Continual Improvement In Small Soaps Company

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Abstract: In this paper, using quality management tools, we track root causes and principal causes of the rising manufacturing cost of the bar soaps and propose solution to solve the problem. First, we identify and analyze the roots causes of problem with the Fishbone Diagram. We use multivoting approach to reduce roots causes to main causes, from which we identify, classify and analyze principal causes using the Pareto Diagram. We then perform a deep analysis of these principal causes using the 5 whys analysis technique. Three principal causes were found high level of overtime, poor machine performance and poor employee's performance and were weighing 55% of the problem. For that reason, working on these areas was necessary to address the problem of the rising manufacturing cost of the bar soaps. With the result, we then use the PDCA/ 7 steps of TQM method to solve the problem of the rising manufacturing cost by testing whether expanding production capacity leads to performance improvements of these areas. We decide to expand production capacity by adding two more machine groups. Six months after implementation of the proposed solution, the result shows an enhanced workload and schedule, an increased production capacity, an elimination of the overtime issue, an increased machines performance and an improved workers performance. Two main savings were achieved as wage costs and maintenance costs. As a result, while competitor's bar soaps prices increased, the company bar soaps price decreased by 50%, making the company bar soaps more attractive on market, as this performance permitted the company to apply price reduction at the retailer level.

Keywords: Continual Improvement, Quality management tools, Ishikawa Diagram, Pareto Diagram, 5Whys, Histogram, PDCA and 7 steps of TQM.

1 INTRODUCTION

IN this difficult economy environment, with a growing demanding price reduction from customers and a fierce increasing competition, continually improving productivity is becoming more and more vital for companies to maintain competitiveness, preserve market share and margins. As a result, every organization, large or small, is becoming interested in continual improvement and constantly getting better to meet both internal and external needs. According to the International Organization for Standardization (ISO), continual improvement is a recurring activity to increase the ability to fulfill requirements. Its base is quality improvement, which is defined as part of quality management, focused on increasing the ability to fulfill quality requirements (1). Continual improvement is classified as the sixth principle of ISO 9000 quality management system. For the American Society for Quality (ASQ), a continual improvement, also called a continuous improvement, is an ongoing improvement of processes that lead to achievement of higher levels of performance through incremental change. It is an ongoing effort to improve products, services, or processes. These efforts can seek incremental improvement over time or breakthrough improvement all at once. Delivery (customer valued) processes are constantly evaluated and improved in the light of their efficiency, effectiveness and flexibility (2). From these two definitions, we can state that continual improvement is the ongoing improvement of processes that lead to achievement of higher levels of performance through incremental change. It is an important element for keeping organizations in competitiveness and should be a permanent objective for any organization. However, practical experiences and subjective studies confirmed that many companies are going out of business simply because they are not able to improve as quickly as their competitors and to differentiate continual improvement to problem solving. Improvement activities are very similar to the problem solving activities. The main difference is that improvement activities are planned and usually organized as part of larger program, while problem solving is usually more reactive and unplanned (3). This study consists on improving the productivity of an Ivorian Soaps company in difficult situation. The Ivory Coast is facing, since the mid-1990s, a number of challenges and weaknesses coming from an economic policy that has underpinned the dynamics of past growth. The main challenge is the productivity improvement in the manufacturing and private services sectors. In an economy in crisis, the need to reduce costs and improve productivity is a challenge to win. The productivity of the Ivorian companies is low, as it is less than 25% compared to the European industrial companies and 50% compared to the service companies. This improvement in productivity could raise the growth rate of the country by 50%, according to the estimate of the government. The primary objective of this study was to identify and analyze the causes of the rising manufacturing cost of bar soaps at the plant of a small soaps company. The secondary objective was to propose and implement solution to overcome and eliminate the causes of this high manufacturing cost. The third objective was to participates to the Ivorian government efforts to develop industrial competitiveness by providing the Ivorian industrial sector with modern quality management tools, methods and techniques such as PDCA, 7 step TQM, Ishikawa diagram, Pareto diagram, and 5 why.

2 QUALITY TOOLS, METHODS AND TECHNIQUES

If organizations wish to achieve quality continuous

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improvement process, they need to use appropriate selection of quality tools, methods and techniques. All can be used for continuous improvement achievement in all process phases, from the beginning of a product development up to management of a production process and delivery (4). Currently there is a significant number of quality assurance and quality management tools available, so the selection of the most appropriate is not always an easy task. Tools are essential instruments for the success of a quality program. Many companies have used tools without giving sufficient thought to their selection and have then experienced barriers to progress. Quality tools cannot remedy every quality problem but they certainly are a means for solving problems. Consequently, it needs to be emphasized that while tools can be very effective in the right hands, they can be very dangerous in the wrong hands. It is, therefore, important to know how, when and which tools should be used in problem solving or improvement processes (5). Today there are more than a hundred different tools available. Many scientists have tried to define them and differentiate among them on various bases (6).

2.1 The Seven Basic Quality Tools

The Seven Basic Tools of Quality is a designation given to a fixed set of graphical techniques identified as being most helpful in troubleshooting issues related to quality (7). They are helpful to assist the effective implementation of Quality Control activity. They are called basic because they are suitable for people with little formal training in statistics and because they can be used to solve the vast majority of quality-related issues (8). They were first emphasized by Ishikawa (in the 1960s), who is one of the quality management gurus. His original seven tools include stratification, which some authors later called a flow chart or a run chart. They are also called the seven "basic" or "old" tools. After that other new tools have been developed for various purposes but the basis for every work is related to the 7QC tools (9). These tools are also fundamental to Kaizen and Juan's approach to quality improvement (10). They are easy to learn and handle and are used to analyze solutions to existing problems. There is an opinion says that Stratification is a way of thinking and not a tool. In this case, Stratification is omitted and substituted by Control Charts. Control Charts are considered separately from other graphs. Another opinion says both Pareto Diagram and Scatter Diagram must be included in Graphs. Anyway, they are easy to learn and handle and are used to analyze solutions to existing problems. These seven quality tools which are basic for all other tools are (11):

1. *Check List* is a tool applied at the phase of data collection. There are various kinds. One Check List is designed to check the cells correspond with the data categories. No need to write each numerical data in figures. One Check List contains drawings or designs to check locations of failure occurrences. There are many others, so it is required to use the most adequate Check List when collecting necessary data.

2. *Histogram* is a kind of bar charts. It is applied to view the summary of the collected data, especially when the data is continuous figures. Collected data are divided into 10 to 13 classes. Number of data in each class is counted and summarized on a bar chart. By adding specification limits and other necessary information, you can have a whole view of the process condition.

3. There are various graphs such as *bar chart, line chart, pie chart, radar chart*, etc. Chronological data will fit on a line chat. Bar chart or pie chart is suitable to show the proportions because they are area graphs. Radar chart is often applied to show the balance of several items. To make other people understand easier, the most adequate graph should be adapted. Control Charts are applied when the stability of a manufacturing process is evaluated based on the chronological data of the process. Control Charts for Control and Control Charts for Analysis are used differently according to the purpose of use. There are various types of Control Charts. The suitable type of Control Chart is chosen and used depending on the type of data. Control Charts in Japan follows the concepts of Shewhart. They are founded on the concept of three sigma limits.

4. *Scatter Diagram* is a figure applied to visualize the relation of two variables. One variable is scaled on X-axis and another on Y-axis. The data is plotted on the space consisted by X-axis and Y-axis. The condition of the plots shows the relation of two variables such as the bigger variable X results the bigger variable Y.

