Optimizing Facility Layout Through Simulation

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Abstract - *A greater emphasis is being placed on sophisticated manufacturing systems to increase productivity and reduce costs as a result of increased competitiveness in many industries. A well-liked technique for planning and assessing the functioning of these intricate and dynamic systems is simulation modelling. In order to better meet user needs, this study examines the characteristics of conventional industrial simulators. An actual assembly line manufacturing system was used in a case study to evaluate software. Different simulators were used to produce a variety of simulation models, and a thorough evaluation framework was constructed to make it easier to choose simulation software for industrial system modelling. Based on the aims of the programme, such as use in education or industry, various hierarchies of evaluation criteria were created. In addition, a survey was carried out to learn what users thought of simulation software and what features they wanted. A technique for choosing simulation software was developed, including instructions for the evaluation and selection procedures. The results led to recommendations for improving manufacturing simulations for both educational and commercial use. By lowering the time and effort needed to construct simulation models, these software improvements hope to increase the use of simulation as a tool.*

***Key Words*: Optimization, Simio, Discrete Event Simulation, Simulation Model, ARENA, Facilities, Layout.**

1.INTRODUCTION

The study also emphasises the role that facility design plays in improving operational performance and production efficiency. The existing design, which mainly relies on manual labour, might be constrained in terms of output, resource use, and potential bottlenecks. It is feasible to assess and contrast various layout configurations, including the addition of semi-automatic operations employing robotics, by using simulation software like ARENA.

The goal of the simulation study carried out as part of this research is to evaluate the effectiveness of the current manual-oriented arrangement and contrast it with the suggested semi-automatic layout. We'll analyse and evaluate key performance indicators for the two layout options, including production throughput, resource utilisation, cycle time, and inventory levels.

The goal is to pinpoint areas that could use improvement and choose a facility plan that maximises overall efficiency, maximises resource utilisation, and minimises production bottlenecks.

The study offers important insights and suggestions to guide decision-making on facility design and layout optimisation by utilising the capabilities of simulation software. The results of this study can help management and technical teams make wise decisions to raise the manufacturing plant's productivity and competitiveness. In the end, adopting an optimised facility layout could result in higher resource utilisation, streamlined production procedures, and improved overall performance and profitability.

It is significant to emphasise that the scope of this study is restricted to the manufacturing process at the Godrej and Boyce facility in Mumbai, with a focus on the Global Safe product. However, the research's approach and conclusions can be extended to many manufacturing facilities and sectors, offering a useful framework for facility layout optimisation and performance enhancement.

2. RESEARCH OBJECTIVE

The research project includes a number of goals intended to analyse and enhance the global safe manufacturing system. These goals comprise:

1. Data Collection and Analysis: The first goal is to collect and examine the information needed to accurately model the Global Safe production process. This entails gathering pertinent data on a range of topics, including operational metrics, resource utilisation, inventory levels, and production processes.

2. Development of a Simulation Model: The next goal is to use ARENA software to create a computer simulation model of the Global Safe manufacturing system. By simulating actual manufacturing processes, this model will make it possible to assess how well the system performs in various situations and environmental factors.

3. Manufacturing System Behaviour Analysis: This study attempts to examine how Phase I and Phase II manufacturing systems behave in various situations. The goal of the study is to understand how the system responds to changes and spot

any patterns or trends in its behaviour by adjusting input parameters and running simulation exercises.

4. Problem Identification and Analysis: The research aims to identify typical problems encountered within the Global Safe manufacturing system and investigate their root causes using the built simulation model. Potential bottlenecks, inefficiencies, or difficulties influencing performance can be found and understood by analysing the simulated data and monitoring system behaviour.

5. Suggestions for Improvement and Performance: The research seeks to suggest alternative solutions to address certain issues within the production system based on the learnings from problem identification. These fixes can entail streamlining processes, redistributing resources, or changing the design. To show how incorporating these changes can improve the system's overall performance, a proposed model will be created.

