

# Paper Title: Productivity improvement using value stream mapping in a beef abattoir

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**Abstract—** Beef abattoirs continue to face challenges of improving productivity, in order to remain successful in a highly competitive industry. As every input cost goes higher year on year, it is important to provide better products, processes and services at lower costs to the end user by improving process cycle time efficiency of the plant. The aim of this paper is to illustrate the implementation of value stream in a beef abattoir to improve productivity. This study started with conducting site visits, touring the plant, conducting interviews, direct observation and conducting time study for the existing current production process. Current process was mapped to identify problems and bottlenecks within the beef abattoir. Long manufacturing lead time, waiting or delays within the production and too much time spent on handling the carcass. In order to address these productivity inefficiencies in a beef abattoir; future state map, estimated calculated process improvements and suggestions were proposed on how value adding time can be improved. These proposed improvements and calculated process cycle time efficiency could lead to a better system for the organization under study. The contribution highlights 21-23% process cycle time improvements and efficiency.

**Keywords:** beef abattoir; cycle time efficiency; process improvement; value stream mapping

## Introduction

Beef abattoir in Botswana are impeded by production inefficiency, long manufacturing lead time and unoptimized business process. In today's competitive world, productivity is one of the components that lead to successful industrial organizations. Increase in productivity can reduce the cost of work or increase in output. Productivity depends on various factors such as labour, machinery, raw materials and quality. To reduce these production inefficiencies and remain competitive with other companies, meat processing industry and other abattoirs, companies use a variety of different methods. One of the main methods is lean manufacturing. Main aim of lean manufacturing tools is to reduce waste in an

operation, such as long lead time, production inefficiencies, waiting, defects and waiting. Value Stream Mapping is a lean tool that visual display where waste occurs in the process. Value stream mapping are often used assess current manufacturing processes as well as create ideal and future state processes. For this research paper, an abattoir was chosen as an industry to work with. This study is to illustrate the implementation of value stream mapping in an abattoir to improve productivity is mainly focused on the production of carcass, that is from the cattles are received from the abattoir building up until now the carcass is delivered to the customer. The focus of this study is to illustrate the implementation of value stream mapping in an abattoir to improve productivity. Current value stream with the help of time study and observations were made to identify bottlenecks in the process. Conclusion and proposed improvements were made based on the data accumulated from observations and time study analysis.

## I. LITERATURE REVIEW

This section of the report provides a brief background on the documents, literatures sources and other documentary reports that were used to solve productivity and production inefficiencies through value stream mapping. Productivity, lean manufacturing and value stream in an abattoir were crucial topics to consider when studying this research area. Value stream mapping is a lean manufacturing tool which originated from Toyota Production System (TPS) and uses techniques of lean manufacturing to analyze and evaluate certain work processes in a manufacturing operation [1]. Value stream mapping (VSM) is used to find waste in the value stream of a product. Once waste is identified, then it is easier to decide to eliminate it and the purpose of VSM is process improvement at the system level [2]. The key benefit

to value stream mapping is that it focuses on the entire value stream to find system wastes and try to eliminate the pitfall [3]. Value stream mapping in a product or a service as a flow of sequence of activities from the beginning to end in a form of visual representation accompanied with lead times [4]. The author adds that this tool is a core element of lean transformation because it gives a basic blueprint for various changes needed to move from a disconnected, dysfunctional flow kind environment one where material flows smoothly from one process to the next to the next, rather than making isolated improvements to individual activities within a larger value adding process. Value stream mapping provides an overall structure for applying other tools and kaizens, and for seeing beyond the symptoms of wastes to real root causes [5]. Furthermore the author stated that there are three essential parts in a value stream map, which information, material flow map and lead time ladder.

**Information flow-** depicts the current state of the value stream map, observing the flow of data or information at the top of the map. Here the customer communicates daily requirements to the production control section via fax, verbal, email or through phone call.

**Material flow-** depicts the movement of product from raw material to finished product

**Lead time ladder-** summarizes the cycle times (i.e value adding time in each process) per piece and it is contrasted with total time spent in the value stream.