5. *Stratification* is stratifying or categorizing of data. Each category has to have a meaning. What is a meaningful category? Can you imagine proper direct actions to each category? Then the categories are meaningful. Categories can be determined by equipment, by operator, by operation method or by raw material. Data are stratified into some groups according to their common characteristic.

6. Cause and Effect Diagram was developed by Dr. Kaoru Ishikawa. It is also called Ishikawa Diagram, Fishbone Diagrams, Herringbone Diagrams or 5M. It is called Fishbone Diagram because of its shape like a fishbone. It is used to show the relationships of an effect and its causes. The effect should be the result of a process. The causes should be the root causes most strongly influential to the effect. The causes are chosen out of many which bring the result. A line is drawn in the middle of the diagram. It is often compared with the backbone of a fish. This line represents the process. When they are added, the causes appear on the process (the fish backbone) as linguistic data. The 5M represents the following 5 categories:

1) People (Workforce, Manpower) : Anyone involved with the process.
2) Methods (Process): How the process is performed such as policies, procedures, rules, regulations and laws
3) Methods (Process): How the process is performed such as policies, procedures, rules, regulations and laws
4) Machines (Machinery, Equipment): Any equipment or tools required to accomplish the job
5) Materials (Raw Materials): Any raw materials used to produce the final product
6) Environment: The conditions, such as location, time, temperature, and culture in which the process operates

7. *Pareto Diagram* was developed by Vilfredo Pareto, an Italian Economist. It is applied to determine priorities. 80-20 principle is the famous Pareto principle. 80 % problems can be solved by tackling with only 20 % items out of all. Pareto

Diagram consists of two graphs. One is bar chart. The items are arranged in the order of the number of problems or the amount of money. Another graph is line chart of accumulations of bars. The bars show the number of every problem and the line shows the transition of the accumulated number of problems. If the bars show the amount of money, the line shows the transition of the accumulated amount of money. This line chart is often called "Pareto Curve". The best proportion of X-axis to Y-axis is 1:2 for easier analysis of Pareto Diagram. In Industrial Engineering field, Pareto Diagram is called ABC Analysis. These simple but effective tools of improvement are widely used as graphical problem solving methods and as general management tools in every process between design and delivery. These tools must be used in daily works and managed well. Knowing the tools is not enough. There is a big difference between knowing tools and being capable to use tools. The challenge for the manufacturing and production industry is for everyone to understand and use the improvements tools in their work (10). Some of the seven tools can be used in two approaches for process identification and/or for process analysis and are represented in Figs. 3 and 4. The first approach is presented in Fig. 1 where Pareto and Cause and effect diagrams are common and essential in both processes (identification and analysis). The second approach for using 7QC tools is shows in Fig. 4. In this approach, the process of data acquisitions includes three tools (Check sheet, Histogram and Control chart), and the process of analysis another four tools (Pareto diagram, Cause and effect diagram, Scatter plot, and Flow chart) (12).

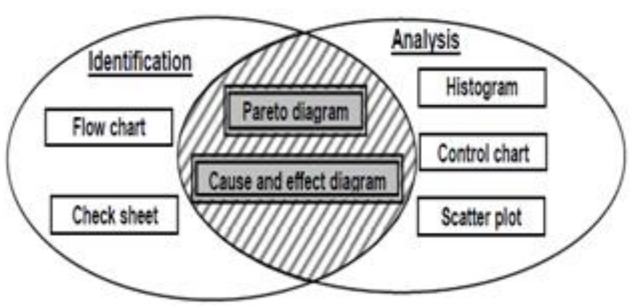


Fig.1. *The 7 Quality Tools and Process Identification and Analysis*

There is a distinction between the two approaches. The approach in Fig. 2 is much older, from 1990, and therefore, there are some key distinctions. Some tools which are now used only for analysis were at that time considered as tools for identification or for both processes (identification and analysis). But even then scientists were attempting to find appropriate utilizations of each tool in different processes and methodologies of improvement. The tools must meet the main purpose or reason for their application. No single tool is more important in isolation, but could be most significant for a specific application (6).

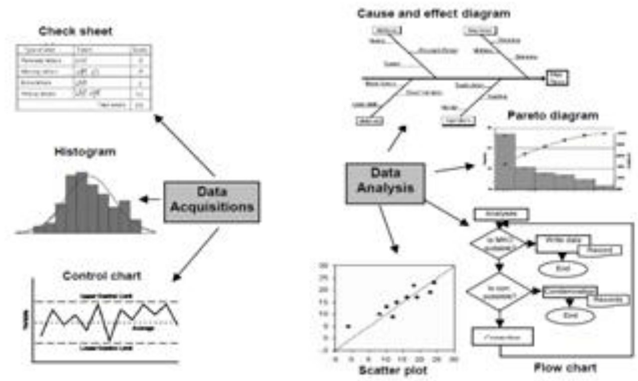


Fig.2. *Current Approach for Using Quality Tools*

2.2 The PDCA (Plan–Do–Check–Act) Cycle

PDCA (Plan–Do–Check–Act) is a four-phase continuous improvement methodology used in business for the control of processes and products. Basically it is a problem solving tool used for testing and implementing improvement. Although PDCA is often referred to as the Deming Cycle, after its proponent W Edwards Deming, this model can be traced back to a statistician Walter Shewart back to 1920. It was later personalized by Edward Deming. Later, Deming modified the PDCA phases to PDSA (Plan, Do, Study and Act) because he felt that "check" emphasized inspection over analysis. Deming preferred "study" because STUDY has connotations in English closer to Shewhart's intent than "check". Today, some modern trainers now also refer the A as ADJUST for Plan, Do, Study and Adjust. In Six Sigma programs, the PDCA cycle is called DMAIC for Define, Measure, Analyze, Improve, and Control. The iterative nature of the cycle must be explicitly added to the DMAIC procedure. The completion of one cycle continues with the beginning of the next. A PDCA-cycle consists of four consecutive steps or phases, as follows:

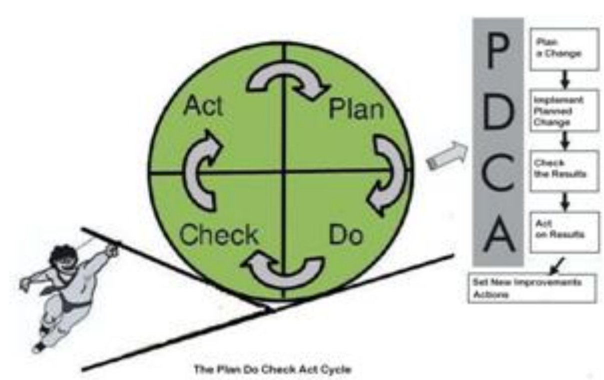


Fig. 3. *The PDCA Cycle*

1. The Plan - Analysis of what needs to be improve and decision on what should be changed. Companies need to consider what they will do to meet certain business objectives. Planning is an important part and a critical first step in the continuous improvement process.

2. The Do - Implementation of the changes that are decided on in the Plan step. Once a plan has been developed, it is time to put that plan in place, or implement it. Well-developed plans

will contain strategies, tactics and action plans that clearly outline for the organization and its members what is to be done, when and by whom. Actually "doing" involves putting into place a series of activities or actions.

3. The Check – Report, Control and measurement of results in accordance to changes made in Do steps. Once a plan has been implemented, the next step is to study the impact of that implementation.

4. The Act - Adoption or reaction to the changes or running the PDCA-cycle through again. Keeping improvement on-going. Based on the results after plan implementation, companies then take action. If the results have been favorable, the company will continue to implement the plan and perhaps spread the plan to other parts of the organization. If the plan has not been a success, the company will consider what it has learned and begin the planning cycle--plan, do, study, act--again, as part of its continuous improvement efforts. The PDCA-cycle is used to coordinate continuous improvement efforts. It emphasizes and demonstrates that improvement programs must start with careful planning, must result in effective action, and must move on again to careful planning in a continuous cycle, the Deming quality cycle is never-ending.

