



Evaluation of Value Stream Mapping Application in Pasta Manufacturing: A Case Study of Golden Pasta Company, Lagos

Mauton Gbededo^{1,2,*}, Peter Farayibi², Tiamiyu Mohammed²

¹Department of Mechatronics Engineering, Bells University of Technology, Ota, Nigeria

²Department of Mechanical Engineering, Federal University of Technology, Akure, Nigeria

Email address:

mgbdedo@gmail.com (M. Gbededo)

*Corresponding author

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Abstract: Over the years manufacturing industries faced persistent increase in global competition to the extent that most industries find it difficult to make profits. This unfavorable trend in global competition coupled with high costs of production were responsible for the new trend in business. In order to survive in today's fiercely competitive market, and remain profitable while producing at a lower cost, many manufacturing outfits started thinking on the best way to eliminate wastes through the lean methodology. This work evaluated the application of lean approach of wastes elimination through the application of Value Stream Mapping (VSM) techniques. The manufacturing operations of Fava Long Goods 3 (FLG3) production line of Golden Pasta Company (GPC) was carefully understudied. Data collected from the company's Enterprise Resource Planning system (ERP) and shop floor including feedback from the customers were analysed and evaluated. The results of the evaluation of these data were used to derive the Value Stream Mapping parameters for the developing the current state map and exposure of pasta manufacturing activities that accumulated to wastes generation. A Kaizen Blitz, a lean improvement workshop was held at the workplace where improvement suggestions were made towards the elimination of the wastes. The improvement suggestions were approved and implemented using a series of Value Stream Mapping techniques such as 5S, Kanban pull system, Supermarket pull system, Single Minute Exchange of Die (SMED), Kaizen idea sheet, Lean implementation tracking sheet and root-cause analysis to remove all the identified wastes. The results of the lean implementation showed that Production Lead Time (PLT) was massively reduced from 34.4 hours to 5.04 hours with a 85.3% waste reduction. A practical approach of implementing the value stream mapping, using Microsoft Visio 2016 software was suggested. An actual cost savings of ₦158, 515,200 was realised after third quarter (nine months) of lean implementation between September 2016 and June 2017. This was revealed in the Financial Statements of Accounts approved by the General Manager/Director of the Golden Pasta Company.

Keywords: Value Stream Mapping, Lean Methodology, Production Lead Time, Enterprise Resource Planning

1. Introduction

Pasta manufacturing companies in Nigeria have been facing fierce competition in price differentiation, higher cost of production and distrusted customer's feedback since year 2010 when the first pasta manufacturing company, Golden Pasta started the pasta business. In early 2014, several pasta companies such as Dangote Pasta, Honeywell Pasta and

BUA Pasta find it difficult to cut the high costs of production [1]. In the middle of the year 2015, several of these pasta manufacturing adopted some lean approaches to cut production costs such as mass production, quality demerit matrices, 5S methodology, Total Productive Maintenance, reliability management etc. but instead of reducing their production costs, most of these methodology resulted to higher costs of production and decreasing customers'

satisfaction as a result of higher delivery time and significant amount of scraps. The reasons for this persistent rise in production costs was as a result of the non-value added manufacturing activities that gulped up most of the initial capital invested without any value addition to the customers. Most of these non-value added manufacturing activities were mere wastes that are often neglected which later boomeranged at the end of the lean implementation. Lean manufacturing philosophy was practiced in Japan many years ago with associated cost benefits that includes reduced inventory, reduction in production lead time, and increased customer satisfaction [2]. The core idea about lean methodology is maximizing customer value while minimizing wastes. A lean organization understands customer value and focuses its key processes to continuously increase it. Eliminating these non-value added processes are best done by learning to see through the processes from its input stage to the finished output, and to the point of delivery to customers [3].

Waste elimination should be a priority for any manufacturing industry that is aiming to beat stiff competition, achieved customers' satisfaction at lower production cost because 90% of manufacturing activities are directly or indirectly non-value addition [4]. This research work will explore various lean methods adopted in the past years and look out for opportunities for continuous improvements. The research work focused on application of Value Stream Mapping (VSM) techniques towards achieving quick delivery of customer's request within a short time by identifying the wastes and eliminates them from inception of raw material to the point of delivery to customers, and deliver the expected cost benefits for the overall lean improvement objective of the manufacturing company.

1.1. Definitions of Value Stream Mapping

A Value Stream includes both value-added and non-value added elements that occur to a given product from its inception through delivery to the customer. A Value Stream is all actions currently required to bring a product from raw material to the arms of the customer or through the design flow from concept to the point of delivery to customers. Value Stream Mapping (VSM) is a lean technique that was first developed in 1990 by the Toyota Production System (TPS) in the automobile industry. Value Stream Mapping has been deployed to other automobile industries and construction companies with results showing significant wastes identification and elimination.

Value Stream Mapping (VSM) is a hands-on process to create a graphical representation of the process, material and information flows within a value stream. It is a planning tool to optimize the results of eliminating wastes. It simply entails drawing the current state map of the manufacturing processes, material and information flow, then identifying and eliminating the non-value added activities through lean techniques and finally mapping the future state map for the lean organization. The relationship between VSM and Lean is depicted in Figure 1.

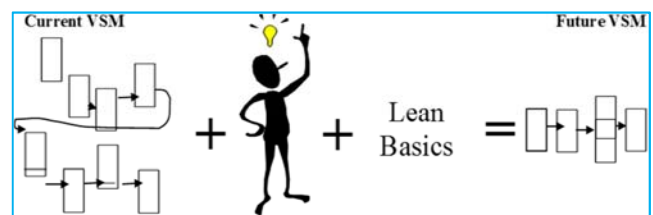


Figure 1. Value Stream Mapping and Lean Relationship.

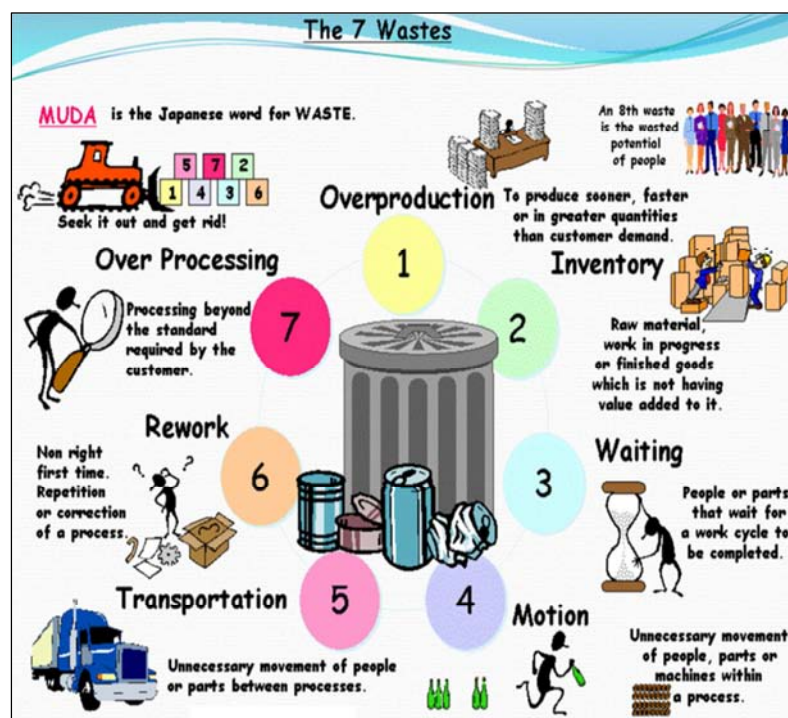


Figure 2. Types of Wastes.

1.2. Types of Wastes

According to the Toyota Production System (TPS), there are seven original wastes known as “muda,” which means “waste” in Japanese [5]. Waste is any activity that absorbs resources and creates no value. TPS was the pioneer of lean philosophy in 1980s, which was later conglomerated into Lean Manufacturing System, LMS in 1999 [6]. In order to create a lean working environment, these wastes need to be identified and depleted. The seven wastes of lean manufacturing include;

- i. Overproduction
- ii. Defects.
- iii. Waiting
- iv. Inventory
- v. Unnecessary motion
- vi. Transportation
- vii. Overprocessing

Figure 2 shows the description and activities that resulted to these wastes in a manufacturing outfit.

1.3. Significant of the Research

The research work was done, to establish the Value Stream Mapping (VSM) parameters, analyse production operations for a single pasta production line and establish a future state

map in order to eliminate wastes and achieve customer's delight in manufacturing. This Value Stream Mapping technique contributed to the knowledge of the application of lean methodology in food industries and validated that it was an effective tool in wastes elimination and also established that Value Stream Mapping when properly implemented could serve any manufacturing company to achieve lean implementation fully.

1.4. Objectives of the Research

The specific objectives of the study are to:

- (a) develop a current state map of the spaghetti production line and identify non-value and value added activities along the production processes
- (b) carry out problem solving techniques to eliminate wastes; and
- (c) propose a future state, operate and evaluate performance using the future state map.

2. Research Methodology

The following Value Stream Mapping (VSM) methodology were applied along Golden Pasta company (GPC) spaghetti production line to achieve the research objectives.

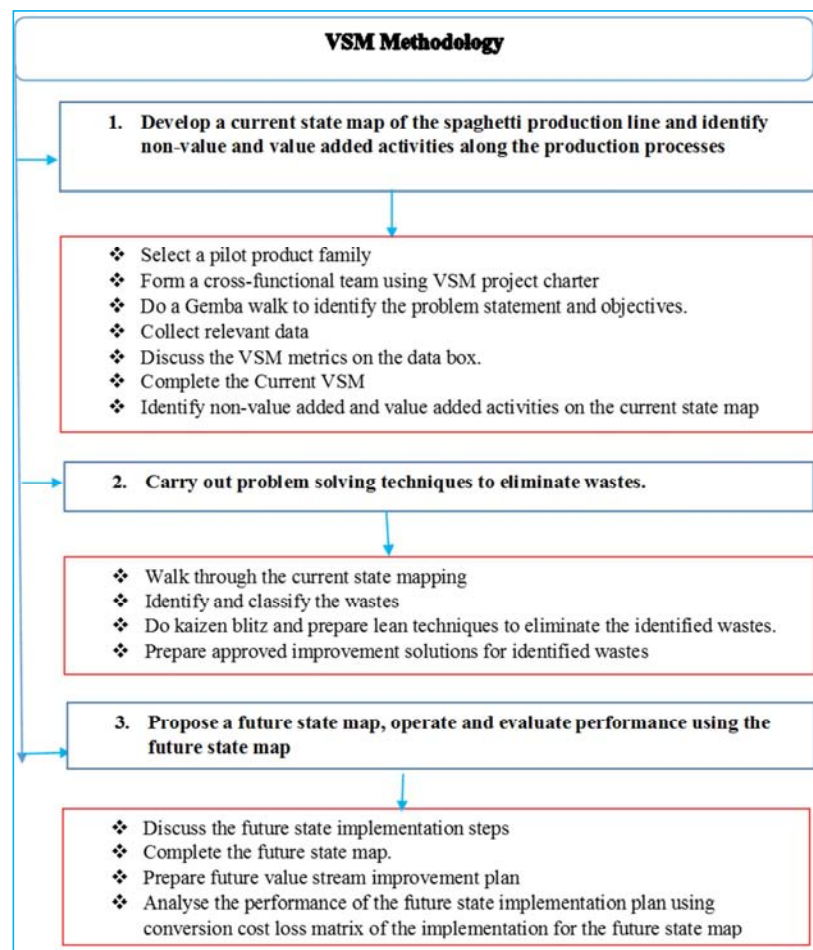


Figure 3. Research Methodology for Golden Pasta Company.

