € per month. These figures compelled us to take immediate action.

To remedy these problems, several actions have been taken. Indeed, the parameter “machine failure” is the one that has the most important effect on production. The company is moving towards the application of a TPM (TOTAL PRODUCTIVE MAINTENANCE) plan whose objective is to increase efficiency and productivity and change the mentalities of staff [19]. There is also the application of the curative maintenance procedure as a solution to measure the number of minutes of daily breakdowns, allowing recording and analysis to realise an action plan. Moreover, total productive maintenance is an equipment and process improvement strategy to achieve a high level of equipment efficiency [20]. For this goal, repairing broken down machines is essential to keep them running and improve their profitability. In this case, TPM makes it possible to increase the availability of equipment by reducing the need for additional capital investments [19].

To improve the efficiency of the maintenance department, it is necessary to make a preparation plan for the machines that have a high risk of failure and use them as a reserve. The main objectives of TPM obliges the involvement of operators in the daily maintenance of the equipment, which necessitates a training plan for the personnel involved in order to introduce autonomous maintenance to avoid failure waiting time. The maintenance team must insert the culture of TPM and divide tasks by planning and making adjustments for a new launch.

To properly apply TPM culture, it is necessary to measure the performance of the maintenance service by the OEE index (OVERAL EQUIPEMENT EFFICIENCY), which makes it possible to treat all losses caused by the equipment by measuring the rate of quality and performance of the equipment.

$$OEE = A \times PR \times Q \qquad (1)$$

Where,
OEE – overal equipement efficiency;
A – availability proportionate to the time in which the machine is available;
PR – performance rate and PR = RE × SR;
Quality rate (Q) – refers to the quality rate, which is the percentage of good parts out of the total produced.

The reference value for OEE is 85%, but on a practical scale it varies between 40% and 60%. The main objective of TPM methodology is to have zero failures and zero faults, therefore the procedure involves having a linear organisational structure with a versatile workforce. Rigorous reassessment of the method by introducing improvements leads to simplifications and standardisation [19].

The production department had an average rate of 12% for versatility. The target

Table 2. *Grid to control the launch preparation, model change, and production monitoring.*

Model	Conception Code				Chain	
Preparing						
Time Line	**Global Status**	**CHECK LIST DETAILS**	**Who**	**Tools**	**Statut**	**Comments**
D-8 (Mini)	**Planification**	Deadline production + OUTPUT + responsible line	Planning Leader	Planning		
D-8 (Mini)	**Supplies/ Fabric**	Availability of fabric and accessories	Planning Leader	Stock status		
D-8	**Feedback Sampling room**	Is there a meeting with the Sampling Manager to identify specific machine and critical operations’ needs?	Development Leader + Production Leader + Line Leader + Quality Manager + Industrial engineering + Mechanics	Sampling room return sheet		
Always	**Skills matrix**	Is there an updated competency matrix?	Industrial engineering + Production Leader	Skills matrix		
Always	**Maintenance plan**	Is there an up-to-date list of machines and spare parts?	Mechanics	Machine data sheet and equipment		
D-7	**Timeline**	Is the assembly plan available?	Industrial engineering	Assembly process sheet		
D-7	**Layout of line**	Is there a study on the design of theoretical lines with n° of machines and workers (using the skills matrix + the list of machines available)?	Industrial engineering	Layout & balancing		
D-7	**Machines and spare parts (equipment)**	Availability of machines, spare parts, and equipment necessary to launch the line?	Mechanics	Machine and equipment needs sheet		
D-6	**Cut parts**	Controlled trace + controlled cut parts at cut and screen printing level	Cutting and quality service	Cut parts control plug		
D-6 => 1	**Machine preparation**	The mechanics prepare the machines. guide, models, etc. if necessary	Mechanics	Machine and equipment needs sheet		
D-6 => 1	**Preparation SOP**	Prepare SOPs for critical positions	Industrial Engineer + Mechanics	Standard operation time (SOP)		
D-6 => 1	**Training for critical positions**	Train the worker in critical operations identified by the sampling manager (use overtime if necessary) => Remember to prepare the parts /semi-finished products in advance (in the sampling room, for example)	Workers + Line Leader + Mechanics + Industrial engineer	Master sample		
D-6 => 1	**QC end line**	Quality end-of-line verifiers supervised in the control plan	QC + Line Leader + Quality Manager + Production Leader	Master sample + control plan		
D-3 => 1	**Wipwordk**	Check the outstanding amount (flow of 5 coins for day D)	Line Leader			

