Analysis and Reduction of Waste in Beverage Industries Using Pareto Principle and Value Stream Mapping

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Abstract-
Elimination of waste has been the focus of beverage industries in Nigeria and in so many parts of the world. A lot of tools have been employed in the analysis and reduction of waste without the in-depth studies of the origin of these wastes. This present work carried out in-depth studies on the cause of waste in the beverage industry concentrating on canned beverages. Primary data were collected from a beverage industry, assessment of the production line and packaging section were carried out and the managers and employee were interrogated so as to obtain information used for this research. The data were analysed using the Pareto principle and the information obtained was used to design the current and future state mapping of the industry. The Pareto chart shows that production line and distributors constitute more than 90% of the channel of waste while the in-house and transit waste constitute less than 10%. The future state mapping proposed a reduction in the manpower from 17 to 12 which represents 29.41% reduction and this will go a long way to affect the industries annual expenditure. The lead time was also reduced by 15 seconds, although this time seems small, the accumulation of this time is a whole lot in production.

Keywords: VSM; Pareto; Industry; Beverages; Wastes.

1. Introduction
Production control has been extensively carried out using Values Stream Mapping (VSM) and statistical analysis in several manufacturing outfits in recent time [1]. These have helped to evaluate and improve the procedures required to effectively deliver products or services with minimal itches and wastes. The VSM is a potent method for exposing the section where waste is predominant in any process, not just production [2]. The step by step analysis of production stages using the Value Stream Mapping provides an outcome of whether any stage is value added or not. Value Stream Mapping is preferred to other methods because it shows the flows from the position of demands to the end of all activities after products and services must have been made available [3]. A lot of manufacturing companies and organizations have been tutored on how to generate current state maps as a snapshot of the existing production process; many are still struggling with the creation of future mapping of their value stream. Visually, wastes are identified with VSM and how they can be eliminated or improved on. It provides clear information about every parameter involved [4]. It can be combined with other statistical principles like the Pareto principle to further expose areas of physical wastes. The Pareto principle is a law that states that 80% of waste comes from 20% of causes. In other words, most of the activities have little effect. It also means that 80% of the industries output is produced by 20% of the workers [5] [6]. The Pareto analysis is a technique used where a lot
of possible courses of events are competing for action. It helps to identify the top portion of causes that must be addressed to proffer solution to majority of the problems. [7]. This work contains details of the process and principles of production management. The techniques employed in this work comprise of data collection from the beverage industry, statistical, physical and theoretical prowess which are well outlined.

2. Research Design
This research explores a case study of a beverage manufacturing company located in Agbara, Ogun State, Nigeria. The research was initialized by visiting the company for three days in order to understand their mood of operation and to obtain relevant information on their current production process and production stages that are vital for this work. The information obtained is the number of shifts per day and major task performed in the shifts, break and lunchtime, lead time, manufacturing inventory, change over time, waiting time and the total numbers of operators involved in each operation including data of physical waste and destruction processes which were obtained from the beverage manufacturing company. The cycle and lead time were also computed. This information was used to draw the current mapping state which shows the product flow, process flow, communication and information flow. The amount of inventory and other information from each process was used to analyse areas of value and non-value added. The extent of packaging wastes was also analysed using Pareto statistical analysis principle base on the information obtained pertaining to it and this shows the summary of the waste at a glance.

2.1 Method of Data Collection
Data was collected from a beverage company in Agbara, Ogun State, Nigeria. The instrument used included data storage service and scheduling interview with the company’s managers and employees. Also, some counting was carried out by sampling for the purpose of validation at the company. Observation of the production and packaging was done before the commencement of operation and after operation in order to understand the techniques of operation.

2.2 Information Obtained for the value stream mapping

2.2.1 Lead time (L/T)
The manufacturing lead time is sometimes preferably called production lead time. In production, lead time is similar to that of the supply chain management which is the time between the period an order is placed by the customer to the period it is ready for delivery. Although this includes the time needed to transport raw materials from the suppliers. The transportation time is included because the company needs to have a good knowledge of the arrival time of the raw materials so as to carry out material requirement planning which involves production planning, inventory control and scheduling. Occasionally, lead time might also include the time it takes the company to process and get raw materials ready once it has been received. [8]. The lead time is made of:

