International Journal for Research in Engineering Application & Management (IJREAM)
ISSN : 2454-9150 Vol-06, Issue-06, SEP 2020

Productivity Improvement -A Case Study

Harika Prabandapu

ABSTRACT - In the present day improving productivity and efficiency of Material Handling plays a prominent role for manufacturing based industries to sustain in markets. The current project intends to study the effect of implementing JIT and Lean Manufacturing to improve productivity and reduce wastage. Also, techniques like mechanical automation and Reconfigurable Manufacturing Automated System (RMAS) are considered to improve efficiency. In order to study and modify the existing layouts of an industry, a study visit at PepsiCo Pvt. Ltd. has been done. The data of three different production lines and inventory management was acquired. All these lines are modelled and simulated in FlexSim 2017 software. Simulation are carried out for existing lines, then The Taguchi optimization is applied for bottle necks like ASRS and blow moulding for modified lines and modified lines using RMAS in MINITAB15 software the optimum values are applied for the lines. The simulation is carried out for modified lines with space management, robot, rack system and ASRS system further modified lines using RMAS. After modifications productivity for modified and modified with RMAS is increased for Aquafina line by 19.77% and 11.66% for existing line, SIPA increased with 59.06% and 48.3% and KHS with 16.9 % and 11.8%. Also processing time for modified layout is increased by 0.11%, 13.32%, 18.0% for modified lines using RMAS is decreased by -16.17%, -2.16%, -2.32% for some machines in production line. By keeping parallel machine systems setup time decreased by 75% approximately. Modified plant layout will help the industry to get more productivity in less time with optimum usages of input materials and profiting the industry in long term gain.

Key words: Material handling system, Lean Manufacturing, Reconfigurable Manufacturing Automated System, JIT

I. INTRODUCTION

PepsiCo is an American multinational company that produces food, snack, and beverages. PepsiCo is in many fields like manufacturing, marketing, and distribution, of snack foods, beverages, and other PepsiCo products. The products which are produced by PepsiCo Company are – Pepsi, 7up, Miranda, Slice, Aquafina, Tropicana, Lays, Mountain dew, Revive, Quaker oats, Kurkure, Doritos Etc.

(a) Lean manufacturing: It refers to the concept of minimizing any waste utilizes resource, time or space without any value to services or product, while not sacrificing any productivity. Lean manufacturing the word lean means week the week areas are found and optimized There are different types of wastes transport, stock, processes, down time, stagnation, over processing, fault.

(b) Just in time (JIT): It is a strategy to manage inventory in such a way that goods/ raw materials are received only as their need arises and hence increases efficiency and minimizing waste.

(c) Reconfigurable Manufacturing System (RMS): Reconfigurable Manufacturing System (RMS) is a new cost-effective manufacturing process that incorporates rapid changes to system depending on the requirement

(d) Mechanical automation: Mechanical automation means the automated equipment such as robots which are replaced with manual workers. There will be less human errors and repeatability of same work the production cost will be reduced, large production volume in manufacturing industries.

(e) Work-in-progress (WIP): Work-in-progress (WIP) is an unfinished product or service that is still being added value to during the process of converting it from raw material to finished product.

(f) Production time: Number of bottles produced per given time is called production time.

(g) Cycle time: The total time from starting to the end of a process is called as cycle time.

(h) Productivity: The productivity is measured in terms of ratio of output to input which is used in the production process i.e. output per unit of input.

(i) Lead time (LT): The time between the orders placed by the customer to the delivery of a product is called as lead time.

Types of plant layout:

(a) Product layout: The layout of the workstations is done in such a way that they are in line with the production system shown in Fig.1.1.

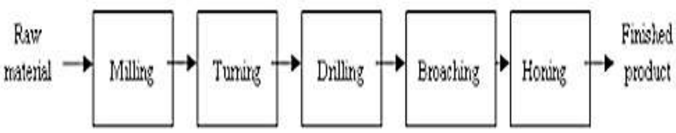

Fig.1.1 product layout

 DOI : 10.35291/2454-9150.2020.0593

ISSN : 2454-9150 Vol-06, Issue-06, SEP 2020

(b) Process layout: It is also known as functional layout and is characterized by keeping similar machines or similar operations at one location (place) shown in Fig.1.2. In other words, all lathes will be at one place, all milling machines etc.

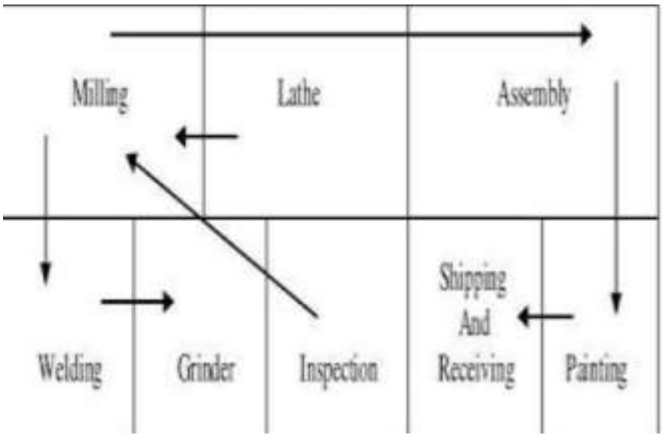

Fig.1.2 process layout

(c) Combination Layout: A combination of process and product layouts combines the advantages of the both types of layouts. Most of the manufacturing sections are arranged in process layout with manufacturing lines shown in Fig.1.3.

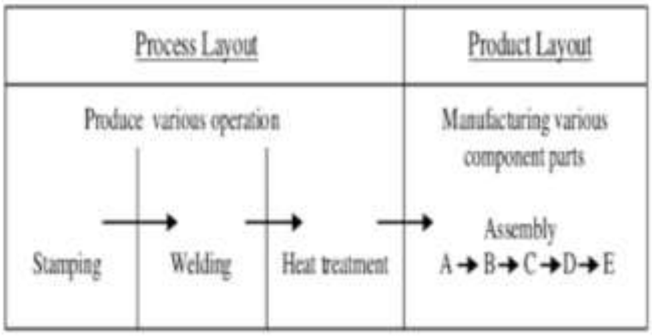

Fig.1.3 combination layout

(d) Fixed Position Layout: Layout by fixed position of the product is inherent in ship building, aircraft manufacture and big pressure vessels fabrication shown in Fig.1.4.

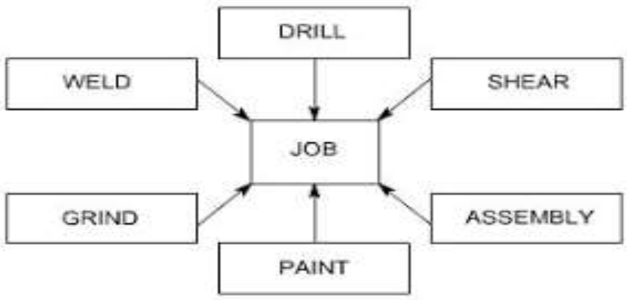

Fig.1.4 Fixed layout

1.1 FlexSim Software

FlexSim is 3D simulation software that will models, simulates, predicts and material handling, this software is used in many fields like manufacturing, healthcare, mining and logistics etc. FlexSim is user-friendly and powerful. FlexSim helps in optimizing current and planned processes, these Decreases waste, cost will be reduced. FlexSim software is different from other simulation software's in FlexSim by using different material handling systems we can create industrial environment like different varieties of conveyors like curved conveyor, straight conveyor, fixed conveyor. Operators, workstations, forklift trucks, automated guided vehicles, racks, robots, elevators, cranes, elevator, transporter, etc. these software we pick and place the objects and join with connections to run the simulation.

1.1.1 Modeling

This FlexSim software consists of 3D objects users can build their model according to their required design or pattern. In these software users built there model by dragging and dropping the predefined 3D object and create the required model. In this software modeling we can design an assembly line and production line these includes conveyors, Operators, workstations, forklift trucks, automated guided vehicles, racks, robots, elevators, cranes, transporter etc. by dragging and dropping required objects according to our model. Then connect the material handling systems by giving connections serially from one object to another from starting object to the end object without breaking the connection in the middle. If any connection is in disorder the patters will not run.

1.1.2 Simulation:

The simulation run panel is found at the top of the main windows in FlexSim and they are describe in three sections

1. **Reset:** This should be selected before running a model
2. **Run:** start the model running. This model will run continuously until the model is stopped.
3. **Stop:** stops the model while it is running. It also states all objects in the model.

After modeling the pattern or model, then run the mode for certain time period. Then go to statistics which is on top of the main windows then report and statistics. In these report and statistics we contain summary report and state report. This report will display values as percentages.

- **Summary Report:** In this summary report we contain different standard attributes we have to choose the standard attributes according to our requirement. Some of the standard attributes are: minimum stay time, maximum stay time, average stay time, time collecting, time releasing, time waiting for operator, loading time, unloading time, setup time etc.
- **State Report:** state report we contain different available states such as: idle, processing, busy, block, breakdown, releasing, collecting, down, setup, waiting for operator, waiting for

 DOI : 10.35291/2454-9150.2020.0593

transporter, etc. Then generate the report the report will display in excel sheet.

1.2 Material Handling Systems:

Material handling system is used for moving, storage, protection and controlling the materials and products in manufacturing industry. This material handling system are used in industries for transferring materials from ware house to different places picking, moving and placing of a complete product. Material handling system had wide range of semi-automated, automated and manual equipment's and technologies available in the movement, storage and controlling the materials, protection, distribution. There are different material handling systems

Automated storage and retrieval system, Conveyors, Automated guided vehicles, Hoisting equipment, Industrial robots, cranes, Lift trucks, Integrated material handling system, Monorails, Workstation cranes, Overhead cranes, Packaging, Racks, Storage, Protective guarding

Material handling systems are used in every industry, including: Aerospace, Automotive, Chemical, Construction, Beverage, Food, Manufacturing, Paper, Plastics, Pharmaceutical, Warehousing and distribution

1.2.1 Automated storage and retrieval system

ASRS systems are used to minimize the floor space. These system used to transfer the materials automatically locate and deliver the material from the conveyor system shown in Fig.1.5 these transfer of materials reduce the number of labors and reduce the floor space. This storage application includes order picking, tooling, and work in progress and clean room environments.

There are several types of automated storage and retrieval system they are: Unit-load ASRS System, Mini-load ASRS System, Micro-load AS/RS System, Vertical lift modules, Horizontal carousels,

ASRS are used in many areas to processing and picking they are: Order picking, Storage, Assembly, Security, Retail, and Production

Fig.1.5 Automated Storage and Retrieval System

1.2.2 Conveyors:

Conveyors are used for moving the material, product or loads from one place to another there are different shapes of conveyors like horizontal conveyor, vertical conveyor and incline conveyor these conveyors transports the product through the electrical power or hydraulic power shown in Fig.1.6. Loads are placed on top of rollers or a belt that travels along a fixed path.

Different types of conveyors are: Gravity conveyor, Chute conveyor, Gravity roller conveyor, Gravity wheel conveyor, Powered conveyor, Accumulation conveyor, Belt conveyor, Chain conveyor, live roller conveyor, Slat conveyor, and Vertical reciprocating conveyor

Conveyors are used in variety of areas to move materials are: Assembly, Transportation, Warehousing, Order packing, and Staging

Fig.1.6 conveyor

1.2.3 Automated Guided Vehicles (AGV):

Automated guided vehicles (AGV) are load carries that are operated without an operator or driver that travels on the floor space. These vehicles are controlled by computer and wheel based system these automated guided vehicles are combination of both sensor-based guidance system and software shown in Fig.1.7. AGV are mostly applied for transportation of raw materials and finished goods in manufacturing production lines.

There are several types of AGVs they are: Automated carts, Unit load AGVs, Tugged AGVs, Automated forklift trucks

AGVs are used in variety of areas such as: Assembly, Warehousing, Order packing, Just-in-time, Staging, Transportation, Kitting, and Transfer

Fig.1.7 Automated Guided Vehicles (AGV)

 DOI : 10.35291/2454-9150.2020.0593

1.2.4 Hoisting Equipment:

Hoisting equipment's is used to lift very heavy and bulk amount of materials these equipment's is used for vertical lifting shown in Fig.1.8. The material is travelled by these equipment is depends upon the operator. By manually or wireless control or wired pendant station and there lifting of the materials are depend upon their capacity and construction.

There are three types of hoisting equipment Manual hoists, Air hoists, and Electric hoists

Fig.1.8 Hoisting Equipment

1.2.5 Industrial Robots:

These robots are programmed to perform repetitive tasks with high precision and accuracy. Industrial robots are increasingly used in many and variety of industrial applications to perform different type of tasks shown in Fig.1.9. There are wide ranges of robots with different capacities and reaches large distance. In material handling applications and production the robot utilizes an end effector for travelling the loads. The robot technology increases the productivity, decreases the number of labors and prevents the workers from injury and physical stress.

Industrial robot has variety of applications like: Handling, Palletizing, Cutting, Finishing, Sealing, and Welding

Fig.1.9 Industrial Robots

1.2.6 Lift Trucks:

The fork lift trucks are used to transfer the materials from one place to another. These trucks are used for moving, lifting, placing, of loads Trucks can be fitted with forks on the outside for palletizing and unit load picking. Shown in Fig.1.10 these are mobile, self-loading trucks, are powered to carry, pull, push, lift, materials the maximum load is carried by the truck is depends upon the capacity of the vehicle.

There are wide range of lift truck styles and accessories for handling the materials they are: Electrical motor rider trucks, Electrical motor narrow aisle trucks, Electrical motor hand trucks, internal combustion engine trucks, Electrical and internal combustion engine tractors, Rough terrain forklift trucks

Fig.1.10 Lift Trucks

1.2.7 Integrated Material Handling System:

Integrated material handling system the location of items travel throughout a facility through processing can be monitored and managed. This Integrated material handling equipment's are semi-automated, automated, manual works together shown in Fig.1.11. This process will reduce the delivery time and overall handling cost in manufacturing of component, distribution of material, improves the customer services

Integrated material handling system are used in Assembly, Order picking, Production, Conveyance

Fig.1.11 Integrated Material Handling System

 DOI : 10.35291/2454-9150.2020.0593

ISSN : 2454-9150 Vol-06, Issue-06, SEP 2020

1.2.8 Monorails and Workstation Cranes:

These cranes are used for moving the materials that are too heavy and bulky. The loads are moved and positioned at a place by fixed, floor-mounted conveyors monorails and workstation cranes. They maximize the vertical space by transporting loads overhead shown in Fig.1.12. Their travel the material by manually or by an operator these cranes are worked by wired pendant station or wireless controls. The movement of materials is vertical, horizontal or lateral.