2.1. Develop a Current State Map and Identify Value and Non-Value Added Activities

The section discussed the method of analysis used to develop current state map of the spaghetti production line, identify non-value, and value added activities (value stream) along the production processes.

a. Select a pilot product family

The first step towards developing a current is to select the pilot line in order to simplify the application of value stream mapping techniques. There are six production lines in Golden Pasta having the same sequences of operation and producing the same brand of spaghetti pasta. Investigation was carried

out along the six production lines using a lean statistical method called “Production Line-Breakdown Matrix to determine the pilot production line [7]. The Production Line-Breakdown Matrix is a graphical representation production line versus number of breakdowns per machine for a given period. The production lines were represented on the x-axis while the number of breakdowns were represented on the y-axis of the graph.

The Table 1 represents the Enterprise Resource Planning (ERP) data for number of machine breakdowns between 2012 and 2016 for the six (6) production lines for spaghetti manufacturing.

Table 1. Production lines output by Number of Breakdowns from Year 2012-2016.

Production Line	Number of Breakdowns Per Year				Total	Average
	2015-2016	2014-2015	2013-2014	2012-2013		
FLG1	411	356	324	300	1391	347.75
FLG2	443	342	234	235	1254	313.50
FLG3	452	421	339	348	1560	390.00
FLG4	421	404	359	308	1492	373.00
PLG1	432	401	342	234	1409	352.25
PLG2	411	399	321	347	1478	369.50

The analysis of the PL-Breakdowns Matrix was depicted in Figure 4.

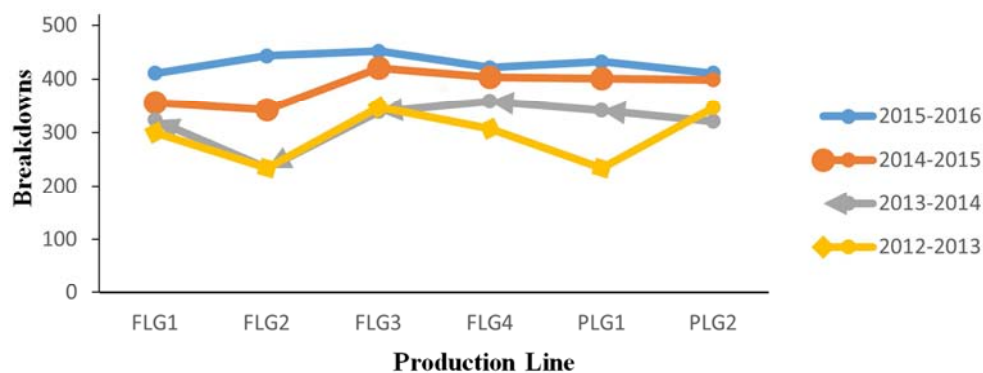


Figure 4. Production Line-Breakdowns Matrix for Spaghetti between Year 2012 and 2016.

The values of the PL-Breakdown Matrix as shown in Figure 4 revealed that Fava Long Goods 3 (FLG3) predominantly increases in breakdowns (which includes all downtimes due to machine failures) between Year 2012 to 2014 more than the remaining five lines FLG1, FLG2, FLG4, FLG5, and FLG6. Since these bottlenecks occurred most in FLG3 throughout the years under review, it was selected as the pilot production line.

b. Form a cross-functional team

At the first phase of the project, a Value Stream Mapping (VSM) Project Charter describing the subject matter was drawn with the General Manager/Director (GM/D) on day1 after discussing the thesis proposal. Briefing session was held at the Company's conference room with the top executives for 3 days. The session involved, training the top executives of the management team on VSM fundamentals, setting goals and objectives of the VSM, selection of mapping team and sign-off of the project by the GM/D (executive sponsor). A cross sectional mapping team was formed. The Team

members includes the shift manager, ERP administrator, operator, warehouse manager, quality control supervisor and the external customer. Besides attending meetings with the team, the external customer key role was to actually define the value from the customer's perspective. All the team members were trained on the lean methodology, collecting relevance data for value stream, and drawing, lean methods to identify wastes and lean improvement strategies.

c. Walk through the entire production processes

The purpose of performing a workplace walk-through the entire production processes is to visualize the current state situation and understand how each process are interrelated in the transforming of raw material into finished goods from inception of raw material to the point of delivery to customers and establish problem statement of objectives. The mapping team constituted on the project charter, led by the Production Manager were deployed at this stage. Gemba walk was conducted and joined by all the team members including Fava Long Goods 3 (FLG3) process operators,

process supervisor, stripper operator and packers so that a full understanding on the operations and manufacturing processes can be obtained and to ensure the process owners do it by themselves. Detailed of the manufacturing operations were summarised below [8].

Raw material supply

The Golden Pasta Company (GPC) production operations runs two shifts per day (12 hours per shift) and seven days a week production schedules. The planning department raised monthly transfer orders for semolina supply to GPC using Enterprise Resource Planning ERP electronic platform. Raw material semolina supplied via bulk truck by Flour Mills of Nigeria Plc (FMN) is first weighed on arrival at the GPC factory. The trucks are positioned at the nearest discharge point where three Quality tests (moisture analysis, granulation, and high base tests) are performed before discharging into the silo bins. The semolina discharged into silo bins are transported to the feeder (hopper) in the FLG3 production line via pneumatic automation system.

Mixing and spreading processes

The next production stage is the mixing of semolina and water at the pre-mixer to form dough. The dough undergoes compression at the extrusion unit and strands of spaghetti are formed with the aid of a die at the die chamber. The strands of spaghetti formed are conveyed into the sticks at the spreader unit. The sticks-carrying pasta are transported into the pre-dryer unit through the intermediate chain assembly.

Pre-drying process

At the pre-dryer unit, initial amount of moisture is removed from the pasta strands through thermoregulation process using circulating pumps and ventilation fans driven by electric motors. This involves the removal of initial water added at early stage of the process via: conduction, diffusion, evaporation.

Drying process

The Pasta moves to the dryer through a chain drive. At the end of the drying process, the pasta still has quite an elevated temperature. But from this moment on, the temperature of the product start decreasing in order to reach values (temperature, pressure and humidity) close to the ambient ones. The main aim is to avoid that the surface of the pasta drying up too much and too quickly which normally leads to cracked spaghetti.

Humidifying process

The dried pasta is transported through into the humidifier unit in order to stabilize the product once the drying phases are terminated. Here moisture content M_t of the product is increased by 0.5% to attain 12.5% total moisture.

Cooling process

The pasta moves through the chain drive to the cooler. In this phase, the product is cooled until ambient temperature is reached. The cooled product which has attained the desired stability is transported by roller chain drive to the storage silos, where the material would be called for packaging.

Stripping process

The next stage of the production process is the stripper unit, where spaghetti strands arranged on sticks are moved by

chain and accumulator to the stripper cutters where pasta strands are stripped off from the sticks cut into sizes and the plain sticks removed back to the spreader unit through the lowerator and chains. The off-cut materials stripped and cut off are manually packed into bags as Talia while the remaining stripped length of the pasta strands are packed into sachets as finished product, spaghetti.

Elevator and packaging processes

The sized spaghetti length, measuring 21cm each are transported by means of elevators and conveyors to the packing machines where the finished products are packed into sachets, with each sachet weighing 500g. Arrangement of spaghetti sachets into cartons are manually done by operatives. Each carton contains 20 sachets of pasta each. Cartons are arranged on wooden pallet manually while each pallet contain 80 cartons. The pallets are then moved to the transit area by forklift. Finished product remains in the transit area for 24 hours for inspection and counting operations to the warehouse for storage.

Warehouse processes

The products are stacked on the pallets for a long time in the warehouse and there is no effective procedure for First-in First-out (FIFO). Products demand is considered in the customer service department, a sub-unit of the sales department when a customer walks-in or calls to place an order while on queue. The total number of customer's orders received in a month are sent to the logistics department while annual sales forecast is forwarded to production planning department by sales team. Golden Pasta Company, is currently meeting demand raised the customers but at a longer lead time and with several production bottlenecks.

After the walk-through was completed, the following problem statements were observed;

- i. It takes a longer production lead time to fulfil customers' requests.
- ii. Customers' demand are met but with several delays and bottlenecks.
- iii. Downtime due to equipment failures were not resolved. This has contributed to low Overall Equipment Efficiency (OEE).
- iv. Major quality issues on the die such as cracked and spotted spaghetti impedes production output.
- v. Operators and material handling operations were not well utilized.
- vi. High inventory cost due to over-production and damages to finished products were discovered in the production floor and warehouse.

d. Collection of data

The next step towards the development of Current State Mapping after the walk-through exercise, is data collection, which started on the twelfth day from the point of raw material supply to the point of shipping to external customers. The whole data collection exercise lasted for two weeks. At the end of the twenty-sixth day, the following data were collated.

Customer requests

The data is used to determine the customer's demand,

which was collated from shop floor daily production reports and customer request orders in Enterprise Resource Planning, ERP. The analyzed data was shown in Table 2.

Table 2. Customers' Requirements for Spaghetti.

S/N	Customer Requests	ERP Data
1	Customer order, Co	320,000 Cartons (per month)
2	1 Pallet	80 Cartons
3	Number of pallets sold Np	4,000 pallets (per month)
4	Receiving days for orders	25 days per month
5	Average Demand, Dv	12800 Cartons (per day)
6	Maximum demand, Max. D	13320 Cartons (per day)
7	Minimum demand, Min. D	12640 Cartons (per day)
8	Loading days for customers	20 days per month
9	Working period, Wp	8 hours per day

Customer demand for spaghetti as shown in Table 2 was 4,000 pallets in a month.