- Pre-processing Lead Time: Also referred to as the planning time or paperwork. It is the time needed to make an order for the purchase of items or raw materials.
- Processing Lead Time: This is the time required to produce the desired product.
- Post-processing Lead Time: The post-processing lead time represents the time to make a procured item ready in inventory from the period it is received [9] [10].
2.2.2 Cycle time (C/T)
The cycle time in manufacturing system describes the length of time a specific task is completed from start to finish or the total time taken to produce an operational order. It is also regarded as the time between two consecutive deliveries. A production cycle time is value added, however, some waste can be found in between which must either be eliminated or reduced. In the analyses of the value stream, all the cycle time are summed up and compared to the total lead time and this helps to come up with a conclusion on the production process effectiveness. The cycle time of the product and the available resources for the manufacture of the product determine the overall capacity of a productive process. Production capacity is the output limit of a production line which can be expressed in an output rate. Production cycle time should not be confused with the takt time. While takt time is the duration of time between starting units, the production cycle time is the required time to conclude a unit [11] [12].

2.2.3 Waiting time (W/T)
Waiting time is a component of the cycle time. Waiting time represents the time in which the machine is idle i.e the time when the machine has stopped working. In the manufacturing industry, any delay in production for a period of time is regarded as a waiting time [13].

2.2.4 Changeover time (C/OT)
Changeover is a periodic activity in manufacturing that involves the conversion of a machine or line from running a product to another. The period within which these activities take place is commonly referred to as change over time which can last for few seconds, minutes or hours, depending on the complexity of the production outfit and nature of the machine in operation. It is essential to devise a mechanism of achieving quick change over because it reduces manufacturing cost and this eventually minimise waste. Single Minute Exchange Dies (SMED) is the quick change over techniques that minimise the time waste in a changeover process [14] [15].

2.2.5 Manufacturing Inventory
In production, the list of goods or materials needed for the manufacturing process that is in stock is continuously updated. These materials, goods or parts are referred to as the inventory. Manufacturing inventory can also be described as the idle stocks of visible products that are valuable but still in custody and awaiting final packaging, processing, modification and sale in the nearest future. Management of inventory is a vital function that determines the healthiness of the supply chain and also impacts on the financial fitness of the balance sheet [16] [17]. Manufacturing inventory requires continuous and careful evaluation of internal and external factors and control via review and planning [18]. Most production companies have a set-aside department known as an inventory planner whose responsibility is to continuously evaluate and control the company’s inventory [19]. Inventory can be grouped into three based on function. These are input inventory, process inventory and output inventory [20] [21].

- Input inventories: These are the raw materials, processing consumable such as fuel, bolts and nuts, maintenance items and packaging materials [22].
- Process inventories: Process inventory is the productions that are yet to be concluded at various stages, in various departments. Other examples of process inventories are production scraps and wastes, defectives and rejections [23].
Output inventories: The output inventories are the finished products that are ready for supply or in transit. Rejects, defectives, sales returns, sample stocks and sales promotion could also be referred to as output inventories [24].

2.3 Production Stages in beverage industry utilized in the design of value stream

2.3.1 Cleaning and Sterilization
High level of safety standard and hygiene are some of the major requirement in the beverage manufacturing industry. Cleaning and sterilizing equipment are employed to ensure operational maintenance and safety. These also help in contamination control and consequently keeping the operating cost to the minimum. Beverage packaging uses surface disinfectants and decontamination equipment for product safety and production waste control. In can and bottle line sterilization is achieved with the use of steam. The advantage of the latent heat of vaporization is taken since steam is a gas; this enables heat distribution everywhere in the line. During the sterilization of the can and bottle line, mostly with in-line filters, it is necessary to reduce the output pressure to 1.7 bar or less [25]. The contact of the steam with a colder surface makes the surface condenses and give up the heat and with sufficient delivery of heat, sterilization is accomplished. Substances such as tartrates in the beverage storage tanks cling to the inner walls of the tanks the usual practice is to utilize a pressure washer with hot water to blast the interior of the tank via the gun. Steam offers a reliable and safe alternative not only for cleaning of the tank but also as effective sterilizer without the use of chemicals. In the beverage industry, the same techniques are applied cleaning and sterilization of can line, tanks and pipes. It is desirable to ensure that the inner surface has achieved a temperature of 212 °F (100 °C) after which the steam is made to flow through continuously for at least 15 minutes. Beside the inner applications of steam, it is usually applied on the surface of equipment and facilities to kill or reduce the effect of bacteria in the processing environment [26].