[1 - 5] stated that value stream mapping can be created simply using a pen or pencil, nevertheless more advanced maps are created using Microsoft Visio as well as Excel. Moreover, the author further stated that VSM is divided into five basic steps which are identifying the product, creating a current VSM, evaluating the current map by identifying problem areas, creating a future state VSM and lastly implementing the final plan. The first step in value stream mapping is choosing a specific product the VSM will focus on, then followed by creating an initial VSM current process [6]. After the current map has been completed; the team evaluates the process and the process and the steps involved. All this data is then compiled on a map and analysis is performed. Furthermore the author stated that parameters such as cycle time, Takt time, work-in progress (WIP), set up time, down time, number of workers, and scrap rate are included in each step. Non value adding time will be shown at each step [1 - 6]. Moreover, the author stated that problem areas are identified after analysing and evaluating the current process of the product so as to create the final VSM state [6]. Final state is created after the current process has been changed and the problem areas have been minimized [6]. The last step of the value stream mapping process is to implement new ideas and thus turning a more efficient lean manufacturing process [6]. Benefits of value stream map were stated by [1 - 6] as it helps to visualize more than the

single process level, links material and information flow, provides a blueprint for implementation, and it ties together lean concepts and techniques.

#### A. Background of beef industry in Botswana

Most Botswana families own cattle and are a potential stakeholder in government support to the beef value chain [7]. According to [8] cattle are both a production good that is being a draught power, transport and calves and consumption good (as milk, meat & hides) and a form of saving for future consumption and production. Cattle production in Botswana is highly cyclical, depending upon rainfall and pricing structures [9]. Farmers sell animals during droughts, flooding the market with poor-quality animals and driving prices down, and they rebuild their herds when rainfall is good reducing the number of animals for sale and driving up prices [8 - 9]. Productivity is the relationship between the outputs generated from a system and the inputs that are used to create those outputs. It is concerned with the efficiency and effectiveness with which goods and services are produced. Productivity are very essential in making sure inputs are utilized in an efficient way when they are being processed by machines into final product. Efficiency measures the resources expected to be consumed to the resources consumed (actual) and effectiveness measures what the system sets out to accomplish with what was accomplished (actual); plan vs actual [10]. Productivity in abattoirs is investigated through use of time study, determination of standard times, standardized work, takt time (or drum-beat) production smooth flow, process mapping, value stream analysis and other necessary measurements for productivity such as labor productivity and efficiency [11].

## II. METHODOLOGY

Methodology of paper relied on secondary research (such as reviewing available literature and data), informal qualitative approaches (such as engagement discussions, consultative meetings) and formal qualitative research (such as face to face interviews, direct observation, case studies, audits, site tours and plant tours). It explores application of value stream mapping in a meat processing industries (an abattoir). Value stream mapping has not been applied in beef industries rather a value chain was evaluated for a beef value chain. Site visits, company audits, engagement discussions, consultative meetings and plant tours were done to understand and investigate the flow of materials and information required to bring a service to the customer. The methods are further explained;

#### *A. Face to face interviews*

Face to face interviews were used to develop a common understanding of the current process. Production manager, three-line supervisor and twelve-line operators were interviewed to understand the relationship of the process steps, a true picture of the process to create a baseline for process measure.

#### *B. Plant tour and site visits*

Botswana Private Abattoir was mapped during site visits after consultation with the process users, production manager, and line supervisor and production team to give the actual current business process. The company currently uses batch production layout system in which workstations, machines and equipment used are arranged in a line but carcass is processed in batches. The carcass and cattle are physical moved or manually moved through rails by workers using trolleys, hands or semi-automated machines. The production system is designed in such a way that a small amount of the total work is added along as the carcass is moved along the production line and the stunned cattle's are moved in batches which encourages delays and more queuing time. It is also categorized by high production volume and low variety as of the abattoir is only cattle / small stock (usually goats) of any size. Farmers are the ones that bring their cattle's or small stock in the abattoir and documents are checked at the receiving gate. These documents include verification from the Department of Veterinary Services, kgotla, and police officers. The company receives cattle a day before they are slaughtered and it's mandatory for them to spend a night before they are slaughtered. Receiving days are Mondays to Thursdays during weekdays from 0600 hours till 1900 hours. Killing of cattle's takes place from Tuesday to Friday from 0700 hours till 1600 hours operating nine hours (in one shift). If the cattle have all the requirements, it is allowed in the building, if it does not have all the necessary documents it is sent back to the owner at the owner's expense. Cattle are then offloaded, and lair aged in holding pens according to their holding capacity. Before there are lair aged there are branded for identification. This identification is helpful for the production manager to prepare killing agenda. The cattle are then inspected often known as ante mortem inspection, where they are checked for fitness. If the cattle are not fit, it is verified by the veterinary inspect to be stunned at the emergency stunning box. If the cattle are fit and fine, it is sent to the stunning box where it is slaughtered. Halaal checking takes place after stunning, then the slaughtered cattle are hoisted using mechanized hoist machine. The carcass is hoisted above the ground, creating less chance of contamination of carcass by filth and blood on the blood. Platform is a system that operators use for movement. Upon hoisting, skinning of heads takes place and they are tagged systematically in a trolley where they will be

