Implementation of Lean Principles in a Food Manufacturing Company

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Abstract Lean is a powerful tool, which can bring significant benefit to manufacturing industries by creating value through reduction of waste. Although the lean concept has become very popular in mass production industries such as the automotive industry, more recently the concept has been adopted in different batch processing industries and service sectors. The application of lean tools into the food processing industry has not received the same level of attention compared to the traditional manufacturing industries. The paper focuses on implementation of lean tools in a food manufacturing company in UK. The company produces diverse ranges of meat-free and dairy-free food products such as vegetable burgers, sausages, cutlets etc., and supply to the major supermarket chains in UK. In general, the typical manufacturing cycle includes raw material preparation, cooking, mixing, forming into a desired shape, coating with a crumb mixture, and frying. Finally, the products are frozen and then packaged. First, lean tools and lean practices in food manufacturing industries have been briefly presented. The implementation of lean into the company started with reviewing the products, manufacturing processes, technical facilities, and process flow charts. Key areas have been identified to achieve tangible benefits by implementing lean tools such as waste elimination, 5S, single minute exchanges of dies (SMED), Andon system, visual management, work standardisation etc. The results have been presented in the form of a case study. The paper concludes that lean tools can be successfully implemented in a food manufacturing company to improve production efficiency, to improve product quality, and to reduce production cost by reducing waste and adding value. The information presented will be of interest to general food manufacturers and in particular to frozen food manufacturers.

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1 Introduction

In the constantly changing environment, businesses whether large or small are facing tougher competition than ever. Food and drink industries are no exception. Rising operational costs, highly variable material costs, increased regulation on carbon emissions and waste reduction, food safety and improved quality requirements are some of the major challenges the food manufacturers have to deal with [1–3]. Furthermore, customer demand of high quality and tasty food at a lower price, organic food, balanced nutritional content in the food, and efficient food supply increases pressure on the manufacturers. In an attempt to achieve these multidimensional objectives while maintaining profitability, the industry has to develop an integrated approach of improved food processing efficiency, better quality management, effective use of energy and resources, and efficient recycling of manufacturing by-products and waste. Application of lean principles in food manufacturing could be considered as a viable solution to these challenges [4, 5]. The concepts of customer driven manufacturing and following the best practices in other industries were also suggested [6, 7]. Lean is defined as a concept of manufacturing high quality products at the lowest cost with the shortest time by systematically identifying and eliminating non-value adding activities. Although the concept was originated in automotive industry [8], it has been applied extensively in other manufacturing and service industries.

It is generally perceived that lean manufacturing principles cannot be easily applicable in industries where the production operation is carried out in large batches such as in food and drink industry. Typically, they are not considered as make to order business [7]. Although the food industry is similar to other traditional manufacturing industries in many respects, lean has not yet been widely adopted within it. However, evidence found in the literature suggests that lean manufacturing can be successfully applied in some food manufacturing areas such as red meat processing, seafood processing, production of canned food, bakery, meal production in kitchen, pizza, ketchups, sauces and jam production etc., [9–15]. The following lean tools have been generally applied in the food industries: Value Stream Mapping, 5S, quick changeover, Total Productive Maintenance (TPM), cellular flow, Kaizen, work standardization, and visual management. Typical improvements such as production efficiency, product quality, employee involvement, team spirit, co-ordination between production and maintenance, and reduction in waste, production cost, batch size, changeover time, and lead time were reported as the key achievements from the implementation of lean. However, no study on the application of lean or continuous improvement program in frozen ready-meal manufacturing was found in the literature. This paper illustrates the implementation of lean principles in a ready-made vegetable-based frozen food manufacturing. The aims of this work program are to reduce waste, increase production efficiency, improve overall business performance, and to reduce the impact on environment.

2 Food Manufacturing in UK

The food and drink industry in the UK is characterized by efficient and high quality manufacturing processes. This is the largest manufacturing sector in terms of both value (representing over 15 % of manufacturing turnover) and employment (almost 380,000) [3, 16, 17]. In a recent report, the impact of food and drink manufacturers on the UK economy has been analyzed [18]. The statistical figures show that the food and drink industry has remained a resilient element among the manufacturing sectors despite the recent economic downturn and has returned to the pre-recession output level at the fastest rate.