Supplier's information

A total of 20 bulk trucks is normally supplied on weekly basis and once delivered; it is stored in silo bins for further processing. The suppliers' transfer orders obtained from the Enterprise Resource Planning data is shown in Table 3 for more details.

Table 3. Suppliers' Transfer Orders for Raw Material.

S/N	Raw Material Information	ERP Data
1	Supplier order, So	20 trucks (per week)
2	One bulk truck	35,000 kg or 35 tonnes
3	Fava Long Goods 3 operating capacity, Opt	4500kg/hour
4	Current operating hours, Oh	24 hours per day
5	Current output, Nos	420 sticks per hour
6	One stick, Ns	8kg of pasta
7	Number of shift, Ns	2 (Morning and night)
8	Working hours, Wh	22 hours per day
9	Break hours, Bh	2 hours per day

The above information become necessary to meet customer's target. The purpose of doing this is to find rate of customer demand through the "Takt time"

Takt time

Takt time is the rate at which products or services should be produced to meet the rate of customer demand. It is derived from the German word, Taktzeit, which is often referred to as heartbeat or drumbeat of production in lean manufacturing. The value, in conjunction with current production rates, is used to analyze pokes loads, bottlenecks, and excess capacity. In any VSM, it is fundamental to determine the 'Takt time' for the current production operations of the FLG3 production line before drawing the future state map. The data derived from the ERP as shown in the Table 4 was used to analyze the Takt time.

Table 4. Takt Time data for FLG3 Production Line.

Data for Calculating Takt Time for GPC FLG3 Production line		
A	Customer Demand Rate	Shop floor Data
1	Demand, De	4000 Pallets per month
2	Number of shifts	2
3	Demand rate, DA	2000 Pallets per month
4	Customer delivery, Cd	20 days per month

Data for Calculating Takt Time for GPC FLG3 Production line		
5	Delivery time, Lt	8 hours per day
B	Available Time/Unit of time	ERP data
1	Working days, Wd	28 days per month
2	Total Working hours, Th	24 hours per day
4	Break time, Bh	2 hours per day
5	Available time, Ta	616 hours per month
6	1 hour	60 minutes
7	Available time	2 hours per day

At the end of the data collection, analysis and investigation, it was observed that GPC were not meeting the current delivery to customers which was found out be 20 days per month while orders were placed 25 days in a month. The available time irrespective of breakdowns and planned maintenance was 36,960 minutes per month while the demand rate was 2000 Pallets per month.

Mathematically,

$$\text{Takt time, Tk} = T_a / DA \quad (1)$$

where; T_a is the available work time/unit of time,

DA is the customer demand rate

From the value of Takt time in equation 1, it follows that Golden Pasta; FLG3 Production line must produce 1 pallet (80 cartons) of spaghetti every 18.48 minutes to meet customer demand within the available time. The Take Time value is again used to determine the "Cycle Time" which is the time required to complete a process i.e. drying.

Cycle time

Cycle time CT: It is the time required to complete a process or make a part. In this research work, the cycle time is the time to complete a process i.e. drying, which includes the process time, inspection time, move time and wait time etc. Cycle time, CT was measured with a standard stopwatch in minutes. The values for cycle time appear at the troughs of the VSM timeline. The cycle time comprises both Value added cycle time (VACT) and non-value added cycle time (NVACT).

Mathematically,

$$CT = VACT + NVACT \quad (2)$$

Inventory time

Inventory time IT: Inventory time value for the inventory shapes that appear on the peaks of the timeline.

Mathematically,

$$\text{Inventory time IT} = Q / Tk \text{ (minutes)} \quad (3)$$

where,

Q = Inventory Quantity (Pallets)

Tk = Takt time (minutes per Pallet)

The value of the Cycle Time and Inventory time were used to evaluate the plant efficiency. The value stream mapping parameter used to measure the plant efficiency is called the Overall Equipment efficiency, (OEE).

Overall Equipment Efficiency

Overall Equipment Efficiency, OEE: The results of the data analysis of the cycle time, inventory quality, and Takt time were used to determine the Productivity, Availability

and Quality rate for spaghetti manufacturing processes. The results obtained were further used to determine the Overall Equipment Efficiency (OEE), a lean metric used to evaluate how effectively a manufacturing operation was utilized. It is commonly used as a key performance indicator (KPI) in conjunction with lean manufacturing efforts to provide an indicator of success.

Mathematically,

$$OEE = \frac{P.A.Q}{100} \quad (4)$$

where;

P is performance, A is availability, and Q is quality of product.

P = Parts produced X ideal cycle time/Operating time

A = Net operating time/Scheduled time

Q = Units produced-defective units/Units produced

At the end of these data collection, analysis and evaluation, the results obtained were used to develop the Current State Mapping.

e. Identification of non-value and value added activities

The non-value added activities constituted the real time wastes, this thesis tends to identify and consequently eliminate. It was achieved by walking through the current state mapping by a cross-functional mapping team involving senior, middle and shop floor staff who were actually working at the Gemba. The full participants of the team members foster team building and brought about, the expected cultural change required for the sustenance of continuous improvement. The main purpose of walking through the current VSM as is to expose opportunities for improvements and help in prioritizing them. The walk through was led by the GM/D (sponsor) alongside the mapping team with guidance from the researcher (facilitator). It lasted for two days (4 hours per day). This session involved looking at the processes, material flow and information flow, step by step until we got to the finishing point (customer). The Current State Map were segregated into four loops namely; Supplier Loop, Processing Loop, Packaging Loop and Customer Loop. Each loop on the Current State Map was thoroughly understudied by dedicated mapping team who has a thorough knowledge of all the activities under the loop. At the end, the wastes were spotted out clearly along the seven tenets wastes of lean manufacturing which includes;

- i. Overproduction (OP)
- ii. Defects (DF)
- iii. Waiting (WT)
- iv. Inventory (I)
- v. Unnecessary motion (MO)
- vi. Transportation (TP)
- vii. Overprocessing (OPR)

The identified wastes were mapped out along the entire Current State Map using a Kaizen burst icon. The mapping team agreed on six Key Performance Indicator to drive the company objective of meeting customers' requests and reducing cost. The KPIs consists of Productivity, Delivery, Quality, Cost and Safety. The results of the KPIs were used

to evaluate if VSM methodology will be a success or failure in eliminating wastes, achieving customers' requests at shorter time and saving cost of production.

2.2. Carry Out Problem Solving Techniques to Eliminates Wastes

The lean technique employed for eliminating the identified wastes is called "Kaizen Blitz".

Kaizen Blitz Method

Kaizen is a Japanese word for continuous improvement while Blitz also means, "lightening fast". Kaizen Blitz is an intensive and focused approach to process improvement. A Kaizen Blitz method is a rapid improvement workshop or event designed to produce results to discrete process issues within a few days. It is a way for teams to carry out structured, but creative problem solving techniques in a workshop environment, over a short time scale. The Kaizen Blitz event is divided into three stages; Preparation, The Blitz Event and Follow-up.

i. Preparation: The preparation stage involves preparation of agenda for the work, setting goal, preparation lean tool sheets to be used for the main blitz event and compiling of Current Value Stream Mapping data and information for pilot line FLG3.

ii. The Blitz Event: This involves taking the detailed video of current state activities, investigating the current video records of identified wastes as captured on the time observation sheets and circulation of identified wastes documents for current VSM among team members, brainstorming sessions to find the root causes of the wastes, making and approving improvement suggestions, applying the improvements suggesting directly on the all the areas of wastes segregation along the current state mapping to eliminate the wastes. The results of the improvement suggestions implemented were documented using the lean improvement tools such as Kanban tools, Supermarket Pull system, 5S Checklists and Oval and Kaizen Worksheet.

iii. Follow-up; Involved details checks and action on new changes, reviewing the progress results, taking videos of the new processes after lean implementation, test-running the solutions to avoid difficulties/bottleneck, re-planning and scandalizing results.

2.3. Proposed Future State Map, Operation and Evaluation of Performance

This section will discuss, the proposed Future State Map drawn after wastes elimination, setting of goals and objectives of each of the four loops as earlier discussed, followed by the yearly lean improvement plan to be implemented, and evaluation of performance using the Future State Map.

a. Development of the Proposed Future State Map

The proposed Future State Map was drawn using with all the Kanban tools, and Improvement suggestions implemented after carrying out the Kaizen blitz method.

b. Setting of Goals and Objectives for Future State

Operation

The main goal of drawing the future steam map is to build a production chain where each processes would be linked to the external customer (s) by either continuous flow or pull and ensuring that these processes were close as possible to produce only what the customer only needed. This was achieved by prioritize objectives and goals along the four loops established during the waste identification exercise. The following implementation steps were taken on each of the value stream mapping loops to operate future steam map.

Loop 4: Customer Loop

The objectives to be achieved are

- i. Determine the takt time,
- ii. Establish buffer stock to address demand fluctuations
- iii. Initiate a continuous flow from between stacked FG (finished goods) and loading by replacing the manual loading conveyor with an automatic belt conveyor.

The main targets/goals to be achieved at the customer loop are

- i. Produce to customers' requests
- ii. Zero finished goods inventory (except the buffer stock).

Loop 3: Packaging Loop

The objectives to be achieved are

- i. Produce to the Takt time,
- ii. Initiate a continuous flow from stripping operation to the warehouse entry by installing an automated conveyor belt from packing machines to the warehouse entry point that in order to transfer finished goods directly to the warehouse. This will eliminate cartonizing operation and reduce palletizers from 12 employees to zero.
- iii. Implement kaizen to reduce cycle time from 1,567 minutes to 33 minutes
- iv. Increase uptime at stripping, elevator and packing processes to 95%
- v. Establish supermarket pull system between stripping and elevator processes to control excess inventory.
- vi. Introduce continuous hourly quality control checks on the packed products between packing and the automated belt conveyor and eliminate the 24 hours non-value added time at the transit process.
- vii. Eliminate excess packing material inventory at the production floor by using a kanban card every 4 hours to keep material inventory in check between the material supplier and the cartonizing operation.
- viii. Establish a FIFO system to prevent over-production and storage of unwanted stock at the warehouse
- ix. Maintain a buffer stock of 1,100 cartons of finished goods at the warehouse operation to meet fluctuating customer's demand at peak period.

The main goals/targets to be achieved at the packaging loops are;

- i. Only 160,000 kg of pasta stands should be supplied to the stripper unit from the finished good silos with only 1.3 minutes of inventory time allowed on a continuous flow.