By achieving these goals, the research activity aims to advance knowledge of the Global Safe manufacturing system, its behaviours, and the variables affecting its effectiveness. The system's efficiency, productivity, and overall operational effectiveness are all intended to be optimised by the suggested fixes and improvements, which will ultimately result in better manufacturing process outcomes.

3.RESEARCH METHODOLOGY

There are many software solutions available to help with the production of precise and dynamic models in the field of computer-aided simulation modelling. Awe Sim (2011), AutoMod (2011), Arena (2011), and Extend (2011) are notable instances of this type of software. However, the robust and adaptable ARENA simulation tool, notably the Academic version 10, has been used to construct the computer simulation model for the purposes of this study.

ARENA was chosen as the preferred programme based on a number of elements that make it appropriate and efficient in this situation. A number of features that ARENA provides make it a desirable option for simulation modelling. It is a readily available tool that is comparatively simple to use thanks to its accessibility, user-friendly interface, and adaptability. Additionally, ARENA offers a broad range of features and functionalities that make it possible to build and analyse complicated manufacturing system models.

Researchers can create a reliable and accurate computer simulation model of the global safe manufacturing system by using the ARENA simulation tool. Researchers can accurately reflect the complex dynamics and behaviours of the industrial processes within the model by utilising ARENA's capabilities. This simulation model will act as a digital representation of the actual system, enabling thorough study and evaluation.

Additionally, the adaptability of ARENA enables researchers to experiment with numerous settings and test multiple situations, simplifying the investigation of the system's behaviour under varied circumstances. Researchers may thoroughly simulate and observe the behaviours of the Phase I and Phase II production systems thanks to the software's wide variety of simulation choices and modelling approaches, which enables a thorough understanding of their performance characteristics.

Researchers can efficiently analyse the Global Safe manufacturing system, spot any problems, and suggest fixes to improve its performance by making use of ARENA's power. The software is a useful tool for creating and analysing simulation models thanks to its extensive feature set, user-friendly design, and widespread accessibility. The use of ARENA in this study project highlights the importance of the programme as a dependable and potent software solution for simulation modelling in the manufacturing industry.

3.1. Arena Overview

A versatile and effective tool used by analysts to create animated simulation models is the ARENA modelling system, created by Systems Modelling Corporation (Kelton et al., 2007). By combining animation with simulation, it offers a way to faithfully represent almost any system. Notably, unless the user specifies otherwise, ARENA estimates the 95% confidence interval automatically. Additionally, collecting adequate probability distributions for use in the models is made possible by the ARENA Input Analyzer.

The ARENA Output Analyzer enables users to carry out statistical studies in order to examine the data obtained. The Process Analyzer also helps in investigating various potential outcomes based on chosen system control parameters. The animation component that comes with the model, which shows system behaviour visually, is quite appealing.

Figure no. 1's depiction of the research methodology's structured action plan. The steps taken to accomplish the research study are outlined in this strategy.

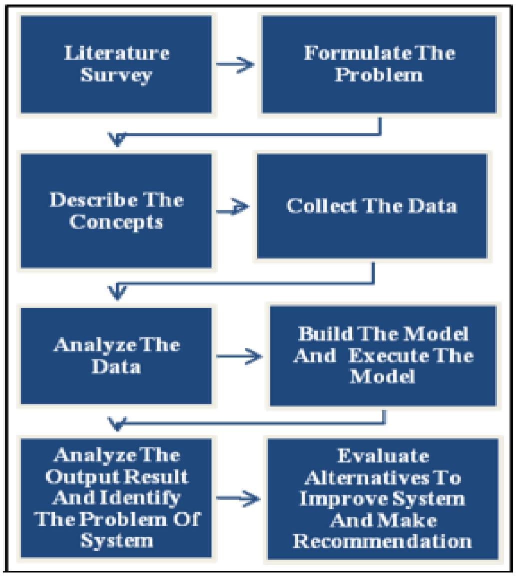


Figure no. 1. Steps of the research study

Furthermore, utilising queuing theory and the Arena simulation tool, the process flow line of the chosen Global Safe manufacturing system has been examined. Rockwell Automation Inc.'s arena simulation software is a potent tool that enables users to make precise duplicates of systems. Its user-friendly interface makes it suited for a variety of business sectors, including manufacturing, customer service, and healthcare, and makes quick comprehension and implementation possible. Without interfering with the real system, it helps in forecasting the best options.