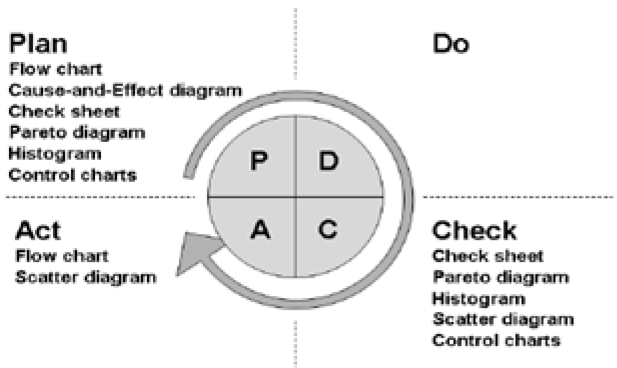


Fig. 4. *The 7 Quality Tools through PDCA Cycle*

It is a strategy used to achieve breakthrough improvements in safety, quality, morale, delivery cost, and other critical business objectives (5). The main purpose of PDCA-cycle application lies in process improvement (13). When process improvement starts with careful planning, it results in corrective and preventive actions supported by appropriate quality assurance tools which lead to true process improvement. The application of the seven basic quality tools in correlation with four steps of PDCA-cycle is shown in Table 1.

TABLE 1
The 7 Quality Tools in Correlation with PDCA Cycle

Seven basic quality tools (7QC tools)	Steps of PDCA-cycle				
	Plan	Do	Plan, Check	Plan, Act	Check
	Problem identification	Implement solutions	Process analysis	Solutions development	Result evaluation
Flow chart	✓			✓	
Cause-and-effect diagram	✓		✓		
Check sheet	✓		✓		✓
Pareto diagram	✓		✓		✓
Histogram	✓				✓
Scatter plot			✓	✓	✓
Control charts	✓		✓		✓

Most of the 7QC tools can be used for problem identification: Flow chart, Cause-and-Effect diagram, Check sheet, Pareto diagram, Histogram and Control charts. For problem analysis the following tools can be used: Cause-and-Effect diagram, Check sheet, Pareto diagram, Scatter plot and Control charts. When a team is developing a solution for the analyzed problem, Flow chart and Scatter plot can be useful as well. In the phase of achieved results evaluation, most of 7QC tools can also be successfully implemented: Check sheet, Pareto diagram, Histogram, Scatter plot and Control charts. For effective and successful team work in solving daily quality problems, we propose a simple model for systematic usage of "basic quality tools" for process monitoring, data acquisition and quality improvement (14) and (4). Loop 1 focuses on the analysis of the biggest causes for defects which are found by Pareto diagram, and Loop 2 focuses on continuous process improvement, which is one of the eight QMS principles. The implementation of this principle is a big stride forward which a company can take in order to change their static quality management to a dynamic one.

2.3 The 5 Why's Analysis

The 5 Whys is an iterative question-asking technique used to explore the cause-and-effect relationships underlying a particular problem (15). The primary goal of the technique is to determine the root cause of a defect or problem. The "5" in the name derives from an empirical observation on the number of iterations typically required to resolve the problem. The technique was originally developed by Sakichi Toyoda and was used within the Toyota Motor Corporation during the evolution of its manufacturing methodologies. It is a critical component of problem-solving training, delivered as part of the induction into the Toyota Production System. The architect of the Toyota Production System, Taiichi Ohno, described the 5 Whys method as "the basis of Toyota's scientific approach by repeating why five times, the nature of the problem as well as its solution becomes clear (□16). The tool has seen widespread use beyond Toyota, and is now used within Kaizen, lean manufacturing, and Six Sigma. While the 5 Whys is a powerful tool for engineers or technically savvy individuals to help get to the true causes of problems, it has been criticized by Teruyuki Minoura, former managing director of global purchasing for Toyota, as being too basic a tool to analyze root causes to the depth that is needed to ensure that

they are fixed. Reasons for this criticism include:
1. Tendency for investigators to stop at symptoms rather than going on to lower-level root causes.
2. Inability to go beyond the investigator's current knowledge - cannot find causes that they do not already know.
3. Lack of support to help the investigator ask the right "why" questions.
4. Results are not repeatable - different people using 5 Whys come up with different causes for the same problem.
5. Tendency to isolate a single root cause, whereas each question could elicit many different root causes.

These can be significant problems when the method is applied through deduction only. Example: The vehicle will not start. (The problem)
1. Why? - The battery is dead. (1st why)
2. Why? - The alternator is not functioning. (2nd why)
3. Why? - The alternator belt has broken. (3rd why)
4. Why? - The alternator belt was well beyond its useful service life and not replaced. (4th why)
5. Why? - The vehicle was not maintained according to the recommended service schedule. (5th why, a root cause)

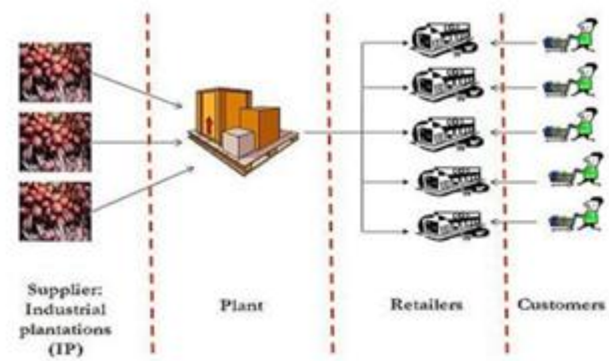
It is interesting to note that the last answer points to a process. This is one of the most important aspects in the 5 Why approach - the real root cause should point toward a process that is not working well or does not exist. Untrained facilitators will often observe that answers seem to point towards classical answers such as not enough time, not enough investments, or not enough manpower. These answers may be true, but they are out of our control. Therefore, instead of asking the question why?, ask why did the process fail?

3 REASON FOR IMPROVEMENT

3.1 Overview of Plant

Located in the center of the Ivory Coast, the plant of this soaps company has existed for 12 years and is built on a large surface measuring approximately 100 acres. The plant itself has about 12 acres. The building is of block construction with a brick exterior. This type of construction, while unusual now was common when this building was built. One unique feature of this building is the shingled roof. Most industrial buildings have flat roofs instead of a pitched roof. The building cost of a pitched roof is much higher than that of a flat roof system, even though a pitched roof lasts much longer and has lower maintenance costs. The primary business of this plant is to manufacture and deliver soaps to customers designed as stores and supermarket. The plant manufactures three major categories of soaps as product lines, bar soaps, powder detergent and liquid detergent. Bar soaps and detergents manufactured are available in different flagrances, colors, size and packaging and can be customized as per needs of the customers. The plant currently employs approximately 180 employees who work in 1 shift of 10 hours for 7 days each week. Before the loss attributed to the state of emergency (2002 to 2011), the plant had as many as 400 employees. The plant has its own specialized team of lab technicians to manufacture all types of products. The technical lab provides proper work facilities, to make products of world class standards and environmental friendly. The latest science techniques are utilized to formulate products for effective use.

Fig. 5. *The Distribution System*



As technology evolve and customer price pressures increased, new equipments were purchased and installed to reduce the amount of handwork involved in making soaps. However, the plant outsources its machines maintenance activities to a company located in Abidjan, 260 km. Maintenance was done only one day a week, on Sunday for 6 hours (6pm to 12am). The main raw materials (Oils) are supplied by 3 Industrial Plantations (IP) located in the same area as the plant. Each Industrial Plantation regroups at least 5 Village Plantations (VP). The plant channels its total production directly to retailers and supermarkets around the country.

