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Research Article

Revolutionizing Manufacturing Layout: Enhancing Efficiency and Productivity Through Simulation and Time-Motion Analysis at Arabian Metal Industries

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ABSTRACT

Effective planning is crucial for maintaining efficiency in modern manufacturing systems, particularly in complex operations such as dump truck assembly. This study investigates the integration of simulation modeling and time-motion analysis to enhance efficiency in the assembly process of M-16 Tipper trucks at Arabian Metal Industries (AMI). The simulation revealed substantial inefficiencies, including insufficient coordination, wasteful delays, and workflow disruptions. Time-motion analysis enabled thorough oversight of activities, identifying non-value-added behaviors and sources of waste. Three simulation scenarios were developed to evaluate performance improvements. In the baseline model, only 68 of 135 trucks were completed, resulting in an efficiency of 50.4% and an average cycle time (Time in System) of 233.34 hours. In the second scenario, Opt Quest optimization improved throughput to 119 trucks (88.1% efficiency) and reduced the average cycle time to 55.69 hours, indicating a 76.1% drop. The third scenario focused on eliminating waiting periods between activities without increasing resources. This led to the manufacture of 127 trucks (94.1% efficiency) and a subsequent reduction in cycle time to 19.62 hours, indicating a 91.6% decrease from the baseline. The results demonstrate the effectiveness of combining simulation with time-motion analysis to identify bottlenecks, improve process flow, and support data-driven decision-making. This cohesive strategy improves production efficiency while promoting a more sustainable and human-centered industrial setting.

Keywords: Simulation, Time motion Study, M16 Tipper.

1. Introduction

Arabian Metal Industries (AMI) specializes in manufacturing a diverse range of heavy-duty vehicles, including tippers. The M-16 tipper is a crucial element of the company's product range. Contemporary manufacturing settings encounter several issues concerning operational efficiency and escalating production expenses. A significant contributing reason to these issues is the prevalence of several non-value-added activities. This encompasses superfluous worker movements, prolonged waiting periods, recurrent searches for equipment or materials, and production interruptions resulting from inadequate layout or insufficient coordination across production stations. Consequently, total manufacturing time escalates, product cycle time extends, and operating expenses grow. Furthermore, these inefficiencies impede the factory's capacity to adhere to delivery schedules, potentially leading to customer attrition and diminished confidence in the factory's production capabilities. This research offers a redesign of the manufacturing architecture and workflow utilizing Simio simulation software alongside a Time and Motion Study methodology to tackle these difficulties. Simio facilitates the modeling and simulation of various production situations, aiding in the identification of bottlenecks and inefficiencies. The time

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Research Article

and motion research will yield data-driven insights into task execution, facilitating the elimination or reduction of non-value-added operations. This integrated strategy seeks to improve production efficiency, optimize resource use, lower costs, and eventually boost total productivity while enhancing responsiveness to market demands**.**

2. Related Work:

2.1: Manufacturing Process Modeling and Simulation:

Modelling and simulation offer a structured approach to analyzing manufacturing processes, crucial for identifying inefficiencies and improving planning (4, 5, 6). Discrete-event simulation (DES) allows realistic testing of production changes and helps prevent bottlenecks (7, 8). Case studies highlight simulation's success in optimizing processes and reducing failure rates, especially when tracking KPIs like lead time and resource use (9–12). Despite their benefits, simulation models face challenges in continuous validation, which affects their reliability and impact on decision-making (13–15).

2.2: Enhancement of On-time Delivery Maintenance Services by Lean Manufacturing Tools in the Automotive Industry:

Altering production procedures and layouts is essential for enhancing productivity and minimizing costs in vehicle manufacturing. Lean methodologies such as 5S, ABC analysis, Kaizen, and value stream mapping have demonstrated significant outcomes, including a 95.41% decrease in production time and an 87.59% reduction in cycle time (16, 17). The integration of 5S and ABC has markedly enhanced warehouse and inventory efficiency (18, 19). Standardization enhances productivity and reduces cycle time, with multiple case studies validating the efficacy of lean manufacturing in reducing costs and improving efficiency (20, 21).

2.3: Truck Assembly Line Reconfiguration to Reduce Cycle Time with Lean Manufacturing Approach in the Indonesian Automotive Industry

The automotive industry plays a crucial role in Indonesia's economy, and this research seeks to improve truck assembly efficiency through lean manufacturing and time study techniques (22, 23). Through the implementation of MILP and the minimization of waste by lean principles (24–28), the model optimizes workstation cycle times, reducing the total cycle time from 205 to 192 seconds by incorporating an additional workstation (29, 30). It also identifies non-value-added activities to reduce idle time and related expenses.