Product and process innovation through significant investment in research and development (4 % of the total R&D spend) is a core strength of the sector. The food and drink manufacturing in the UK has shown strong and positive response to environmental and health concerns by reducing CO_2 emissions (by at least 11 % since 1990) and lunching new health products. Although exports for food and drink in the UK have increased significantly over the past decade (by approx. 15 %), the growing trade deficit is a major concern due to faster rise in imports. UK government is planning to invest in research and development to encourage an increase in efficiency, sustainability and competitiveness in the food processing, and manufacturing sector [3].

3 Case Company and Manufacturing Processes

The case company manufactures a range of vegetarian and vegan (meat-free) ready meal products in the form of burgers, sausages, cutlets etc. The company produces its own brand as a key supplier in vegan products and also produces for major supermarket chains in UK. Although the company's main business is focused on manufacturing supermarket brands (90 %), the launching of own branded products has opened up opportunities to increase the customer base, to promote brand image and to strengthen the company's competitive offering. The company employs approximately 100 people and manufactures over 100 products of different recipes. The product development team continuously introduces new products every year.

The manufacturing cycle starts with collection of required raw materials, preparing, cooking and mixing them according to the specified recipe. The raw material is subsequently formed into the desired shape. Frying is carried out after coating with powdery crumb materials. Finally, the products are frozen and packaged ready for delivery or storing. The overall manufacturing steps of the food products are presented in Fig. 1. The manufacturing process is deemed as semiautomatic with two lines operating for fried and non-fried products.

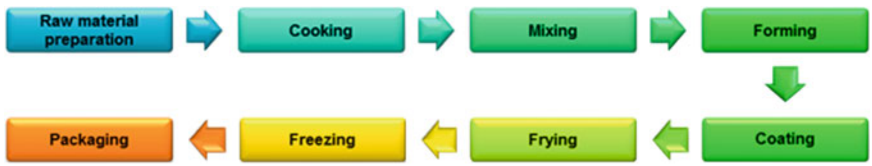

Fig. 1 General food products manufacturing cycle

4 Methodology

First, a lean team was formed with the people from different departments in the company, who were knowledgeable and experienced about the products, processes, equipment, and planning. Lean team leader collected the production data and generated the process map by studying each stage of the manufacturing processes with the help from the team members. Strategic areas for implementing lean tools were identified based on the data and observation. Among many issues related to manufacturing, high waste in raw materials and motion, high consumption of water, electricity and liquid nitrogen, lack of 5S and Total Productive Maintenance (TPM) in practice, high machine downtime during changeover and lack of communications between departments were considered for investigation.

Five Key Performance Indicators (KPIs) were identified: Safety, Quality, Volume and delivery, Cost, People and Morale, and Environment. The lean projects strongly relevant to the KPI of the company were carefully and systematically selected and implemented in order to achieve immediate tangible benefits with minimum investment. A data collection procedure and structured problem solving technique were established. Boards were displayed in the shop floor to communicate action lists and control charts. The progress of lean implementation was regularly reviewed in senior management meetings as well.

5 Results of Lean Implementation

Although a number of lean techniques were applied in the production, packaging and warehouse areas, in this paper the results were presented based on mainly four lean principles: Waste reduction, 5S, Single Minute Exchange of Dies (SMED), and Overall Equipment Effectiveness (OEE).

5.1 Waste Reduction

Data collection on food waste over a three-month period indicated that forming, frying, mixing, X-ray, and crumbing represent the high waste areas (Fig. 2). Waste