The steps below must be completed in order to construct and analyse a model using Arena:

1. Model Creation: The first step is to create the model in Arena by dragging the required elements from the project bar into the model window. For modelling purposes, a number of menu options are offered, including basic process, advanced process, flow process, and advanced transfer.

2. Data Input: After the model has been built, pertinent data is given into it, such as scheduling time, arrival rate, maximum arrivals, transfer time, processing time, and setup time. This polishes the model and gets it ready for tests.

3. Simulation Run: To verify the model's accuracy and contrast it with the real system, simulation runs are carried out once the model has been improved and the data has been fed. The validity of the inputted data has a significant impact on the model's quality. Runs of simulation help with bottleneck investigation as well.

4. Output Reports Generation: Following simulations, ARENA automatically produces reports. Insights into queue behaviour, work in progress (WIP), parts in and out, waiting time, transfer time, total number seized, machine utilisation, and other user-specified outcomes are provided via these reports.

5. Choosing the Best Solution: By adjusting input parameters, one can explore numerous scenarios using ARENA's Process Analyzer tool. This enables the most advantageous scenario to be chosen based on the intended outcome.

Researchers may efficiently construct, analyse, and optimise simulation models to acquire useful insights into system performance and decision-making by following these steps and utilising the capabilities of ARENA.

The creation of an entity, task, or part when it enters the system is the first stage in the ARENA operation. The part is then put through a number of procedures, each of which has a specific processing time. The part is examined when the processing is finished. The part is then finally removed from the system using the discard module. Figure No. 2 shows how the create, process, and dispose modules are used to describe the fundamental architecture of ARENA.

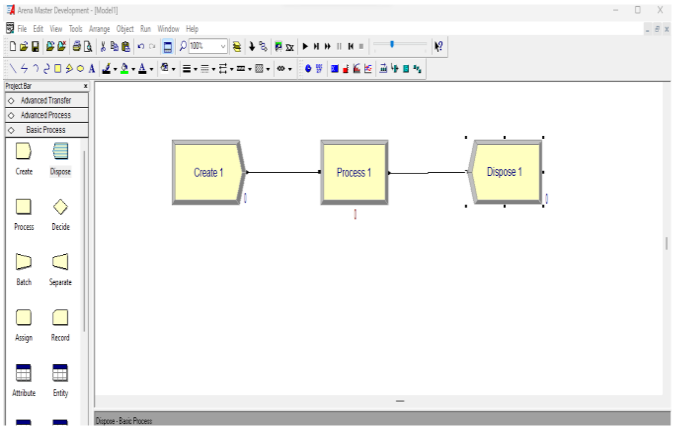


Figure No 2 Basic Structure of ARENA modelling

In Figure No. 2, the part is first created using the create module, which is followed by the process module, which processes the part utilising multiple resources. Finally, the disposal module removes the processed and completed portion from the system. This modular design makes it easier to build and simulate large systems and enables a thorough depiction of the movement and change of system constituents.

Researchers can precisely model and analyse the behaviour of systems using these modules and their interconnections thanks to ARENA, which also offers insights into process performance, resource utilisation, and system efficiency. ARENA is a useful instrument for comprehending and optimising the operations of manufacturing systems and other complicated processes because of its flexibility and modular design.

4. MODEL CREATION

The creation of a computer simulation model to analyse and assess the performance of the under-researched Global Safe manufacturing system was the main goal of this study. This model's specific goals were to reduce flow time, enhance layout design, and increase production rate. Production output and average part queuing time were two important performance indicators that showed how well the system performed.

4.1 Procedure for Data Collection and Analysis

Important information was gathered on a number of characteristics, including part arrival rates, resource availability, part processing durations, and batch sizes in order to build the Global Safe manufacturing model.