- ii. Maximum packaging material supplier to the production floor should not exceed 2,500 in every 4 hours while the wrapping reels should not exceed 64 reels within the same period.

iii. Zero scraps

Loop 2: Processing Loop

The objectives to be achieved are

- i. Establish continuous flow of material between the flour dosing and mixing.
- ii. Carry out kaizen to eliminate Work-In- process (WIP) inventory between the spreader the pre-dryer process.
- iii. Introduce daily production schedules.
- iv. Increase uptime from the mixing to the cooler unit to 100%
- v. Carry out kaizen to eliminate the root cause of failing sticks at the stripper entrance.

The main goals/targets to be achieved at the processing loops are;

- i. Only 4.5 seconds of flour dosing time and 1 minute of mixing time allowed.
- ii. Zero WIP
- iii. Zero scraps

Loop 1: Supplier loop

The objectives to be achieved are

- i. Initiate and sustain a load levelling balance of raw material supplier into the silo bins.
- ii. Eliminate all quality inspection tests prior to semolina discharge by establishing, quality conformance assurance with Flour Mills of Nigeria (FMN) Plc.
- iii. Eliminate wastes at charging point through the entry of only 100% certified reliability-tested bulk trucks for raw material discharge.
- iv. Merge the raw material supply for further processing at the processing loop using a kanban pull system to eliminate excess inventory.
- v. Reduce the size of bulk supply of semolina from 30 tons per truck to 20 tons per truck.

The main goals/targets to be achieved at the processing loops are;

- i. Only 40 minute of charging time allowed throughout the day on a continuous production
- ii. Zero WIP at the spreader unit
- iii. Increase uptime at the flour dosing operation to 100%.
- c. Preparation of Yearly Improvement Plan for Future State Map

The Future State Map gives a picture of where Golden Pasta desire to go. In order to accomplish this onerous task. All the goals and objectives intended to be achieved were incorporated into a yearly improvement plan. The implementation plan was created to reveal;

- i. Exactly what Golden Pasta plan to do with details in sequential order
- ii. State/review clearly the measurable goals that would be accomplished with clear checkpoints of the deadlines and the names of person (s) that would be responsible for the execution of the goals.
- iii. Highlight clear checkpoints with practicable deadlines

and detailed particulars of the person (s) responsible for reviewing the plan.

An interactive forum was held at the Golden Pasta Conference room on the second week of September 2016, to re-evaluate the set targets to be achieved for the realization

and sustenance of the proposed future state map. At the end of meeting that lasted for three hours, a Value Stream Mapping improvement plan shown below was drafted by the team,


VALUE STREAM PLAN +A1:L35					Signatures							
DATE	SEP. 15TH, 2016				Site Manager	Engineering		Quality Assurance				
PROD. MANAGER	Shonibare Ayodeji											
V.S.MANAGER	Yiannis Katsichtis											
FACILITATOR	Mauton Gbededo				Yearly							
Product-Family Business Objectives	Value Stream (VS) Loop	Value Stream Objective	Goal (Measurable)	2016/17				Person in Charge	Dept.	Reviewer Schedules		
				Q1	Q2	Q3	Q4			Reviewer	Date	
1. Improve profitability in Spaghetti Manufacturing	4. Customer Loop	Continous flow from point of loading and customer's truck	Increase uptime time to 100%									
	3. Packaging Loop	Continuous flow from Stripping to elevator process	Zero WIP									
			Increase uptime to 95%									
		Introduce quality control process at the the terminal of the packing machines	<1.3 minutes of inventory time									
			Hourly quality checks									
	2. Processing Loop	Continuous flow between flour and mixing processes	Zero transit operation									
			<4.5 seconds of dosing time									
			<1 minute of Mixing time									
	1. Supplier Loop	Kaizen to 2 minutes at spreader unit	100% uptime									
			Zero WIP									
		Continuous flow for further flour processing	Zero WIP at the spreader unit									
			Increase uptime to 100%									
2. Reduced cycle time	4. Customer Loop	Eliminate repeated weighing	<40 minutes of charging time allowed									
			Daily transfer order									
		3. Packaging Loop	Kaizen to reduce current to 33 minutes	Zero WIP								
				<33 minutes of cycle time								
	Eliminate excess inventory of packing material		<2500 cartons every 4 hours									
		<64 reels every 4 hours										
	2. Processing Loop	Daily production schedule	Zero WIP									
			100% uptime									
	1. Supplier Loop	Quality Conformance Certificate	Zero quality inpection time									
		Load levelling and reduced bulk size to 20tons/truck	<40 mins of daily inventory time									
	3. Reduction in scrap level	4. Customer Loop	Eliminate over-stocking	Zero inventory								
				Produce to customer request								
3. Packaging Loop		Elimination of cartonizing process	Redeployment of 12 palletizers									
2. Processing Loop		Kaizen to eliminate failing sticks at cooler entrance	Zero scrap									
			Zero WIP									
1. Supplier Loop		Certified Reliabilty-tested trucks	Zero WIP									
	Daily transfer order											
Legend			PRODUCT FAMILY		SPAGHETTI							
Achieved												
Not achieved												

Figure 5. Future State Mapping Improvement Plan.

d. Performance Evaluation Using the Future State Map

The Accounting department of the Golden Pasta Company was presented with the evaluated implementation plan using all the data gathered so far including non-value added time, cycle time, uptime, productivity, available time,

uptime, scrap level, demand etc. to decide the best way to determine the cost benefits [9]. The cost benefits of implemented plan against targets were summarised in the Cost-Loss Matrix from the Accounts Department as shown in below.


FLG3 CONVERSION COST STATEMENT SEPT. 2016- JUNE 2017

Key Performance Indicators (KPIs)	Metrics Measurements	Actual value Counts :240 days		
		Current	Future	Difference
COST	Material cost (Naira/ton)	4050	1020	3030
	Maintenance cost (Naira/ton)	2302	500	1802
	Power (Energy) cost (Naira/ton)	500	350	150
	Labour cost (Naira/ton)	348	170	178
Total conversion cost savings Naira/ton				5160

GM/D: Yiannis
 N158, 515,200

Date: June 20 th, 2017

Figure 6. Comparison of Current and Future State Map on Cost-Loss Matrix.

The evaluated performance of the nine (9) months conversion costs from the financial statement of the Golden Pasta Company (GPC), directly released by the Accounting Department and approved by the General Manager/Director was used to determine the cost benefits of lean implemented for the elimination of wastes in Pasta Manufacturing.

The conversion cost is defined as the unit cost of transforming a single unit of raw material into finished goods. The composition of the conversion cost varies from one company to another. In a typical pasta manufacturing, the flowing costs made up the conversion cost.

i. Material cost: cost of raw material and packaging materials need for production.

ii. Maintenance cost: Costs of spare parts usage, planned (lubrication, overhauling, preventive and unplanned maintenance (breakdown, corrective and delays due to non-availability o spare parts).

iii. Power costs: These includes the cost of electric supply, gas consumption, diesel consumption, compressed air, heat ventilation and air conditioning systems (HVAC) and lighting.

Labour cost; costs savings from labour optimization, elimination of over production that consumed unnecessary man hour lost

Figure 6 shows clearly the results comparisons of the various conversion costs performance metrics between the current and future state the conversion costs.

In Figure 6 above, the total value of conversion cost savings for 9 months of lean implementation was 5160 naira/tonne

In a day 12,800 cartons of pasta are demanded in average.

$$\begin{aligned}
 1 \text{ Carton} &= 500\text{g} \times 20 \text{ pieces} = 10000\text{g} \\
 &= 10\text{kg or } 0.01 \text{ tonne}
 \end{aligned}
 \tag{5}$$

Therefore,

$$\begin{aligned}
 12800 \text{ cartons} &= 0.01 \times 12800 \text{ tonnes} \\
 &= 128 \text{ tonnes of pasta}
 \end{aligned}
 \tag{6}$$

But,

1 tonne is equivalent to 5160 naira in conversion cost

Finally,

$$\begin{aligned}
 128 \text{ tonnes sold in a day} &= (5160 \times 128) \text{ naira/day} \\
 &= 660,480 \text{ naira/day}
 \end{aligned}
 \tag{7}$$

Golden Pasta ran and made of pasta in 240 days excluding holidays and planned maintenance The achieved cost benefits in 9 months' savings in a year will amounted to;

$$\begin{aligned}
 \text{Cost Savings (Q1, Q2, Q3)} &= 660,480 \times 240 \\
 &= \text{N}158,515,200
 \end{aligned}
 \tag{8}$$

3. Results

The results of evaluation of evaluation of Value Stream Mapping application in Fava Long goods 3 (FLG3)

production line for golden Pasta were presented as follows;

3.1. Results for the Development of the Current and Future State Value Stream Mapping

The results of the Value Stream Mapping (VSM) parameters was presented on the data box on the maps with details of each process flow, information flow and material

from the input stage to the point of delivery to customer. The completed Current State and Future State Maps were drawn using Microsoft Visio 2016, software as shown in Figure 7 and Figure 8. The current state and future state maps have the following processes presented on the map with all the measured Value Stream Mapping parameters

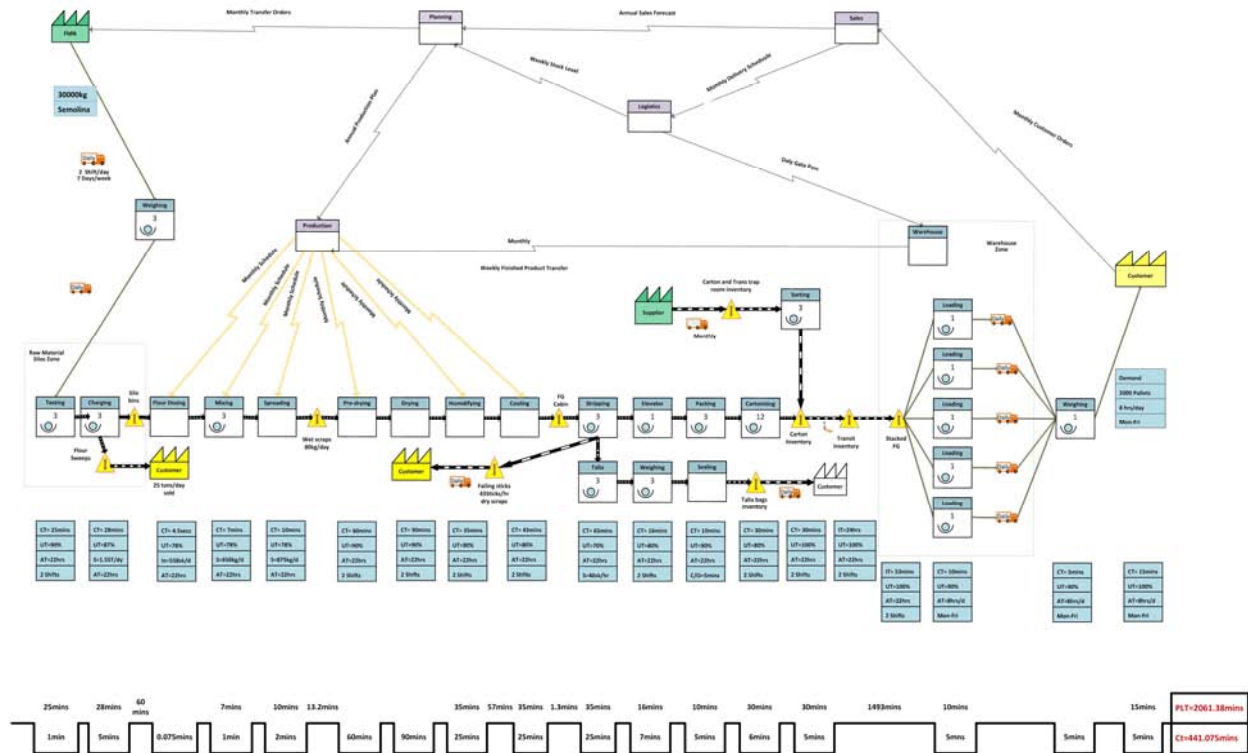


Figure 7. Current State Map for FLG3 Production line.

