Productivity Improvement in a Vegetable Canning Manufacturing Facility

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Abstract. This paper investigates current productivity levels of baked beans in a fast manufacturing consumer goods (FMCG) company. The market demand for baked beans on average has increased by 14% year on year over the past two to three years. This growth was unexpected and was unplanned for, hence equipment was utilized to maximum capacity, at times ignoring maintenance issues. The outcome of this approach was a major concern of unplanned stoppages on the production line. The canning process has manual activities such as soaking and sorting. Blanching is semi-automatic while filling and seaming are fully automated. The filling station was identified as the bottleneck station due to its slow speed (145 cans/minute) as compared to the seamer (200 cans/minute). The major objective of this study was to evaluate how the productivity of the canning process was achieved. Efforts were made to increase the output of soaking, sorting and blanching. This led to the reduced cycle time of the filler and the elimination of sources of contaminations. Industrial engineering tools such as autonomous maintenance, total productive maintenance, total quality management and some of the 20 keys were used to improve the plant's production output. This paper contributes to the theory of productivity improvement and to industry practitioners it highlights challenges faced when improving productivity.

Keywords: Automation, bottleneck, cycle time, productivity and total quality management

Introduction

In today's business environment, manufacturing organisations face challenges such as meeting delivery targets, producing quality products, creating shareholder value and improving productivity [1]. Literature suggests that some companies have successfully addressed some of these problems through the implementation of the following tools and techniques: total quality management (TQM), total productive maintenance (TPM), just in time (JIT), Kaizen, 5S, 20 keys to workplace improvement, Lean and Lean Six Sigma, [1]; [2]. Improving productivity positively impacts on revenue and profits, enhances competitiveness and maintains market share. Components that influences productivity include employees, efficient use of the equipment and standardized processes [3].

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This paper analyses how a fast-moving consumer goods (FMCG) company improved its productivity. This study focuses largely on dry small white bean for baked beans manufacturing process. 80% of baked beans produced in South Africa are used in the canning industry. Canned beans are normally made ready by hydration in the water earlier before being canned in a brine of tomato sauce [4]. However, most canned beans manufacturing is largely manual. These manual processes are causes of delays on the line, with every slight stoppage affecting productivity.

The studied company will be known as Company DW, to safeguard its confidentiality. DW is the largest diversified food manufacturing company in South Africa and other African countries. The company's products cover a wide range of canning and bottled food. In the financial year of 2014, the company recorded revenue of R3.6 billion and a trading profit of R1 billion from all its operations. South Africa accounts for 85 per cent of DW group profits. The Company DW currently employs around 4800 workers throughout its South African operations.

DW has been facing some challenges in improving its productivity mainly due to a lack of adaptability to culture change in the past years. It has tried many times to implement tools to improve productivity without much success. However, the company made a new approach to improving its productivity by hiring and setting up a continuous improvement department. The department was manned mainly by Industrial Engineers who were tasked to improve productivity. The company has implemented tools like TPM, 20 Keys, TQM, and mission directed work teams.

When researchers joined this company it was realized that there was no maintenance system followed on the canning process line. Software to plan and control maintenance for all equipment in the manufacturing plants was available but it was not being used effectively. However this company was partially using a system like Pragma, and part of the 20 keys namely keys: 3 (improvement team activities); 6 (manufacturing value analysis- methods improvement); 11 (quality assurance system) 9 (maintaining equipment); 17 (efficiency control) and 19 (conserving energy and materials). This paper evaluates how Company DW implemented these tools and to what extent did these tools improve productivity.

This paper has the following objectives: to evaluate how productivity improvement was carried out on a bean canning process line. To automate and reduce cycle times on the soaking, blanching, sorting and filling stations and to eliminate the source of contaminations.

This paper answers the following research questions: To what extent does the current production practices affect productivity? What are the constraints to productivity improvement on the bean canning line? What are the current maintenance practices on the bean canning line? How did DW make use of TQM, TPM and 20 keys in improving the bean canning line?