3.2 Process Overview

The plant production of bar soap involves continuous processes, such as continuous addition of fat and removal of product. Continuous process is best understood in terms of two streams: soap flowing in the order given below against a counter-current of lye.

Step 1 - Saponification

The raw materials are continually fed into a reactor in fixed proportions. These ingredients alone would give a low water, high glycerine soap. Soap needs to be about 30% water to be easily pumpable, and even then needs to be held at around 70oC, so excess lye is added to hydrate the soap and dissolve out some of the glycerine. The lye added is known as "half spent lye" and is the lye discharged from the washing column (see below). This lye already contains some glycerine, but it is further enriched by that formed in the saponification reaction.

Step 2 - Lye separation

The wet soap is pumped to a "static separator" - a settling vessel which does not use any mechanical action. The soap / lye mix is pumped into the tank where it separates out on the basis of weight. The spent lye settles to the bottom from where it is piped off to the glycerine recovery unit, while the soap rises to the top and is piped away for further processing.

Step 3 - Soap washing

The soap still contains most of its glycerine at this stage, and this is removed with fresh lye in a washing column. The column has rings fixed on its inside surface. The soap solution is added near the bottom of the column and the lye near the top. As the lye flows down the column through the centre, a series of rotating disks keeps the soap / lye mixture agitated between the rings. This creates enough turbulence to ensure good mixing between the two solutions. The rate of glycerine production is calculated and the rate at which fresh lye is added to the washing column then set such that the spent lye is 25 - 35 % glycerine. Glycerine is almost infinitely soluble in brine, but at greater than 35% glycerine the lye no longer efficiently removes glycerine from the soap. The soap is allowed to overflow from the top of the column and the lye ("half spent lye") is pumped away from the bottom at a controlled rate and added to the reactor.

Step 4 - Lye separation

The lye is added at the top of the washing column, and the soap removed from the column as overflow. As the lye is added near the overflow pipe the washed soap is about 20% fresh lye, giving the soap unacceptably high water and caustic levels. Separating off the lye lowers the electrolyte levels to acceptable limits. The soap and lye are separated in a centrifuge, leaving a soap which is 0.5% NaCl and 0.3% NaOH, and about 31% water. The lye removed is used as fresh lye.

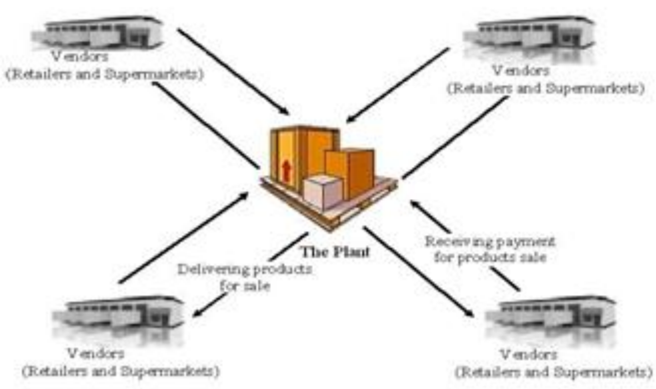
Step 5 - Neutralization

Although the caustic levels are quite low, they are still unacceptably high for toilet and laundry soap. The NaOH is removed by reaction with a weak acid such as coconut oil (which contains significant levels of free fatty acids), coconut oil fatty acids, citric acid or phosphoric acid, with the choice of acid being made largely on economic grounds. Some preservative is also added at this stage.

Step 6 - Drying

Finally, the water levels must be reduced down to about 12%. This is done by heating the soap to about 125oC under pressure (to prevent the water from boiling off while the soap is still in the pipes) and then spraying it into an evacuated chamber at 40 mm Hg (5.3 kPa). The latent heat of evaporation lost as the water boils off reduces the soap temperature down to 45oC, at which temperature it solidifies onto the chamber walls. The soap chips are scraped off the walls and "plodded" (i.e. squeezed together) by screws known as "plodder worms" to form soap noodles. The soap is now packaged for sale.

Fig. 6. *Selling and Receiving System*



Step 7 - Delivery

The plant channels its total production directly to retailers and supermarkets around the country. Payments are received after products sale.

3.3 Problem Statement

The Plant is currently experiencing rising costs in the manufacturing of one of its product lines, the bar soaps. As a result, the Plant is experiencing a high retailer price of its bar soaps, thus resulting in loss in market share.

TABLE 2

Price Comparison

	The Company	Competitor #1	Competitor #2	Competitor #3
Power Detergent	250 cfa	350 cfa	300 cfa	350 cfa
Liquid Detergent	300 cfa	450 cfa	350 cfa	450 cfa
Bar Soaps	600 cfa	400 cfa	450 cfa	400 cfa

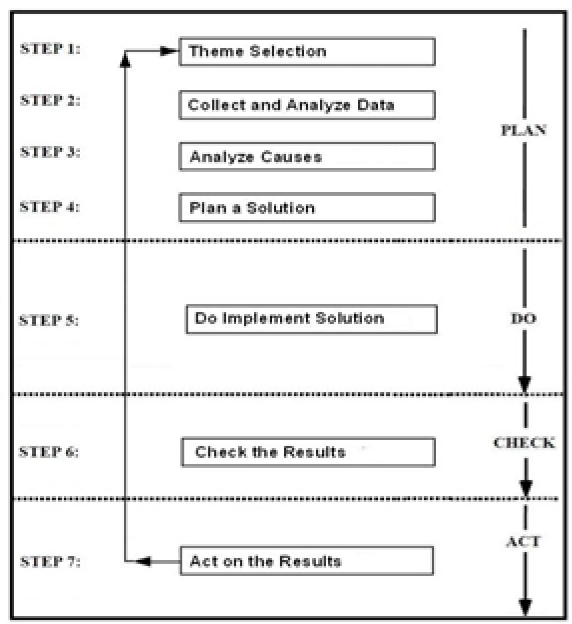
Change: $1 = 550cfa

Consequently, the price of the unit bar soaps is higher than competitors on market. In the country where customers attention are more focused on product price than on product quality, this problem places the company at a competitive disadvantage resulting to an increasing price pressures from customers.

4 PDCA / TQM Approach

The PDCA (Plan Do Check Act)/7 Step Process is an approach to structured problem solving, particularly focused on continuous improvement of existing processes. The PDCA/7 Step Process is structured as follows:

Fig. 7. *The PDCA/7 Step TQM Approach Flow Chart*



4.1 Step 1. Theme Selection

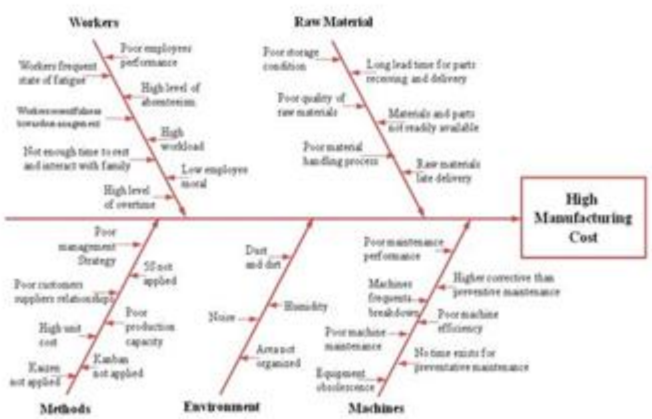
Our study consists on improving the productivity of an Ivorian Soaps company in difficult situation, using quality tools, methods and techniques. With this aim, we selected our theme to be "Reduce the unit cost of the bar soaps at the plant so that it aligns more closely with the demanding customer’s price reduction." This theme was consistent with the overall objective of improving productivity performance.