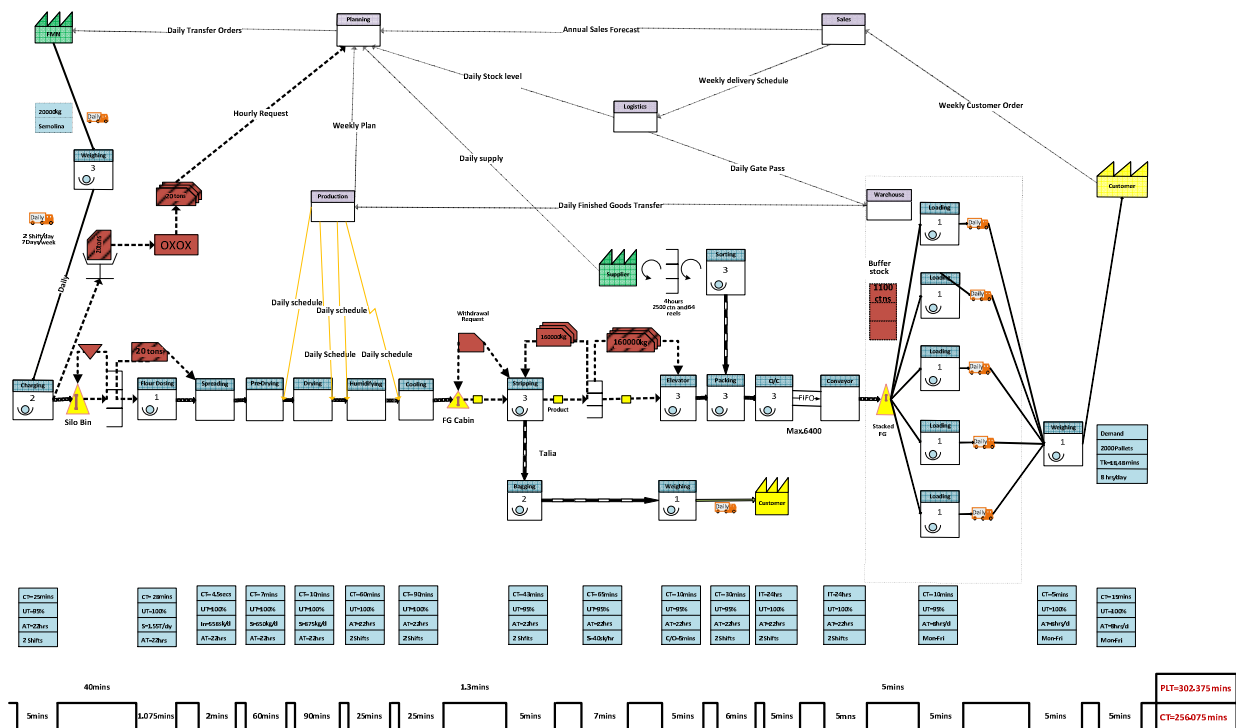


Figure 8. Future State Map for FLG3 Production Line.

3.2. Results of Waste Identification

The following results were wastes identified along the current value stream mapping along the four loops of the production processes -supplier loop, processing loop, packaging loop and customer loop. Each of the identified non-value added activities were spotted with kaizen burst in red colour indicating areas of improvement opportunities and the needs to eliminates these wastes in manufacturing.

The wastes on the Current State Map are marked out with a

- “Kaizen Burst” indicating areas for improvement opportunities from the input state to the point of delivery to customers.
- i. Overproduction was denoted by letters “OP”
 - ii. Over processing was denote by letters “OPR”
 - iii. Defect was denoted by letters “DF”
 - iv. Motion was denoted by letters “MO”
 - v. Waiting was denoted by letters “WT”
 - vi. Inventory was denoted by letters “I”
 - vii. Transportation was denoted by letters “TP”

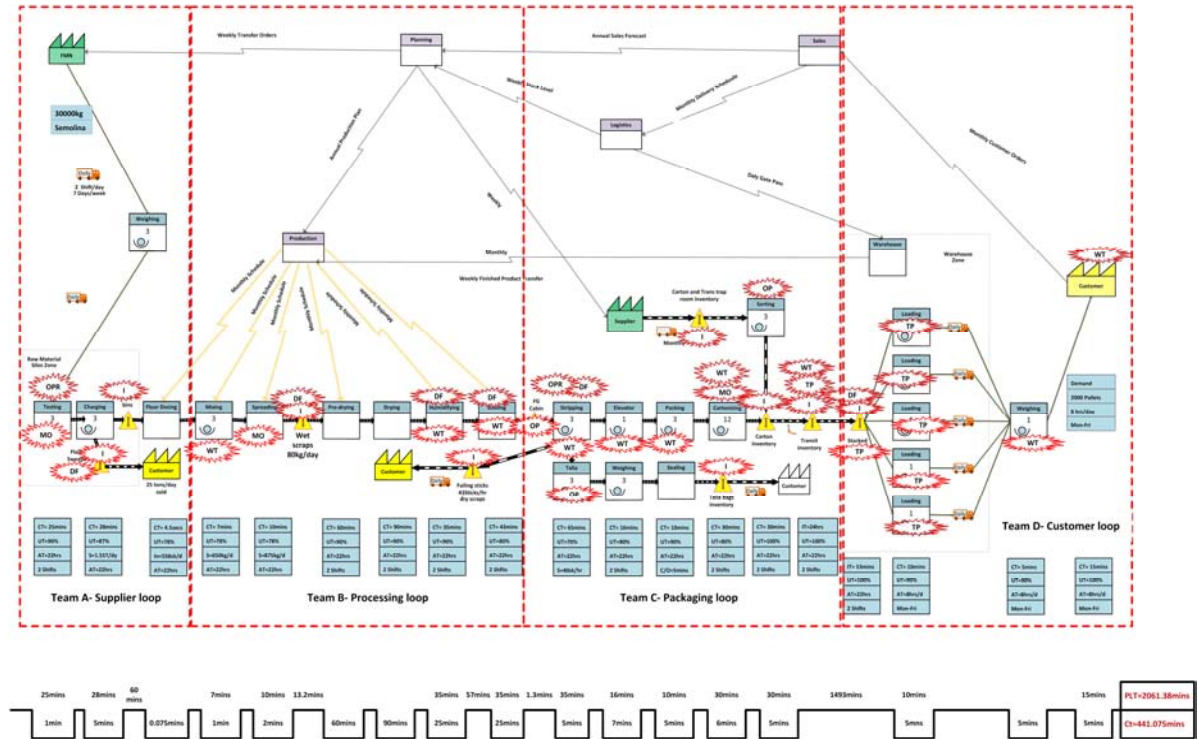


Figure 9. Identified wastes on Current Value Stream Map.

3.3. Results of Wastes Elimination

The outcomes of the Kaizen Blitz workshop carried out for the eliminating of wastes for each process on the current VSM were discussed below in Table 5, 6, 7 and 8 accordingly.

- a. Supplier Loop
- Kaizen improvements results from lean implementation were in Table 5.

Table 5. Implemented Kaizen suggestions for Supplier Loop.

Supplier Loop	Type of Wastes	Kaizen Solution implemented
Quality Testing	Over processing	Records shows that, there have been insignificant number of quality issues from raw material supply from FMN. Since the sister company FMN supply the raw material, a certified test analysis of the raw material from FMN was incorporated to guarantee quality raw material supply to Golden Pasta.
	Motion	Eliminated. All quality tests is now performed by supplier prior to the supplier of raw material to Golden Pasta with authorized signatory that validated raw material quality.
Charging	Inventory	Only ISO certified bulk trucks with history and guaranteed effective maintenance record were allowed for raw material delivery.5S housekeeping were implemented to eliminate inventory at the silo area.
	Defects	Problem solving sheet together with root cause diagram was used to isolate causes of coupling failures. Standard Operating Procedures (SOP) and Preventive Maintenance (PM) checklists were developed to prevent re-occurrence
Silo bins	Inventory	The frequency of daily orders was increased and bulk truck supply was reduced from 30,000kg per truck to 20,000 kg per truck using signal and supplier Kanban.

Attendance: Yiannis Katsichtis, Gbededo Mauton, Oludare Bolaji (Team Leader), Dimitris Fronosis, Shonibare Ayodeji, Simon Enaholo, Kehinde Kazeem (Silo Operator), Ada Amogu (Quality Assurance Manager).

b. Processing Loop

Kaizen improvements results from lean implementation were in Table 6.

Table 6. Implemented Kaizen suggestions for Processing Loop.

Processing loop	Type of Wastes	Improvement Solution
Mixing	Waiting	Single Minutes Exchange of die (SMED) reduced mixing time.
Spreading	Motion	Stick extractor sensor from the stick storage unit was re-located to the press-leg to enable touch-and-go effect.
Wet Scrap	Inventory	Installed conveyor belt to the point of waste accumulation removes wastes. Installed crushing crumbler for recycling to deliver crushed scraps for discharge into the mixer. This action mixed the crushed wet scraps with contents at the mixing unit
Humidifying	Defects	Why-why analysis was done to find the root cause. Sprayer joint alarm was caused by constant deflection of the cam-lever due to piled up sticks. Monitoring the control unit and keeping the gap at 5mm to the stick carrier eliminated the alarm. A conditioned based monitoring program kept the cam-lever in position. Visual marking was done to know when the cam-lever dislocate.
	Waiting	Implemented visual control to rest the control unit every 1 hour prevented hooked sticks from re-occurring and eliminates waiting time.
Cooling	Defects	Why-why analysis was done to find the root cause. Sprayer joint alarm was caused by constant deflection of the cam-lever due to piled up sticks. Monitoring the control unit and keeping the gap at 5mm to the stick carrier eliminated the alarm. A conditioned based monitoring program kept the cam-lever in position. Visual marking was done to know when the cam-lever dislocate.
	Waiting	Implemented visual control to rest the control unit every 1 hour prevented hooked sticks from re-occurring and eliminates waiting time.