1 Literature review

1.1 Dry Bean Value Chain

South Africa produces three types of beans, namely Red Speckled, Small White and Large White Kidney [5]. The Small White beans are used for canning. Figure 1, shows the market value chain of dry beans. Dry beans are sold to the market either as dry beans or processed canned beans. The branded canned beans are sold through well-established chain stores such as Pick'n Pay, Spar and Shoprite. The value chain diagram shows that there is potential for exports of canned beans. The potential for Company DW to expand its market share locally and venture into exports was the motivation of this study. Export earnings improve the exchange rate of the Rand.

 https://doi.org/10.1051/matecconf/202031205004

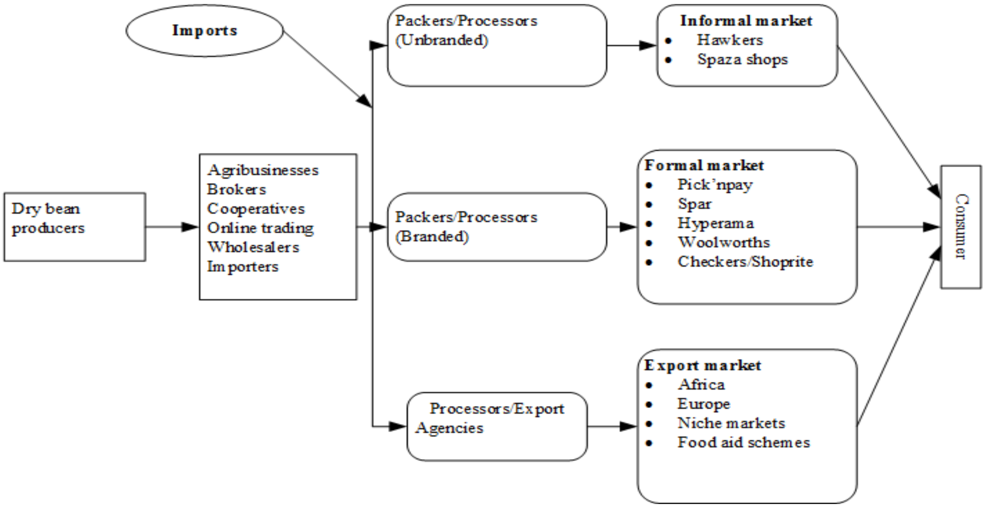

Figure 1. The market value chain of dry beans [5]

The Dry Bean Producers Organisation, [5] have indicated that bean consumption is a good source of plant proteins and beans have less salt, fat and with no cholesterol. The composition of cooked dry beans is shown in Figure 2.