inspected by a meat inspect during production. Dressing takes place, then tagging of carcass takes place. Splitting takes place after the carcass has been tagged. Evisceration then takes place where the offal's will be separated and removed. Post mortem inspection takes place and done by meat inspector and veterinary officer. A report is made after the post mortem inspection has been done and it is awarded by a veterinary specialist inspect. In that report the veterinary specialist verifies whether the carcass and its offal's are good for human consumption. If there are not good for human consumption, the products are either detained in a chiller for some days or they are thrown away. If the report states that the carcass and its products are good for human consumption it is passed along the production system. All documents are then checked which includes report by an inspector. If all documents are fine, an establishment stamp is issued. The carcass is weighed, loaded, invoiced and delivered to the end user. Furthermore, activities in the plant are categorized in three sections which are gate receiving section, lair aging and the production shop floor.

#### *C. Time study*

Time study was also used to collect data for a process. Time study was used to measure the current state steps and to create a baseline measure. First a process was selected, which illustrates how cattles enter the building, then all involved stakeholders were engaged and made aware of the project task. After awareness was made to employees, cattle slaughtering was directly observed in order to familiarize oneself with the process. All process steps were noted down. Process cycle time was considered from the time the of cattles enters the building up until they are loaded in refrigerated trucks for delivery to the designated customer. Three cycles were performed on three consecutive working days for the nine hours working shift. Stop watch technique was used with direct observation of the operator while timing the duration of the activity. When using this technique actual times required to perform different activities were recorded in their elemental form and according to the steps involved in the slaughtering of cattle. Random operators of two per each operation were timed. Reason was that the supervisor allocate task according to the availability of work content. For example, if there is more work content in dressing, one operator would be shifted to that section to add labor intensity. Tools used for conducting time study are digital and electronics stop watch, board for holding time study sheet, video camera recorder, observation time study sheet and stationary such as pen, pencil, eraser and calculator. After actual times were recorded, data was analyzed so as to obtain the time necessary to carry out a specified job at a specified level of performance rating and specified allowance such personal, fatigue and delay

(abbreviated as PFD allowance). Performance rating was taken to be 100% and PFD was taken as 15% as stated by International Labour Organization (O'Rourke, 2003). A sample size of 5 beasts and five cycles were selected and recoded their times for accuracy. Five observed cycle times were recorded and averaged. The average cycle time helped to determine how well the current operation is doing in relation to the TAKT time. TAKT time is the total available time divided by the number of units in demand for that day, see Equation (1) for calculation.

#### D. Data Analyzing tools

When analyzing results collected; pareto graph, computer software's (Microsoft Visio), and other forms of visualized data were used; such as process maps, and images. Below in Table 1 summarizes tools used in order to map the value stream of the cattle slaughtering production line.

Table 1: Data analyzing tools used

| Problem issue                | Data analyzing tools                                                                                                                                                                                                                                |
|------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Long manufacturing lead time | -Microsoft Visio<br>-Stop watch technique<br>-CCTV surveillance camera analyzing<br>-Minitab<br>-SIMO (Simultaneous Motion Chart)<br>-MOST (Maynard Operating Sequence Technique) Index parameter<br>-Two hand process chart<br>-Process flow chart |

### III. RESULTS AND DISCUSSION

This chapter illustrates value stream that was identified during site visits, plant tour, direct observation, workstudy and interviews. Current value stream map was identified, and from the value stream; current cycle time was identified as shown in Figure 1. Current value stream map was identified through direct observation, site visits and plant tour. Current value stream shows that the production lead time is 50 cattle's for 9 hours. Microsoft Visio was used to map the current value stream map with the help of time study conducted and motion study observed. Current state map was created using process mapping symbols and others. Based on the current state map shown in Figure 1; waiting time is far greater than the value-added time, thus increasing the lead time and operating costs due to higher levels of carcass queuing for a long period of time. Based on the available work identified through work measurement and customer demand, Takt time was identified as illustrated in