2.4. Scientific and Practical Challenges for the Development of a New Approach to the Simulation of Remanufacturing

The annual production of 2.5 billion trash products in the EU underscores the necessity for a transition to a circular economy (31). Research emphasizes the significance of digital transformation and adaptable factory configurations to facilitate reuse, remanufacturing, and sustainability (32). Technologies such as IoT and advanced analytics improve production precision and adaptability (33). The Arab Company for Metal Industries necessitates intelligent platforms, enhanced logistics, and minimized material transport (34). Factory designs must facilitate disassembly, reassembly, and internal material flow (35). emphasizing sustainable, modular products and versatile stations to support the expanding remanufacturing industry (36,37,38).

This literature shows that reinventing factory layouts requires integrating digital technologies, sustainable material flows, lean manufacturing principles, and circular process models to achieve sustainability goals and improve operational efficiency.

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Research Article

3. Data

3.1 Data Identification:

To conduct a comprehensive time and motion study, various parameters were identified, including crane time, clean time, waiting time, welding time, and measurement time.

3.2 Data Source:

The data for this study were collected from the Arabian Metal Industries company.

3.3 Data Analysis:

Extensively analyzed and measured data categorized into five distinct types: welding, waiting, measuring, craning, and cleaning. Classifying tasks into these categories facilitated the elucidation of time distribution among roles. Stopwatches were employed to precisely quantify work durations. This technique analyzed workflow inefficiencies and identified possibilities for enhancement.

3.4 Data Collection:

Table 3.4.1: Data Collection
Methodology

Name of products			Total
Floor	Floor-type of assembly	1:58:16hr	7:20:27hr
	Floor full weld	5:22:11hr	
Front	Assembly of front type	2:27:59hr	5:48:44hr
	Full welding of the front	3:20:45hr	
Sides	Assembly and tack welding	4:01:37hr	13:00:25hr
	Making the automatic welding of vertical lines	2:03:18hr	
	Making an automatic welding oblique line	2:32:26hr	
	Complete Full Welding	6:14:04hr	
Tailgate	Assembly and tack welding	1:23:45min	5:13:38hr
	Complete Full Welding without making automatic welding	3:49:53hr	
Tipping and Assembly tipper	Making the Assembly of all the Tipper (Sides, Front, Floor)	5:47:44hr	27:44:33hr
	Make Full Welding for the Assembly of all Tipper	10:36:57hr	
	Make Tipping	10:59:52hr	
Subframe	Make Subframe	4:56:48hr	13:56:52hr
	Assembly of Subframe	3:58:44hr	
	Full Welding of Subframe	5:01:20hr	
Paint	Sand Blasting	1:50:20hr	24:59:21hr
	Painting primary and secondary	8:46:28hr	
	Painting tertiary	14:21:33hr	
Last Step	Install the tipper and box	19:01:46hr	20:10:09hr
	Electricity	1:08:23hr	
Total			118:14:09hr

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Research Article

This study uses a quantitative research methodology to examine time and motion in the manufacturing setting, incorporating simulation modeling to enhance production workflows.

4.1 Data Collection

Data was collected through stopwatch-based time tracking and verified using factory production logs.

4.2 Simulation Modeling

A mathematical optimization model was developed based on a simulation framework created using Simio software. Simio is a sophisticated simulation software used to model and analyze industrial and service systems with a high degree of interactivity and accuracy. It enables users to examine every component of a production line, such as resources, processes, and flow paths, allowing for a detailed and realistic visualization of operations as if they were taking place over days, weeks, or even months, all within a matter of seconds. The significant advantage of Simio is its capacity to detect operational bottlenecks and identify delays inside the production line. Through comprehensive analytics and visual indicators, users may formulate data-driven solutions to optimize operations. Simio provides unparalleled versatility in evaluating diverse resource allocation scenarios, encompassing both human labor and machinery. Performance metrics, including throughput, utilization, and latency, are measured accurately, enabling planners to ascertain the most efficient and cost-effective configuration.

4.3 Identification of Industrial Waste

The key challenges to efficiency were categorized into the seven types of industrial waste, as defined by lean manufacturing principles in Figure (4.3.1) :

Figure 4.3.1: 7 Step Types of Waste Diagram

A time and motion study was conducted on the M-16 Tipper truck using Simio to analyze waste from waiting and overproduction. By adjusting worker distribution and station distances through Opt Quest, travel times were balanced and congestion reduced. Relocating stations and shortening transport distances improved flow and minimized waste. Data was revised to exclude wait times, optimizing staffing levels. This approach aligns with lean manufacturing principles to enhance efficiency, reduce waste, and increase value.