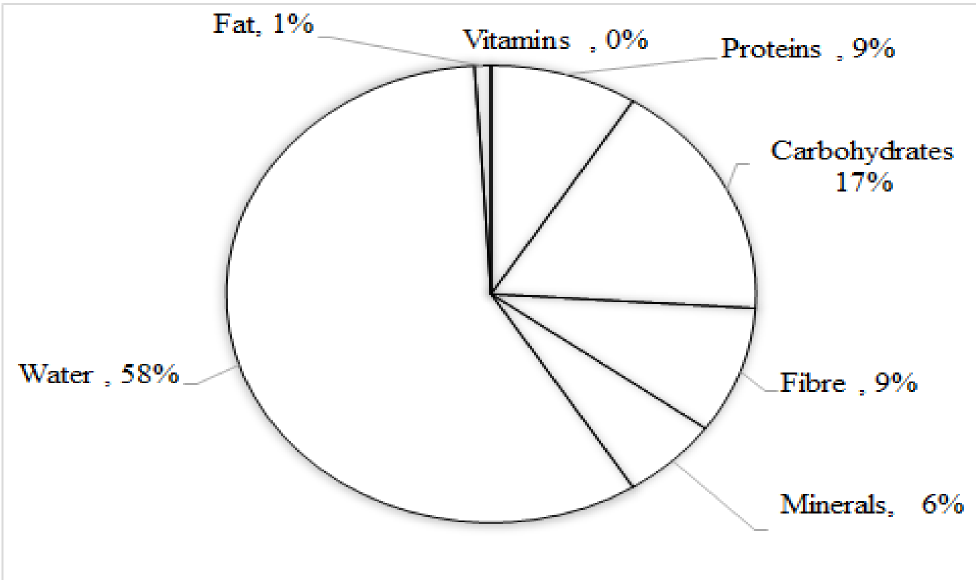

Figure 2. Composition of Cooked Dry Beans

Figure 3, shows the bean canning flow process. Targeted processes for improvement were soaking, sorting, blanching and the filling station. The filling station was identified to be a bottleneck station and the study sought to reduce the filling cycle times.

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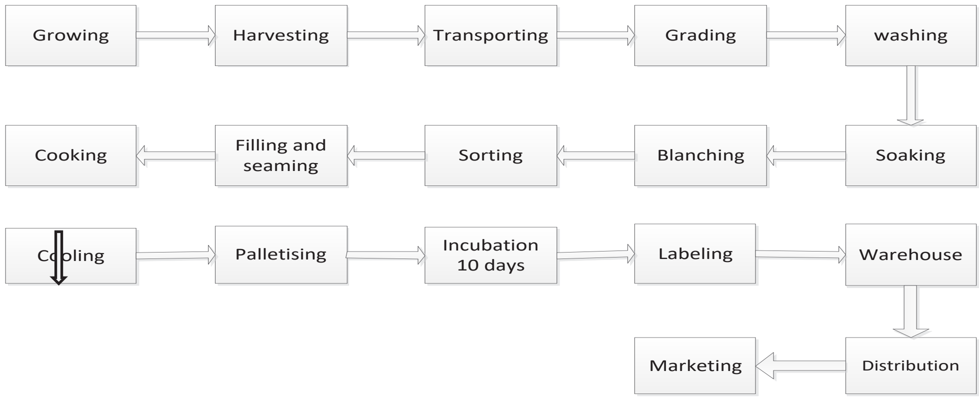

Figure 3. Bean canning flow process

Figure 4, shows that bean production increased drastically as from 2013 to 2015. This has been attributed to the demand by consumers.

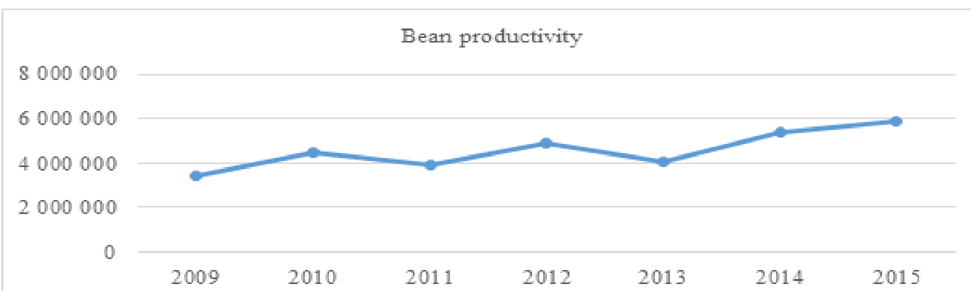

Figure 4. Bean productivity in the past seven years, [5]

Figure 5, shows an increasing gross value contribution of dry beans from the year 2005 to 2014.