Monorails and Workstation cranes comes in variety of styles they are:

Enclosed tacks, patented tracks

Monorails and Workstation cranes are used in Assembly, Transportation, Storage, Warehouses, Positioning

Fig.1.12 Monorails and Workstation Cranes

1.2.9 Overhead Cranes:

Overhead cranes are used to move extremely bulky and heavy loads in industries through the overhead space. Overhead cranes are also called as industrial cranes, overhead travelling cranes, cranes, and this machine that lift the loads move horizontally and place the loads in the required place shown in Fig.1.13. These cranes have very high lifting capacity for moving the loads. The cranes travel in the manually direction or by an operator these cranes are worked by wireless controls, or wired pendant station. Overhead cranes move the material in multi-direction in manufacturing, storage, loading and unloading activities.

There are variety of styles is used in load lift includes: Single girder crane, Double girder crane, Box girder crane, Truss girder crane, I-beam crane, Straddle cranes, Tower crane, Stacker crane

Overhead cranes are used in many areas like: Assembly, Transportation, Storage, and Warehousing

Fig.1.13 Overhead Cranes

1.3 PepsiCo Company Production Lines:

There are three different production lines are used in the industry

- Aquafina
- SIPA line
- KHS line
- **Aquafina:** In this line Aquafina water bottles are produced of 500ml, 1lr, and 2ltr.
- **SIPA line:** In this line the products are produced Pepsi, mountain dew and 7up 250ml, 200ml, 600ml, 750ml,
- **KHS line:** In this line the soft drinks are produced are Pepsi, Miranda, 7up, mountain dew, of 1ltr, 1.5ltr, 2ltr, 2.5ltr

The step by step process of lines are Blow molding**,** Un scrambler**,** Cleaning**,** Filling**,** Capping**,** Warmer**,** Labeler**,** Wrapping**,** Palletization, shrink wrapper shown in Fig.1.14.

 DOI : 10.35291/2454-9150.2020.0593

International Journal for Research in Engineering Application & Management (IJREAM)
ISSN : 2454-9150 Vol-06, Issue-06, SEP 2020

Fig.1.14 step by step Production Line process

1.4 Design of Experiments

The Design of Experiments (DOE) is the most powerful statistical technique in product/process development. The general quantitative approach which is more logical has been selected for designing the experiments to achieve a predictive knowledge of a complex; Following are the major approaches in DOE

(a) Factorial Design,

(b) Taguchi Method (Fractional Factorial Design)

(a) Factorial Design

A full factorial experiment is an experiment whose design consists of two or more factors, each with discrete possible values or "levels", and whose experimental units take on all possible combinations of these levels across all such factors. A full factorial design may also be called a fully crossed design. Such an experiment allows studying the effect of each factor on the response variable, as well as the effects of interactions between factors on the response variable. A common experimental design is one with all input factors set at two levels each. If there are k factors, each at 2 levels, a full factorial design has 2k runs.

(b) Taguchi Method

Taguchi method was proposed by Dr. Genichi Taguchi. The Taguchi process helps to select or to determine the optimum cutting parameters for turning process. In Taguchi method, the main parameters have influence on process results, which are positioned at different rows in a designed orthogonal array. The difference between the functional value and objective value is recognized as the loss function that can be expressed by signal-to-noise (S/N) ratio. In addition, a statistical Analysis of Variance (ANOVA) performed to observe which parameters are significantly affecting the responses. Traditional experimental design methods are very complicated and difficult to implement, as it require a large number of experiments by increasing the process parameters.

1.5 Organization of thesis

This thesis comprises of six chapters that put forth the procedure followed to accomplish the project.

The first chapter is an introduction to the project and various concepts used.

The second chapter summarizes the literatures referred for the project

The third chapter includes the layout for different lines and Appling Taguchi optimization

The fourth chapter includes the simulation of layouts and results

The fifth chapter gives the conclusions.

The sixth chapter briefs the additional modifications to the project and future scope for research on the topic.

Finally references to the literatures have been provided.

Summary: In this chapter different material handling equipment used in industries and also explained about FlexSim software, and design of experiments, Taguchi optimization and Introduction about PepsiCo Company.

II. LITERATURE REVIEW

2.1 Introduction

Following literature reviews for the present work contains the current knowledge including substantive findings, as well as theoretical and methodological contributions by various authors relative to the title of the project.

2.2 Reconfigurable Manufacturing Systems

Dawn Zammit et al. [1] examined about reconfigurable manufacturing automated system (RMAS) is used in industries for reducing the cost of the product variety. This literature is the lack of promoting the theory and field studies of the industry. This study contains the research of previous papers about the RMAS in the industries. The guidelines survey and questioner survey about the RMAS based industry. The survey and interviews to discuss the implementation of RMAS industrial test and feasibility of

 DOI : 10.35291/2454-9150.2020.0593

implementing the RMAS were investigated through the guidelines of the investigation is used for further feedback from industry.

C. N. V. Sridhar et al. [2] studied reconfigurable manufacturing system (RMS) is the effective solution for the present manufacturing environment handling changes in the production. In this paper, the production scheduling considered in reconfigurable machine tools. The challenges for dedicated manufacturing line (DML) and FMS do not meet up to the expected level because of lack of support and production capacity and high production cost. RMS provides the solution for new manufacturing system in manufacturing industry. In this paper, RMS is selected for performing different operations. The aim is to develop the simulation models and minimizing the make span of the production

A. A. G Bruzzone et al. [3] studied the manufacturing cycle involves several production processes according to the required technologies they are carried out. The production capacity provided by machine tools and the customers' orders time schedule. In this paper a new type of reconfigurable manufacturing system and scalable machining center is presented these results in the modifying the machine capacity and exchanging the role between workpiece and operating resources. These create new opportunity for efficient manufacturing and new approach for the jobs scheduling and machining control

2.3 Flexible Manufacturing Systems

Song Zhen Tong et al. [4] experimentally studied flexible manufacturing system is mostly applied in automation technology. This automation technology is increasing highly. This decreases the job satisfaction and creates pressure for operators who deal automation technology. This study is done in a truck company of a truck body production line applied in DYNAMO++ for the material handling system and the simulation program in any logic 6.9.0. This simulation is used to know the effect of mechanical automation and cognitive automation in material handling system and the results show the levels of mechanical automation and cognitive automation. This results in the improvement in cycle time and down time. This shows the effect of cognitive automation on manufacturing flexibility in material handling system.

Abdulziz M. El-Tamimi et al. [5] experimentally studied about Flexible manufacturing system (FMS) is tremendously increasing manufacturing system the mathematical programming are very difficult and complex in solving the simulation in FMS. The simulation of FMS is widely used for analyzing the performance and the FMS component is costly. It is better to analyses the results using simulation if we implement FMS which involves in less labor time and money. FMS is studied by performing modeling and simulation analysis. In this paper implementing of perinets for measuring and analysis of performing of FMS is applied these system is modeled in AWESIM software and bottle neck technique are applied for comparison of simulations results.

A.V. Kapitasnor et al. [6] this paper is study of flexibility in manufacturing system. Flexibility is defined as a manufacturing system ability to transfer manufacturing of new product they have different parts like small, medium, batch production. The manufacturing is classified into different flexibility forms and its levels. In order to choose the flexibility ensures that the whole manufacturing system is divided into classes for each dimensionless, weight coefficient also talking into account the degree of utilization the capabilities. For the flexibility assessment use geometrical average of the equipment flexibility

2.4 Just In Time

Lucia Botti et al. [7] experimentally studied about lean manufacturing is a production process which helps in reducing the wastage in the manufacturing industry. These lean manufacturing was spread entire world manufacturing industries. Lean manufacturing not only improves profits also includes just-in-time (JIT), work in progress (WIP) and zero defect in quality management these study consist of mathematical model to design lean process in hybrid assembly line. The main aim is to provide design tool for an assembly line to meet the lean characters and workers ergonomics. These hybrid assembly lines consist of both automated machines and manual workers. They provides the tasks by repetitive movement of machines this models are tested in shell hard tool in hybrid assembly line which results in lean manufacturing and worker ergonomics is an important parameter of an assembly line.

Nurul Hayati Abdul Halima el al. [8] experimentally studied on small, medium and large scale industries have grown rapidly because of the customer demand in the market is increasing to increase the market shares the companies are implementing various techniques such as just-in-time (JIT) and lean manufacturing, Kanban and six sigma. In order to increase the shares the manufacturing companies are producing high quality on time delivery and product efficiency. Implementing of JIT in automotive assembly line it was found that there is bulk storage of materials in storage system called as wire mesh. In this case study a mew storage system is designed in CATIA V5R20 software and evaluation the effectiveness in computer aided manufacturing software. These results in introducing the poly boxes and a gravity flow rack system and the storage of material in inventory level.

2.5 Modeling and Simulation

Ashkan Negahban et al. [9] studied about the papers published from 2002 to 2013 about the comprehensive review of simulation in manufacturing. This literature is divided into three class design system operation and simulation of manufacturing system. This study is covered over 290 papers and provided detail analysis of the

 DOI : 10.35291/2454-9150.2020.0593

literature and the existing schemes. The results are used for the analysis of the future research suggestions.

Dae S. Chang et al. [10] experimentally studied about the analysis of an assembly line in a material handling system and development of simulator. Congestion in material handling system on the assembly line will reduce the performance and material handling system congestion will stop feeders and vehicles to move or travel freely on assembly line. There are many studies for reducing the congestion in the system but they are different to apply on the work site directly because these studies have only mathematical approaches. The congestion material handling system has 5 nodes for simulation and analysis of a model they are source, buffer, vehicle, work, sink for simulation of engine. The main idea of material handling system analysis and simulator is the feeding manage will route the feeders. The simulator is implemented for analyzing the efficiency of material handling system and working balance among feeders.

Cristina Cristallia et al. [11] studied about industrial robots are used in the manufacturing industries for performing the repetitive tasks. Robots are high accuracy machines while performing tasks but they are lack of absolute accuracy. Robots are fully automated machines they perform fully automatize manufacturing processes. Usually high precision tasks are performed by robots and they work with sensors to improve the accuracy. This paper refers about the robot position with respect to workpiece by cognitive and self-learning stereo-vision system they increases robot accuracy. The case is taken from am industry and experimental results are presented.

Kemal Subulan et al. [12] experimentally studied the modern production system contain performance of the system. The production phase and development phase should be improved to the highest level. Taguchi experimental techniques use to minimize the uncontrollable factors using orthogonal arrays. The experiment is carried with different levels and solution models are generated in ARENE3.0 program using SIMAN. In this paper many experimental investigations on automated-guided-vehicles about the capacity and speed. The time between main depots to shipping is the major criteria that affect the storage system. Experimental results are S/N ratio, variance are carried out by MINITAB15software according to orthogonal array table L16. This will result in performing optimization improvement of the material handling and transfer system

Daniel P. Campos et al. [13] experimentally studied about manufacturing and logistics operation the modeling and simulation support in decision making. The automation level is properly balanced by the material handling system for considering efficiency and flexibility. In this paper modeling and simulation is evaluated in material handling system. This is based on the combination of IDEF-SIM techniques along with implementation of simulation software. Two different material handling systems are compared one comparison is automated based system and other is human based system. The outcomes from this comparison are by modeling and simulation, decision making in industrial operation.

Nyemba, Wilson R et al. [14] studied about increasingly become complex for multi-product assembling plants for movement of materials within a manufacturing environment. Analyzing this factor by modeling and simulation tools is very complex. In this paper the modeling and simulation of material flow of a multi-product assembly plant to develop the product delivery at less cost. The 2 product simulation models are simulated in ARENA simulation software. The simulation experimental results the average hourly throughput and additional storage place for the materials for processing workstation was created hence these genetic model is used for the companies for production planning and scheduling

Azzopardi, Sandro et al. [15] experimentally studied about the genetic manufacturing automation testbed has wide range of applications in different manufacturing sectors. This study is academia-industry collaborative project aimed at increasing the large cluster of manufacturing firms. Which are operated in small economy to develop a genetic testbed various manufacturing solutions will be developed by implementing RMS. The design and development of various testbeds are discussed in this work.

N. V. Ruikar, M. T. Telsang [16] experiment to improve the productivity; improve the quality and reducing the waste in production method integration just-in-time with simulation is implemented for the appropriate options to implement successfully. There are different simulation software's with WITNESS simulation software the integration is studied. This model is taken from different literature reviews and the parameters like machine alteration, setup time, shift alteration and output parameters in throughput are taken with the help of Taguchi method design of experiments and the results used for statistical analysis in MINITAB software These results in optimal solution to get maximum throughput.

Stephen T. Newman et al. [17] studied about next generation industries are increasing the flexibility in manufacturing along with mass customization between quality and productivity. Intelligent manufacturing plays an important role. The resources converted into intelligent objects so that they can sense, act, and behave with smart environment. This paper provides a compression review of intelligent manufacturing like enable manufacturing and cloud manufacturing, big data analysis that is used for enable intelligent manufacturing.

Abhinav Simha Reddy et al. [18] studied about the estimation of feet size of AGV in the job shop environment. The AGV feet size plays a prominent role in the detain study of the simulation of AGV feet size in flexible

 DOI : 10.35291/2454-9150.2020.0593

manufacturing system. The present method is about minimizing of total travel time or overall cost simulation results gives better results bit in complex situation.

B. Vijaya ramnath et al [19] studied about there is more pressure on the designers and the manufacturers to respond to the consumer needs. In this paper the crankshaft is designed in CATIA software and the optimization analysis is studied and simulation is carried by the ANSYS software geometric consideration and different manufacturing feasibilities like cost, maximum stress points and more possibilities are found

M. Abbass et al [20] mathematically studied about mixed integer linear programming model configuration based on co-platforming strategy by mapping product platform to a corresponding machines platform is introduced synthesize the manufacturing system. The proposed model is beneficial in synthesizing manufacturing system to reduce investment costs by maintaining a group of platform machines that do not change with the change in product variants in different production periods the introduction of new product variants with new features belonging to the same product family which supports economic sustainability of manufacturing systems

OBJECTIVES

- Optimization of process parameters in shop floor
- To implement Mechanical Automation in Material Handling.
- To introduce RMAS (Reconfigurable Manufacturing Automation Systems) in Material Handling.
- To implement JIT (Just in time) and Lean Manufacturing

Summary: this chapter briefly explains about different research papers which are used for this project.

III. METHODOLOGY

There are three production lines which are taken from the PepsiCo company these three models contain different material handling equipment's. In this line the products which are produced are Pepsi, 7up, mountain dew, slice, Miranda, Tropicana, and Aquafina.