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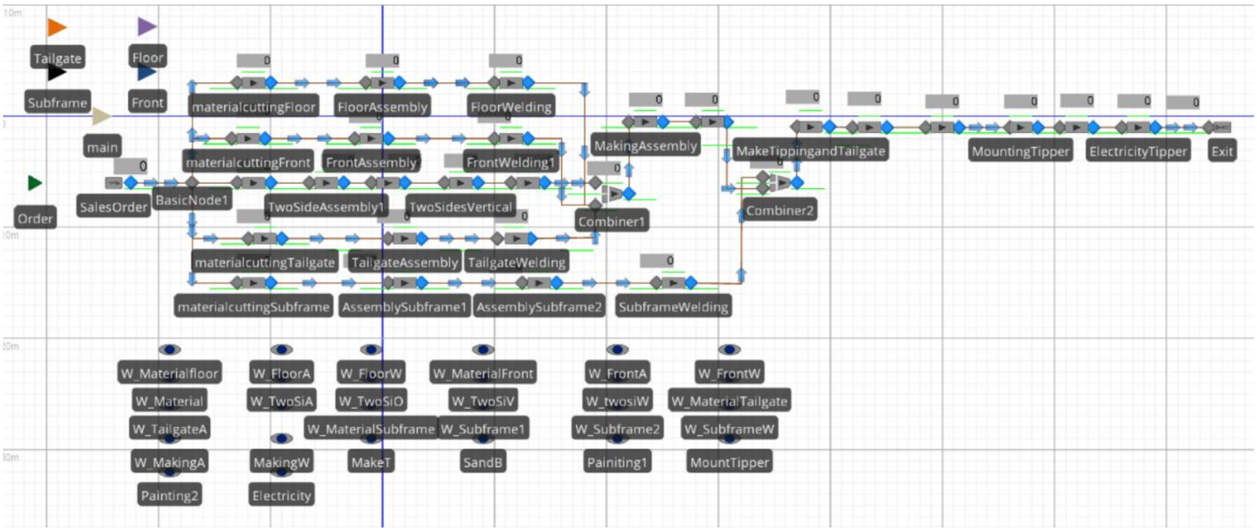

Figure 4.5.1: All Process

4.4 Time Study and Performance Factors

Time analysis utilizing a stopwatch accurately quantified each production phase. A study analyzed durations of crane operation, surface cleaning, idling, welding, and dimensional measurement. The production time of a unit is contingent upon all these factors. Evaluating these attributes revealed methods to enhance efficiency and eliminate non-value-added activities. The data facilitated authentic simulation models and evaluations of process enhancements. In competitive manufacturing, precise information is essential for enhancing workflow, managing resources, and reducing production cycle time.

4.5 Simulation and Process Flowchart

A comprehensive simulation model of the production process, illustrated in Figure 4.5.1, was developed using Simio to visually and dynamically assess industrial processes and pinpoint their challenges. It accurately replicates the production chain from sales order to Tipper truck assembly, emphasizing time-related performance metrics. Six entities represented critical steps in the manufacturing workflow within the model. The components are floor, front, main, tailgate, and subframe. The order entity commences production upon receipt of the sales order. Full-day manufacturing commences every 18 hours for each order cycle. Five employees commence work immediately on the production lines. Commence with the primary entity, as the order, floor, front, tailgate, and subframe require the most time. Trim, assemble, and weld lateral components. Oblique, vertical, and complete welding stages are located on the sidewalls. Due to the several stations (floor, front, tailgate) and extended hours (the stage is repeated twice and necessitates additional welding time), the primary entity was selected to traverse the tipper side. The entity will traverse it, with its time, number of processes, and exit being ascertained from this juncture to the endpoint. Originating from the material cutting station. The material cutting station takes input for material cutting. This phase assembles the M-16 Tipper's "box" using processed floor, front, two sides, and tailgate components. To guarantee structural integrity and efficiency, specialized assembly and welding stations must collaborate and synchronize. This phase integrates the constructed and welded box with the subframe. Combiner2 constructs the structural components of the Tipper truck. The final production encompasses hydraulic system preparation, box installation on the subframe and chassis, sandblasting, priming, and final painting to complete the product. Electrical work, the completion of electrical preparation, dictates product quality and readiness for delivery. This phase measures the wasted time and operational challenges of the simulation model.