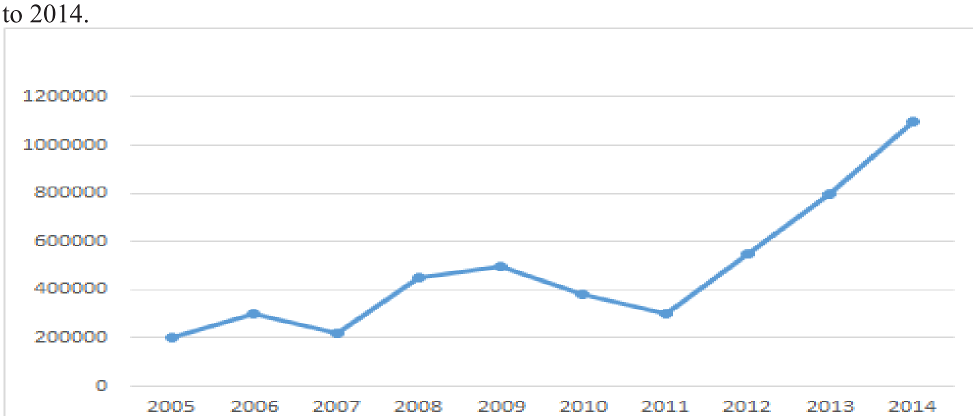

Figure 5. Gross Value of Production for Dry Beans, [5]

1.2 Productivity

Deming [6], described productivity as, "a ratio between output and input". Drucker [7], defined productivity as, "a balance between all factors of production that will give the maximum output with the smallest effort". Three productivity factors that are used when analyzing how productive a manufacturing entity is are: partial factor productivity which considers a single input in the ratio such as output/labour, output/machine, output/energy or output/capital [7]; multi-factor productivity uses more than a single factor, for example, it may consider labour and materials or at times capital [7]; and total factor productivity combines the effects of all resources used in the production to come up with an output, [7]. Productivity can be improved by reducing wastage of input resources: labour, material, machine, time, space and capital. Productivity can be improved by tools and techniques such as TQM, TPM, 20 keys, value analysis and operations research. Netland [8], highlighted 5 rules of productivity improvement and these are:

- "Deliver value for the customer,
- Get processes under control,
- Sync processes as a system,
- Shorten throughput times and
- Continuously improve".

Drucker [7], summarized the importance of productivity as an influence to the generation of wealth through higher sales due to lower cost per unit and this results in lower prices thereby improving profits for the organization. Workers can be paid more, thus improving their standard of living and productivity can be used as a vehicle to reduce poverty and unemployment. Higher productivity enhances shareholder value and improves the country's export capacity thereby generating more foreign currency.

1.3 Total Quality Management

Gunasekaran et al. [9] defined TQM as, "a management philosophy and set of techniques, procedures, involving total system approach to quality". TQM is a comprehensive method used by competitive companies to attain and maintain organisational excellence [10], and fulfilling the ever-changing demands of the customer. TQM implementation requires top management commitment, availability of resources and education and training of the workforce. This was supported by Deming [6] who presented 14 points for management to follow when implementing TQM. A brief summary of Deming's 14 points are: management must adopt a new philosophy and have a desire to improve quality of products and service; build quality into the product and avoid inspections; stop awarding business based on the price tag; improve productivity and decrease costs; train workers at the job; develop good leadership; create a conducive environment without fear; departments must work together and provide methods on how to achieve zero defects and meeting set targets. Figure 6 shows TQM implementation factors, [9], [10], [6]. This paper evaluates how TQM implementation helped productivity improvement in DW.