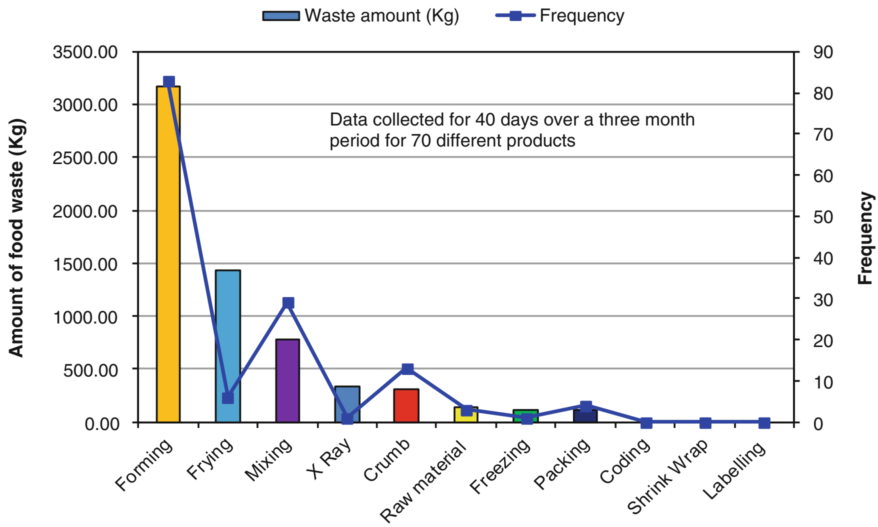

Fig. 2 Total amount of product waste in different areas of production and the corresponding frequency of waste occurrences

was generated in the forming process more frequently than the other areas in production. With the application of good practices, the daily waste produced in mixing, raw materials during weighing, packing, and freezing areas were drastically reduced.

Significant waste was detected due to oil dripping from both ends of the fryer. On average approximately 30 kg waste of oil per day was measured as shown in Fig. 3. An oil re-routing mechanism was designed and installed to return the dripping oil back into the fryer leading to substantial reduction in oil waste.

It was also noticed that a lot of crumb covering was pulled off from the product to fall on a tray under the belt due to belt transfer problems. The measurement showed that the daily crumb waste was approximately 40 kg as shown in Fig. 4. The best way to resolve this issue was to reduce the amount of belt transfer after the crumbing operation wherever possible. To achieve this, a new belt was installed in the production line and the crumb waste was significantly reduced. The new belt also provided a sustainable solution to this waste reduction as seen in the review after almost a year.

In an attempt to reduce the cost associated with the utilities (electricity and water), monitoring system was installed to measure and review utility usage. Changes in production procedures such as placing lids on the top of pans resulted in a reduction in water usage by 80 L per cook (30 % less). LED lighting was installed with the help of interest free loan from Carbon Trust in some of the storage areas (freezer and spice room) to reduce electricity consumption. This also enabled further reduction in electricity consumption by installing light switch and motion sensors saving 53 tons of CO_2 per annum. The combination of high belt