Model change						
Time Line	**Global Status**	**CHECK LIST DETAILS**	**Who**	**Tools**	**Statut**	**Comments**
D-3 => 1	**Ramp up target**	Number of critical operations x 15 min + number of easy operations x 10 min + number of manual operations x 5 min => maximum launch time: max 5 h => max 3 days to reach the target	Industrial Engineer + Line Leader	Display tools		
D-DAY	**Meeting to launch**	Is a meeting organised to recall the target and the role of each player (check the availability of all documents and tools: MS, stock of components and accessories...)? + explanation of the power-up object until the end of the line	Production Leader, Line Leader, Mechanics, Industrial Engineer, Quality Manager	All cards prepare a technical file master sample		
/	*** Supply system**	The supply system is composed of 5 pieces by 5 pieces				
D-DAY	**Launch**	Start the launch of the new model following the lines' structure while the previous model is out of the line (for each operation and following the correct balancing sequence)	Workers, Production Leader, Line leader, mechanics, Industrial Engineer, Quality Manager	Layout & balancing,, assembly process sheet, master sample		
D-DAY	**Machine adjustment/ ergonomic validation**	– Configure the machine or implement a new machine => worker or mechanics – Finalise workstation ergonomics => worker, Line Leader, industrial engineering	Workers, Industrial Engineer, Line Leader, mechanics	Layout & balancing, assembly process sheet, master sample		
D-DAY	**Training/ validation of gestures**	– See and train each shift and each operation: Line Leader, Industrial engineering and/or mechanic – The operating procedure and the gestures are validated by the Industrial Engineering and Line Leader as defined in the assembly range;	Workers, Production leader, Line leader, Mechanics, Industrial Engineer, Quality Manage	Layout & balancing, assembly process sheet, master sample		
D-DAY	**Quality Validation**	Quality is validated by the Quality Manager until the quality requirements and subsequent FDP steps are met.	Workers, Production Leader, Line Leader, mechanics, Industrial Engineer, Quality Manager	Master sample, control plan, tape measure		
D-DAY	**Speed/ efficiency validation**	The speed is validated by the IE calculated in line balancing... if we do not reach the 'double check' of the reliability of the SKILLS MATRIX, and update it if necessary	Industrial Engineer	Assembly process sheet, chronometer, skills matrix		
/	*** Validation of steps**	Do not continue with the next workstation until the current workstation is not validated in the previous 4th step (machine setting + training + quality + speed)	Workers, Production Leader, Line Leader, mechanics, Industrial Engineer, Quality Manager			
/	*** Validation of steps**	Do not start producing if previous workstation is not validated => you cannot start configuring the machine	Workers, mechanics			
/	*** Value of WIP**	No work on 5 new parts if the next workstation still has its 5 parts = work in progress for each workstation should not exceed 5 parts (the only exception is when the previous workstation could not get validation with the first 5 pieces)	Workers			
D => + Ramp up target	**End of Launch**	Notify all workers and participants of the launch when the launch is complete + announce the result of the launch in relation to the target	Workers, Production Leader, Line Leader, Mechanics, Industrial Engineer, Quality Manager			
J => + Ramp up target	**Closing meeting**	A roundtable and debrief are required to understand the discrepancies between the launch results and those of the target (debrief daily if the launch lasts more than one day).	Production Leader, Line Leader, mechanics, Industrial Engineer, Quality Manager			
D-DAY and after closing	**Capitalise**	Capitalise on blocking points for improvement at the next launch of the line	Workers, Production Leader, Line Leader, mechanics, Industrial Engineer, Quality Manager			

Follow up						
Time Line	**Global Status**	**CHECK LIST DETAILS**	**Who**	**Tools**	**Statut**	**Comments**
D + 3	**Process stability**	If the efficiency of the line is not satisfactory, double-check that of each workstation and compare it to the target. If it is off target, check why and adjust your actions accordingly: train the worker again or rebalance	Industrial Engineer, Line Leader	Chronometer assembly pocess sheet, skills matrix layout		
From D-DAY until the end of production	**Absenteeism**	If one worker is missing: – try to replace then with an equivalent worker – if not possible, rebalance	Industrial Engineer, Line Leader	Layout skills matrix		

set was 50%. To achieve this objective, an action plan was implemented by setting out the models to be produced until the end of 2020. We also established the needs of multipurpose personnel for critical positions according to the current polyvalence and provided a training plan for a special chain containing at least eight people. The plan must be formulated according to the method, production, planning, quality, and management system for the completion of procedures and all appropriate forms. In fact, a sufficient number of staff, the best weekly training program and fulfilling the needs make it possible to improve the level of versatility and therefore improve productivity. On the other hand, the best choice of organisational structure at the level of job management by the operator and the responsibility of employees are principal elements for the success of the program. Setting a bonus system according to job difficulty is a solution to encourage operators to improve their salary level and, at the same time, the versatility rate.

To minimise the percentage of absenteeism, an action plan was put in place: workers who have a high rate are interviewed to look for causes and find out if there is a solution. Then, do two sessions a week for a medical examination at the company to avoid absence due to illness. In addition, make a monthly bonus for workers who have an absence rate equal to zero.

When there is a lack of supplies, accessories or cut panels, an improvement procedure must be put in place. The production service must receive the complete order including supplies and accessories with the cut parts. Thus, quantity and quality control must be done before each launch and must be noted in the supply sheet.