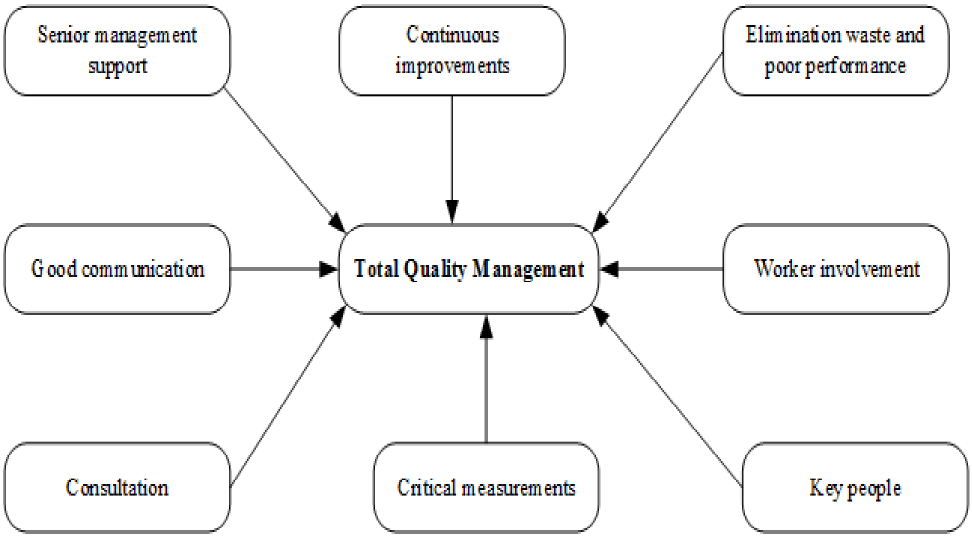

Figure 6. Total Quality Management Implementation Aspects [9], [6]

1.4 Total Productive Maintenance

Eti et al., [11], defined TPM as, "a maintenance philosophy that mitigates organisational failure". Fredriksson and Larsson [12] stated that "TPM aims at improving the efficiency and availability of equipment through the use of teamwork, zero breakdowns, zero defects and zero accidents". Rhyne [13], suggested that "TPM is the synergy between maintenance and production functions in a company aimed at improving product quality, reducing production costs, reducing waste, increases equipment availability and enhances maintenance". Nakajima, [14]; Ahuja and Khamba [3] presented 8 pillars that guides TPM implementation and these are, "autonomous maintenance, focused improvement, planned maintenance, quality maintenance, education and training, safety health and environment, office TPM and development management. Jain et al, [15] identified that TPM makes use of tools and techniques such as 5S, poka-yoke, team-based problem solving, statistical process control brainstorming, 5M, cause and effect diagrams, bottleneck analysis, Pareto analysis, reduction in waste, and simulation as tools to address TPM problems. This paper will evaluate how Company DW made use of the above tools and techniques in improving its bean canning productivity.

1.5 20 Keys to Workplace Improvement

Kobayashi [16], presented a book entitled "20 Keys to Workplace Improvement". This book is used to promote factory revolution as a total package to create synergy among the various departments in a company. The 20 keys are a methodology of implementing a practical program of revolutions in factories (PRORF), aimed at improving production. Some of the keys that are important for this study include "key 3: Improvement team activities; key 5: Quick changeover technology; key 6: Manufacturing value analysis (methods improvement); key 9: Maintaining equipment; key 11: Quality assurance system and key14: Empowering workers to make improvements". This paper will investigate how some of these keys were used by DW in improving its bean canning productivity.

2 Methodology

This study was carried out through a case study approach [17] and [18], where both qualitative and quantitative information was gathered to evaluate how Company DW improved its canned bean production. Mouton [19], stated that "Qualitative research is a correct approach which includes interviews to find information about the industry covered". Face to face interviews were conducted with senior managers, plant managers, supervisors, quality control officers and canned bean process operators. Quantitative data was gathered through close-ended questions [18], that sought to understand to what extent has DW benefited from its canned bean improvement efforts. Both qualitative and quantitative data was gathered through open-ended and close-ended questions that incorporated TQM, TPM and 20 keys' key performance indicators. The study took place from January 2015 to October 2015, but data collected and analysed was from 2012 to 2015. The questionnaire had 20 questions that sought information on the employee's understanding of productivity and implementation of TQM, TPM and 20 Keys of workplace improvement. The data were analysed through graphing techniques.

3 Research Results

A total of 32 questionnaires were distributed and on 28 usable responses were received by the researchers. The following sections present the findings of this study.

3.1 Productivity

Figure 7 summarizes the overall understanding of productivity improvement tools and benefits from the system. The overall response from all employee asked in an interview showed that DW staff understands the system. Data from interviews carried out showed that employees in the canning section had a better understanding of productivity after the company had adopted TQM, TPM and 20 keys as productivity improvement tools.