4.2 Step 2. Collect And Analyze Data
For data collection, we track root causes and principal causes of the rising manufacturing cost of the bar soaps.

1. First, we performed a brainstorming technique to list all possible reasons of this high level of manufacturing cost.
2. Second, we classify these reasons within the 5M categories of the Fishbone Diagram to identify causes of the problem.
3. Third, we use the multivoting approach to identify main causes of the problem.
4. Fourth, we use Pareto Diagram to classify main causes by order of importance based on number occurrences. This allowed identifying principal causes of the Problem.

4.2.1 Ishikawa Diagram
In order to identify the roots causes of this problem, we used the 5M approach of Ishikawa which is: Methods, Raw Material, Machine, Worker, and Environment. The following outputs are the result gained from the data collection and analysis of the Ishikawa diagram. There were 53 roots causes.

Fig. 8. *Ishikawa Diagram of High Manufacturing Cost*



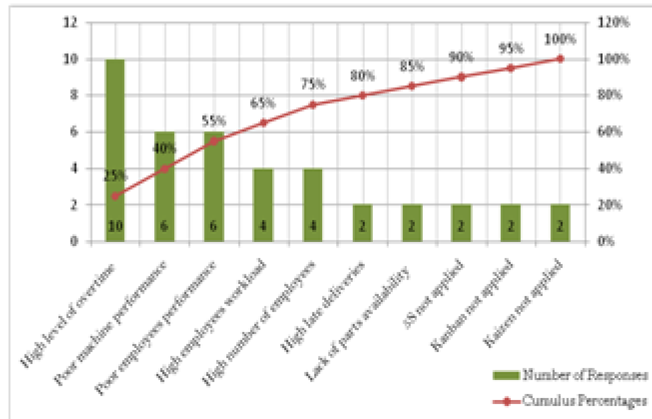
4.2.2 Multivoting Approach
The multivoting approach served to reduce main causes to an acceptable number of main causes, from which principal causes where selected by number of importance. The multivoting approach reduced the 53 causes to 10 main causes.

4.2.3 Pareto Diagram
The purpose of the Pareto chart is to highlight the most important causes on which it would be necessary to act to solve a problem. It allows causes to be categorized and sorted by number of occurrences or order importance. As a result, the diagram of Pareto, served to select the principal causes among these 10 main causes. To do this,

1. A questionnaire was proposed to (40) participants employees and managers . The question was: What causes need more attention to solve the problem of the manufacturing cost of the bar soaps? Then, they were asked to state responses by checking between these 10 :
    1. High level of overtime
    2. Poor machine performance
    3. Poor employees performance
    4. High employees workload
    5. High number of employees
    6. High late deliveries
    7. Lack of parts availability
    8. 5S not applied
    9. Kanban not applied
    10. Kaizen not applied

2. Using EXCEL, we identified three Principal Causes:
    1. High level of overtime
    2. Poor machines performance
    3. Poor employees performance

Fig. 9. *Pareto Chart for Principal Causes of High Manufacturing Cost*



4.3 Step 3. Analyze Causes
To analyze the data gained from the Pareto chart, we used the 5 why's technique for each of the three principal causes of the problem of the rising manufacturing cost of the bar soaps. The following summarize our result analysis for each of the three principal causes that contribute to this problem.

4.3.1 High Level of Overtime
One of the top reasons for the rising manufacturing cost of the bar soaps is the high level of overtime. The plant is currently experiencing high levels of overtime because of the need to run production every weekend in order to meet customer volume levels. This high level of overtime is undesirable for several reasons.

1. It drives unit costs up because of the added wage expenditures. This places the company at a competitive disadvantage with increasing price pressures from customers.
2. It is having an impact on machine group run efficiencies because no time exists for preventative maintenance to take place thereby increasing delays due to breakdowns.
3. It is lowering employee moral because they are being denied the time off needed from work to interact with their families and outside interests.

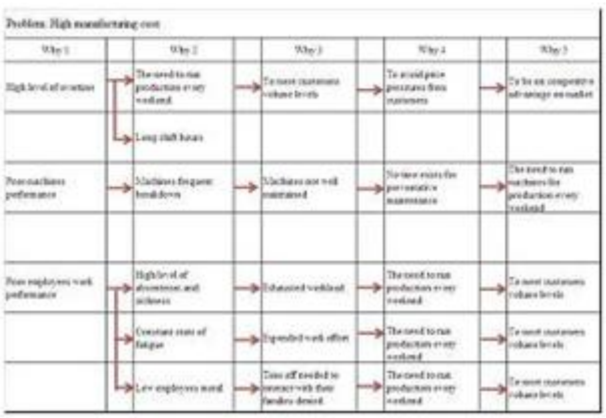
4.3.2 Poor Machines Performance
One of the three reasons for high manufacturing cost of the bar soaps was found to be poor machines performance. Machines group run efficiencies are low because of the high machines workload schedule and the long shift of 10 hours per day, on 7 days per week. There is no time exists for preventive machine maintenance to take place thereby increasing delays in products delivery due to machine frequent breakdowns.

4.3.3 Poor Employees Performance

One of the three reasons for high manufacturing cost of the bar soaps was found to be problems associated with employees performance. Employees work performance is declining because of the exhausted workload. Employees work Monday to Sunday on 10 hours shift. As a result of this exhausted amount of work effort, some workers are becoming in a constant state of fatigue thereby increasing absenteeism and sickness. This results in less output per machine group. Consequently, this exhausted schedule is lowering employee moral because they are being denied the time off needed from work to interact with their families and outside interests.

4.3.4 Step 3 Summary

Fig. 10. *The 5 Whys Analysis*



1. The three principal causes of the rising manufacturing cost of the bar soaps (*high level of overtime, poor machines performance and poor employees performance*) are linked to each other. By working on these areas, we eliminate 55% of the causes of the problem.
2. A reduction of the high level of overtime could certainly (a) allow more times for machine groups preventive maintenance to rest and avoid frequent breakdowns and to (b) to allow more time for employees to interact with their families and outside interests and thus, contributing to improve employee's performance and efficiency.

Therefore, we decided to pay more attention to machines and employees workload and schedule.

5 Planning And Implementing The Change

5.1 Step 4 Planning A Solution

5.1.1. The Solution Proposal

We propose to expand production capacity with two more machine groups with the intention to reduce the unit cost of the soaps so that it aligns more closely with the increasing price pressures from customers at the retailer level.

5.1.2. The Solution Rational

The Plant currently runs four machine groups using one shift of 10 hours per day, seven days per week. This gives the Plant the capacity for 28 group shifts of production, utilizing both days of the weekend. The plant is currently operating at 100% capacity. However, any increase in order volume from the customers cannot be met with the current number of machine groups in the department. By adding two more machine groups using two shifts of 8 hours per day, the Plant will have 60 group shifts of capacity available during the standard 5 day workweek. This will eliminate paying overtime for 8 group shifts while adding 30 group shifts of straight time. This extra capacity will allow more flexibility in employee's workload and will allow time for preventive maintenance during non-productive times. Each machine group could be scheduled for one shift of preventative maintenance per week while still meeting the volume requirements of customer orders. Being able to plan the maintenance needs in advance will help reduce the costs associated with maintenance. Given that the Plant has extra floor space availability, no extra-long term costs will be incurred by the facility to accommodate the two machine groups.