2.3.2 Pasteurization
The filled can is passed through the pasteurization system at a temperature less than 100 °C to eliminate germs or any infectious agents and also to extend the shelf life of the beverage. The heating and cooling that takes place during pasteurization prevent the phase change of the product. It preserves the nutritional value of beverages while ensuring that the natural flavour of the beverage is maintained [27]. However, pasteurization is used in some cases to alter the properties of beverages. In the production, process pasteurization enables the addition of a natural ingredient to the syrup for nutritional value or flavour. In the Pasteurization of beverages with a pH greater than 4.5, a temperature higher than 121 °C is employed. However, for a beverage with a pH less than 4.5, pasteurization can be achieved at a temperature below 100 °C because germs cannot withstand acidic medium [28].

2.3.3 Can seaming and filling
Equipment for the can seaming and filling must be easy to handle for a flexible constant changeover. The beverage seaming equipment is either automatic or semiautomatic depending on the production scale. Can seamer is a special equipment used for capping pop cans made of either aluminium or metal tin [29]. The beverage industry uses rotary filling equipment with high-speed production. The high-speed filling machine shown in figure 3.3 gets about 24,000.00 cans filled in one hour which eventual goes through the conveyor for the sequential arrangement of the cans. The filling machine employed by any production company is a function of their
production capacity and the size of the company [30]. The filling and sealing operations are required to be precise and fast for easy changeover so as to minimize the waiting time. During the filling and seaming operation, the filling head positions the can at the center of operation using gas pressure, remove the air and enables the beverage to the side of the can. The machine positions the lid on the can from the top and gets it crimped in two operations. The lid is engaged by the seaming head from the top and the lid edge is curled by the seaming roller round about the can body. The roller and the head rotate the can in a circle in order to seal it [31] [32].

2.3.4 Coding and marking of the beverage can
Coding and marking are one of the vital tasks in beverage manufacturing company. The coding and making of the beverage can are carried out using coding equipment to print and engrave the products details such as manufacturing date, expiry date, can volume and other important information that is of interest to the customers. This information can also be used in a value chain to track the canned beverage from the production unit to the end user. Code and marking are one of the indicating factors that the manufacturer focuses on building a brand, traceability of products, safety and products quality assurance. The beverage coding equipment has IP55 and IP65 ratings whose operation is reliable in a dusty and wet environment. Laser coders are usually an efficient way of printing information on the beverage packaging which works by altering the body of the can via etching or ablation. In ablation, the outer layer of the can is removed by the laser and ink is printed on it with a visible background. In the case of etching, the surface of the can is melted by the heat from the laser beam leaving a raised mark on it [33].

2.3.5 Shrink wrapping
Shrink wrapping is an aspect of beverage product packaging where shrink-wrapping machine with two sealing bars is utilized to enable high production speed. The shrink wrap is a plastic film polymer that is tightly applied to package beverage cans applying heat to shrink the wrap to the dimension of the product covered. The heat source is either via a shrink tunnel that operates at a full and semi-automatic speed [34].

2.3.6 Stacking/palletizing
This is achieved with the stack and palletizing machine which helps to arrange and package the product on the pallets or crates for easy transportation and handling. Stacking and palletizing plays vital roles in the distribution of the finished product. The pallets are designed to ensure the stability of the product when loading the products into trucks and when they are on transit [35].

2.3.7 Stretch wrapping
The products are stretch rapped using stretch wrappers in order to secure the products. Stretch wrapping reduces damaging of products in the process of transportation [36]. Stretch wrapping can be in the form of a pallet which is commonly known as “pallet stretch wrapping”. This is a type of stretch wrapping where products are stacked on each other on the pallet and the assembly is wrapped.

3. Design and analysis of value stream mapping

3.1 Design and analysis of the current state mapping of the beverage company
The current state value stream mapping of the beverage company is shown in figure 1. This indicates the daily, weekly and monthly production and packaging line of the industry. The
current state value stream shows that it takes 5 days, 130 minutes and 55 seconds for the transformation of the raw material to finished product until it gets to the end customers. The total cycle time was 26 hours. From observation, the number of operators in production was nine (9) which can be reduced considering the demands of the task. Some of the operations can also be merged in order to add value to the operation and also add value to the production. The company employed the concept of mass production ignoring the fact that lead time can be improved by reducing the numbers of operators in some automated sections of the production line. The current state mapping shows that the total waiting time was 55 seconds which can be further reduced. The lead time can also be reduced with improvement in transportation and product loading logistics. This will also help to reduce the hidden wastes and eliminate unnecessary inventory.