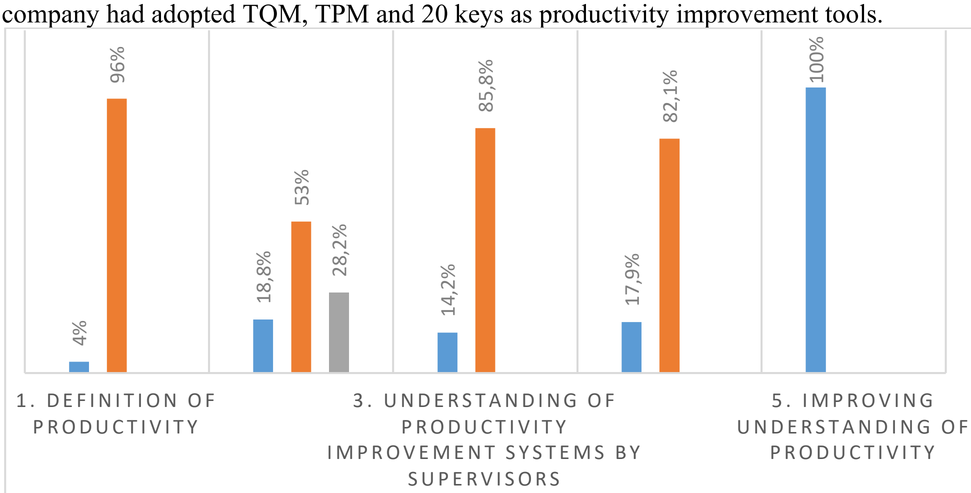

Figure 7. Employees understanding of productivity

Figure 8, shows the challenges that were pointed out by staff in the canning department. The major concern was the filling and seaming stations. The filling station was considered slow, hence it was labelled as the bottleneck station. The filling station had a cycle time of

145 cans/minute which was slow as compared to the seamer which was running at 200 cans/minute. Line preparation was also a cause of concern.

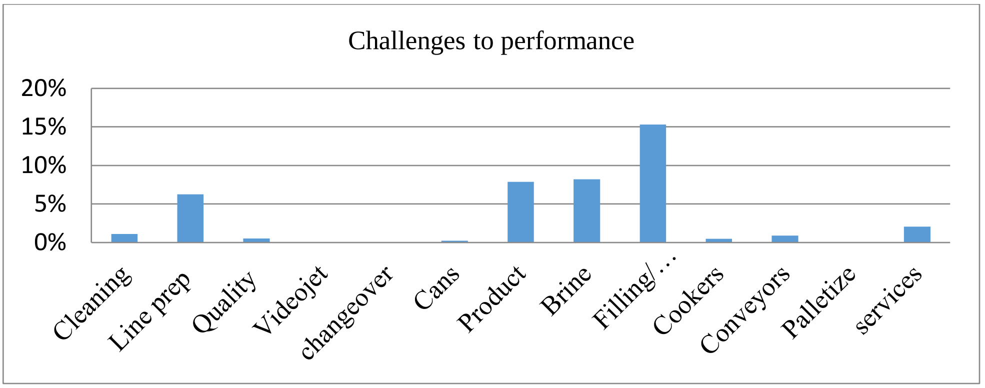

Figure 8. Challenges faced in the canning section

3.2 Total Quality Management Implementation

Senior managers of Company DW understood that TQM is a journey to excellence which cannot be achieved overnight. Their commitment to TQM implementation was witnessed by the recruitment of industrial engineers and the setting-up of a Continuous Improvement department that worked with the production personnel. Resources for training were made available, but all the training was done in-house with the industrial engineers acting as the resource personnel. Most of the production personnel were trained in the seven basic quality tools: Pareto analysis, histogram, cause and effect diagram, check sheet, scatter diagram, control charts and flow chart. The most common tools that workers were using were the histogram and the check sheet. A few of the workers understood the Pareto analysis. The continuous improvement team also used key 11 which focusses on the quality assurance system. Production operators were trained on quality issues and researchers witnessed some inspections that they were now carrying out unlike in the past. There was a reduction in defects.