5.1.3. Projected Solution Cost

A breakdown of the estimated cost of the one-time expenses of the project is as follows:

TABLE 4

Estimated cost of the one-time expenses

Item	Cost
1. Purchasing Machine Group	$150,000.00
2. Preparation of Installation Area	$1,000.00
3. Installation of Equipment	$1,000.00
4. Testing and Startup of Equipment	$500.00
5. Employees Training	$1,000.00
6. Tools for Employees	$500.00
Total Costs =	**$154,000.00**

The cost of the proposal can be divided into two main areas: one-time only expenses and on-going expenses. (1) The first area would be those costs that are one-time only expenses. These would include the cost of the equipment itself, the installation costs of the equipment, and the costs of training the new employees hired to operate the equipment. (2) The second area is the costs which are on-going. These costs would include the maintenance expenses of the equipment, as well as the added utility costs. Employee benefits would also be classed as an on-going expense. On-going costs can only be estimated. It is felt that the maintenance expenses would be small due to the fact that the equipment is new. It is also felt that the added costs of the new employee benefits may be offset by a reduction in benefit expenses for existing employees. The reduced amount of overtime should reduce the costs associated with having a fatigued work force. Absenteeism and accident rates should also decline.

5.1.4. Current Production Capacity

Currently the Plant is running four production machine groups seven days a week during forty-eight weeks of the year. The other four weeks are consumed by plant shutdowns for general maintenance needs and for scheduled vacations. Running production during these times increases the overtime burden on the wage rate, as well as contributes to problems of employee morale. This rate of production gives the following manufacturing capability.

TABLE 3
Current Production Capacity

Single Machine Group Production	
Per Year:	2,096,640 soaps
Per Month:	174,720 soaps
Per Week:	43,680 soaps
Per Day:	6,240 soaps

Department Production	
Per Year:	8,386,560 soaps
Per Month:	698,880 soaps
Per Week:	174,720 soaps
Per Day	24,960 soaps

5.1.5. Expected Production Capacity

With the addition of two machine groups to the plant,

TABLE 5
EXPECTED PRODUCTION CAPACITY
(6 MACHINE GROUPS / 5 DAYS)

Single Machine Group Production	
Per Year:	2,396,160 soaps
Per Month:	199,680 soaps
Per Week:	49,920 soaps
Per Day:	9,984 soaps

Department Production	
Per Year:	14,376,960 soaps
Per Month:	1,198,080 soaps
Per Week:	299,520 soaps
Per Day:	59,904 soaps

production capacity for a standard five day work week will increase to the following levels. This increase will eliminate the current need to run production on overtime and reduce the wage costs of the unit soap. The soap will as a whole should increase its production capacity during the standard work week as compared to the current 7 day work week.

5.1.6. Expected Production Capability Improvement

The expansion of production capacity will also allow for the anticipated growth in the demand for soaps. The plant would have the capacity, using overtime production shifts to produce the following volumes. This production strategy should only be used for a short-term solution, as running production on overtime will increase the wage cost portion of the product.

5.1.7. Actions Plan for Implementation

Actions plan are described below :

1. Expand production capacity with two more machine groups,
2. Change working shift per day from 1 of 10 hr to 2 of 8 hr,
3. Reduce working days per week from 7 to 5,
4. Reduce workers per Machine Groups from 12 to 5.

TABLE 6
EXPECTED PRODUCTION CAPABILITY
(6 MACHINE GROUPS / 7 DAYS)

Single Machine Group Production	
Per Year:	3,354,624 soaps
Per Month:	279,552 soaps
Per Week:	69,888 soaps
Per Day:	9,984 soaps

Department Production	
Per Year:	20,127,744 soaps
Per Month:	1,677,312 soaps
Per Week:	419,328 soaps
Per Day:	59,904 soaps

5.1.8. Performance Indicators

Indicators for performance measurement are described below:

1. Overtime level,
2. Absenteeism and Sickness level,
3. Machines Breakdown level,
4. Productivity level,
5. Bar soaps unit price at retailer level.

5.2 Step 5 Do Implement the Solution

5.2.1. Purchasing, Organizing Area, Installing and Testing New Machines Looking around for best deal, purchasing and receiving the new machine groups were done in four (04) weeks. Finally, we purchased for $120,000.00 the two new machine groups from a local representative of a Chinese manufacturer. Our previous four machines groups were bought from the same local vendor. Payment terms were the following □ thirty percent (30□) up front and the rest payable in two years, for $3,500 monthly. Each machine group provides a production capacity of 624 bar soaps of 800g per hour. The purchasing price includes all the items below. Two (02) weeks were necessary to prepare area for machine groups' installation. Then installation itself required two (02) weeks. It took one (01) week to test equipment.

TABLE 7
Total Costs of the solution

Activities	Total Costs
1. Purchasing Machine Groups	$120,000.00
2. Preparation Area for Machine Groups Installation	
3. Machine Groups Installation	
4. Equipment Testing	
5. Employees Training	

5.2.2. Hiring & Training Employees

We hired twelve (12) new employees for the production department. Hiring and training was done in three (03) weeks. Training was divided in two sections□ Section1 focused on machines utilization and Section2 focused on new workload design and schedule. Only new employees were concerned to the first session, given the fact that all new equipments were the same as the other 4 machines the need to train old production workers wasn't necessary. Training was provided by the supplier as part of contract agreement.

5.2.3. Implementing Employees Schedule

Four machine groups were used for one shift of 10 hours per day □8 am to 6 pm□, seven days per week. This gives the Plant the capacity for 28 group shifts of production, utilizing both days of the weekend. Twelve □12□ employees were used per machine group, making total production workers to 48 employees. With six machine groups (MG), workload utilized 5 days period □Monday to Friday□ on two shifts of 8 hours per day. This gives the Plant the capacity for 60 group shifts of production capacity during the standard 5 day workweek compared to the previous 28 group shifts. We hired twelve □12□ new employees for the Production Department, ranging total production workers to 60 employees. Given the automation of the machines, only 5 employees were employed per machine group instead of the 12 previously. Every two weeks, employees permuted shift. Saturday and Sunday are reserved for high demand. The new schedule is as follow:

5.2.4. Implementing Machines Maintenance Program

Maintenance activities were outsourced to a company located in Abidjan, 260 km. Maintenance was done only one day a week, on Sunday for 6 hours (6pm to 12am). We put in place a new machine maintenance program which was structured around a strong preventive maintenance policy. We stopped outsourcing maintenance activities to promote internal maintenance activities under the supervision of the new created Technical Department. With the new schedule, all 6 machine groups are now scheduled for one shift maintenance of 8 hours, Monday to Friday from 12 am to 08 am. This gives a total of 40 hours maintenance per week compared to the 6 hours a week previously. The new maintenance schedule is as follow:

6 VALIDATING THE CHANGE

6.1 Step 6. Check the Results

6.1.1. Overtime Level

The high level of overtime was necessary to run production every weekend in order to meet the required customer volume levels. However, it droves unit costs up due to huge added wage expenditures and placed the company at a competitive disadvantage with increasing price pressures from customers. Therefore, in order to overcome the high level of overtime while still maintaining the volume of production that is needed, it was necessary to add production capacity with additional equipments to the facility. With the addition of two machine groups to the plant, production capacity for a standard five day work per week increased significantly. This increase eliminated the need to run production on overtime and reduced the wage costs of bar soap. As a result, this increase eliminated the need to run production on overtime and reduced the wage costs of the unit soap. This good result reported in the table below, followed by a combined histogram. We can see that our projection was achieved as overtimes were eliminated totally, passing from 30 hr to 0 hr during the five days work period.