Equation 1 and it was found to be 463 seconds. Takt time means that in order to meet customer demands, Botswana Private Abattoir need to produce a carcass every 10.8 minutes. This is a reference number defined by the customer and it should improve processes to match this time considering downtimes, changeovers and defects. The existing current value stream map of Botswana Private Abattoir that was mapped and is shown in Figure 1. The data learned through the design of the current map is overall lead time which spans from when the customer delivers the cattle to be slaughtered through gate receiving section, Lairaging, production and delivery of the carcass to the customer. Currently the company has a production time of nine hours, working one shift. Out of the nine hours, only 4.12 hours is value added time. Non-value adding time is 4.88 hours.

Therefore, the company has a lot of waste activities that needs to be eliminated. For a production holding capacity of 70 cattle per day, the company can only slaughter 50 herds of cattle with a total lead time of 9 hours. Each process in the value stream produce a batch and push the product to the forward process as planned by the production control as opposed to what the next process really needs. This creates carcass queue at the next process and some defects can remain hidden until it gets noticed the product is inspected at the loading bay in this next process. The time for adding value to the product is less but it takes long time to get through the value chain. The significant problem in the value chain of cattle slaughtering is more non-value adding activities, unnecessary movements and other defects such as mixture and missing of carcass which leads to reassessing, wait, and defects. Table 2 shows non value adding activities identified in the existing value stream

$$\begin{aligned}
 \text{Takt time} &= \frac{\text{Net available time (in minutes)}}{\text{Customer demand}} \\
 &= \frac{540 \text{ minutes}}{50 \text{ cattles}} \\
 &= 10.8 \text{ minutes}
 \end{aligned} \tag{1}$$

From the current study, rollers were proposed to be used to reduce delays experienced when an operator transport some carcass and skinned heads by their backs. Recommendation were made to the research company to consider using pull manufacturing which encourages smooth flow of carcass and reduces some delays within the production line; rather than the batch production that the company is currently using. Future state was mapped and is shown in Appendix A.

Table 2: Non value adding activities

|                        | People/workers            | Machine                 | Material             |
|------------------------|---------------------------|-------------------------|----------------------|
| Non Value Adding (NVA) | waiting for machine       | setup time              | handling carcass     |
|                        | waiting for carcass       | unscheduled maintenance | moving carcass       |
|                        | searching for tools       |                         | Transporting carcass |
|                        | unbalanced work load      |                         | sorting cattle's     |
|                        | sorting condemned carcass |                         | inspecting carcass   |
|                        | inspecting product        |                         |                      |
|                        | fixing equipment          |                         |                      |

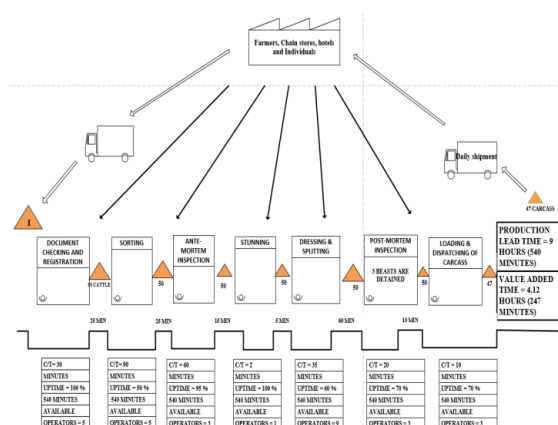


Fig. 1: Current state map

#### IV. CONCLUSION

This paper has examined application of value stream mapping in a beef abattoir. Current value stream was mapped with the help of time study to better understand the process cycle time. The study relived that more time is wasted in handling the carcass within the production line hence possible opportunities can also be explored in better methods of carcass handling such as use of rollers. By doing so it is feasible to improve cycle time efficiency of a projected 21- 23% process cycle time improvement. Value stream mapping has proven to be effective way to analyze abattoir's current production state and point out problem areas.

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#### APPENDIX

##### APPENDIX A: FUTURE STATE MAP