Journal of Information Systems Engineering and Management
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Research Article

The Simio model follows a sequence of stations from order initiation to the final sink, each playing a vital role in ensuring production efficiency. The simulation covers 468 working hours over 26 days, with two shifts of 9 hours each. The process begins at the sales ordering station, where each order is registered and processed, averaging 5 entities over 18 hours. Once the chassis body is completed, it is sent to a central distribution point (basic node), then distributed to five parallel cutting stations (floor, front, two sides, tailgate, and subframe). Each component is handled by a sub-entity created through a sequence of Create, Transfer, and Release steps. The initial manufacturing stage lasts about 300 minutes and takes place in three key areas: CNC cutting, punching, and drilling. Each station is operated by two workers represented as resources. Components then move through successive processing stages based on a defined schedule, ensuring smooth, parallel workflows and reducing delays or bottlenecks in production.

1. Floor Line: The floor assembly line is fully shown within the Floor entity, illustrating the entire processing sequence of the Tipper truck's floor component. The floor assembly procedure commences, necessitating 118 minutes and adhering to a normal distribution with a standard deviation of 10 minutes. Following assembly, the floor component undergoes the welding process, lasting 121 minutes, characterized by a normal distribution with a standard deviation of 10 minutes.

2. Front Line: The front assembly line is comprehensively depicted within the Front entity, demonstrating the complete processing sequence of the Tipper truck's front component. The front assembly procedure begins, requiring 148 minutes and following a normal distribution with a standard deviation of 10 minutes. After assembly, the front component is subjected to a welding procedure that lasts for 200 minutes, exhibiting a normal distribution with a standard deviation of 10 minutes.

3. Sideline: The side assembly line is fully shown within the Side entity, illustrating the entire processing sequence of the Tipper truck's side component. The two-sided assembly1 procedure commences, necessitating 241 minutes and adhering to a normal distribution with a standard deviation of 10 minutes. Following assembly, the two sides Oblique component undergo the welding process, lasting 152 minutes, characterized by a normal distribution with a standard deviation of 10 minutes. Following the process, lasting 123 minutes, is characterized by a normal distribution with a standard deviation of 10 minutes. Following the process, lasting 374 minutes, is characterized by a normal distribution with a standard deviation of 10 minutes.

4. Tailgate Line: The tailgate assembly line is comprehensively depicted within the tailgate entity, demonstrating the complete processing sequence of the Tipper truck's tailgate component. The tailgate assembly procedure begins, requiring 84 minutes and following a normal distribution with a standard deviation of 10 minutes. After assembly, the tailgate component is subjected to a welding procedure that lasts for 230 minutes, exhibiting a normal distribution with a standard deviation of 10 minutes.

5. Subframe Line: The subframe assembly line is comprehensively depicted within the subframe entity, demonstrating the complete processing sequence of the Tipper truck's subframe component. The subframe assembly procedure begins, requiring 296 minutes and following a normal distribution with a standard deviation of 10 minutes. Following the assembly process complete on the assembly subframe2, which requires 238 minutes and follows a normal distribution with a standard deviation of 10 minutes. This stage is dedicated to preparing the subframe that will subsequently be integrated into the overall frame of the truck. After assembly, the subframe component is subjected to a welding procedure that lasts for 300 minutes, exhibiting a normal distribution with a standard deviation of 10 minutes. Upon completion of the assembly and welding processes across the five distinct tracks, the production sequence advances to the component integration stage. At this critical juncture, the floor, front, two sides, and tailgate components converge at a designated combiner station. Specifically, the