TABLE 8
Overtime Level

	Overtime	Observation
Before (4MG/ 7 Days/ 1 shift/ 10hr)	30 hr/ Worker/ Week	Eliminated Totally
After (6MG/ 5 Days/ 2 shifts/ 8hr)	0 hr/ Worker/ Week	

6.1.2. Machines Breakdown Level

With the addition of two machine groups and a well implemented workload and schedule, the plant gained in extra time. This extra time allowed more time to implement preventive maintenance during non-productive times (12am to 08 am, Monday to Friday). As part of our preventive maintenance program, machines all six machine groups are now scheduled for 40hr per week of preventative maintenance as compared to the 6h per week previously (Sunday 6pm to 12am). This resulted in a huge reduction in machines breakdown. While in the past, machines breakdown were 14 times per week, today we have only two failures per week, thus reducing the costs associated with maintenance. Therefore expanding production capacity impacted positively on machine groups run efficiency, and thus, contributed to improve machine group's performance and efficiency. This good result reported in table below, followed by a combined histogram. We can see that our projection was achieved as machines breakdown rate decreased by 85.71% during the five days work period.

TABLE 9
MACHINES BREAKDOWN LEVEL

	Machines Breakdown	Observation
Before (4MG/ 7 Days/ 1 shift/ 10hr)	14 times per Week	Decreased by 85.71%
After (6MG/ 5 Days/ 2 shifts/ 8hr)	2 times per Week	

6.1.3. Employees Absenteeism and Sickness Level

While with the old schedule each employees worked 70 hr/week (7 days/week for 10 hr/day), with the new schedule employees gained in extra time by working only 40 hr/week (5 days/week for 8 hr/day), with 2 days off per week. This extra time allowed employees to interact with their families and outside interests, to be in good health due to reduced workload and to be presents at work frequently, thus reducing absenteeism rate. Also, the reduced high level of overtime also reduced the costs associated with having a fatigued work force. Therefore expanding production capacity impacted positively employees work conditions and morale, and thus, contributed to improve employee's performance and efficiency. This good result reported in the table 10. We can see that our projection was achieved as absenteeism and sickness rates decreased by 83.33% during the five days work period.

TABLE 10
Employees Absenteeism and Sickness Level

	Workers absenteeism and Sickness	Observation
Before (4MG/ 7 Days/ 1 shift/ 10hr)	18 per Week	Decreased by 83.33%
After (6MG/ 5 Days/ 2 shifts/ 8hr)	3 per Week	

6.1.4. Productivity Level

The Plant is running now six production machine groups five days a week during forty-eight weeks of the year. With the addition of two machine groups to the plant, production capacity for a standard five day work per week increased significantly. Compared to the past production capacity, the current production capacity as a whole increased significantly by 68%. This production improvement eliminated the need to run production on overtime, and thus, reduced the wage costs of the unit soap. This good result reported in the histogram below. We can see that our projection was achieved as we reached 98% of our expected production capacity.

TABLE11
Productivity Level

	Production Capacity (6 months)	Observation
Past Production	4,193,280 bar soaps	– Actual Production increased by 68% – Actual Production reached 98% of our Expected Production
Expected Production	7,188,480 bar soaps	
Actual Production	7, 044,710 bar soaps	

6.1.5. Summary

In the country where customers attention are more focused on product price than on product quality, this rising manufacturing cost need to be addressed and solved. By reducing all added wage expenditures, we intend to reduce manufacturing cost thereby reducing bar soaps unit price at the retailer level. With this aim, we tracked root causes and principal causes of the rising manufacturing cost of the bar soaps and propose solution to solve the problem. First, we identified and analyzed the causes of problem with the Fishbone Diagram. We used multivoting approach to reduce roots causes to main causes, from which we identified, classified and analyzed principal causes using the Pareto Diagram. We then performed a deep analysis of these principal causes using the 5 whys analysis technique. Three principal causes were found high level of overtime, poor machine performance and poor employee's performance and they are weighing 55% of the problem. Therefore, working on these areas was necessary to address the problem of the rising manufacturing cost. With the result, we then use the PDCA/ 7 steps of TQM method to address and solve the problem of the rising manufacturing cost by testing whether expanding production capacity leads to performance improvements of these areas. We decide to expand production capacity by adding two more machine groups. Table 11 and 12 show the improvements observed after 6 months of solution implementation

Fig. 11. *Overtime, Absenteeism and Sickness Level*

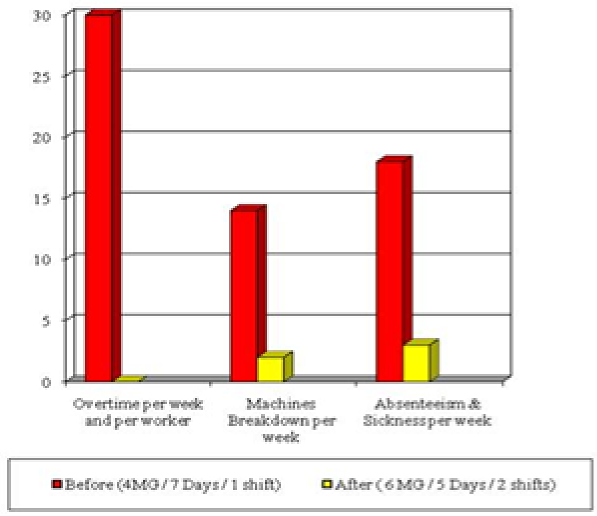
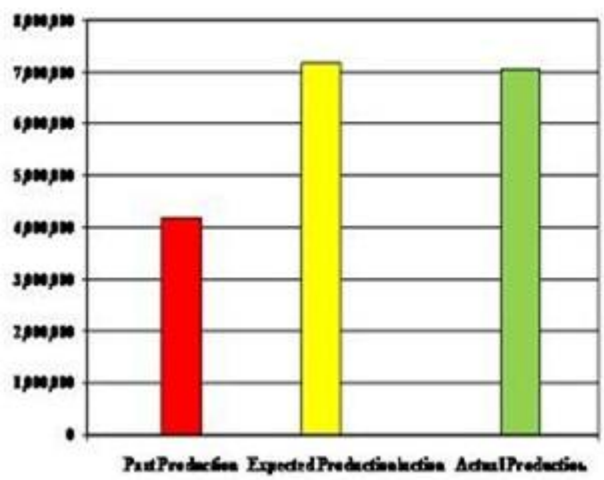


Fig. 12. *Past, Expected and Actual Production*



As a result, with the addition of two machine groups and a well implemented new schedule and machine groups preventive and effective maintenance program, production capacity increased significantly. The result showed an increased production capacity. The new workload and schedule in place eliminated the problem of paying overtime, increased machines performance and improved workers performance. Consequently, this performance permitted the company to apply price reduction at the retailer level. While competitor's bar soaps prices increased, the company bar soaps price at the retailer level dropped from 600 cfa to 300 cfa, making the company bar soaps more attractive again on market stores and supermarket. This good result reported in the table below, followed by a histogram.

TABLE 12
New Bar Soaps Price Comparison Among Competitors

	The Company	Competitor #1	Competitor #2	Competitor #3
Old Price	600 cfa	400 cfa	450 cfa	400 cfa
New Price	300 cfa	425 cfa	500 cfa	450 cfa
Observation	Decrease by 50%	Increased by 6.25%	Increased by 11%	Increased by 12.50%

Change:
$1 = 550cfa

We see that our bar soaps selling price dropped significantly compared to competitors. The price decreased by 50%.