FLOW CHART: this flow chart includes with step by step process of the project shown in Fig.3.1

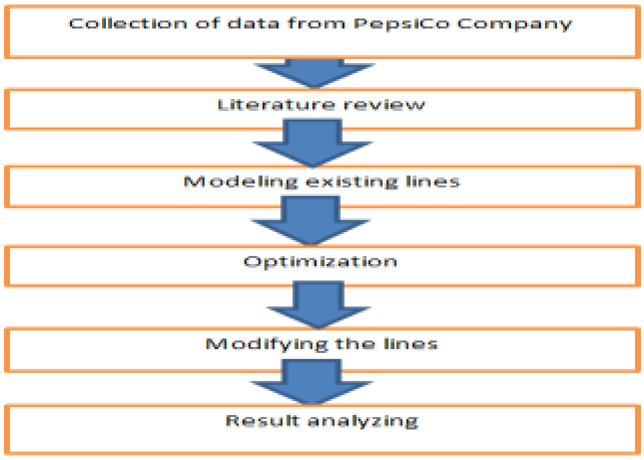

Fig.3.1 Flow chart of process

The three lines are SIPA, KHS and AQUAFINA. The step by step procedure for the lines is

- **Blow molding:** In these workstation the raw sample material which is placed inside the die. In the die due to high temperature and pressure the same is turned into required shape in the form of bottle. In the blowing process, the stretched blown perform material is forced to expand to make contact with the walls of the mold Then these bottle which is send to un scrambler
- **Un scrambler:** In un scrambler the bottles are arranged in order and through the conveyor these bottles are send to the filler section
- **Cleaning, Filling, and Capping:** the bottle when enters to the filling machine first the bottle is cleaned from inside and then the liquid solution is filled and then the bottle is sealed by providing caps on the top which are sealed by the machine. Then the bottle is send to the warmer.
- **Warmer:** In this warmer section the bottle is sprinkled by warm water to clean the bottle from outside and then cool water is sprinkled and then the bottles are send to the labeler section
- **Labeler:** labeler section the bottles are labeled according to their names and then coder machine which gives bar coding like date and rate are displayed to the bottles. From the labeler the bottles are set to the wrapping section
- **Wrapping:** In these wrapping section the set of 24 bottles are arranged on the carton base and a plastic sheet is wrapped tightly for the bottles.
- **Palletization:** These set of bottles which are palletized through a palletizer
- **Shrink wrapper:** Wrapping the set of cases of bottles in one row and wrapping with a plastic cover

3.1 PROBLEMS THAT COMPANY IS FACING:

The PepsiCo Company is facing problems due to present layout shown in Fig3.2. In summer season due to high demand of the soft drinks there will be 24hrs production.

 DOI : 10.35291/2454-9150.2020.0593

There will be breakdown in machines during the production it consumes time for repairing the machine so they production is becoming delay and also change of the solution from one to another like Pepsi to 7up change in total solution and raw bottle samples it takes 4hrs this motivated me to research for new layout to provide best output shown in Fig 3.5 and 3.8

The production in the company from January to June is 5lakh pallets per month

The production in the company from June to October 1lakh pallets per month

The production in the company from October to December 50000 pallets per month

Data Collected From the Company

i. The cycle time for an Aquafina line is 7minutes

ii. The cycle time for a SIPA line (small bottles) is 25 to 30 min

iii. The cycle time for a KHS line (big bottles) is 15 to 18 min

iv. The changeover time for the production line is 240 minutes

3.2 EXISTING LINES

AQUAFINA LINE:

The configurations of Aquafina line 400BPM (Bottle per minute)

1. **BLOWMOULDING**
   Capacity = 24000BPH
   Power = 270kW
   Air LP=40Bar, HP=10Bar
   Normal = (2, 0, 0)
   Number of bottle per pallet = 21
2. **UNSCRAMBLER**
   Capacity=33000BPH
   Power=15kW
   Air=6-7Bar
   Normal = (2, 0, 0)
   Number of bottle per pallet = 21
3. **FILLER,CAPPING**
   Capacity=24000BPH
   Power=16kW
   Air =6-7 Bar
   Normal = (5, 0, 0)
   Number of bottle per pallet = 21
4. **LABLER**
   Capacity=26300BPH
   Air =6-7 Bar
   Normal = (1, 0, 0)
   Number of bottle per pallet = 21
5. **WRAPPING**
   Capacity=26300BPH
   Power=108kW
   Air =6-8Bar
   Normal = (5, 0, 0)
   Number of bottle per pallet = 21
6. **PALLATIZING**
   Capacity=26300BPH
   Power=108kW
   Normal = (12, 0, 0)
   Number of bottle per pallet = 21
7. **STRETCH WRAPPER**
   Pneumatic=8Bar
   Electrical=440V
   Normal = (8, 0, 0)
   Number of bottle per pallet = 21

The Model of AQUAFINA LINE

The production line shown in Fig.3.2 is Aquafina line which produces Aquafina water bottles. This line same as in the PepsiCo Company which contain all the workstations with forklift truck and 4 racks

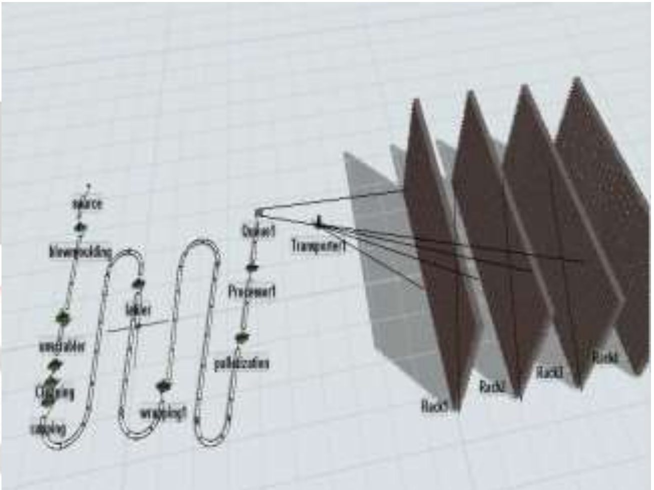

Fig.3.2 Existing Aquafina line

SIPA LINE:

The configurations of SIPA line 600BPM (Bottle per minute)

1. **BLOWMOULDING**
   Capacity=36000BPH
   Power=417kW
   Air=36 Bar
   Air consumption=1200CFD
   Normal = (2, 0, 0)
   Number of bottle per pallet = 25
2. **UNSCRAMBLER**
   Capacity=41000BPH
   Power=9.5kW
   Air=6-7Bar
   Air consumption=135 m3/HR
   Normal = (2, 0, 0)
   Number of bottle per pallet = 25
3. **FILLER,CAPPING**
   Capacity=36000BPH
   Power=20kW
   Air =7 Bar
   Normal = (5, 0, 0)

 DOI : 10.35291/2454-9150.2020.0593

Number of bottle per pallet = 25

4. **WARMER**
Capacity=36000BPH
Power=11kW
Water consumption=500LT/HR
Normal = (8, 0, 0)
Number of bottle per pallet = 25

5. **LABLER**
Capacity=26300BPH
Air =5-6 Bar
Normal = (1, 0, 0)
Number of bottle per pallet = 25

6. **WRAPPING**
Capacity=26300BPH
Power=108kW
Air =6-8Bar
Normal = (5, 0, 0)
Number of bottle per pallet = 25

7. **PALLATIZING**
Capacity=26300BPH
Power=108kW
Normal = (12, 0, 0)
Number of bottle per pallet = 25

8. **STRETCH WRAPPER**
Pneumatic=8Bar
Electrical=440V
Normal = (8, 0, 0)
Number of bottle per pallet = 21

The line shown in Fig.3.3 is SIPA line which produces Small bottles of different soft drinks. This line same as in the PepsiCo Company which contain all the workstations with forklift truck and 4 racks

The model of SIPA LINE

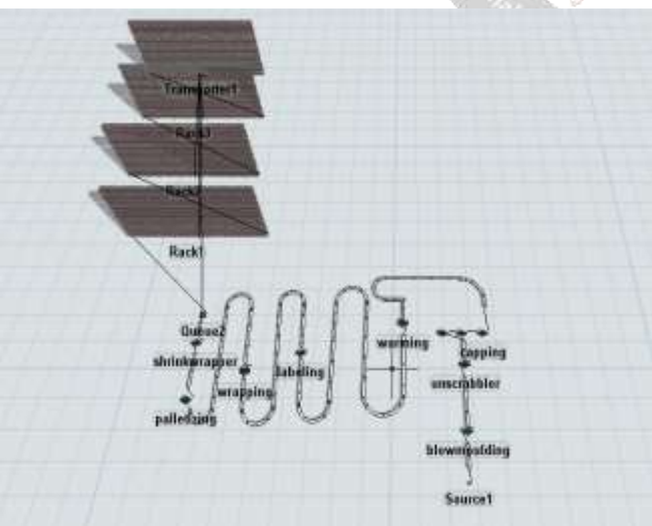

Fig.3.3 Existing SIPA line

KHS LINE:

The configurations of KHS line 400BPM (Bottle per minute)

1. **BLOWMOULDING**
Capacity=24000BPH
Power=270kW
Air=20 Bar
Air consumption=1200CFD
Normal = (2, 0, 0)
Number of bottle per pallet = 21

2. **UNSCRAMBLER**
Capacity=33000BPH
Power=915kW
Air=6-7Bar
Air consumption=135m3/HR
Normal = (2, 0, 0)
Number of bottle per pallet = 21

3. **FILLER,CAPPING**
Capacity=24000BPH
Power=20kW
Air =7 Bar
Normal = (5, 0, 0)
Number of bottle per pallet = 21

4. **WARMER**
Capacity=24000BPH
Power=11kW
Water consumption=500LT/HR
Normal = (8, 0, 0)
Number of bottle per pallet = 21

5. **LABLER**
Capacity=26300BPH
Air =5-6 Bar
Normal = (1, 0, 0)
Number of bottle per pallet = 21

6. **WRAPPING**
Capacity=26300BPH
Power=108kW
Air =6-8Bar
Normal = (5, 0, 0)
Number of bottle per pallet = 21

7. **PALLATIZING**
Capacity=26300BPH
Power=108kW
Normal = (12, 0, 0)
Number of bottle per pallet = 21

8. **STRETCH WRAPPER**
Pneumatic=8Bar
Electrical=440V
Normal = (8, 0, 0)
Number of bottle per pallet = 21

The line shown in Fig.3.4 is KHS line which produces big bottles of different soft drinks. This line same as in the PepsiCo Company which contain all the workstations with forklift truck and 4 racks

The model of KHS LINE

 DOI : 10.35291/2454-9150.2020.0593

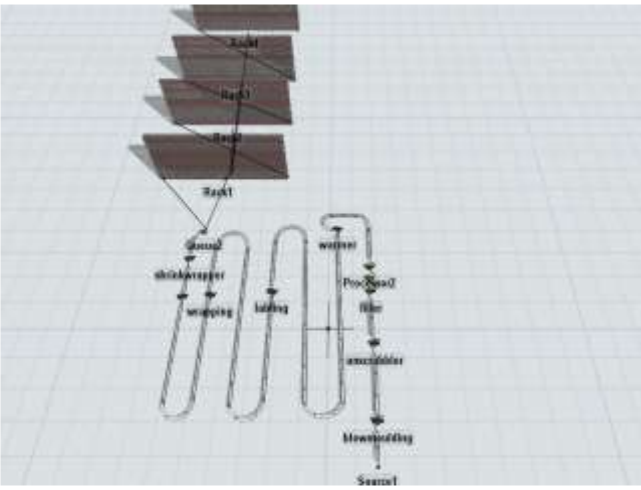

Fig.3.4 Existing KHS line

3.3 Taguchi method applied for Automated Storage and Retrieval System (ASRS) and blow molding For Modified Line and Modified Line Using RMAS:

The table for an L9 array which is used for the optimization shown in Table 3.1

Table 3.1 L9 array table

Exp. No				
Factors	**1**	**2**	**3**	**4**
1	1	1	1	1
2	1	2	2	2
3	1	3	3	3
4	2	1	2	3
5	2	2	3	1
6	2	3	1	2
7	3	1	3	2
8	3	2	1	3
9	3	3	2	1

Taguchi optimization for automated storage and retrieval system (ASRS) and blow molding for modified lines the parameters taken shown in Table 3.2 and 3.3

Table 3.2 Taguchi optimization parameters for ASRS system

S no	Speed of ASRS (m/s)	Capacity of ASRS (Nos)	Loading time of ASRS(S)	Unloading time of ASRS(S)
1	4	60	3	3
2	6	80	4	4
3	8	100	5	5

Table 3.3 Taguchi optimization parameters Blow molding

S no	Processing time of blow molding (s)	Capacity of blow molding(B/s)	Down time (s)
1	2	21	200
2	3	23	250
3	4	25	300

Modified Lines and Modified Line Using RMAS

AQUAFINA LINE (ASRS system)

These are the modified line and modified line using RMAS of Aquafina the Taguchi optimization for automated storage and retrieval system and blow molding where the values are obtained in MINITAB software and there pictures shown in Table 3.4, 3.5, 3.6 and 3.7

Table 3.4 Modified Aquafina 86400sec of ASRS

Speed of ASRS (M/S)	Capacity of ASRS(Nos)	Loading of ASRS(s)	Unloading of ASRS(s)	Output (no of pallets in rack)
4	60	3	3	2864
4	80	4	4	2864
4	100	5	5	2862
6	60	4	5	2864
6	80	5	3	2864
6	100	3	4	2864
8	60	5	4	2863
8	80	3	5	2864
8	100	4	3	2865

Table 3.5 Modified RMAS Aquafina line 28800Sec of ASRS

speed of ASRS(M/S)	capacity of ASRS(Nos)	loading of ASRS(S)	unloading of ASRS(S)	Output (no of pallets in racks)
4	60	3	3	945
4	80	4	4	944
4	100	5	5	944
6	60	4	5	945
6	80	5	3	947
6	100	3	4	945
8	60	5	4	947
8	80	3	5	946
8	100	4	3	946

BLOW MOLDING:

Table 3.6 Modified Aquafina line 86400Sec of Blow molding

Processing time of blow molding	Capacity of blow molding (b/s)	Down time (s)	output (no of pallets in rack)
2	21	200	2864
2	23	250	2864
2	25	300	2861
3	21	250	2857
3	23	300	2861
3	25	200	2857
4	21	300	2864
4	23	200	2857
4	25	250	2864

Table 3.7 Modified RMAS Aquafina line 28800Sec of Blow molding

 DOI : 10.35291/2454-9150.2020.0593

Processing time of blow molding	Capacity of blow molding (b/s)	down time (s)	output (no of pallets in rack)
2	21	200	945
2	23	250	946
2	25	300	944
3	21	250	947
3	23	300	946
3	25	200	948
4	21	300	946
4	23	200	947
4	25	250	948

The line shown in Fig.3.5, 3.6 is Aquafina Modified Line and Modified Line Using RMAS which produces water bottles. Which contains all the workstations, rack, robot, and ASRS vehicle line is modified in FlexSim software