Attendance: Yiannis Katsichtis, Gbededo Mauton, Shonibare Ayodeji (Team Leader), Daniel Owhin, Aliogo Ewere (Process Supervisor), Luigi Nicole (pasta Technologist), Andrea Girolimento (Maintenance manager).

c. Packaging Loop

Kaizen improvements results from lean implementation were in Table 7.

Table 7. Implemented Kaizen suggestions for Packaging Loop.

Packaging loop	Type of Wastes	Improvement Solution
FG Cabins	Overproduction	Produced and stored to takt time
	Overprocessing	Overprocessing due to rework of dry-scraps for failing sticks. This was caused by starwheel constant breakage due to misalignment of stick carrier. A calibrated bolt installed eliminated starwheel breakage. Also an alarm will signal once the carrier moves out of position, which stops the machine to avoid starwheel breakage.
Stripping	Defects	Cracked spaghetti was caused by lack of quality matrix for various grades of high base material. Non-effective cleaning of ventilation fans at the dryer and cooler units were addressed by 5S. Implemented quality maintenance matrix with required actual and start-up set- points were incorporated as countermeasures
	Waiting	Waiting as a result of broken starwheel replacement was eliminated.
Talía bags inventory	Overproduction	Kanban pull system set up and implemented prevents overproduction
	Overproduction	Established Kanban pull system eliminates overproduction
Elevator	Waiting	This is due to intermittent tripping off of the elevator motor caused by wrong timing of the calling sensor as a result of bad relays. A conditioned based program for sensor monitoring eliminates elevator motor tripping off.
Packing	Waiting	Minor stops caused by photo eye moving out of position led to constant jaw jamming that stops the machine. SMED implemented led to visual marking that eliminates photo-eye faults and also reduced reel change over to less than 1 minute
Carton and trans-wrap room	Inventory	Established Kanban supermarket pull system where a material handler or pool man, always fills the carton trays with 400 pieces after every 2 hours eliminate excess inventory. Once the carton on the trays are less than 20 pieces, replacement is made from the store room.
Cartonizing	Waiting	Eliminated through the installation of automated belt conveyor
	Motion	Eliminated through the pool man and automated belt conveyor

Attendance: Yiannis Katsichtis, Gbededo Mauton, Shonibare Ayodeji (Team Leader), Daniel Owhin, Aliogo Ewere (Process Supervisor), Shola Adegbite (Headman).

d. Customer Loop

Kaizen improvements results from lean implementation were in Table 8.

Table 8. Implemented Kaizen suggestions for Customer Loop.

Customer Loop	Type of Wastes	Improvement Solution
Stacked Products	Defects	Implement First-in-First-out system (FIFO).
	Inventory	Establish and keep only buffer stock in checks.
	Over-production	Produce to customer request and maintain a buffer stock to address fluctuation in demand.
Loading	Transportation	Replace manual loading with automated loading conveyor belt between the point of loading and the customer awaiting trucks
Weighing and dispatch to customers	Waiting	Eliminate repeated loading at point of loading and the other one at the weighing point I the security point. Only carry out the final weighing since the final weighing is computerised and more reliable.

Attendance: Yiannis Katsichtis, Gbededo Mauton, Patrick Obotu (Team Leader-Warehouse Manager), Akeju Thomas (Logistics Manager), Ahmed Musa (External customer).

3.4. Results for Production Lead Time and Cycle Time

The results of Production Lead time and Cycle Time for Current State Map is shown in Table 9.

Table 9. Current State Total Time Records for Spaghetti Manufacturing processes at FLG3.

FLG3 Spaghetti Processes		Time Observation Sheet (minutes)			
Step	Component Task	CT	VACT	NVACT	IT
1	Quality Testing	25	1	24	0
2	Charging	28	5	23	0
3	Silo cabins	0	0	0	60
4	Flour dosing	0.075	0.075	0	0
5	Mixing	7	1	6	0
6	Spreading	10	2	8	0
7	Wet scrap	0	0	0	13.2
9	Pre-drying	60	60	0	0
0	Drying	90	90	0	0
11	Humidifying	35	25	10	0
12	Falling Sticks	0	0	0	56.76
13	Cooling	35	25	10	0
14	FG cabin	0	0	0	1.3
15	Stripping	35	5	30	0
16	Elevators	16	7	9	0
17	Packing	10	5	5	0
18	Cartonizing	30	6	24	0
19	Sorting	30	5	25	0
20	Transit inventory	0	0	0	1440
21	Stacked products	0	0	0	53
22	Loading	10	5	5	0
23	Weighing	5	5	0	0
24	Dispatch	15	5	10	0
Total time in minutes		441.08	252.08	189	1620.3
Production lead time (PLT) (minutes.)		2061.38=34.4 hrs. or 1 day, 10.4 hrs.			
Total employees=		43 employees			

The results of Production Lead time and Cycle Time for Future State Map is shown in Table 10.

Table 10. Future State Total Time Records for Spaghetti Manufacturing processes at FLG3.

Activities: FLG3 Spaghetti Processes		Time Observation Sheet (minutes)			
Step	Component Task	CT	VACT	NVACT	IT
1	Charging	5	5	0	0
2	Silo cabins	0	0	0	40
3	Flour dosing	1.075	1.075	0	0
4	Spreading	2	2	0	0
5	Pre-drying	60	60	0	0
6	Drying	90	90	0	0
7	Humidifying	25	15	10	0
8	Cooling	25	15	10	0
9	FG cabin	0	0	0	1.3

Activities: FLG3 Spaghetti Processes		Time Observation Sheet (minutes)			
Step	Component Task	CT	VACT	NVACT	IT
10	Stripping	5	5	0	0
11	Weighing	7	5	2	0
12	Packing	5	5	0	0
13	Quality Control	5	5	5	0
14	Conveyor	5	5	0	0
15	Stacked FG (Finished products)	0	0	0	5
16	Loading into Trucks	5	5	0	0
17	Weighing	5	5	0	0
18	Customer dispatch	5	5	0	0
Total time in minutes.		256.075	234.075	22	46.3
Production Lead Time, PLT (minutes) =(CT+IT)		302.375			
Summary Total employees= 28		PLT =5.04 hours			
		CT=4.268 hours or 4hours, 16 minutes			

3.5. Results for Overall Equipment Efficiency, OEE

The Table 12 present the collected data for analyzing the Overall Equipment efficiency (OEE) for Current State Map of Fava Long Goods 3 (FLG3) production line.

Table 11. Current State Records of Value Stream Mapping Parameters.

Activities: FLG3 Spaghetti Processes		Time Observation Sheet		
Step	Component Task	AT (Hours)	U (%)	S (%)
1	Quality Testing	22	90	0
2	Charging	22	87	16
3	Silo cabins	22	75	0
4	Flour dosing	22	78	5
5	Mixing	22	78	7
6	Spreading	22	78	4.5
7	Wet scrap	22	72	0
8	Pre-drying	2	90	0
9	Drying	2	90	0
10	Humidifying	22	90	0
11	Falling Sticks (Dry scrap)	22	80	0
12	Cooling	22	80	0
13	FG cabin	22	80	0
14	Stripping	22	70	10
15	Elevators	22	80	0
16	Packing	22	90	0
17	Cartonizing	22	80	0
18	Sorting of packing material	22	75	0
19	Transit inventory	22	100	0
20	Stacked products	22	90	0
21	Loading into Trucks	8	78	3
22	Weighing	8	70	0
23	Customer dispatch	8	80	0
Results of analysis		Average= 22 hrs	Average=82.7%	Total=42.5%
Units produced (kg)		429 sticks/hour or 3.432 tonnes/hour		
Defective Units (kg)		= 131 sticks/hour = 1.048 tonnes/hour		
Overall Equipment Efficiency, OEE		= Productivity x Availability Quality rate		

From Table 11,

$$OEE = \frac{P.A.Q}{100} \quad (9)$$

Productivity = Actual output/expected output
= Unit produced/Operating capacity

Operating Capacity = 4.5 tonnes/hour

Unit Produced = 3.432 tones/hour

Therefore,
Productivity, P = 3.432/4.5

$$= 0.76. \quad (10)$$

Availability, A = Average Uptime

$$= 82.7\%$$

$$= 0.827. \quad (11)$$

$$\begin{aligned}\text{Defective units} &= \text{Scrap level} \times \text{unit produced} \\ &= 42.5\% \times 3.432 \text{ tonnes/hour} \\ &= 1.4586 \text{ tonnes/hour}\end{aligned}$$

Therefore,

$$\text{Quality, } Q = (3.432 - 1.4586) / 3.432$$

$$= 1.8614 / 3.432$$

$$= 0.54$$

(12)

$$\begin{aligned}\text{OEE} &= 0.76 \times 0.827 \times 0.54 \times 100 \\ &= 33.9\%\end{aligned}$$

$$\text{OEE, (Current state)} = 34\%. \quad (13)$$

Table 12 present the collected data for analysing the Overall Equipment efficiency (OEE) for Future State Map of Fava Long Goods 3 (FLG3) production line.

Combining Eqn. (2), (3) and (4) into (1);

Table 12. Future State Records of Value Stream Mapping Parameters.

Activities: FLG3 Spaghetti Processes		Time Observation Sheet		
Step	Component Task	AT (Hours)	U (%)	S (%)
1	Charging	22	100	0.2
2	Silo cabins	22	100	0
3	Flour dosing	22	100	0.2
4	Spreading	22	100	0.2
5	Pre-drying	2	100	0
6	Drying	2	100	0
7	Humidifying	22	100	0
8	Cooling	22	100	0
9	FG cabin	22	100	0
10	Stripping	22	99	0.2
11	Weighing	22	99	0
12	Packing	22	99	0
13	Quality Control	22	99	0
14	Conveyor	22	100	0
15	Stacked products	22	99	0
16	Loading into Trucks	8	99	0.2
17	Weighing	8	100	0
18	Customer dispatch	8	100	0
Results of analysis		Average = 22 hrs	Average = 99.7%	Total = 1.2%
Units produced (kg)		552 sticks/hour or 4.416 tonnes/hour		
Defective Units (kg)		= 8 sticks/hour = 0.64 tonnes/hour		
Overall Equipment Efficiency, OEE		= Productivity x Availability Quality rate		

3.6. Results for Key Performance Indicators (KPIs)

The following results were achieved from the all the list of final audits conducted by examining the Current and Future State Map of the Spaghetti Production Line along Fava Long Good 3 (FLG3). The results of the KPIs is presented in Table 13.