4.1.1 Data Gathering

It was important to collect information on component arrival rates, part processing rates, and the amount and availability of resources in order to determine system performance indicators such as average waiting time, resource utilisation, and average time in the system. Data were gathered for each part using the time study approach, including arrival times, processing start times, and processing finish times at each work station. Each of the three working days that made up the data collection process had eight hours of work.

Data gathering is crucial to simulation modelling since only high-quality data will allow the model to faithfully represent the real system. Statistical methods must be used to gather accurate data. Utilising mathematical methods to analyse and characterise the data is part of statistics. It is possible to model the system and explain its behaviour meaningfully by using statistical methodologies. This chapter will go over the procedures for collecting data while using statistical techniques.

4.1.2 Data Type

The majority of the data was real-time shop floor data gained through direct observation in order to precisely represent the physical setup. This needed meticulous oversight over a period of two to three months while we collected processing times for various products on various resources. Senior organisation members provided secondary data, such as the facility's layout, information about the machinery, the total number of employees, and other pertinent information. Additionally, leaders from the company provided criteria and product listings. According to Table No. 1, the gathered information is divided into primary, secondary, and tertiary types.

A thorough dataset was created by categorising the acquired data into primary, secondary, and tertiary kinds, which included all the information needed for precise modelling and analysis.

Table no 1. Data Type

Primary Data	Processing Time, Set up Time , Batch Size , Modification in Plant Layout , Detailed Process Flow diagram.
Secondary Data	Plant Layout, Working Hrs. per Day , Demand Pattern , Number of recourse, Material Information , Scheduled Maintenance
Tertiary Data	Product List , Material information , System Used, tool used, Standard used, throughput time.

4.1.2.1 Primary Data: Stopwatch measurements, worker interviews, plant engineer interviews, and direct observation were just a few of the techniques used to gather primary data from the manufacturing facility. The simulation model was developed in large part using these original data. It contained crucial details including processing times, flow times, setup times, alterations to the plant layout, and thorough process flows for comparable items.

4.1.2.2 Secondary Data: Senior organisation members and other sources were consulted to gather secondary data. The facility's floor plan, industry standards, and product lists made up this data. It included details about the number of resources, the number of working hours per day, the structure of the plant overall, the inventory stock information, the general process flow of the goods, demand trends, material information, and planned maintenance.

4.1.2.3 Tertiary data had already been gathered from top employees of the organisation . Along with the product list, this data also included details regarding the equipment and standards that would be applied during the production process.

To enable the creation and study of the simulation model, a thorough dataset was produced by gathering primary, secondary, and tertiary data. The secondary and tertiary data gave context and extra information required for precise modelling and analysis, while the primary data provided specific insights into the manufacturing processes.

4.2 The Phase I System Model

The ARENA programme was used to build a simulation model when the data collection phase was finished. Figure No. 2 shows the model for Phase I of the manufacturing system.

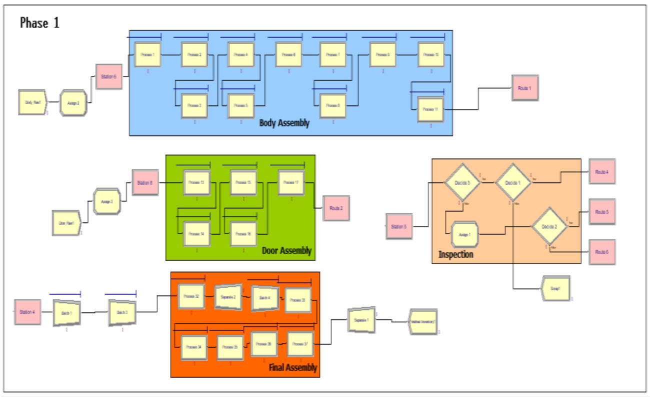


Figure No. 3 Phase 1 layout

The design of Phase I is displayed in Figure No. 3. Processes 1, 3, 4, 7, 9, 11, 12, and 14 in this model are carried out by hand.