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Research Article

two sides serve as the parent inputs in Combiner 1, whereas the floor, front, and tailgate function as member inputs within the same combined entity. Upon the conclusion of the merging process at Combiner 1, the assembly phase commences, lasting 348 minutes. Upon completion of this phase, the primary entity is directed to the comprehensive welding station, This welding procedure necessitates 637 minutes. Upon completion, the primary entity advances to Combiner 2 through the subframe input gate, while the Subframe entity enters the same combiner via the main input gate. In Combiner 2, the ultimate integration of the full weld and subframe weld occurs, signifying the concluding phase of the structural assembly process. The synchronized convergence of entities at Combiner 2 illustrates the complex and well-coordinated flow among several processes in the manufacturing line. The Combiner Box is then sent to the Tipping and Tailgate-Making Station, where the swing door is prepared, and the entire box is fully assembled. This involves the integration of the sides, front, floor, tailgate, and subframe components. The procedure requires roughly 660 minutes. After the fabrication process, the Combiner Box is conveyed to the Sand Blasting Station, where an extensive surface preparation procedure is conducted. This station employs sandblasting technology to eliminate impurities, weld residue, and other surface contaminants from the box. The sandblasting procedure necessitates a length of 110 minutes. Upon concluding the sandblasting phase, the tipper truck is meticulously conveyed to the specified station for primary and secondary painting, where an extensive and rigorously regulated surface preparation and coating process is executed. This process commences with careful sanding of the truck's surface to guarantee a uniform and smooth finish, crucial for excellent paint adherence and enduring surface integrity. Two separate layers of paint are subsequently applied: a primer coat and a topcoat. The layers are deliberately chosen and applied to create a robust and resilient protective barrier that markedly improves resistance to corrosion, oxidation, and diverse environmental stresses, including moisture and chemical exposure. The complete painting activity requires a total of 525 minutes. Upon completion of the painting process, the tipper is conveyed to the Mounting Tipper Station, where it is integrated onto the truck chassis at its designated base. At this stage, specialized lifting equipment is utilized to mount the tipper onto the chassis, including the subframe, ensuring a secure and precise installation. The mounting process requires 1140 minutes. Following the installation process, the assembled unit is routed to the tertiary painting stage, where a final, cosmetic layer of paint is applied to the visible components. This stage, known as Painting Tertiary, ensures a uniform and aesthetically pleasing finish to the assembled unit. The tertiary painting process requires 860 minutes. The next stage involves the Electricity Tipper Station, where the electrical wiring, lighting, and control systems for the tipper are meticulously connected and integrated. This critical step ensures the proper functioning of the tipper's electrical components and is the final stage prior to the product's full release. The electrical connection process requires a duration of 68 minutes. This task is executed by Electricity, which employs a team of two skilled technicians. Upon completion of all assembly, welding, installation, cleaning, painting, and electrical connections, the tipper is conveyed to the Exit Station, marking the culmination of the production process. The Exit Station serves as the point of departure from the production line, where the finished product is inspected and prepared for subsequent stages, such as quality control and shipping.

4.6 Conclusion

Visual planning, empirical time analysis, operational evaluation, and simulation modeling are all components that are included in this methodology, which offers an integrated approach. The result is a collection of results that are precise, objective, and reproducible, and they considerably improve the performance of products on the production line.

Result

The simulation model provides a thorough and quantitative assessment of the planning and production strategy currently employed for the M-16 Tipper truck. It can discover vulnerabilities in the production

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Research Article

process and reveal operational inefficiencies that affect workforce productivity, all while operating effectively. The model was created to accurately represent the manufacturing system of the Arab Company for Metal Industries Ltd. The differences between the three models are outlined as follows: Model number one: The computation incorporates all relevant information, consisting of five elements, including the waiting time factor, to accurately measure actual work under all conditions. The time allocated for cleaning, welding, measurement, and operation of the crane is cumulatively assessed with the processing duration. This enables us to recognize the natural scenario we are addressing, after which we will initiate the development process. The process commences when a sales order is recorded, corresponding to five units entering every 18 hours, comparable to a complete workday. Approximately 135 orders are received, proceeding via the material cutting stations, followed by an initial assembly and welding, then box assembly and welding, and ultimately through the paint stations for sandblasting and painting. Subsequently, the chassis is introduced and installed, followed by the electrical phase, culminating in the final exit stage, which encompasses inspection and delivery. It is anticipated that there will be 68 orders requiring a total of 468 hours, as calculated. The task consists of 18 hours divided into two shifts daily across 26 actual workdays, facilitating precise documenting of all production line phases and a clearer interpretation of the scene. The model based its analysis of the results on the Main Entity entering from the Two Sides stage, which signifies the station with the longest duration among the material components. Consequently, it commenced from this point to illustrate the total production demand, tracking the process from product reception at the station with the longest duration, representing Two Side, through the initial combiner, until the concluding stage, which encompasses inspection and delivery. The entity was represented by specific findings illustrated in the image below. The mean quantity inside the system was 36. Figure (5.1) illustrates that the system exhibited a minimum length of 42.6263 hours and a maximum duration of 232.1038 hours. The mean duration in the system was 140.8792 hours.

ModelEntity	main	[Population]	Content	NumberInSystem	Average	36.4696
					Maximum	67.0000
			FlowTime	TimeInSystem	Average (Hou...	140.8792
					Maximum (Ho...	232.1038
					Minimum (Hou...	42.6263
					Observations	68.0000
			Throughput	NumberCreated	Total	135.0000
				NumberDestroyed	Total	68.0000

Figure 5.1: Main Entity

The data revealed significant bottlenecks at specific stations, especially the Combiner stations situated near the center of the production line, as illustrated in Figure (5.2). This congestion arises from the necessity for these stations to finalize the treatment of several sub-entities prior to merging them and advancing the primary entity to later phases. The synchronization of completion times among the many components has been shown to delay the primary entity. This delay causes the accumulation of queues, adversely affecting the total production pace. It is advisable to reevaluate resource allocation and equilibrate operational hours among the substations while examining the potential to reengineer the production process to minimize waiting times, enhance operational efficiency, and optimize overall workflow. The substantial necessary quantities and low productivity led us to conclude that the workflow and division were illogical. This epiphany transpired when the issue was elucidated. The