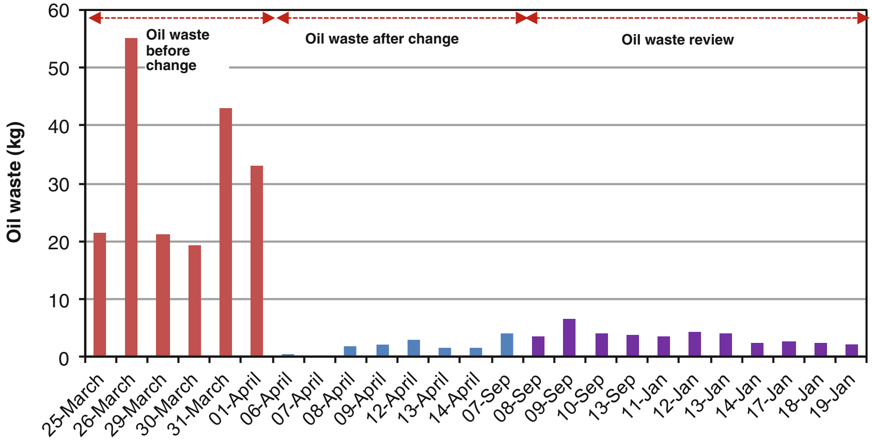

Fig. 3 Cooking oil waste before and after the change

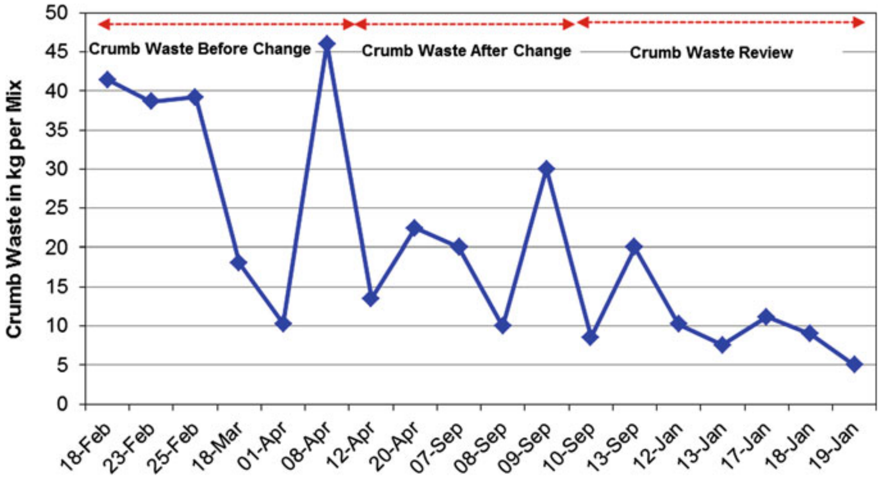

Fig. 4 Food crumb waste before and after the change

speed (27 % higher) and low temperature (−120 °C) in the freezing tunnel resulted lower production efficiency (transfer belt was not fully loaded with products) and high consumption of liquid nitrogen. Optimizing the belt speed (medium) and temperature (−100 °C), it was possible to reduce the liquid nitrogen consumption and to improve the production efficiency.

As a part of lean implementation, the team concentrated further efforts on reducing the amount of time travelled by production staff. The staff needed to leave the production area to collect raw materials for cooking. However, they cannot re-enter production without rewashing their boots in order to ensure no contaminants enter the production. This means that staff have to take a long walk

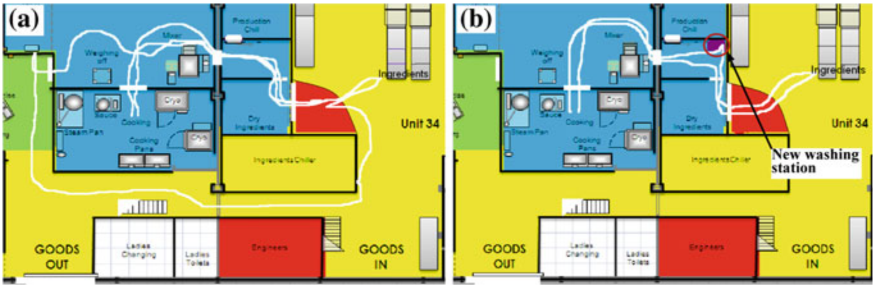

Fig. 5 Movement path of production operator **a** before and **b** after installing a new washing station

around to enter into the production area again as the washing station is close to the production entrance (Fig. 5a). As a solution to eliminate this waste in motion, a new washing station was installed close to the production exit (Fig. 5b) so that staff do not waste time (45 % saving) in walking around leading to a higher production efficiency.

5.2 5S

The housekeeping tool 5S has been implemented in the daily routines across the entire site from production to office space to improve the organization of production. 5S areas of responsibilities were distributed among the employees to own the process. Single point lessons were learnt from each activity and 5S audits were carried out regularly to generate 5S score point. New 5S audit boards for production, packing, warehouse, and office were put in the shop floor to communicate the activities and scores. Although, the initial score was low (between 30 and 40), gradually the score was improved as shown in the data collected for three months (Fig. 6). Dramatic improvements were achieved in housekeeping and cleanliness, which was absolutely essential in food manufacturing [5]. Furthermore, 5S activities generated standard operating procedure, reduced the time searching for tools, improved 5S awareness, and increased employee motivation through ownership.