4.3 The Phase II System model,

Figure No. 3 displays the simulation model for the production system's Phase II.

Figure No. 4 Phase 2 layout

Figure No. 4 shows how Phase II is laid out. Robots carry out Processes 1, 3, 4, 7, 9, 11, 12, and 14 in this scenario.

Phase I and Phase II behaviour and performance can be independently evaluated and assessed by using different simulation models. In order to optimise and improve performance, it is necessary to take into account the unique characteristics and elements introduced by the use of manual labour in Phase I and robots in Phase II.

5.THE FINDINGS AND DISCUSSION

After comparing different performance indicators of interest, both the Phase I and Phase II systems were examined. The number of entities coming in and going out, the average total waiting time for all entities, and the average total transfer time are some of these metrics. Table No. 2 displays the results' condensed form.

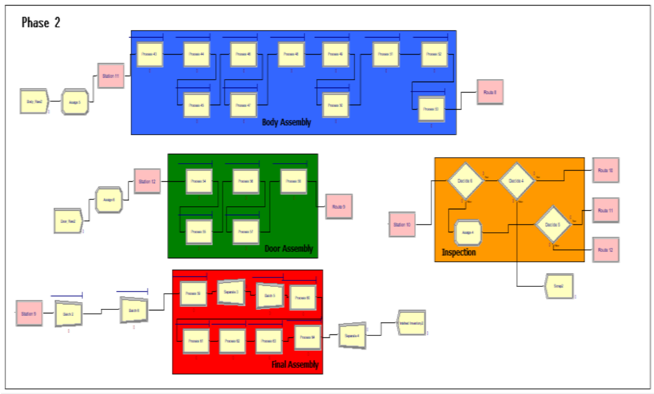
Comparing the Phase I and Phase II Systems in Table No.

Differentiation based on	Phase I System	Phase II System	Remark
Number In	128	147	
Number Out	102	135	
Production in %	79.6875	91.8367	12.14 % Increased
Avg. Total waiting time Per entity in System	10.4901 (hour)	08.2888 (hour)	Reduced
Avg. Total Transfer time	3.0667 (hour)	1.5335 (hour)	50% reduced

Table No.2 Comparison between Phase I and Phase II System

It is clear from the comparison table above that the Phase II System, when used in conjunction with the established model, shows considerable gains in performance measurements. A 50% reduction in the overall average transfer time results in increased production output. Global Safe goods are now produced at a rate of 135 per three days, up from 102 previously. This results in 330 Global Safe items being produced each month, which represents a 12.14 percent increase in overall production.

The outcomes show that the Phase II System's automated processes and implementation have improved the Global Safe manufacturing system's overall output and production efficiency. Improved system performance and productivity are indicated by the shorter transfer times and higher production rates. These results demonstrate how well the suggested model works to improve the manufacturing system's performance.



6. CONCLUSIONS

Through the use of simulation modelling, this research's goal was to enhance the facility layout of a Global Safe manufacturing system. A safe manufacturing industry was chosen, and the built ARENA simulation model was used to analyse and pinpoint the production flow line's bottlenecks.

The present product flow layout in the Global Safe manufacturing system did not follow the conventional design of production layout, it can be inferred from the analysis of the simulation results and the changed system model. The simulation model was essential in locating these bottlenecks and assessing potential fixes for the issues that were discovered.

The improved simulation model's trial runs produced positive outcomes. The amount of Global Safe items generated significantly increased as a result of the decrease in the system's typical part waiting time. A number of suggestions were made to the management of the Global Safe production system, including redesigning the structure of the facilities, modifying the level of resources, hiring more people, and automating the system.

The necessity of improving facility architecture in manufacturing systems is highlighted by this research effort, as is the efficiency of simulation modelling in pinpointing and resolving performance concerns. The results offer insightful suggestions and useful information for improving the manufacturing system's production process and output. The system can gain more efficiency and productivity by putting the suggested changes into practise, which will ultimately improve overall performance.

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