To reduce the launch time, several actions must be taken; a maintenance team should support only the preparation phase of the machines, which must be done by the service method before the launch. The method team with the planning department must prepare the following sheets for each new launch:

- A detailed sheet of the time of each operation

A balance between the available workforce according to the versatility grid [21] and the production department. The balancing method is very essential to make the workflow almost smooth and to improve efficiency between workposts. Balancing must be done according to the skill of the operators and of the machines to improve productivity and shorten production times [22].

- Adequate chain implementation to improve the efficiency of the corresponding chain [23].

- A machine and equipment file must be completed and transformed into maintenance service within 15 days of the launch date to prepare the machines and equipment, as well as make adjustments and purchase parts if necessary.

The use of information technologies and better communication between the various departments of the company are important keys to success. To control and evaluate the improvement process, a grid was developed for three phases: launch preparation, model change, and production monitoring. The grid is summarised in the following ***Table 2***.

According to ***Table 2***, 8 days before the launch, you need the best preparation at the planning level. It is necessary to check the level of stocks of fabric and supplies. The method department must prepare the assembly process sheet, layout, balancing, SOP based on feedback from the sampling room and depending on the materials, and the skills matrix.

The maintenance department must prepare the machines and equipment. Moreocer, the cutting service must prepare the cut pieces according to the schedule and the quality department ensure quality at the various stages of production.

In the second phase: "Model change", it is necessary to start with a meeting with the various managers in charge to indicate the objective and to check the availability of the various tools. The launch must start with 5 pieces. For each post, it is necessary to validate the quality, gestures, and ergonomics to move on to the next position. Then the efficiency and WIP are checked. Finally, a closing meeting must be held to compare the results obtained with the objective and to take corrective actions if necessary.

This study allows to apply corrective actions using lean tools. This system improved efficiency from 57% to 77% in June, Whereas there was a gradual decrease in July and August (66% and 64%). mainly due to environmental factors i.e. temperature increases during this period. in this case, corrective actions are needed to improve the working environment. According to research carried out to provide the optimum environment for the optimal comfort of humans, the optimum humidity should be between 40% and 65% at a temperature of 22 °C [24].

Application of the improvement system can increase efficiency. This is approved by other research, such as Fahad (2016), who used the systematic technical layout schedule (SPL) to improve the flow of materials in a multinational company that produces a product with a wide variety. Using Lean tools, the main activities without added value were identified. In addition, the SPL method allows to decrease the delivery time, increase the production rate and reduce the cost [25]. Technical change gave productivity growth of 7.6% for Taiwan and 9% for China [26]. Turkish textile and clothing companies have undergone productivity growth thanks to technical changes [27]. According to a study made in Tunisia, the average level of efficiency resulting from the generalised method of the moments system increases from 58% to 68%. Exporting firms are more productive and efficient than non-exporting ones. Exporting would encourage companies to upgrade and improve the production system. The use of modernised equipment increases efficiency and productivity [28]. Over the past two decades, the sector has restructured and modernised its production, leading to a large number of exits of companies in the industry. However, productivity grew by 2.1% following technical changes. According to this study, the application of lean principles (value stream mapping – VSM, total productive maintenance – TPM) increases efficiency to 30.09% [29]. An integrated approach of the "multicriteria decision method" (e.g. the theory of constraint – TOC, analytic hierarchy process – AHP) and simulation reduced the in waiting time and lead time by over 50% – without overtime and with overtime [30].

This study was devoted only to the parameters that influence the decline in production in a clothing workshop, while there are other factors that influence the pace of work. The method of planning in a clothing company is an important element for the successful delivery of each order within the allotted time. Indeed, production capacity, material resources and human needs must always be defined according to a renewable strategic plan [31]. Simulation for the planning of production in uncertainty and study of the planning method enable to give the best modelling of the forecast [32]. Research is being done to control the planning system by applying PPCS (Planning and Production Control System). This system determines the market need for manufactured products and plans production in workshops [33, 34].

Conclusions

This monitoring study was done in a clothing company to determine the parameters that influence the decline in production. The results showed that the parameter "machine failures" had a 34.6% effect on production and "lack of versatility" 19.7%, while the parameter "heavy launch" had an effect of 17.1%, "lack of supplies" 9% , touch-ups 3%, and "lack of cut parts" 2% . Based on these results, an action plan was developed to reduce these percentages and improve efficiency. Indeed, the application of lean and six sigma tools and especially the D.M.A.I.C method as well as TPM method are two tools that improve efficiency and productivity in a production workshop at the level of maintenance service, quality, production and method. In order, to stabilise the efficiency of the improvement system, a grid was developed to monitor and maintain the effectiveness of improvement actions and for the continuity of the spirit of improvement within the production department. Indeed, it is true that the continuous improvement system increases the productivity of the company in terms of quantity, quality, cost and deadlines, but it is necessary to have strong coherence between personnel and to have team spirit. To have this system, it is necessary not only to improve the work system but also the quality of personnel by continuous training at the technical level and at the spirit level by promoting the culture of group work.

This study focused only on the parameters influencing production, namely those related to material, personnel and managerial resources. What is missing in this study is an analysis of ergonomic factors, such as organizational , work environment and psychosocial factors. This analysis should be done in the future to study the influence of these parameters on productivity.

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