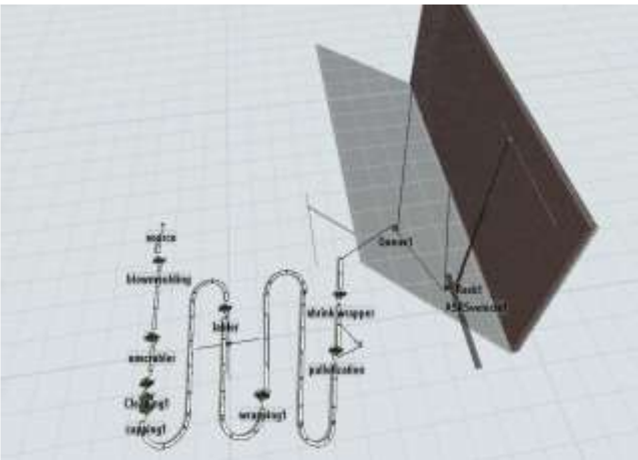

Fig.3.5 AQUAFINA modified line

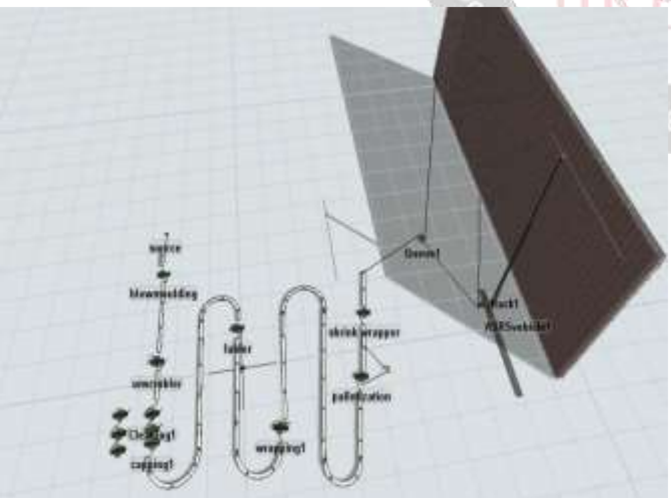

Fig.3.6 AQUAFINA modified RMAS line

SIPA LINE:

These are the modified line and modified line using RMAS of SIPA line the Taguchi optimization for automated storage and retrieval system and blow molding where the values are obtained in MINITAB software and there pictures shown in Table 3.8, 3.9, 3.10 and 3.11

Table 3.8 Modified SIPA 86400sec of ASRS

speed of ASRS(M/S)	capacity of ASRS(Nos)	loading of ASRS(S)	unloading of ASRS(S)	Output (no of pallets in racks)
4	60	3	3	3560
4	80	4	4	3557
4	100	5	5	3544
6	60	4	5	3562
6	80	5	3	3560
6	100	3	4	3562
8	60	5	4	3560
8	80	3	5	3565
8	100	4	3	3567

Table 3.9 Modified RMAS SIPA line 28800Sec of ASRS

speed of ASRS(M/S)	capacity of ASRS(Nos)	loading of ASRS(S)	unloading of ASRS(S)	Output (no of pallets in racks)
4	60	3	3	1176
4	80	4	4	1175
4	100	5	5	1174
6	60	4	5	1175
6	80	5	3	1175
6	100	3	4	1176
8	60	5	4	1174
8	80	3	5	1175
8	100	4	3	1177

Table 3.10 Modified SIPA line 86400Sec of Blow molding

Processing time of blow molding	Capacity of blow molding (b/s)	Down time (s)	output (no of pallets in rack)
2	21	200	3566
2	23	250	3566
2	25	300	3562
3	21	250	3558
3	23	300	3562
3	25	200	3558
4	21	300	3566
4	23	200	3558
4	25	250	3566

Table 3.11 Modified RMAS SIPA line 28800Sec of Blow molding

Processing time of blow molding	Capacity of blow molding (b/s)	Down time (s)	output (no of pallets in rack)
2	21	200	1175
2	23	250	1174
2	25	300	1175
3	21	250	1176
3	23	300	1177
3	25	200	1175
4	21	300	1178
4	23	200	1175
4	25	250	1176

 DOI : 10.35291/2454-9150.2020.0593

ISSN : 2454-9150 Vol-06, Issue-06, SEP 2020

The line shown in Fig.3.7, 3.8 is SIPA Modified Line and Modified Line Using RMAS which produces Small bottles. Which contains all the workstations, rack, robot, and ASRS vehicle line is modified in FlexSim software

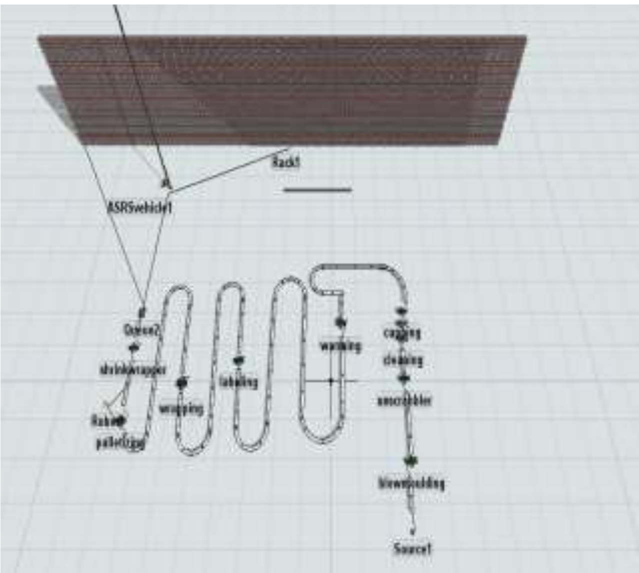

Fig.3.7 SIPA modified line

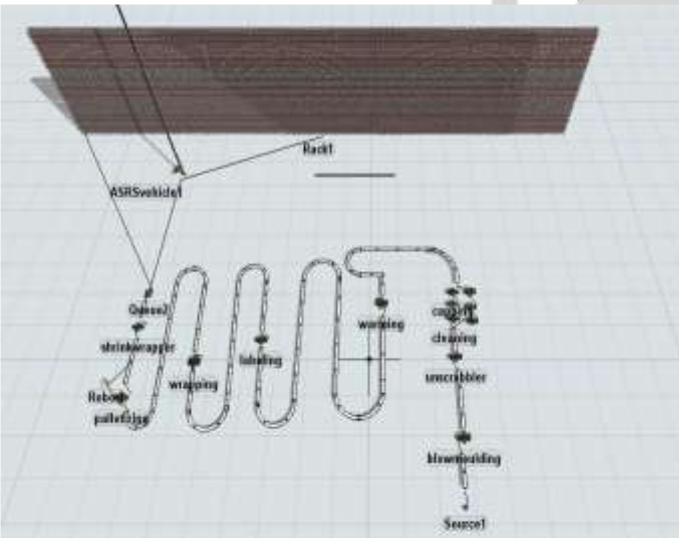

Fig.3.8 SIPA modified using RMAS line

KHS LINE:

These are the modified line and modified line using RMAS of KHS line the Taguchi optimization for automated storage and retrieval system and blow molding where the values are obtained in MINITAB software and there pictures shown in Table 3.12, 3.13, 3.14 and 3.15

Table 3.12 Modifies KHS line 86400Sec of ASRS

speed of ASRS (M/S)	capacity of ASRS(Nos)	loading of ASRS(S)	unloading of ASRS(S)	Output (no of pallets in racks)
4	60	3	3	2843
4	80	4	4	2836
4	100	5	5	2708
6	60	4	5	2785
6	80	5	3	2834
6	100	3	4	2848
8	60	5	4	2806
8	80	3	5	2824
8	100	4	3	2849

Table 3.13 Modified RMAS KHS line 28800Sec of ASRS

speed of ASRS(M/S)	capacity of ASRS(Nos)	loading of ASRS(S)	unloading of ASRS(S)	Output (no of pallets in racks)
4	60	3	3	938
4	80	4	4	934
4	100	5	5	849
6	60	4	5	894
6	80	5	3	933
6	100	3	4	937
8	60	5	4	904
8	80	3	5	931
8	100	4	3	937

Table 3.14 Modified KHS line 86400Sec of Blow molding

Processing time of blow molding	Capacity of blow molding (b/s)	Down time (s)	output (no of pallets in rack)
2	21	200	2725
2	23	250	2710
2	25	300	2725
3	21	250	2710
3	23	300	2725
3	25	200	2710
4	21	300	2725
4	23	200	2710
4	25	250	2725

Table 3.15 Modified RMAS KHS line 28800Sec of Blow molding

Processing time of blow molding	Capacity of blow molding (b/s)	Down time (s)	output (no of pallets in rack)
2	21	200	855
2	23	250	854
2	25	300	856
3	21	250	855
3	23	300	856
3	25	200	855
4	21	300	891
4	23	200	857
4	25	250	855

The line shown in Fig.3.9, 3.10 is KHS Modified Line and Modified Line Using RMAS which produces big bottles. Which contains all the workstations, rack, robot, and ASRS vehicle line is modified in FlexSim software.

 DOI : 10.35291/2454-9150.2020.0593

ISSN : 2454-9150 Vol-06, Issue-06, SEP 2020

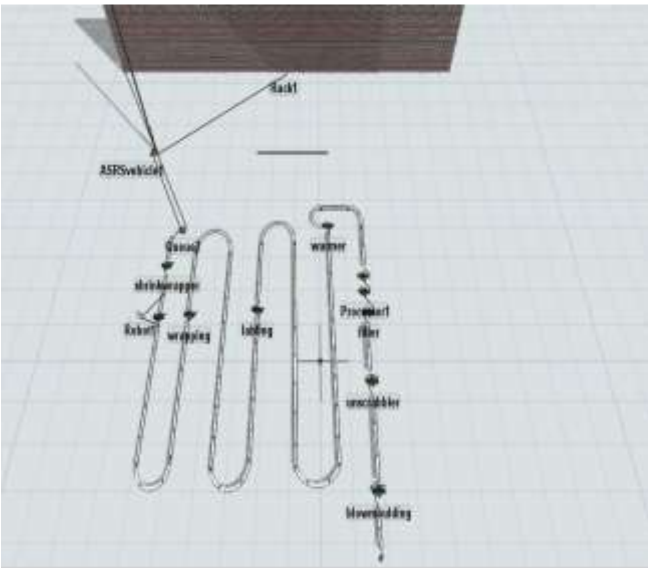

Fig.3.9 KHS modified line

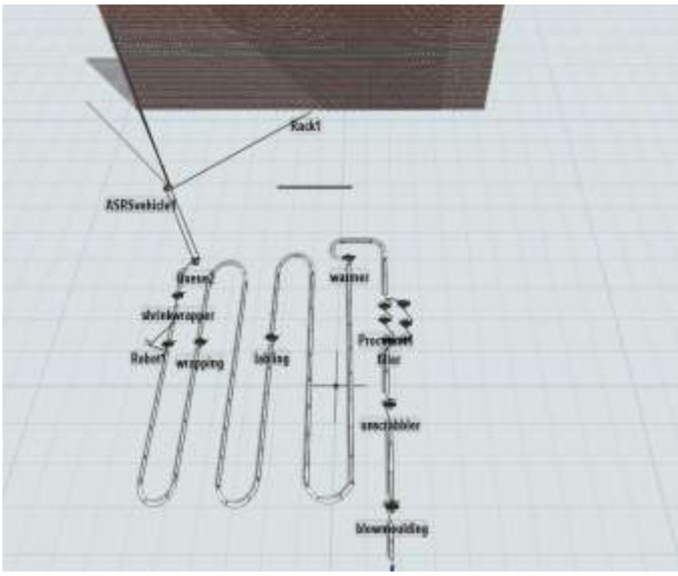

Fig.3.10 KHS modified using RMAS line

Summary: in this chapter different existed production line in PepsiCo Company are designed in FlexSim software and Taguchi optimization is applied for modified lines are modified lines using RMAS in MINITAB software.

IV. RESULTS

After modeling the three lines SIPA, KHS, and AQUAFINA then these models are simulated in FlexSim software the following results are obtained in except sheet by summary report and state report.

4.1 RESULT ANALYSIS FOR AQUAFINA LINES

(a) Existing line: The results are obtained by running the Aquafina line for 86400sec in FlexSim software the summary report, conveying report and state pie are obtained shown in Table 4.1

Table 4.1 Aquafina existing line summary report

FlexSim Summary Report						
Time:	86400					
Object	**Class**	**stats input**	**stats outpour**	**Idle time**	**Processing time**	**Breakdown time**
Source	Source	0	2878	0	0	0
Unscramble	Processor	2877	2877	80655	5745	0
Capping	Processor	2877	2876	71660.9	14338.84	400.20
Labeler	Processor	2874	2874	83526	2874	0
wrapping1	Processor	2872	2872	72085	14315	0
Palletization	Processor	2868	2868	52113	34287	0
Blow molding	Processor	2878	2878	80256.0	5747	396.92
Transporter1	Transporter	2445	2392	372.31	0	0
Cleaning	Processor	2877	2877	72060	14340	0
Filling	Processor	2877	2877	71685.4	14340	0
Processor1	Processor	2867	2867	63464	22936	0
Queue1	Queue	2867	1384	0	0	0
Rack1	Rack	1363	632	971.085	0	0
Rack2	Rack	623	296	1589.07	0	0
Rack3	Rack	291	133	2686.656	0	0
Rack4	Rack	115	0	86400	0	0

Object	**average empty time**	**average conveying time**
average for all conveyors	31138.7	55261.3

DOI : 10.35291/2454-9150.2020.0593

ISSN : 2454-9150 Vol-06, Issue-06, SEP 2020

(b) TAGUCHI OPTIMIZATION RESULTS FOR MODIFIED LINES AND MODIFIED LINE USING RMAS

These are the Aquafina modified line and Modified Line Using RMAS the Taguchi optimization for blow molding and ASRS the results are obtained by main effects plot for mean shown in Fig.4.1, 4.2, 4.3, 4.4