5.3 Single Minute Exchange of Die

European food manufacturing industries are characterized by wide range of product mix, frequent changeover in the production line and shorter production runs. In some food processing operations such as in this case company, one product does not run through a particular production line everyday rather multiple

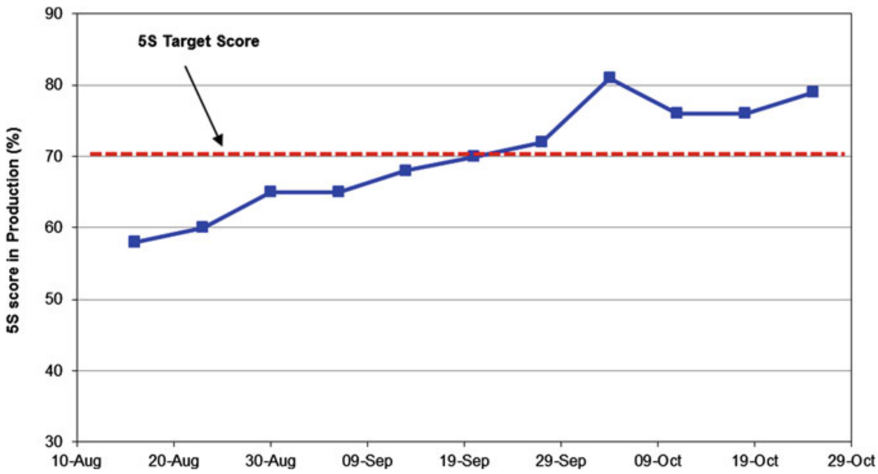

Fig. 6 5S scores in production over a certain period showing a steady rise

products are manufactured even in a single day. This shorter production run means frequent changeover, which leads to increased machine down-time and labor hours. Single Minute Exchange of Die (SMED) is a lean tool, which can dramatically reduce the changeover or set-up time. Set-up time is defined as the time between the last good piece off the current run and the first good piece off the next run. Several SMED activities were carried out at the packing and forming areas. Using Video analysis and reviewing the process, the changeover time in the forming machine was significantly reduced. By working as a team in a Formula 1 pit stop style, the operations of cleaning with hot water, standardizing equipment position in the line and standardizing changeover procedure reduced the changeover time resulting in better production capability, flexibility, and production efficiency.

5.4 Overall Equipment Effectiveness

Overall Equipment Effectiveness (OEE) is a powerful lean manufacturing tool to measures the effectiveness of a machine or a process line by integrating factors related to availability, quality, and performance [15]. An Andon system allows monitoring of production and measuring, and analyzing of OEE. An Andon system was installed on production to collect data on equipment downtime for scheduled and unscheduled activities. To identify the equipment creating the most downtime and to drive forward priorities for the planned maintenance schedule, a scanner was fitted to the Andon system and a barcoding structure was set up to enable effective capturing of the data. Figure 7 presents an example of machine breakdown causes in different equipment and measurement of stoppage time. Significant improvement in performance and quality was also realized through the reduction of machine idling, minor stoppage and set-up times.

The OEE measured in the lines were between 55 and 60 %, which was quite a distance away from the target (85 %). However, with this system in place, the company is in a much better position to measure the OEE to progress towards the world class operation and to prepare for an organized preventative maintenance plan [15].

6 Discussions

In this study, the lean tools have not only been implemented but also the tangible benefits to the company have been measured in each case. Figure 8 presents the estimated cost saving through the waste reduction in six major areas totaling over £45,000. Although a significant waste of expensive raw materials was eliminated in the mixing area, it was difficult to estimate in terms cost saving. However, the activity surely contributed to the improvement in process yield. The elimination of waste not only helped the company financially, but also brought considerable environmental benefit, reducing the company's carbon footprint. Whist the exact changes in environmental impact are yet to be fully determined, it is clear that these changes are very much in the spirit of the company's long-term mission.

It should be emphasized here that financial benefits were achieved with a minimum amount of investment, which could be paid back in a short time in most cases within a year. It has been demonstrated earlier that simple changes to the machines (frying and belt) saved a lot of waste in oil and food crumb. Therefore, working closely with the equipment manufacturers could be a way forward in