Table 13. Key Performance Indicators (KPIs) for Golden Pasta VSM.

S/N	Key Performance Indicators (KPI)	Metrics Measurements	Actual value	
			Current	Future-Done
1	PRODUCTIVITY	Production lead time-PLT (Minutes)	2061.38	302.375
		Cycle Time –CT (Minutes)	441.075	256.078
		Overall Equipment Efficiency-OEE	34%	98%
2	DELIVERY	Output produced -O (Tonnes/hr)	3.432	4.416
		Sales volumes (Cartons)	112	160
		% Scrap Sold -S	9%	1%
3	QUALITY	Quality demerit index/month –QDI (Nos)	25	1
		Customer complaints/month (Nos)	7	1
		Conversion cost (Naira/ton)	2050	1020
4	COST	Maintenance cost (Naira/ton)	1302	500
		Power (Energy) cost (Naira/ton)	400	350
		Labour cost (Naira/ton)	348	170
5	SAFETY	Loss time Accident-(LTA (Nos)	2	0
6	MORALE	Improvement suggestions (Nos)	5	30

3.7. Results of Yearly Implemented Future State Map

VALUE STREAM PLAN +A1:L35				Signatures								
DATE	SEP. 15TH, 2016			Site Manager		Engineering		Quality Assurance				
PROD. MANAGER	Shonibare Ayodeji											
V.S.MANAGER	Yiannis Katsichtis											
FACILITATOR	Mauton Gbededo											
Product-Family Business Objectives	Value Stream (VS) Loop	Value Stream Objective	Goal (Measurable)	2016/17				Person in Charge	Dept.	Reviewer Schedules		
				Q1	Q2	Q3	Q4			Reviewer	Date	
1. Improve profitability in Spaghetti Manufacturing	4. Customer Loop	Continous flow from point of loading and customer's truck	Increase uptime time to 100%									
	3. Packaging Loop	Continuous flow from Stripping to elevator process	Zero WIP									
			Increase uptime to 95% <1.3 minutes of inventory time									
		Introduce quality control process at the the terminal of the packing machines	Hourly quality checks									
			Zero transit operation									
	2. Processing Loop	Continuous flow between flour and mixing processes	<4.5 seconds of dosing time									
			<I minute of Mixing time									
		Kaizen to 2 minutes at spreader unit	100% uptime									
	1. Supplier Loop	Continuous flow for further flour processing	Zero WIP at the spreader unit									
			Increase uptime to 100%									
		Load levelling balance at raw material supply	<40 minutes of charging time allowed									
			Daily transfer order									
	2. Reduced cycle time	4. Customer Loop	Eliminate repeated weighing	Automated weighing at the security post only allowed								
		3. Packaging Loop	Kaizen to reduce current to 33 minutes	Zero WIP								
				<33 minutes of cycle time								
			Eliminate excess inventory of packing material	<2500 cartons every 4 hours								
2. Processing Loop		Daily production schedule	<64 reels every 4 hours									
			Zero WIP									
1. Supplier Loop		Quality Conformance Certificate	100% uptime									
			Zero quality inspection time									
3. Reduction in scrap level	4. Customer Loop	Eliminate over-stocking	<40 mins of daily inventory time									
			Zero inventory									
	3. Packaging Loop	Elimination of cartonizing process	Produce to customer request									
			Redeployment of 12 palletizers									
	2. Processing Loop	Kaizen to eliminate failing sticks at cooler entrance	Zero scrap									
			Zero WIP									
	1. Supplier Loop	Certified Reliabilty-tested trucks	Zero WIP									
			Daily transfer order									
Legend			PRODUCT FAMILY	SPAGHETTI								
Achieved												
Not achieved												

Figure 10. Results of Yearly Implemented Future State Operation.

The Figure 10 shows the results of the yearly plan achieved against the targets for FLG3 production line after the lean implementation.

4. Discussion

This section discusses the results of evaluation of evaluated obtained and presented in section 3 accordingly.

4.1. Discussion on the Current and Future State Maps

In the Current State Map, a total number of 7 bulk weighing 30,000 kg was supplied at the raw material stage which led to excess storage of inventory at the raw material stage. In order to build an effective lean plant-level value stream, the future stream map was developed with Kanban techniques on both the supplier and receiving ends. First, at the raw material supply into the silo bins, the following analysis was computed before applying the Kanban pull system [10]. In the current state mapping, it took 60 minutes of processing time to store 30,00kg of raw material semolina. The following actions were implemented as follows;

- i. In order to reduce the long lead time, each bulk truck material was reduced from 30,000kg to 20,000 kg of semolina.
- ii. The current charging point is three and, 3 trucks were normally discharged per hour. Installation of additional charging point was done to increase the charging point from 3 to 4 while total mass of semolina discharge is

now 80,000kg instead of 90,000 kg. this single action
eliminated excess inventory by 10,00kg
Now computing the storage time into the silo bins;
Total storage time for 30,000kg

$$= 60 \text{ minutes} \quad (14)$$

I kg of truck to be stored (current)

$$= 60/30,000 \text{ minutes} \quad (15)$$

Therefore,

20,000 kg of semolina to be stores

$$= 60/30,000 \times 20,000$$

$$= 40 \text{ minutes} \quad (16)$$

Actual time saved

$$= 20 \text{ minutes storage time} \quad (17)$$

(Note 20 tonnes= 20000kg)

Since a total of 20 trucks were ordered per day, there was need to have load levelling balance at the raw material section using a levelling box. The load levelling box in Table 15 shows detailed scheduling records informing the planning department clerk to order for raw material supply as follows. All orders were done on ERP, so there is no need for physical conventional levelling box.

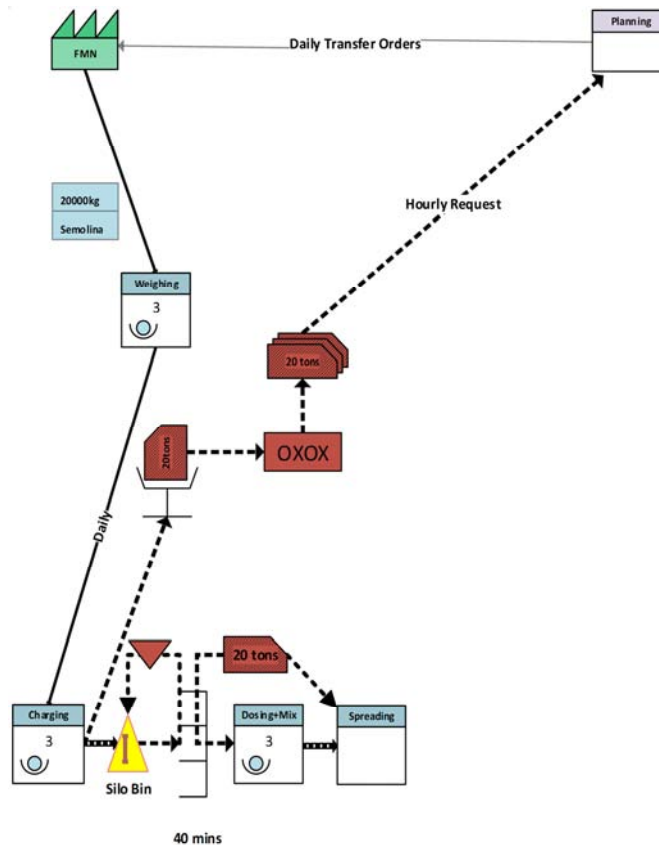


Figure 11. Kanban pull system on the future VSM.

Table 14. Load-levelling scheduling box for Raw material supply.

Load-Levelling Schedule at Raw Material Supply					
Frequency	8-8:40am	9:40-10:20am	11:20-12pm	1-1:40pm	2:40-3:20pm
1st Delivery					
2nd Delivery					
3rd Delivery					
4th Delivery					
5th Delivery					
Cumulative trucks (Nos)	4	8	12	16	20

The Table 14 revealed that, there was one hour of elapsed time between each scheduling delivery to allow for any unwanted delays or bottlenecks while still keeping the pace of normal supply of 20 bulk trucks per day. From 4:20 pm to 7pm, enough time would be available for raw material supply when demand becomes higher and same time, reducing supplier when demand becomes low.

Load levelling is represented by the icon and it portrays a tool used to intercept batches on Kanban and level the volume and mix of them over a period.

The detailed Kanban pull system of the future value stream was highlighted in Figure 11 from the Future State Map.

Also, a load levelling box was implemented at the carton supplier unit to control over-production even though Golden Pasta packing materials supplier is not ready to receive Kanban and produce according to them. At Golden Pasta, an internal withdrawal Kanban was built to every carton and trans-wrap material at the planning department whenever a carton /trans-wrap material is used. With this Kanban system, the Planning department ordered carton/trans-wrap material based on actual demand instead of using Material Resource Planning (MRP) forecast. Therefore, as soon as planning department made the day's order for packing materials, the corresponding Kanban was placed in Kanban slots at the receiving packing machine terminals. The following analysis on the carton/trans wrap inventory on current VSM was done to achieve a future-state map. A buffer stock (sometimes-

called safety stock) was stock used to protect against variation from the company. It was held as a reserve to safeguard against unforeseen shortages or demand [11]. The buffer stock handled fluctuation in demand at peak period and at low peak, once the buffer stock is exceeded supply of cartons would stop to prevent excess inventory.

Similarly, packing machine consumed a reel of trans-wrap per day. Golden Pasta currently ordered for trans-wrap material from Bagco (a subsidiary of FMN Company) with 1000 reels of trans-wrap per week. The following analysis on the trans wrap supply was done to achieve a Future State map.