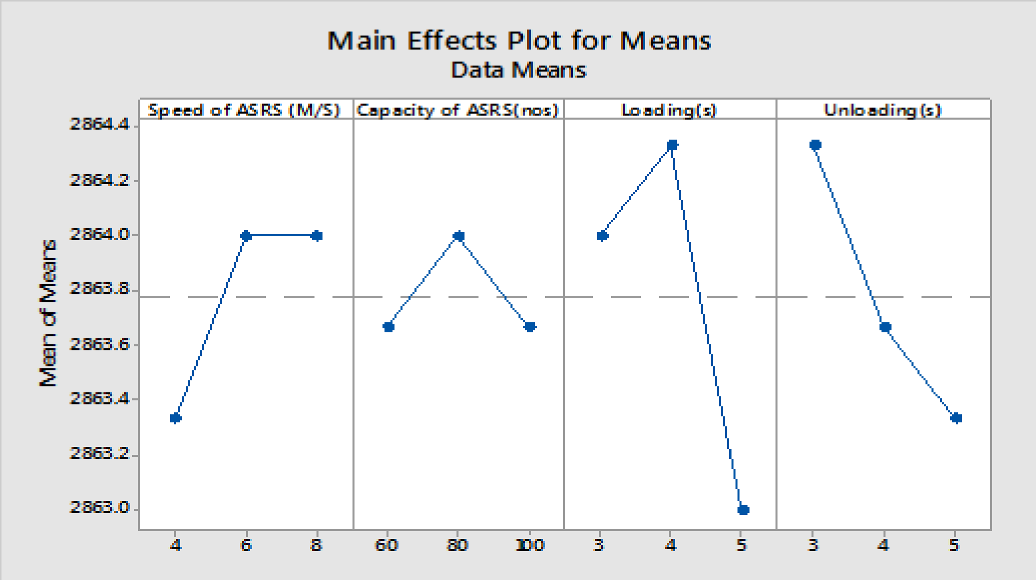

Fig.4.1 modified Aquafina line main effects plot for mean for ASRS

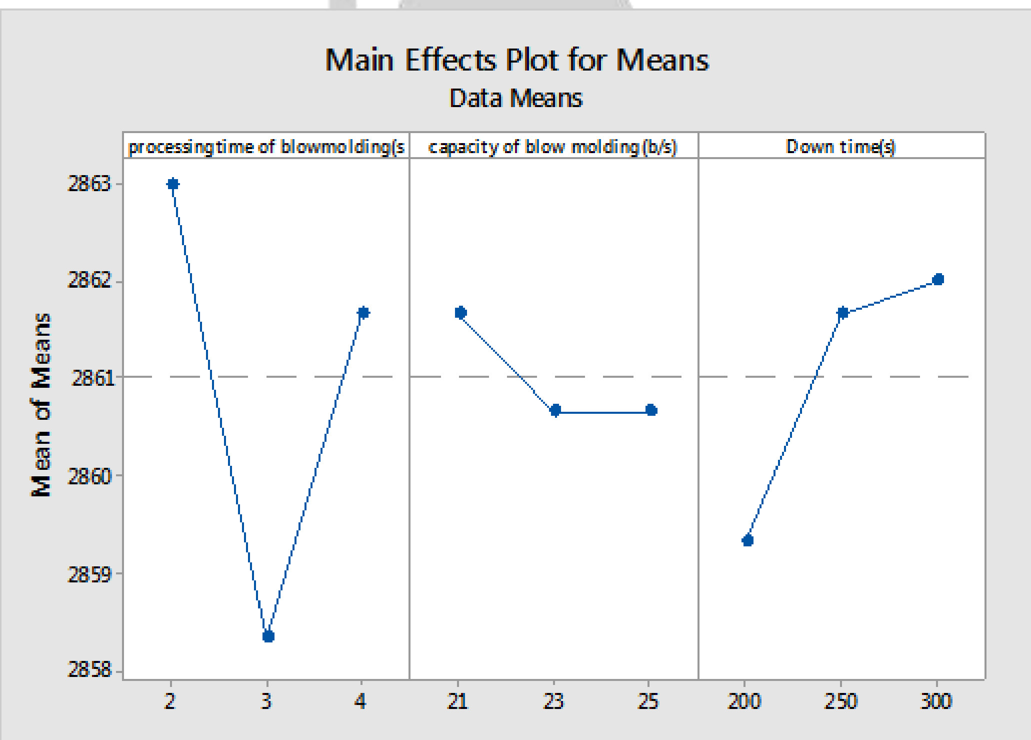

Fig.4.2 Modified Aquafina line main effects plot for mean for blow molding

 DOI : 10.35291/2454-9150.2020.0593

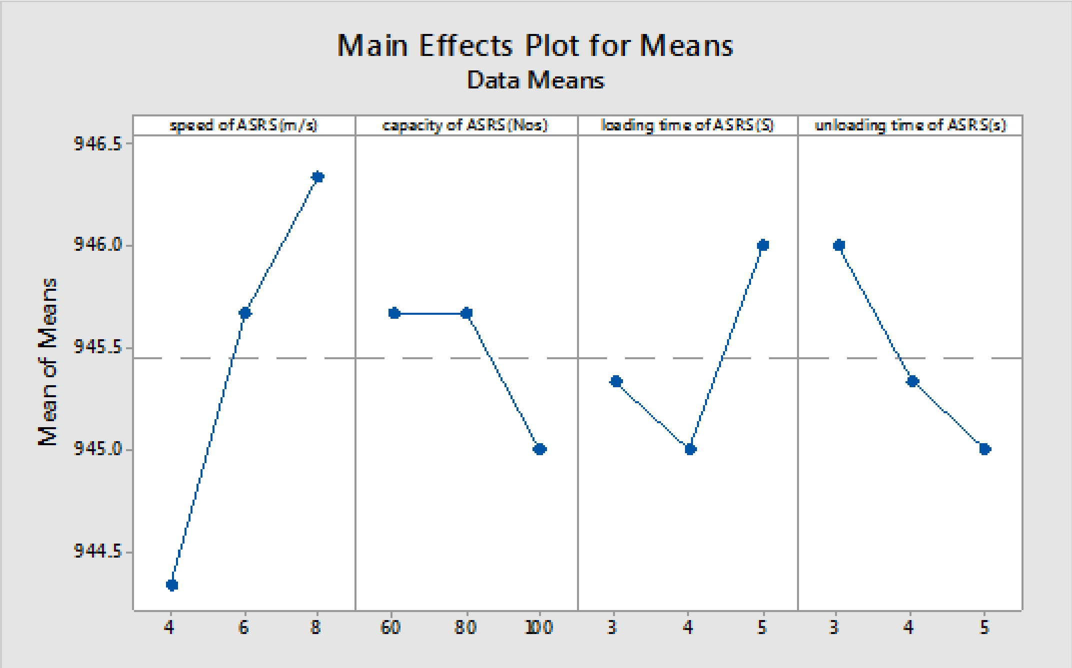

Fig.4.3 Modified using RMAS Aquafina line main effects plot for mean for ASRS

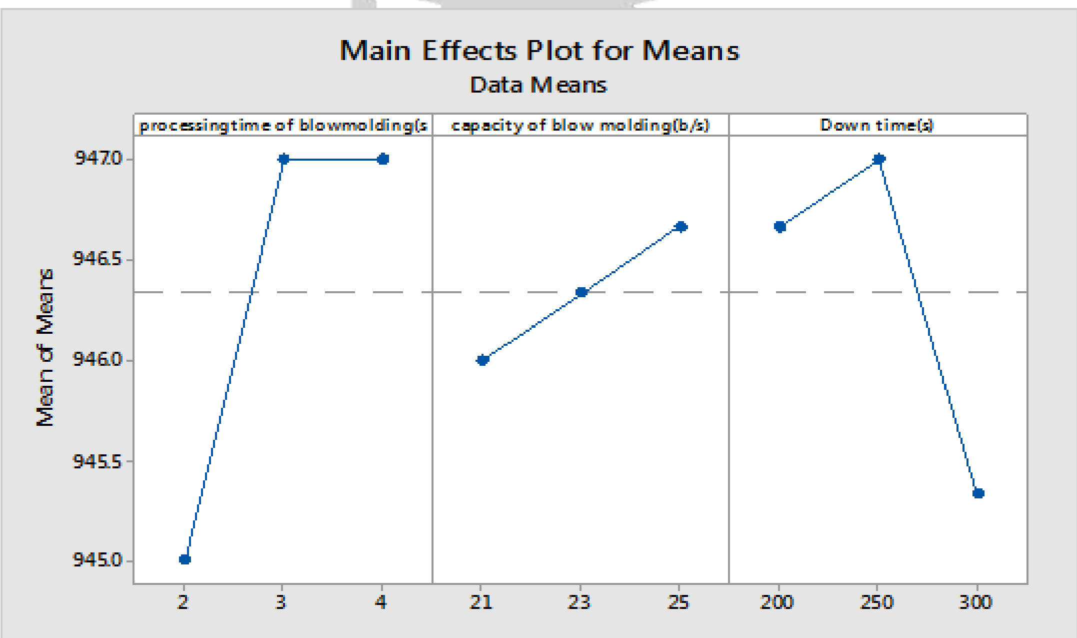

Fig.4.4 Modified using RMAS Aquafina line main effects plot for mean for blow molding

According to the graphs that are obtained from the optimization techniques the values are taken. The values for ASRS and blow molding for different parameters like Speed, Capacity, Loading time, Unloading for ASRS(S), processing time , capacity and downtime for blow molding the final values obtained from the above mean graphs shown in Table 4.2 and 4.3

Table 4.2 optimization of ASRS for modified lines

ASRS(86400)				
	Speed of ASRS(m/s)	**Capacity of ASRS(Nos)**	**Loading time of ASRS(s)**	**Unloading of ASRS(S)**
AQUAFINA LINE	8	80	4	3
SIPA LINE	8	80	4	3
KHS LINE	8	80	3	3

 DOI : 10.35291/2454-9150.2020.0593

Table 4.3 optimization of Blow molding for modified line

BLOWMOLDING(86400)			
	Processing time of blow molding(s)	**Capacity of blow molding(b/s)**	**Downtime(s)**
AQUAFINA LINE	2	21	250
SIPA LINE	2	21	300
KHS LINE	2	21	300

(c) Modified lines of Aquafina

The results are obtained by placing the optimized values of both ASRS and blow molding in Aquafina modified layout and run the model for 86400sec the results are obtained in the form of summary report, average Conveying time and state pie shown in Table 4.4

Table 4.4 modified Aquafina summary report

FlexSim Summary Report						
Time:	86400					
Object	**Class**	**stats input**	**stats output**	**Idle time**	**Processing time**	**Breakdown time**
Source	Source	0	2878	0	0	0
Unscramble	Processor	2877	2877	80655	5745	0
capping1	Processor	2877	2876	74526.26	11474.59	399.15
Labeler	Processor	2874	2874	83526	2874	0
wrapping1	Processor	2872	2872	72085	14315	0
Palletization	Processor	2868	2868	34427	34416	0
Blow molding	Processor	2878	2878	80253.3	5747	399.62
Cleaning1	Processor	2877	2877	74925	11475	0
filling1	Processor	2877	2877	74561.9	11475	0
shrink wrapper	Processor	2867	2867	63464	22936	0
Queue1	Queue	2866	2865	0	0	0
Rack1	Rack	2865	0	86400	0	0
Robot1	Robot	2868	2868	3512.92	0	0
ASRSvehicle1	ASRS vehicle	2865	2865	2280.64	0	0

Object	**Average empty time**	**Average conveying time**
Average for all conveyors	31128.59	55271.41

(d) Modified using RMAS of Aquafina line:

According to the graphs that are obtained from the optimization techniques the values are taken. The values ASRS and blow molding for different parameters like Speed, Capacity, Loading time, unloading for ASRS(S) and processing time, capacity, down time of blow molding shown in Table 4.5, 4.6, 4.7

 DOI : 10.35291/2454-9150.2020.0593

Table 4.5 optimization of ASRS for modified using RMAS line

ASRS(28800)				
	Speed of ASRS(m/s)	**Capacity of ASRS(Nos)**	**Loading time of ASRS(s)**	**Unloading of ASRS(S)**
AQUAFINA LINE	8	80	5	3
SIPA LINE	8	80	3	3
KHS LINE	8	80	3	3

Table 4.6 optimization of Blow molding for modified using RMAS line

BLOWMOLDING(28800)			
	Processing time of blow molding(s)	**Capacity of blow molding(b/s)**	**Downtime(s)**
AQUAFINA LINE	3	25	250
SIPA LINE	4	21	300
KHS LINE	4	21	300

Table 4.7 Modified using RMAS Aquafina summary report

FlexSim Summary Report					
Time:	28800				
Object	**Class**	**Stats input**	**stats output**	**Idle time**	**Processing time**
Source	Source	0	959	0	0
Unscramble	Processor	958	958	26884	1916
capping1	Processor	958	958	24968	3832
Labeler	Processor	955	955	27845	955
wrapping1	Processor	954	954	24030	4770
Palletization	Processor	950	949	11716.48	11389.52
Blow molding	Processor	959	959	24964	3836
Cleaning1	Processor	958	958	24968	3832
filling1	Processor	958	958	24968	3832
shrink wrapper	Processor	948	948	21216	7584
Queue1	Queue	948	946	0	0
Rack1	Rack	946	0	28800	0
Robot1	Robot	949	949	1277.4	0
ASRSvehicle1	ASRS vehicle	946	946	384.33	0
cleaning2	Processor	0	0	28800	0
filling2	Processor	0	0	28800	0
capping2	Processor	0	0	28800	0

Object	**Average empty time**	**Average conveying time**
Average for all conveyors	10403.76	18396

 DOI : 10.35291/2454-9150.2020.0593

(E) Comparision of State Reports: the state pie of existing line, modified and modified using RMAS are shown in Fig.4.5, 4.6, 4.7