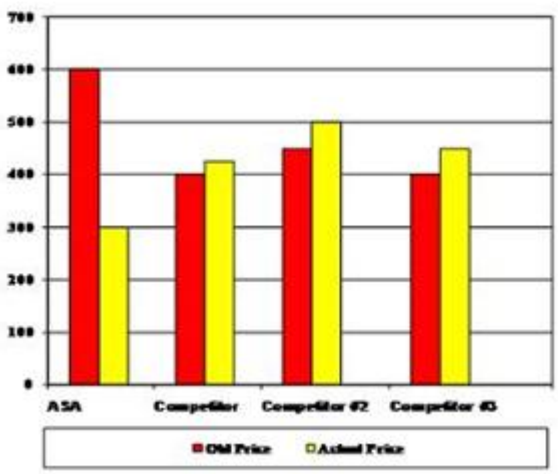


Fig. 13. *New Bar Soaps Price Comparison Among Competitors*

6.2 Step 7. Act On The Results

Our study consisted on improving the productivity of an Ivorian Soaps company in difficult situation, due to the rising manufacturing cost of its bar soaps. This high manufacturing cost of the bar soaps placed the company at a competitive disadvantage with increasing price pressures from customers. The price of the unit bar soaps was higher than competitors on market. We documented the description of the solution and how and when it should be used. The old process was replaced with the improved process, thereby preventing the problem and its root causes from recurring. The effectiveness and efficiency of the improvement project were evaluated and consideration was given for using its solution within other department of the organization.

6.2.1. Recommendation 1: Improving Relationships with Suppliers

Following Principle 8 of ISO 9000 QMS, an organization and its suppliers are interdependent and a mutually beneficial relationship enhances the ability of both organizations to create value. One of the major sources of quality problems of our products and services was the quality of materials purchased from suppliers. If they are defective at the start, products and services will also be faulty following the chain process. The source of defective materials purchased has an impact on the quality of the production and performance and raises the importance of suppliers. A good relationship with suppliers is a major component of quality management. Managing relationships with suppliers is one of the factors that helped and still help Japanese companies to achieve world-class leadership □ISO 9000□. Therefore, the company should improve and create special and privileged relationship with growers, through economic, social and environmental actions, to contribute to the development of local communities. With supplying 60% of the plant processed raw material, they are the center of its production and productivity development. This relationship should focus in the following areas:

6.2.2. Recommendation 2: Expanding Industrial Plantations (IP)

To avoid shortage and secure backup reserve, the company should increase its supplying main raw material (crude oil)by expanding industrial plantations (IP), from 3 to 6 as follow:

Fig. 14. *The Industrial Plantation System*

1. IP1 (Gagnoa):in the Midwest.
2. IP2 (Aboisso):in the South.
3. IP3 (Divo): in the Midwest.
4. IP4 (Dabou):in the south.
5. IP5 (Tabou):in the south.
6. IP6 (Abengourou):in the East.

6.2.3. Recommendation 3□ Expanding Production Capacity on 7 Days per Week

The plans should be open both Saturday and Sunday to boost production capacity. The expansion of production capacity will allow for the anticipated growth in the demand for soaps. The plant would have the capacity, using overtime production shifts to produce the following volumes. This production strategy will now be used for a long-term strategy.

6.2.4. Recommendation 4□ Creating Distribution Centers to Expand Distribution Geography

The company new vision is to conquer the Ivory Coast market and a segment of the ECOWAS region. Throughout a new policy and management system, the company should reorganize its distribution management system by creating Distribution Centers (DC) to expand its Distribution Geography (DG). The Company should build seven (7) Distribution Centers where products could be stored for fast delivery to retailer and consumer's.

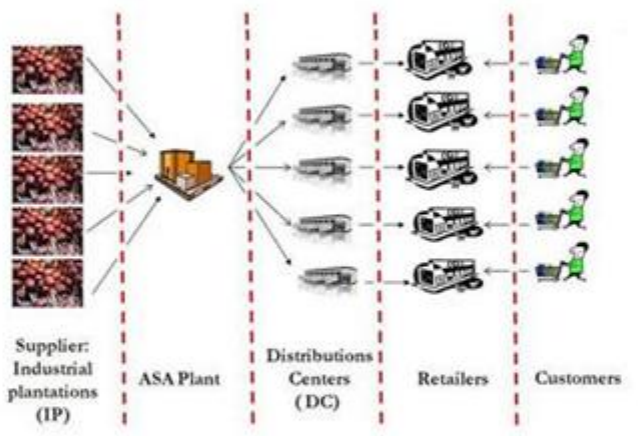


Fig. 15. *The New Distribution System*

All distribution Centers will be located in 7 cities in Ivory Coast: Yamoussoukro, San Pedro, Abidjan, Man, Bondoukou, Korhogo and Odienne. Fourth of them will serve as Distribution Centers for both, the Ivory Coast territory and the ECOWAS region.

DC serving Only the Ivory Coast territory
- DC 1: Yamoussoukro
- DC 2: Abidjan
- DC 3: Man

DC serving both the Ivory Coast and the ECOWAS region
- DC 4: San Pedro
- DC 5: Bondoukou
- DC 6: Korhogo
- DC 6: Odienne

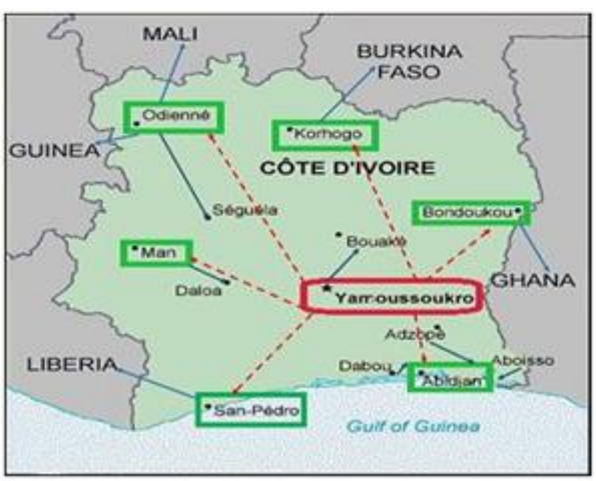


Fig. 16. *The Industrial Plantation System*

7 Conclusion

The purpose of this paper was to reduce the unit cost of the bar soaps at an Ivorian Soaps company so that it aligns more closely with the demanding customer's price reduction. With the addition of two machine groups and a well implemented new schedule and machine preventive and effective maintenance program, production capacity increased significantly □by 68% in 6 months□. This increased production eliminated the need to run production on overtime, and thus eliminated all wage expenditures associated with such as wage bill. With the huge decrease in machines breakdown rate by 85.71% per week□, machine groups performance increased significantly. With a huge decrease in absenteeism and sickness rate □by 83.33% per week□, employees performance increased significantly. The combination of all these performances resulted in a considerable decrease in manufacturing cost, and thus in wage costs of the unit soap. Consequently, this performance permitted the company to apply price reduction at the retailer level. While competitor's unit price increased, our bar soaps price at the retailer level dropped from 600 cfa to 300 cfa, making our bar soaps more attractive again on market □stores and supermarket□. Therefore, we can state that expanding production capacity with two machines groups and workload reorganization allowed The Company to achieve its goal of reducing manufacturing costs, decreasing unit cost of the bar soaps, and thus, reducing price at retailer level. Today machine groups are well maintained and employees have enough time to rest and interact with their families or outside interests. Although a conclusion may review the main points of the paper, do not replicate the abstract as the conclusion. A conclusion might elaborate on the importance of the work or suggest applications and extensions. Authors are strongly encouraged not to call out multiple figures or tables in the conclusion—these should be referenced in the body of the paper.

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