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Research Article

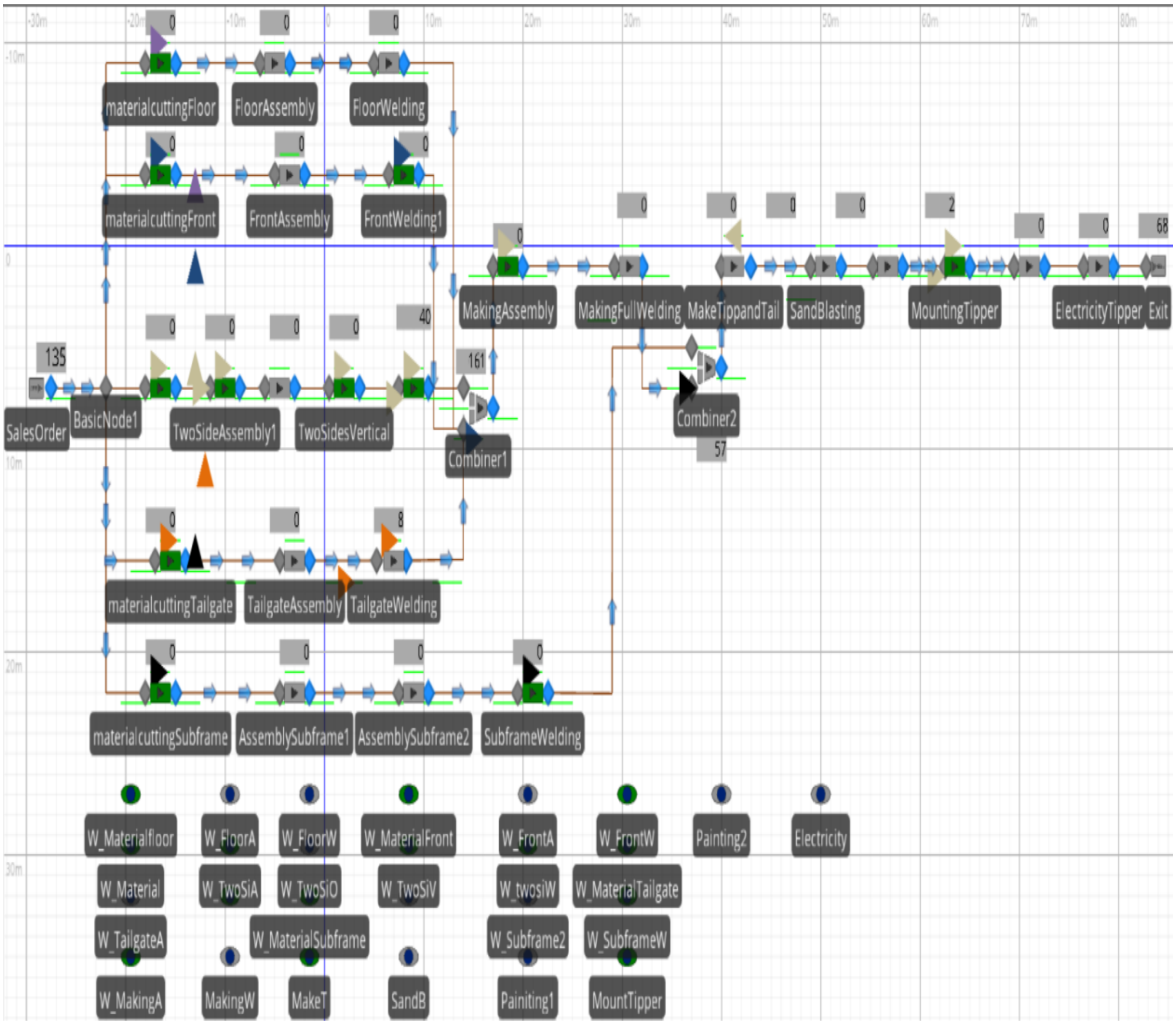

Figure 5.1: Run Model (Model 1)