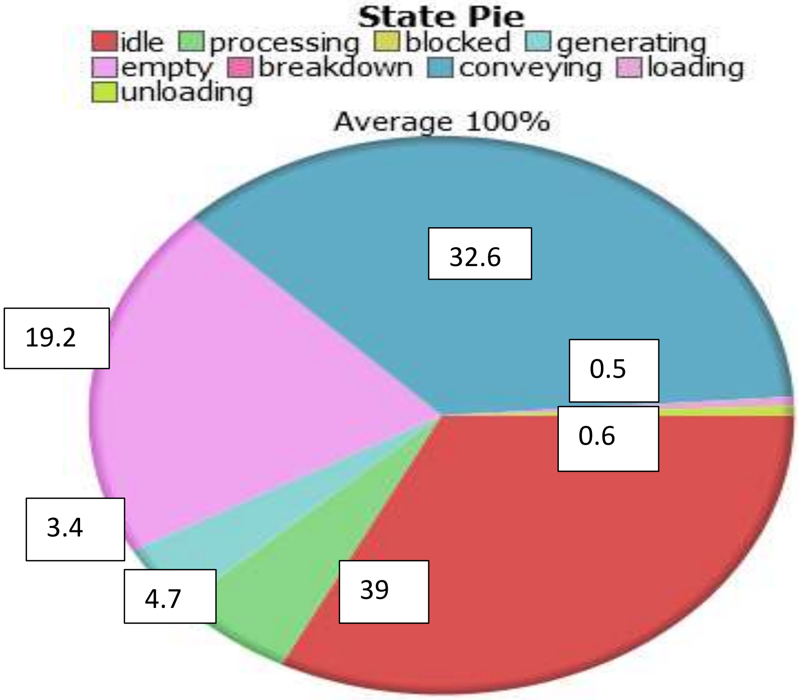

Fig.4.5 Aquafina existing line state pie

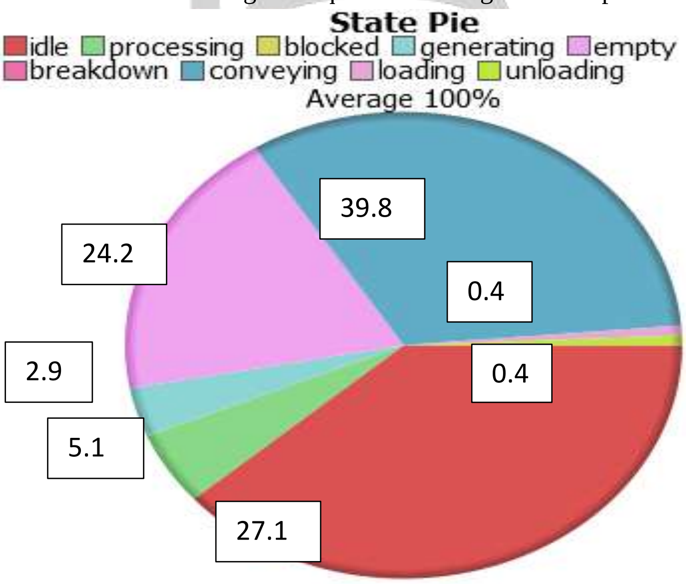

Fig. 4.6 Aquafina modified line state pie

DOI : 10.35291/2454-9150.2020.0593

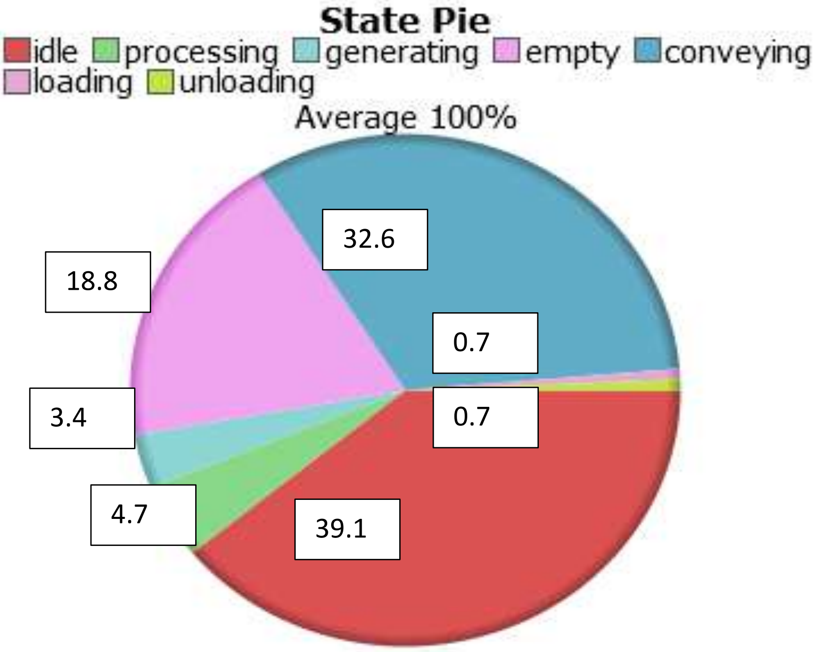

Fig. 4.7 Modified using RMAS Aquafina state pie

4.2 SIPA Modified line and modified line using RMAS

(a) Existing line: The results are obtained by running the SIPA line for 86400sec in FlexSim software the summary report, conveying report and state pie are obtained shown in Table 4.8

Table 4.8 SIPA existing line summary report

FlexSim Summary Report						
Time	86400					
Object	**Class**	**stats input**	**stats output**	**Idle time**	**Processing time**	**Breakdown time**
Source1	Source	0	3596	0	0	0
Blow molding	Processor	3595	3595	78815.4	7181	403.59
Unscramble	Processor	3594	3594	79221	7179	0
Capping	Processor	3594	3593	68475.55	17924.45	0
Warming	Processor	3590	3590	57761	28639	0
Labeling	Processor	3583	3583	82817	3583	0
Wrapping	Processor	3579	3579	68550	17850	0
Palletizing	Processor	3575	3575	43629	42771	0
Shrink wrapper	Processor	3574	3574	57889	28511	0
Transporter1	Transporter	2292	2240	526.6608	0	0
Rack1	Rack	1415	534	1147.566	0	0
Queue2	Queue	3574	1441	0	0	0
Cleaning	Processor	3594	3594	68475	17925	0
Filling	Processor	3594	3594	68475	17925	0
Rack2	Rack	516	213	1924.572	0	0
Rack3	Rack	207	104	2767.069	0	0
Rack4	Rack	102	0	86400	0	0

Object	Average empty time	Average conveying time
Average for all conveyors	28533.4	57866.5

 DOI : 10.35291/2454-9150.2020.0593

ISSN : 2454-9150 Vol-06, Issue-06, SEP 2020

(b) Taguchi optimization results for modified lines and modified using RMAS:

These are the SIPA modified line and Modified Line Using RMAS the Taguchi optimization for blow molding and ASRS the results are obtained by main effects plot for mean shown in Fig.4.8, 4.9, 4.10 and 4.11

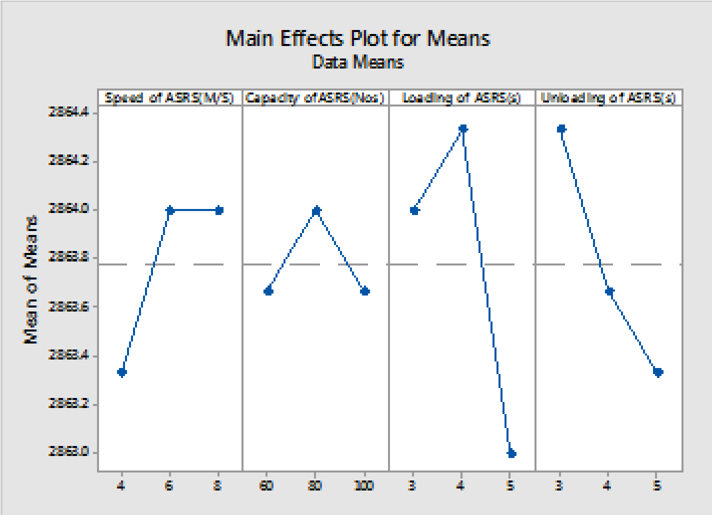

Fig.4.8 Modified SIPA line main effects plot for mean for ASRS

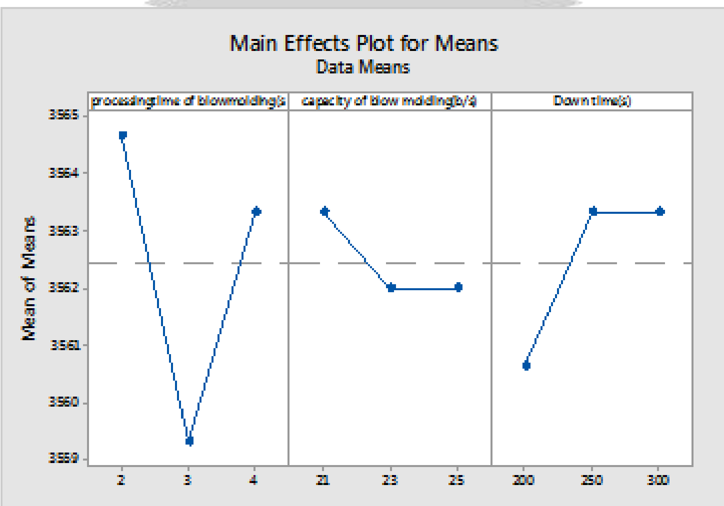

Fig.4.9 SIPA line main effects plot for mean

Modified using RMAS:

Fig.4.10 Modified using RMAS SIPA line main effects plot for mean for ASRS

DOI : 10.35291/2454-9150.2020.0593

ISSN : 2454-9150 Vol-06, Issue-06, SEP 2020

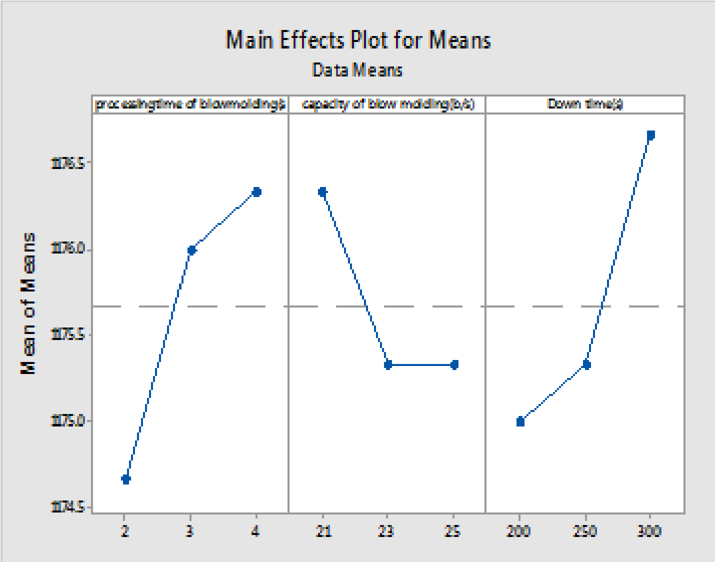

Fig.4.11 Modified using RMAS SIPA line main effects plot for mean for blow molding

(C) Modified line for SIPA

The results are obtained by placing the optimized values of both ASRS and blow molding in SIPA modified layout and run the model for 86400sec the results are obtained in the form of summary report, average Conveying time and state pie shown in Table 4.9

Table 4.9 Modified SIPA summary report

FlexSim Summary Report						
Time:	86400					
Object	**Class**	**stats input**	**stats output**	**Idle time**	**Processing time**	**Breakdown time**
Source1	Source	0	3591	0	0	0
Blow molding	Processor	3591	3591	78725.58	7173	501.41
Unscramble	Processor	3590	3590	79229	7171	0
capping1	Processor	3590	3589	68497.33	17902.6	0
Warming	Processor	3586	3586	57793	28607	0
Labeling	Processor	3579	3579	82821	3579	0
Wrapping	Processor	3575	3575	68570	17830	0
Palletizing	Processor	3571	3571	25028	42852	0
Shrink wrapper	Processor	3570	3570	57840	28560	0
Rack1	Rack	3563	0	86400	0	0
Queue2	Queue	3569	3568	0	0	0
cleaning1	Processor	3590	3590	68495	17905	0
filling1	Processor	3590	3590	68495	17905	0
Robot1	Robot	3571	3570	7839.98	0	0
ASRSvehicle1	ASRS vehicle	3568	3563	1744.24	0	0

Object	**Average empty time**	**Average conveying time**
Average for all conveyors	28376.61	58023.3

(D) Modified line Using RMAS for SIPA: the results for modified using RMAS for SIPA line is shown in Table 4.10

Table 4.10 Modified using RMAS SIPA summary report

FlexSim Summary Report					
Time:	28800				
Object	**Class**	**Stats _input**	**stats_ output**	**Idle time**	**Processing time**
Source1	Source	0	1200	0	0

 DOI : 10.35291/2454-9150.2020.0593

ISSN : 2454-9150 Vol-06, Issue-06, SEP 2020

Blow molding	Processor	1200	1200	24000	4800
Unscramble	Processor	1199	1199	26402	2398
capping1	Processor	1199	1198	22808.14	5991.8
Warming	Processor	1195	1195	19240	9560
Labeling	Processor	1188	1188	27612	1188
Wrapping	Processor	1184	1184	22880	5920
Palletizing	Processor	1180	1180	8740	14160
Shrink wrapper	Processor	1179	1179	19368	9432
Rack1	Rack	1177	0	28800	0
Queue2	Queue	1178	1177	0	0
cleaning1	Processor	1199	1199	22805	5995
filling1	Processor	1199	1199	22805	5995
Robot1	Robot	1180	1179	2842.78	0
ASRSvehicle1	ASRS vehicle	1177	1177	1072.40	0
cleaning2	Processor	0	0	28800	0
filling2	Processor	0	0	28800	0
capping2	Processor	0	0	28800	0

Object	**Average empty time**	**Average conveying time**
Average for all conveyors	9486.87	19313.12

(C) Comparison of state pie: the comparison of state pie of existing layout, modified and modified using RMAS are shown in Fig.4.12, 4.13 and 4.14