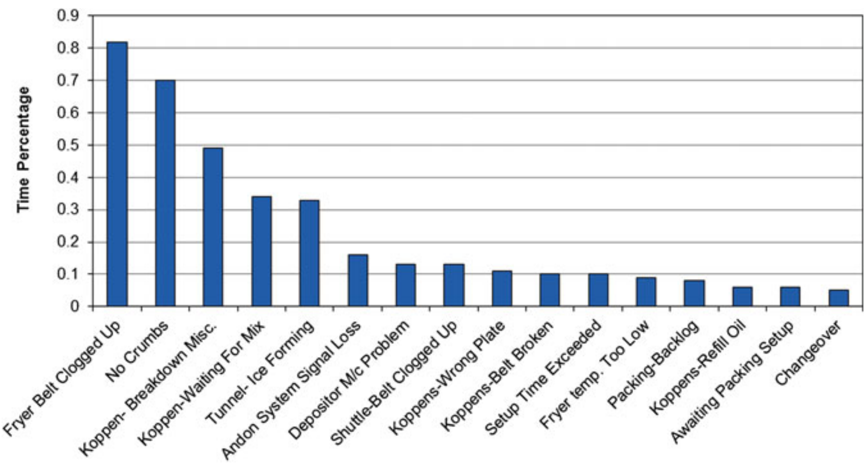

Fig. 7 Pareto chart of machine breakdown estimation for the most common reasons

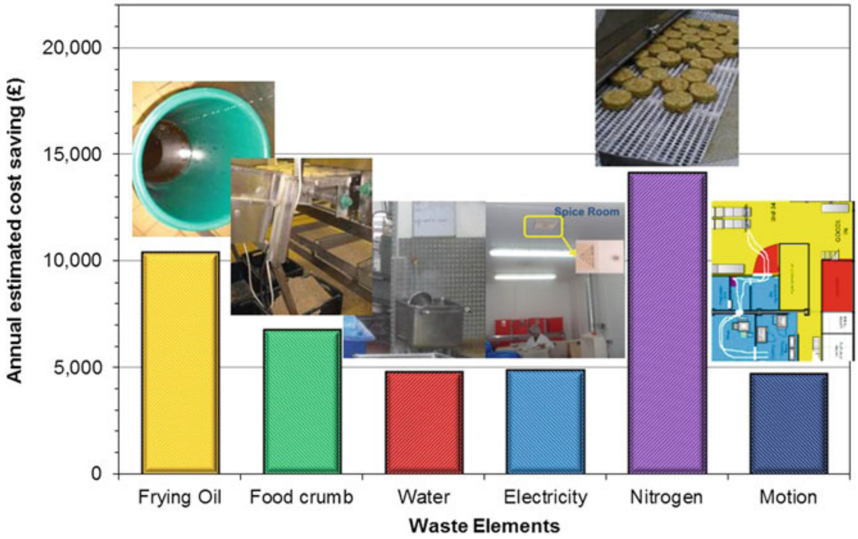

Fig. 8 Estimation of annual cost savings due to the reduction of different waste elements

order to improve the machine design for reducing waste, easy maintenance and quick changeover. Although the general shop floor workers were not familiar with the concept of lean manufacturing, they quickly learned it through a structured training program and hands on practical work in the team. This created a learning environment through team working and a continuous improvement culture in the company by involving everybody from operator to senior management. This also generated friendly competition between shifts resulting in improved production efficiency. Finally, the establishment of continuous improvement team in the company ensured that a long-term improvement plan was in place for sustaining the lean program and the quest for continuous improvement was carried on [2]. The biggest challenges in implementing the lean were the resistance to change from the operators and personnel changes in production management. The implementation of lean manufacturing does not happen overnight; it needs time, stamina, better communication and support from the top management to make the changes a reality. As the competition is rising continuously, it is absolutely vital to accomplish and sustain the incremental changes towards achieving the long term stability and competitiveness in the business.

7 Conclusions

This case study clearly demonstrates that it is feasible to apply lean principles in a ready meal frozen food manufacturing company. The systematic application of lean tools has started with the waste elimination in different process steps of the manufacturing cycle across different product range. Waste reduction in cooking oil, food crumb, water, electricity, liquid nitrogen and operator movement has resulted significant cost savings for the company and created more value for the customers. The introduction of 5S across the whole factory including office areas has led to a more organized, clean and safer production area and also increased efficiency due to motivated operators and shorter time for searching tools. The SMED activities have increased the opportunities for set-up time reduction leading to quick changeover and shorter lead times. The implementation of Andon system in production has provided the opportunity to measure OEE, thus leading to more efficient manufacturing operations. In summary, the lean activities can facilitate the food company to be competitive in the market by reducing cost, improving productivity, teamwork, and consistency of product quality.

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