Figure 1: Current state value stream mapping for beverage industry

3.2 Design and analysis of the future state mapping of the beverage company
The future value stream state was drawn to propose recommendations and suggestions for the possible reduction of wastes. The future state map in figures 2 improved some areas compared to the current state mapping. If the beverage industry implements all suggestion the lead time will be reduced from 5 days, 130 minutes and 55 seconds to 5 days, 130 minutes 40 seconds, even though the cycle time remains the same. The difference is lead time is 15 sec which appears
small, however, the accumulation of this time over the years is a whole lot. The future value map also reduced the number of operators from 17 to 12. The reduction in the operator is prompted by the fact that most of most the section are automated. Apart from the production section, all other section requires one operator. More so, as indicated in the value stream drawn; only one operator is enough to monitor the pasteurization and the coding operation. This reduction in the numbers of operators, if implemented will go on the save the industry a lot of costs.

Figure 2: Future state value stream mapping for beverage industry

3.3 Pareto Analysis of canned beverage wastes

The summary of the canned beverage wastes and cost analysis of the wastes are shown in Table 1 & 2. These data were extracted from the primary data so as to give a clear view of the canned beverage wastes and their cost-effectiveness. This was extracted for easy evaluation using the Pareto principle of analysis.

Table 1: Analysis of numbers of can wastes

| S/N | WASTE CHANNELS          | BST CANS   | RIB CANS   |
|-----|-------------------------|------------|------------|
| 1   | Production line waste   | 113,533    | 57,912.87  |
| 2   | Waste from distributors | 51,288     | 45,144     |
| 3   | In-house leakages       | 5,899      | 3,926      |
The Pareto chart shown in figure 3 indicates that 96% of the beverage canned wastes come from the production line and the distributors while the in-house and transit constitutes 4% of the waste. This is similar to the chart in figure 4 where 95% of the beverage canned wastes come from the production line and the distributors while the in-house and transit constitute 5% of the waste. These charts revealed that maximum attention is required in the production line and by the distributors for minimal wastes to be achieved. The production line and distributor constitute more than 80% of the waste while the in-house and transit constitute less than 20% of the wastes, it is therefore paramount to re-examine the production line and investigate the distributors so as to reduce the waste magnitude.

Figure 3: Pareto Analysis of number of Canned BST Waste
Figure 4: Pareto Analysis of number of Canned RIB Waste

Table 2: Cost of Waste Can Analysis

| S/N | WASTE CHANNELS            | CANNED BST (N) | CANNED RIB (N) |
|-----|---------------------------|----------------|----------------|
| 1   | Production line waste     | 6,744,995.53   | 3,440,603.61   |
| 2   | Waste from distributors   | 3,047,020      | 2,682,005.04   |
| 3   | In-house leakages         | 350,459.59     | 233,243.66     |
| 4   | Transit leakages          | 74,797.19      | 55,390.12      |
|     | Total                     | 10,217,272.31  | 6,411,242.43   |

Similarly, figure 5 & 6 show the Pareto chart of the cost implication of the canned beverage wastes. Figure 5 indicates that 96% of the waste costs come from the distributors and production line; whereas only 4% was accrued to in-house and transit. In the same vain figure, 6 revealed that 95% of the wastes cost come from the distributors and production line while only 5% was accrued to in-house and transit. These indicate that only 50% of the operations accounted for 96% losses and 95% losses. These thus, are a pointer to the fact that these two areas require proper monitoring so as to minimise humongous waste cost incurred in the industry.
4. Conclusions
The in-depth studies on the cause of waste in the beverage industry concentrating on the canned beverages were carried out. Primary data collected from a beverage industry, assessment of the production line and packaging section, information retrieved from the managers and employee were used to draw the value state mappings and Pareto analysis. The Pareto chart shows that production line and distributors constitute more than 90 % of the channel of waste while the in-house and transit waste constitute less than 10 %. The future state mapping proposed a reduction in the manpower from 17 to 12 which represents 29.41 % reduction and this will go a long way
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