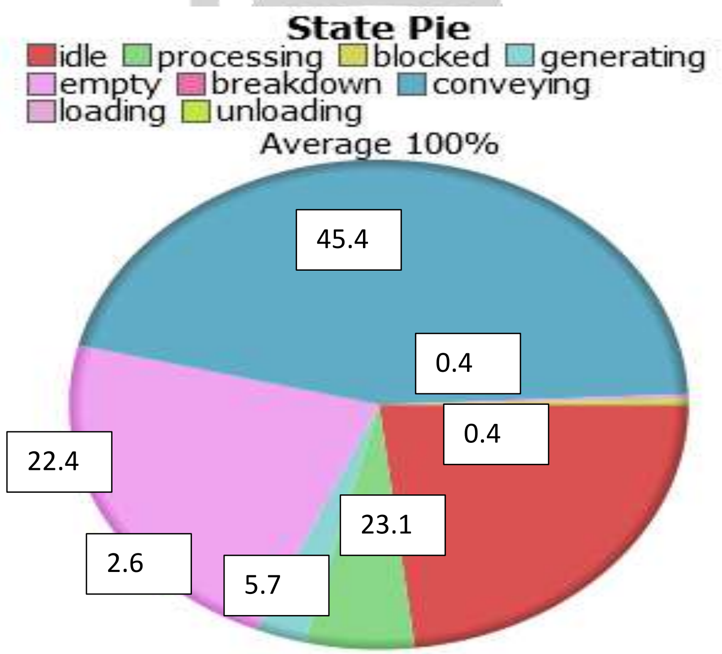

Fig.4.12 SIPA existing line state pie

DOI : 10.35291/2454-9150.2020.0593

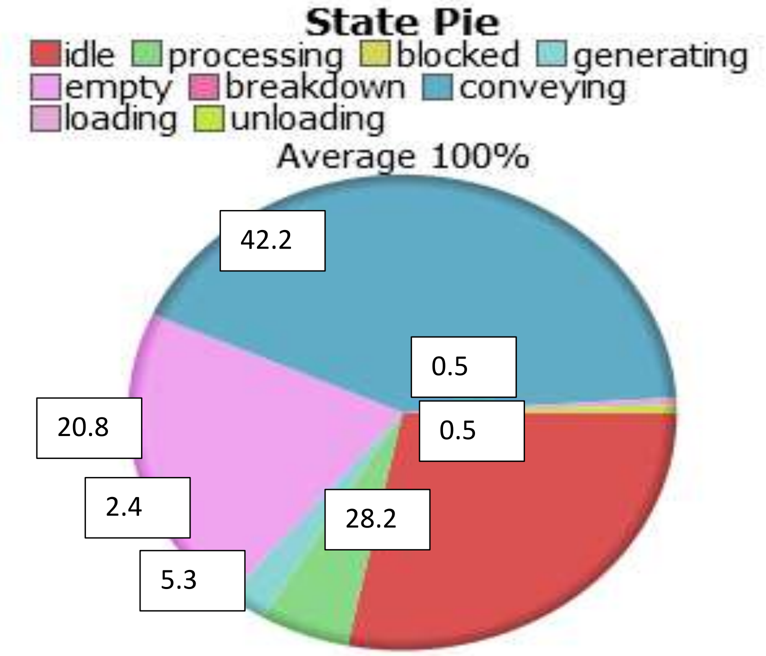

Fig.4.13 SIPA modified line state pie

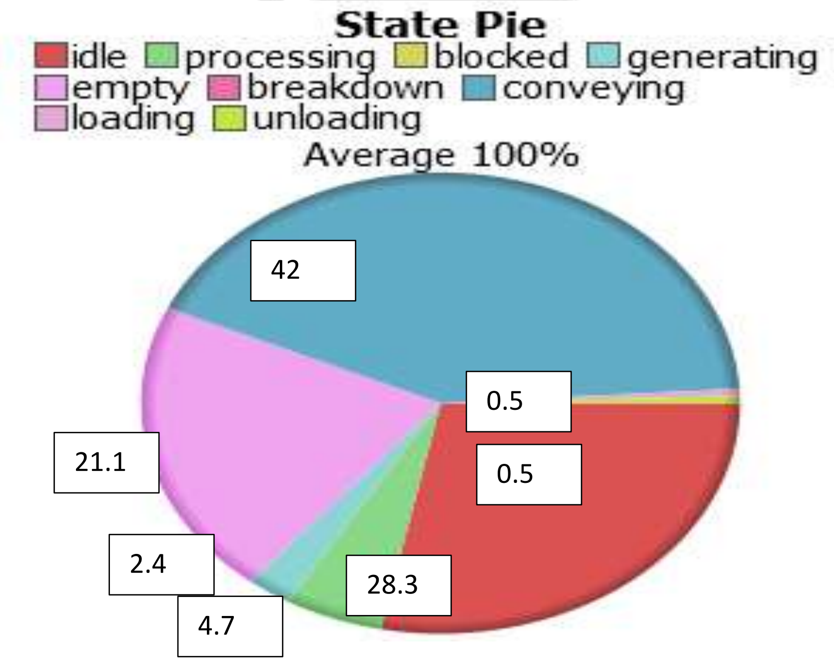

Fig. 4.14 Modified using RMAS SIPA state pie

4.3 KHS Modified line and modified using RMAS

(a) Existing line

The results are obtained by running the KHS line for 86400sec in FlexSim software the summary report, conveying report and state pie are obtained shown in Table 4.11

Table 4.11 KHS existing line summary report

FlexSim Summary Report						
Time:	86400					
Object	**Class**	**stats input**	**stats outpour**	**Idle time**	**Processing time**	**Breakdown time**
Source1	Source	0	2879	0	0	0
Blow molding	Processor	2879	2879	80252.26	5749	398.74
Unscramble	Processor	2879	2879	80651	5749	0
Cleaning	Processor	2878	2878	72055	14345	0
Warmer	Processor	2876	2876	63473.39	22926.61	0

 DOI : 10.35291/2454-9150.2020.0593

Labeling	Processor	2870	2870	83530	2870	0
Wrapping	Processor	2865	2865	72120	14280	0
Palletizing	Processor	2862	2861	52190.23	34209.77	0
Queue2	Queue	2861	1368	0	0	0
Rack1	Rack	1357	602	1137.60	0	0
Transporter1	Transporter	2387	2369	595.75	0	0
Shrink wrapper	Processor	2861	2861	63593.39	22806.61	0
Filling	Processor	2878	2878	72055	14345	0
Capping	Processor	2878	2878	72055	14345	0
Rack2	Rack	598	294	1850.21	0	0
Rack3	Rack	292	123	2643.71	0	0
Rack4	Rack	122	0	86400	0	0

Object	**average empty time**	**average conveying time**
average for all conveyors	32674.9	53725.08

(b) Taguchi optimization for modified lines and modified using RMAS

These are the modified line and Modified Line Using RMAS of KHS the Taguchi optimization for blow molding and ASRS the results are obtained by main effects plot for mean are shown in Table 4.15, 4.16, 4.17 and 4.18

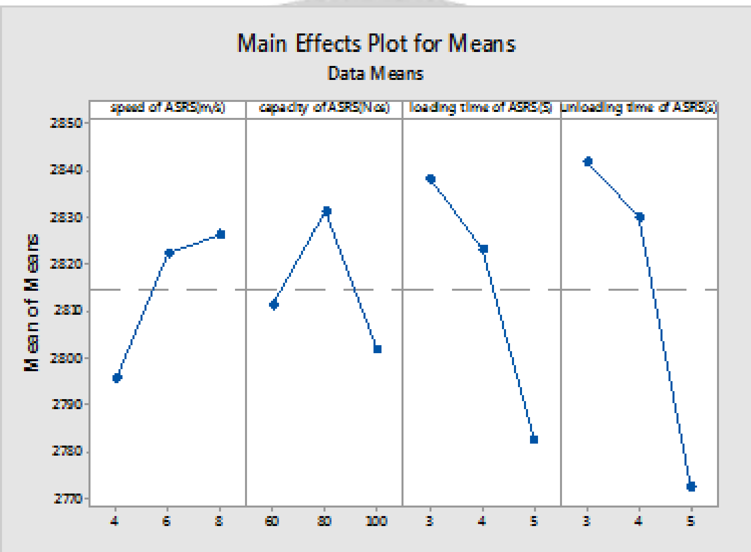

Fig.4.15 Modified KHS line main effects plot for mean for ASRS

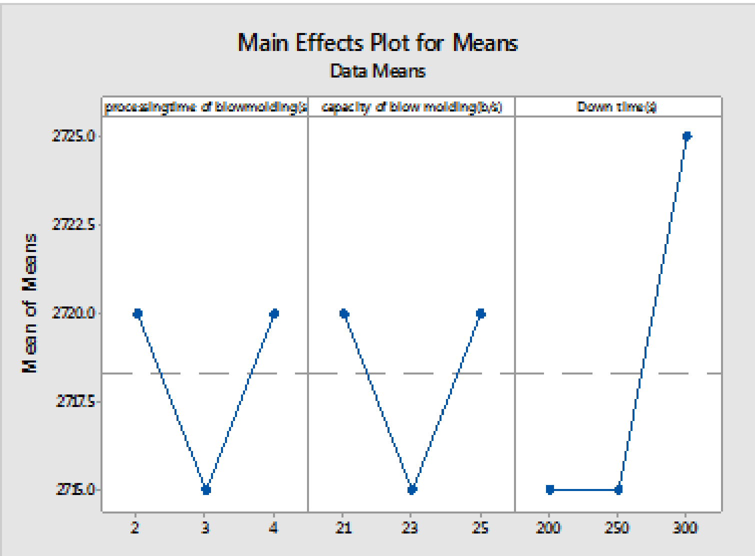

Fig.4.16 Modified KHS line main effects plot for mean for blow molding

 DOI : 10.35291/2454-9150.2020.0593

International Journal for Research in Engineering Application & Management (IJREAM)
ISSN : 2454-9150 Vol-06, Issue-06, SEP 2020

Modified using RMAS:

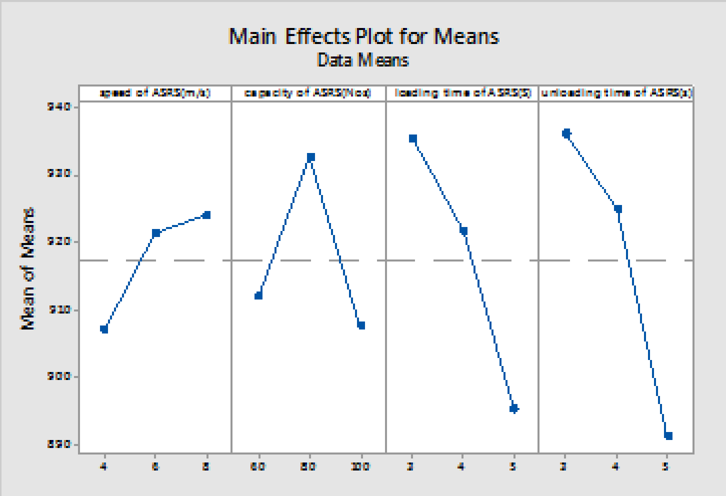

Fig.4.17 Modified RMAS KHS line main effects plot for mean for ASRS

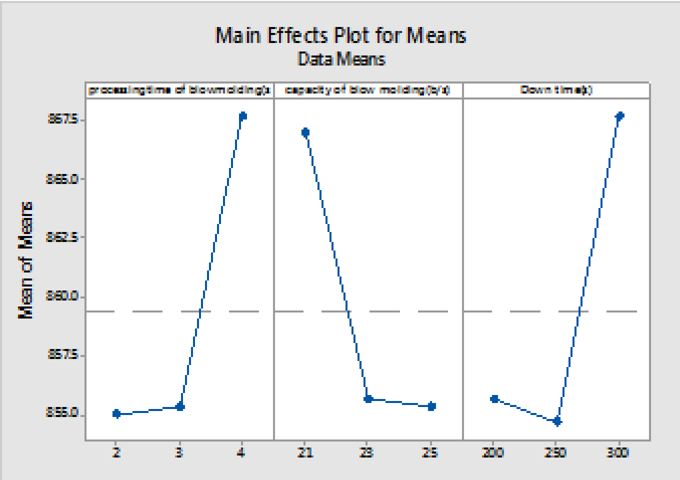

Fig.4.18 Modified RMAS KHS line main effects plot for mean for blow molding

(C) Modified line for KHS

The results are obtained by placing the optimized values of both ASRS and blow molding in modified layout and run the model for 86400sec the results are obtained in the form of summary report, average Conveying time and state pie are shown in Table 4.12

Table 4.12 Modified KHS summary report

FlexSim Summary Report						
Time:	86400					
Object	**Class**	**stats input**	**stats outpour**	**Idle time**	**Processing time**	**Breakdown time**
Source1	Source	0	2879	0	0	0
Blow molding	Processor	2879	2879	74884	11516	395.53
Unscramble	Processor	2879	2878	80643.85	5756.14	0
cleaning1	Processor	2878	2878	72010	14390	0
Warmer	Processor	2876	2876	63392	23008	0
Labeling	Processor	2870	2870	83530	2870	0
Wrapping	Processor	2865	2865	72075	14325	0
Palletizing	Processor	2862	2861	37753.85	34341.15	0
Queue2	Queue	2860	2855	0	0	0
Rack1	Rack	2851	0	86400	0	0
Shrink wrapper	Processor	2861	2860	63512.92	22887.08	0
filling1	Processor	2878	2878	72010	14390	0
capping1	Processor	2878	2878	72010	14390	0
ASRSvehicle1	ASRS vehicle	2855	2851	607.7593	0	0
Robot1	Robot	2861	2861	23448.85	0	0

 DOI : 10.35291/2454-9150.2020.0593

Object	average empty time	average conveying time
average for all conveyors	32313.35	54086.65

(C) Modified line Using RMAS for KHS: Modified line Using RMAS for KHS results are shown are Table 4.13

Table 4.13 Modified using RMAS KHS summary report

FlexSim Summary Report					
Time:	28800				
Object	**Class**	**stats input**	**stats output**	**Idle time**	**Processing time**
Source1	Source	0	959	0	0
Blow molding	Processor	959	959	24964	3836
Unscramble	Processor	959	958	26883.85	1916.145
cleaning1	Processor	958	958	24010	4790
Warmer	Processor	956	956	21152	7648
Labeling	Processor	950	950	27850	950
Wrapping	Processor	945	945	24075	4725
Palletizing	Processor	942	941	12793.85	11301.15
Queue2	Queue	940	939	0	0
Rack1	Rack	938	0	28800	0
Shrink wrapper	Processor	941	940	21272.92	7527.076
filling1	Processor	958	958	24010	4790
capping1	Processor	958	958	24010	4790
ASRSvehicle1	ASRS vehicle	939	938	607.75	0
cleaning2	Processor	0	0	28800	0
filling 2	Processor	0	0	28800	0
capping2	Processor	0	0	28800	0
Robot1	Robot	941	941	8088.8	0

Object	Average empty time	Average conveying time
Average for all conveyors	13188.7	15611.2

(d) comparision of state pie

comparision of state pie results of exisiting line, modified and modified using RMAS are shown in Fig.4.19, 4.20 and 4.21