3.3 Total Productive Maintenance Implementation

Maintenance personnel had a planned maintenance system that was not effectively used. The team worked on breakdown calls and attended to major breakdowns on weekends to gain overtime. The company had a committee that led to the TPM implementation. The senior production manager was in charge of that team and it included TPM Coordinators that worked together with the continuous improvement team. Maintenance strategies, policies and procedures were formulated and adopted. Autonomous maintenance was taught to employees and it followed the 7 steps of Nakajima [14]. However, during the initial phase of training employees demanded extra pay for extra duties. The intervention of top management solved the problem. Workers on the canned bean production line were now responsible for cleaning and inspection of the line. Breakdowns and time to repair were reduced as shown in figure 9. There was a noticeable improvement in Overall Equipment Effectiveness (OEE). Before TPM implementation OEE was around 53%. OEE is calculated from Availability (A) x Product Efficiency (E) x Quality rate (Q), Jain et al., (2014). Therefore OEE = A*E*Q. After TPM implementation the OEE = 0.89*0.9*0.9 = 72%. The mean time to repair (MTTR) has improved as shown in figure 9. There was a noticeable improvement in safety and cleanliness on the canning process line.

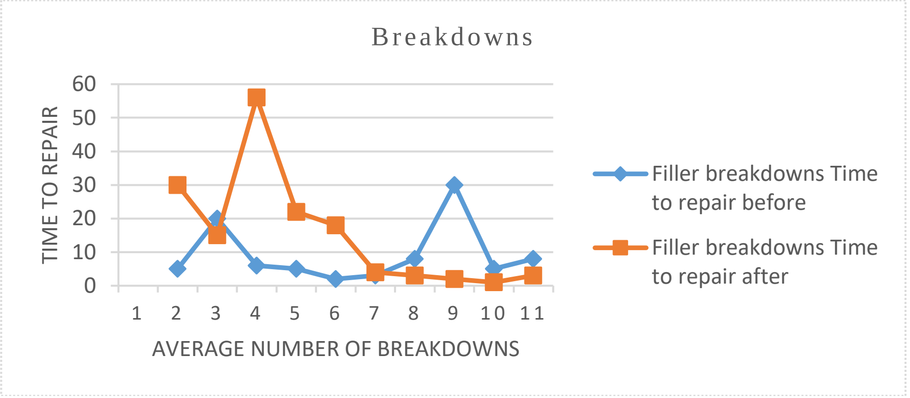

Figure 9. Time to Repair breakdowns

3.4 Automation

The company invested in new equipment, the new Lyco and Tegra machines which replaced the manual sorting and soaking. It used to take 6 hours for soaking beans before preparing for the filling. The Lyco machine takes 1hour and 30minutes to soak and release to filling station, this system improved the cycle time. The Tegra sorter was set by colour and size configuration of the bean, using pneumatics to remove all defects from the batch. New capital equipment improved productivity. A scan track was also introduced just before the cooker, to assure the quality of the product in the cans, checking if the can is over or underfilled. This instrument improved quality.

4 Discussion and Conclusions

The implementation of TQM and TPM is an ongoing process. The company has done well on the canning production line. The investment of new equipment and their efforts in implementing TQM and TPM has yielded some positive results. The researchers observed that workers were involved and communication had improved. Senior management support was clear and this gave workers confidence. The continuous improvement team developed standard operating procedures (SOPs) and they managed to eliminate non-value adding activities. TQM and TPM brought in both tangible and intangible benefits. Tangible benefits were a reduction in defects, reduced stoppages, and improved set-up times. Intangible benefits were enhanced worker morale, a cleaner environment and the general confidence of employees. Employees had a higher level of job satisfaction through their recognized involvement and contribution of new ideas.

This paper concludes that TQM, TPM and 20 keys are tools that when implemented properly can improve a company's production. However only one company was evaluated, hence these results cannot be generalized.

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