1 reel of trans wrap is consumed per hour

1 reel produces an average of 100 cartons per day

Therefore,

1 carton = 1/100 reel

Since demand is 64000 cartons,

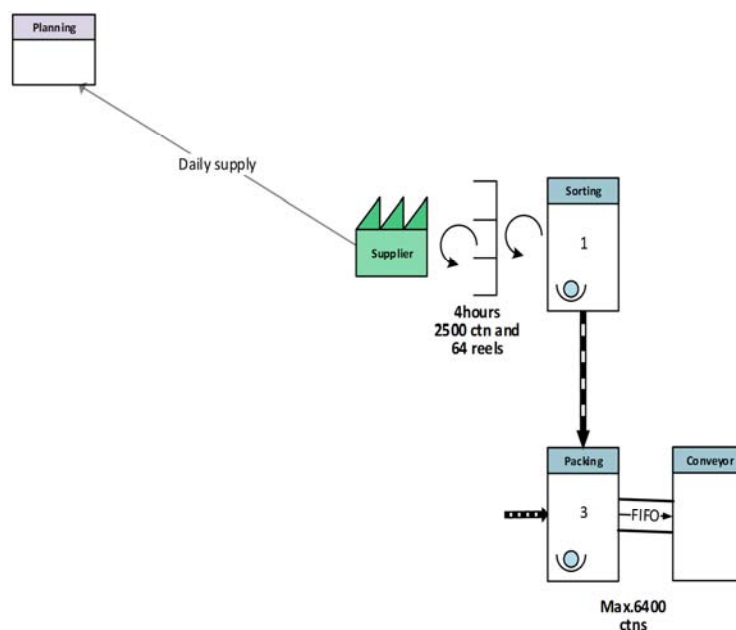
we know that,

6400 cartons will require

$$= 1/100 \times 6400 \text{ reel}$$

$$= 64 \text{ reels of trans-wrap per day} \quad (18)$$

The outcome of the analysis of control of cartons/trans-wraps inventory was drawn on the Future State Map in Figure 12.

**Figure 12.** Supermarket Pull System at Packing Loop Future VSM.

4.2. Discussion on Wastes Identification

The wastes of manufacturing were ranked in accordance with the seven tenets of lean manufacturing and were clearly marked out on the Current State Map. The results obtained and displayed on the current state shows that Value Stream Mapping is a successful tool for wastes identification in pasta manufacturing.

4.3. Discussion on Waste elimination

The high cost of production of the Current State Map was as a result non-value added activities such as of over processing (quality tests), scraps produced during charging of raw material, waiting time- in the mixing, spreading, humidifying, cooling, stripping, elevator, cartonizing, waiting in the transit area, and weighing processes, over production at FG cabins,, defects in stripping, high rate of talia bags, overstocked stacked finished goods at the shop floor and warehouse, unnecessary motion during- quality tests, spreading, cartonizing by palletizers, high accumulation of inventory time- at charging, silo bins, spreading, cartonizing, transit area, and stacked products at warehouse, transportation time- at the transit area and loading operation in the warehouse and finally several defect time consumed throughout the entire production line caused by breakdowns and quality issues. It was also observed that Golden Pasta Company are currently not producing in accordance with customers' requirements but according to the availability of raw materials, which eventually resulted to producing unwanted finished products not desired by the customers. The large improvements achieved in the Future State Map is a direct reflection of the elimination of non-value added activities along the pasta manufacturing processes. The raw material supply has been improved to daily requests with an introduction of load balancing system of four trucks every 40 minutes to meet customer demand. A Kanban post and signal

system was put in place to cushion production at the upstream section, which directly improved the effectiveness and efficiency of the manufacturing processes. The visual inspection and quality tests conducted during raw material discharge were considered as wastes since there have not been quality issues for the past three years from Flour Mill of Nigeria suppliers. A quality conformance certification implemented by Flour Mills of Nigeria Plc for raw material eradicated this quality issues as only certified trucks with test certificate was allowed for raw material delivery. The inventory accumulation and scraps generated by faulty bulk trucks were considered a waste. This waste was eliminated by ensuring that only reliability-certified trucks were into the premises for raw material delivery. The supermarket pull system introduced at the stripper and packing units greatly improved the efficiency of the system between the upstream Processing Loop and Downstream Packaging Loop because it generated the expected continuous flow process that was able to eliminate all bottlenecks along the entire spaghetti manufacturing processes. The twenty-four hours non-valued added time at the transit zone was eliminated after the installation of an automated conveyor belt system directly from packing machine terminal into the warehouse, which had guaranteed higher efficiency and prompt response to customer's demand. At the end of the wastes elimination investigation and elimination, all the non-valued activities were removed.

4.4. Discussion on Production Lead Time and Cycle Time

Comparing the results of the PLT, VACT and NVACT for both Current and Future state gave a clear measure of the summary of the application of Value Stream Mapping (VSM) techniques on pasta manufacturing. The results of evaluated is presented in tabular form below

Table 15. Measurement of the Summary of VSM Technique on Pasta Manufacturing.

Success Measures	Current	Future	Difference	Summary
Production Lead time	34.4	5.04	-29.36	Reduction
% VAT	12.2	77.4	65.2	Increase
% NVAT	87.8	22.6	-65.2	Reduction
Total Waste Reduction			85.3%	

The longer production lead time for pasta manufacturing was shorten by 29.36 hours (1 day and 5.36 hours) while 85.3% of manufacturing activities on current state constituted were mere wastes got from the ratio of the difference between Production Lead Time (for both current and Future State and Current State Production Lead Time). The realization of this result shown in this thesis is in accordance with the fact that approximately 90% of manufacturing activities are directly or indirectly non-value addition (David,

2016). In addition, it was also shown in Table 14 that an assault on the Non-Value Added Cycle Time (NVACT) for the Current State Map produced an automatic measure of improvement on Value Added Cycle Time (VACT) on the Future State Map, which was deduced to be 65.2% on both direction, making the whole exercise of waste reduction "scientific". The summary of the results of PLT, NVACT and VACT for both Current State Map and the Future State Map were shown in Figure 13 below.

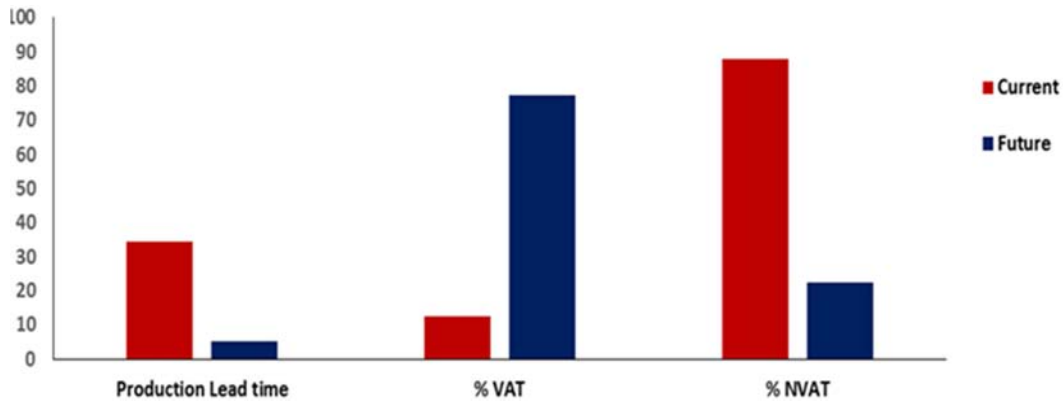


Figure 13. Results of VSM Technique on Value Added and Non-Value Added Cycle Time.

In Figure 13, Production Lead Time is shorter for Future State Map than Current State Map while Non-Value Added Time is higher for Current State than Future State. The total production lead time was reduced from 34.4 hours to 5.04 hours after the implementation of Value Stream Mapping techniques on Current state non-value added time. This is an indication that value stream mapping techniques is a successful methodology for reducing the total delivery time to meet customer's requirements to the overall objective of Lean Manufacturing.

4.5. Discussion on Overall Equipment Efficiency, OEE

Comparing the results of evaluation in Table 11 and Table 12 shows that, OEE increases from 34% to 98% after the implementation of Value Stream Mapping Techniques

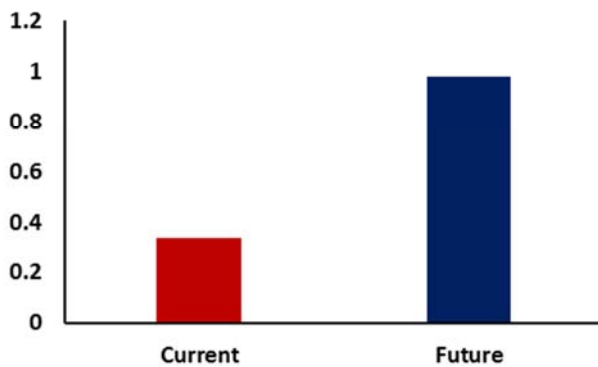


Figure 14. Results of Value Stream Mapping Techniques on OEE.

In Figure 14, Overall Equipment Efficiency of the plant was higher in implemented Future State Map than the Current State Map. This is an indicator that Value Stream Mapping techniques is a successful tool for boosting the productivity of Pasta Manufacturing plant.

4.6. Discussion on Key Performance Indicators (KPIs)

The evaluated results indicated the Future State performance after the Future State was implemented on the Spaghetti production line. All the improvement results in Productivity, Delivery, Quality, Cost and Safety were geared towards reduction in conversion cost.

4.7. Discussion on Yearly Future State Map Implementation

The objectives and targets for all the four loops on the Future State VSM which includes the Supplier Loop, Processing Loop, Packaging Loop, and Customer Loop were fully achieved up to the third quarter of 9 months between September 2016 to June 2017.

5. Conclusion

This work evaluated the implementation of value stream mapping techniques, a lean manufacturing principle for the elimination of wastes along pasta manufacturing company in Nigeria as revealed in this case study. The Current State manufacturing processes for a single Production Line FLG3 was thoroughly understudied, data from Golden Pasta Company, Enterprise Resource Planning (ERP) system and shop floor were collated and analysed and the Current State Value Stream Map was developed using Microsoft Visio, 2016 software. The Value-Added and Non-Value Added activities, which were the actual wastes of manufacturing, were clearly spotted along the Supplier Loop, Processing loop, Packaging loop and Customer loop of the Current State Map. A Kaizen Blitz method, which constituted, series of brainstorming sessions were carried out on the four loops. At the end of the Kaizen Blitz events, recommended Improvement suggestions were implemented to eliminate the Non-Value Added activities which accumulated to wastes. The proposed Future State Map was equally drawn implemented and evaluated to determine the performance of the Value Stream Mapping techniques in Pasta manufacturing. A set of objectives and targets were established along the four loops using the Future State Map. The results of performance evaluation against targets revealed that Value Stream Mapping techniques successfully reduced Production Lead Time (PLT) of Fava Long Goods 3 Spaghetti Production Line from 34.4 hours (1.43 days) to just 5.04 hours with a 85.3% in waste reduction. The cost savings of ₦158, 515,200 was realized after 9 months of lean implementation as revealed in the financial statements of accounts for FLG3 production line, which was sighted in the

conversion cost report of June 4th, 2017 released from the Accounts Department.

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