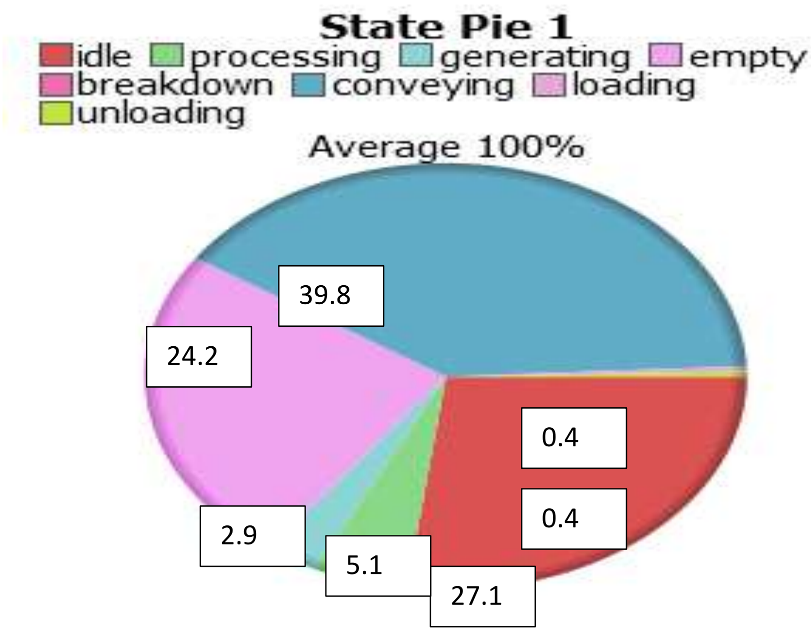

Fig.4.19 KHS existing line state pie

 DOI : 10.35291/2454-9150.2020.0593

ISSN : 2454-9150 Vol-06, Issue-06, SEP 2020

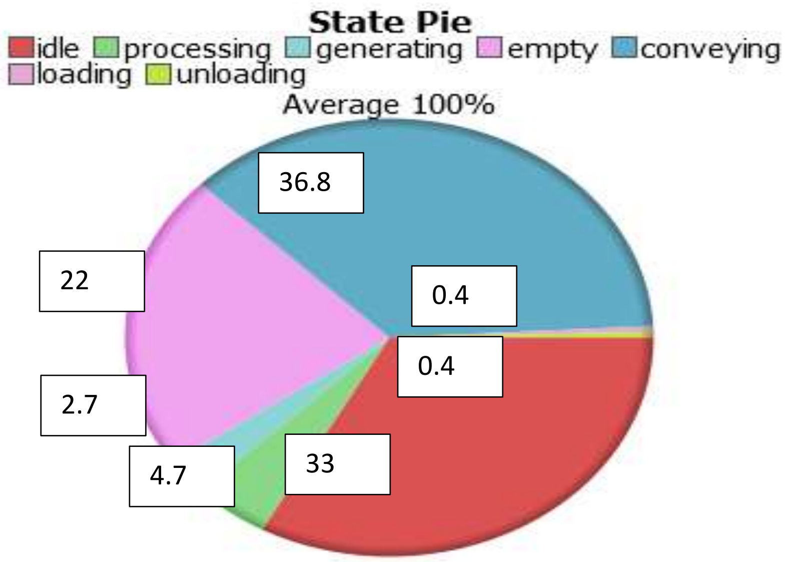

Fig. 4.20 KHS modified line state pie

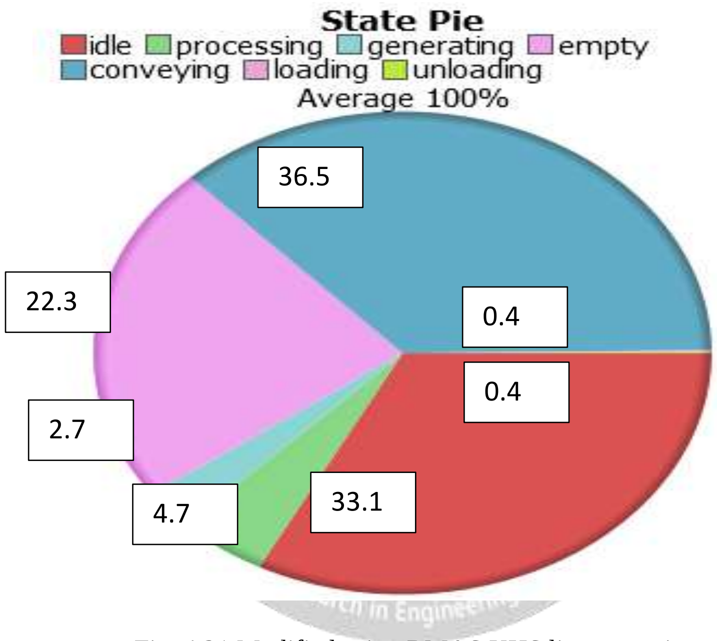

Fig. 4.21 Modified using RMAS KHS line state pie

4.4 Production capacity comparison

Comparing all the three lines Aquafina, SIPA, KHS with existing, modified, modified using RMAS the production capacity of the line in the rack are shown in Table 4.14

Table 4.14 Production capacity comparison

LAYOUT / LINE	AQUAFINA	SIPA	KHS
EXSISTING	2392	2240	2369
MODIFIED	2865	3563	2851
RMAS	2671	3322	2650

4.5 processing time comparison

Comparing all the three lines Aquafina, SIPA, KHS with existing, modified, modified using RMAS the average processing time are shown in Table 4.15

Table 4.15 Average Processing time in seconds

LAYOUT / LINE	AQUAFINA	SIPA	KHS
EXSISTING	8594.8	11146.3	8919.1
MODIFIED	8604.1	12632.3	10524.8
RMAS(8hrs)	2467.4	3635.5	2904

DOI : 10.35291/2454-9150.2020.0593

ISSN : 2454-9150 Vol-06, Issue-06, SEP 2020

4.6 COST ANALYSIS CALCULATIONS:

AQUAFINA (1ltr bottle):

*(All costs mentioned are approximate based on market survey)

The cost analysis calculation for Aquafina line, SIPA line and KHS line are shown in Table 4.16, 4.17 and 4.18

Table 4.16 cost analysis calculation for Aquafina line

Existing layout	
The cost of 1liter Aquafina water bottle is	₹20
Manufacturing cost (operation, labeling, mineral water, packaging, marketing etc.) of each bottle	₹5
Selling price of each bottle	₹6.5
Profit earned on each bottle	₹1 to 1.5
The number of pallets in rack is	₹2392
Each pallet contains	405 bottles
2392*405	968760(bottles)
The profit is ₹1 each bottle, then for total no. of bottles	968760*₹1
Profit per day	₹968760
For modified layout	
No of pallets in rack	2865
2865*405(bottles)	1160325(bottles)
The profit is ₹1 each bottle, then for total no. of bottles	1160325*1
Profit per day	1160325
For modified using RMAS layout	
No of pallets in rack	2671
2671*405(bottles)	1081755(bottles)
The profit is ₹1 each bottle, then for total no. of bottles	1081755*1
Profit per day	₹10, 81,755
The profit % of modified using RMAS line is	11.66%
The cost to company for other expenses like workers salary, equipment purchase etc. 90% (approx.) of the revenue will be utilized. Remaining 10% (approx.) is the profit gained.	
The ASRS System cost	₹60 lakhs
The cost of ROBOT	₹50 Lakhs
The cost of cleaning, filling, capping machine cost	₹20 crores
This cost will be recovered within a period of 1 to 2 years for modified layout and 4 to 5 years modified with RMAS layout.	

SIPA LINE (600ml):

Table 4.17 cost analysis calculation for SIPA line

Existing layout	
The cost of 600ml Pepsi bottle is	₹35
Manufacturing cost (operation, labeling, mineral water, packaging, marketing etc.) of each bottle	₹10
Selling price of each bottle	₹12
Profit earned on each bottle	₹1 to 2
The number of pallets in rack is	₹2240
Each pallet contains	540 bottles
2240*540	1209600(bottles)
The profit is ₹1.5 each bottle, then for total no. of bottles	1209600*1.5
Profit per day	₹18, 14,400
For modified layout	
No of pallets in rack	3563
3563*540(bottles)	1924020(bottles)
The profit is ₹1.5 each bottle, then for total no. of bottles	1924020*1.5
Profit per day	₹28, 86,030
For modified using RMAS layout	
No of pallets in rack	3322
3322*540(bottles)	1793880(bottles)
The profit is ₹1.5 each bottle, then for total no. of bottles	1793880*1.5
Profit per day	₹26, 90,820
The profit % of modified using RMAS line is	11.66%
The cost to company for other expenses like workers salary, equipment purchase etc. 90% (approx.) of the revenue will be utilized. Remaining 10% (approx.) is the profit gained.	
The ASRS System cost	₹60 lakhs
The cost of ROBOT	₹50 Lakhs
The cost of cleaning, filling, capping machine cost	₹20 crores
This cost will be recovered within a period of 10 to 1 years for modified layout and 2 to 3 years modified with RMAS layout.	

KHS - BIG BOTTLES (2ltr):

Table 4.18 cost analysis calculation for KHS line

Existing layout	
The cost of 2ltr Pepsi bottle is	₹85
Manufacturing cost (operation, labeling, mineral water, packaging, marketing etc.) of each bottle	₹20
Selling price of each bottle	₹25
Profit earned on each bottle	₹3 to 5
The number of pallets in rack is	₹2369
Each pallet contains	270 bottles
2369*270	639630(bottles)

 DOI : 10.35291/2454-9150.2020.0593

The profit is ₹4 each bottle, then for total no. of bottles	639630*4
Profit per day	₹25, 58,520
For modified layout	
No of pallets in rack	2851
2851*270(bottles)	769770(bottles)
The profit is ₹4 each bottle, then for total no. of bottles	769770*4
Profit per day	₹30, 79,080
For modified using RMAS layout	
No of pallets in rack	2650
2650*270(bottles)	715500(bottles)
The profit is ₹4 each bottle, then for total no. of bottles	715500*4
Profit per day	₹28, 62,000
The cost to company for other expenses like workers salary, equipment purchase etc. 90% (approx.) of the revenue will be utilized. Remaining 10% (approx.) is the profit gained.	
The ASRS System cost	₹60 lakhs
The cost of ROBOT	₹50 Lakhs
The cost of cleaning, filling, capping machine cost	₹20 crores
This cost will be recovered within a period of 8months to 1 year for modified layout and 2 to 3 years modified with RMAS layout.	

4.7 Production capacity comparison

From the cost analysis the profit earned by the modified and modified using RMAS for all lines (considering all products sold) are shown in Table 4.19

Table 4.19 Profit earned compared to existing layout (considering all products sold)

LAYOUT	AQUAFINA	SIPA	KHS
LINE			
MODIFIED	19.77%	59.06%	16.9%
RMAS	11.66%	48.3%	11.8%

Summary: In the chapter the results which are obtained from FlexSim software both summary report, conveying report and state pie charts of all the three lines like Aquafina line, SIPA line, KHS line are compared and the cost analysis of the three line

V. CONCLUSION

- Modified plant layout will help the industry to get more productivity in less time with optimum usages of input materials. of Aquafina will be having 19.77% and 11.66% productivity SIPA with 59.06% and 48.3% and KHS with 16.9 % and 11.8% productivity
- After optimization the processing time of product in the production line for modified layout is 0.11%, 13.32%, 18.0% the processing increases and for modified lines using RMAS are -16.17%, -2.16%, -2.32% the processing time decreases
- By keeping parallel machine systems setup time decreased by 75%.
- In comparison to the existing layout modified layout of Aquafina will be having 19.77% and 11.66% profits SIPA with 59.06% and 48.3% and KHS with 16.9 % and 11.8% profit

VI. FUTURE SCOPE

- What are the other modifications could be done to improve industrial material handling.
- Different new technologies we can use for improvement.
- Modifications in industry setups and use of space or space management

REFERENCES

[1] Michael A. Saliba, Dawn Zammit, and Sandro Azzopardi "Towards practical, high-level guidelines to promote company strategy for the use of reconfigurable manufacturing automation" Robotics and Computer-Integrated Manufacturing" 47 (2016): 53–60

[2] Bhargav A, C. N. V. Sridhar, and MLS Deva Kumar. "Study of Production Scheduling Problem for Reconfigurable Manufacturing System (RMS)" *Materials Today: Proceedings*4, no. 8 (2017): 7406-7412.

[3] Bruzzone, A. A. G., and D. M. D'Addona. "New Perspectives in Manufacturing: An Assessment for an Advanced Reconfigurable Machining System" *Procedia CIRP* 67 (2018): 552-557.

[4] Choe, Pilsung, Jeffrey D. Tew, and Songzhen Tong. "Effect of cognitive automation in a material handling system on manufacturing flexibility" *International Journal of Production Economics* 170 (2015): 891-899.

[5] Kapitanov, A. V. "Manufacturing System Flexibility Control." *Procedia Engineering* 206 (2017): 1470-1475.

[6] El-Tamimi, Abdulziz M., Mustufa H. Abidi, S. Hammad Mian, and Javed Aalam. "Analysis of performance measures of flexible manufacturing system." *Journal of King Saud University-Engineering Sciences* 24, no. 2 (2012): 115-129.

[7] Botti, Lucia, Cristina Mora, and Alberto Regattieri. "Integrating ergonomics and lean manufacturing principles in a hybrid assembly line." *Computers & Industrial Engineering* 111 (2017): 481-491.

[8] Halim, Nurul Hayati Abdul, Noriah Yusuf, Roseleena Jaafar, Ahmed Jaffar, Nur A'in Kaseh, and Nur Nida Azira. "Effective Material Handling System for JIT Automotive

 DOI : 10.35291/2454-9150.2020.0593

Production Line" *Procedia Manufacturing* 2 (2015): 251-257.

[9] Negahban, Ashkan, and Jeffrey S. Smith. "Simulation for manufacturing system design and operation: Literature review and analysis." *Journal of Manufacturing Systems* 33, no. 2 (2014): 241-261.

[10] Chang, Dae S., and Sang C. Park. "Development of Simulator for a Material Handling System Analysis of Assembly Line" *International Journal of Computer Theory and Engineering* 7, no. 1 (2015): 70.

[11] Cristalli, Cristina, Luca Lattanzi, Daniele Massa, and Giacomo Angione. "Cognitive Robot Referencing System for High Accuracy Manufacturing Task" *Procedia Manufacturing* 11 (2017): 405-412.

[12] Subulan, Kemal, and Mehmet Cakmakci. "Feasibility study using simulation-based optimization and Taguchi experimental design method for material handling—transfer system in the automobile industry" *The International Journal of Advanced Manufacturing Technology* 59, no. 5-8 (2012): 433-443.

[13] Francisco, Roberto P., Daniel P. Campos, Enzo M. Frazzon, and Ricardo L. Machado. "On the application of modelling and simulation to compare human-and automation-based order-picking systems" *IFAC-Papers Online* 49, no. 12 (2016): 1062-1067.

[14] Nyemba, Wilson R., and Charles Mbohwa. "Modelling, simulation and optimization of the materials flow of a multi-product assembling plant." *Procedia Manufacturing* 8 (2017): 59-66.

[15] Azzopardi, Sandro, Michael A. Saliba, Dawn Zammit, and Conrad Pace. "An intersect oral reconfigurable manufacturing automation testbed" *2009 Remark 2009. ASME/IFToMM International Conference on*, pp. 696-704. IEEE, 2009.

[16] Ruikar, N. V., and M. T. Telsang. "Modeling and Simulation of Manufacturing Performances using WITNESS" *IOSR Journal of Mechanical and Civil Engineering (IOSR–JMCE)* 5 (2013): 11-17.

[17] Zhong, Ray Y., Xun Xu, Eberhard Klotz, and Stephen T. Newman. "Intelligent Manufacturing in the Context of Industry 4.0: A Review." *Engineering* 3, no. 5 (2017): 616-630.

[18] Valmiki, Puneeth, Abhinav Simha Reddy, Gowtham Panchakarla, Kranthi Kumar, Rajesh Purohit, and Amit Suhane. "A Study on Simulation Methods for AGV Fleet Size Estimation in a Flexible Manufacturing System" *Materials Today: Proceedings* 5, no. 2 (2018): 3994-3999.

[19] Ramnath, B. Vijaya, C. Elanchezhian, J. Jeykrishnan, R. Ragavendar, P. K. Rakesh, J. Sujay Dhamodar, and A. Danasekar. "Implementation of Reverse Engineering for Crankshaft Manufacturing Industry" *Materials Today: Proceedings* 5, no. 1 (2018): 994-999.

[20] Abbas, M., and H. ElMaraghy. "Synthesis and optimization of manufacturing systems configuration using co-platforming" *CIRP Journal of Manufacturing Science and Technology* 20 (2018): 51-65.

 DOI : 10.35291/2454-9150.2020.0593