outcomes of the initial model indicate 135 input orders and 68 output final products. The system contained roughly 67 units, and the average duration within the system was assessed to be around 141.1945 hours from entry to the output of the product specified in the primary entity. The findings suggest that the entities Floor, Front, Tailgate, and Subframe are impeded by the obstruction of stations and their inability to offer additional support. Consequently, OptQuest was developed to serve as a changeable parameter for all stations via experimentation. Validation is accomplished through this process, wherein findings are produced and evaluated repeatedly to confirm the data's validity and accuracy. Consequently, we meticulously calculated the duration spent at a station from inception to completion, emphasizing the resultant figure within the system. I conducted experiments using OPT QUEST, establishing the default at 10 replications, with a minimum of 10 and a maximum of 15 replications, deemed enough for a model exhibiting a minor deviation of 10 minutes. A maximum scenario of 50 was established, deemed adequate to evaluate the impact of quantity where the workers are variable, and the optimal arrangement of manufacturing lines is dictated by them. The predominant statistical criterion, offering substantial accuracy and dependability, is the 95% confidence level, with a relative error of 0.1 to yield optimal results. This control relies on the beginning capacity of the workforce, regarded as variable. Optquest identifies the optimal option, employing fifty distinct

Journal of Information Systems Engineering and Management
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https://www.jisem-journal.com/
Research Article

scenarios within a unified objective framework to analyze the influence of initial capacity on the Number in System (NIS) performance metric. A variety of scenarios were developed to identify optimal outcomes that minimize time and enhance efficiency. The program simulates many scenarios depending on the differing initial energy of worker resources, with the optimal solution identified as 10.1472 units in the system and 37.184 time in the system. This trend suggests that increasing initial production capacity did not produce the expected positive results; instead, it may have caused bottlenecks at critical points in the production lines. The sudden increase in resources or production efficiency has likely exceeded the capacity of specific stages, resulting in backlogs and operational delays, thereby disrupting the entire production flow. Through these conclusions and analysis of the results, it was concluded that the system is sensitive to initial capacity at stations. Therefore, scenarios with low Number in System (NIS) were associated with balanced and stable resource allocation, while scenarios with high Number in System

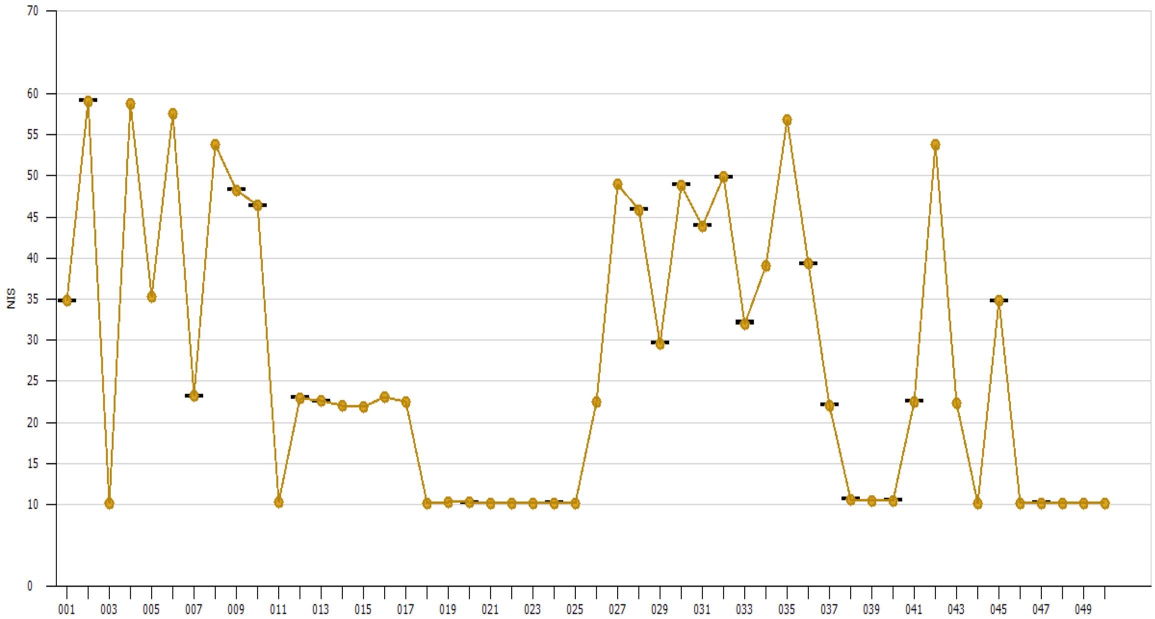

Figure 5.3: Performance Experiment for the first model

(NIS) were associated with disproportionate initial capacities.The attached illustration in Figure (5.3).

Model number two: A simulation model, as illustrated in Figure (5.4), was developed to obtain an accurate and comprehensive assessment of actual performance across all operational scenarios, including all relevant variables, realistic time parameters, workflow dynamics, labor distribution, and inter-process waiting times. This model consists of five essential components, one of which is the waiting time factor—an essential statistic of process efficiency and operational flow. The early findings from the model's first iteration revealed several inefficiencies, including the underutilization of manpower and equipment, as well as bottlenecks at specific manufacturing stations. Consequently, a series of structural and operational enhancements were executed, as outlined in Table (5.1), which highlights the qualitative differences between the original and the upgraded model. A notable improvement was aligning labor allocation with station demands based on actual operational needs, hence enhancing the reliability of outcomes generated by the OptQuest optimization module. The results from the second model demonstrated a significant improvement in performance metrics. Production optimization increased throughput to 119 trucks (88.1% efficiency) and decreased the average cycle time to 55.69 hours, reflecting a 76.1% reduction. Exhibiting a notable enhancement in operational efficiency and resource distribution. The number of congested or delayed stations has decreased, with only the Mounting Tipper seeing a waiting time of 7, however, the station remains a

Journal of Information Systems Engineering and Management
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https://www.jisem-journal.com/
Research Article

concern. This highlights the effectiveness of the changes in improving operations and minimizing downtime.

Table 5.1: Difference between model 2 and model 1

Process	Number in the station resource from the First model	Number in the station from OptQuest
Material Cutting Floor	2	5
Floor Assembly	1	5
Floor Welding	2	5
Material Cutting Front	2	4
Front Assembly	1	5
Front Welding	1	5
Material Cutting	2	5
Two-Side Assembly 1	1	5
Two-Side oblique	1	5
Two-Side Vertical	1	5
Two-Side Welding	1	5
Material Cutting Tailgate	2	5
Tailgate Assembly	1	4
Tailgate Welding	1	3
Material Cutting Subframe	2	5
Assembly Subframe 1	2	5
Assembly Subframe 2	2	5
Subframe Welding	2	5
Making Assembly	2	5
Making Full Welding	3	5
Make Tipping and Tailgate	3	5
Sand Blasting	1	5
Painting Primary and Secondary	3	5
Mounting Tipper	3	5
Painting Tertiary	4	5
Electricity Tipper	2	5
Total	46	126

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Research Article

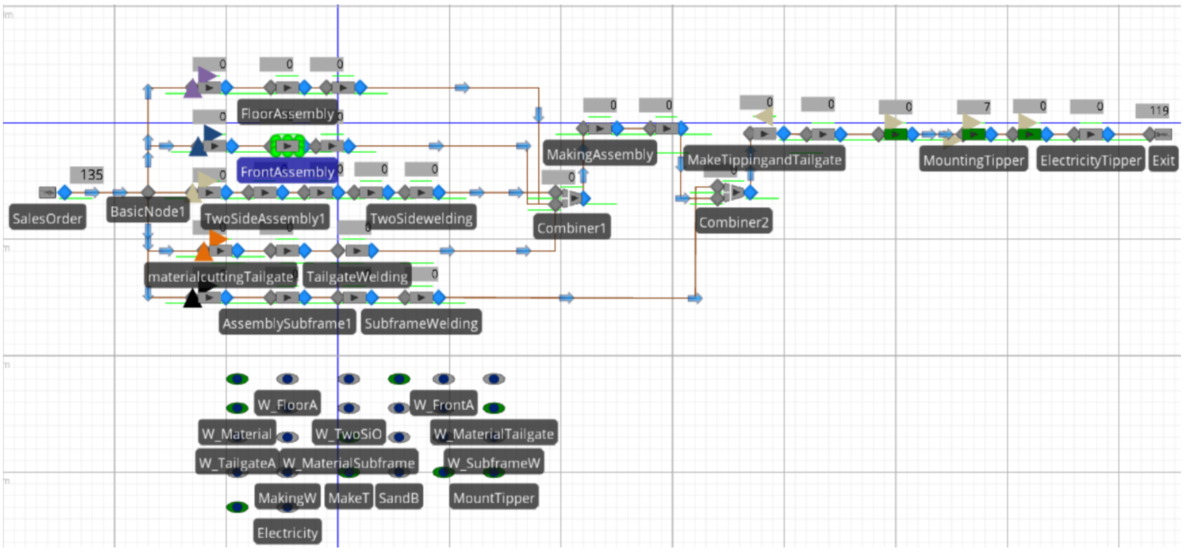

Figure 5.4: Run Model (Model 2)

Model number three: A third simulation model, as illustrated in Figure (5.5), was created to improve process efficiency by excluding the waiting time factor. This methodology concentrated exclusively on job execution, material flow, and labor distribution. The model was constructed utilizing the optimal configurations suggested by OptQuest, as indicated in Table (4.1), assuring alignment between the optimization results and simulation parameters. The results indicated a significant improvement. The third scenario concentrated on eradicating waiting intervals between actions without augmenting resources. This resulted in the production of 127 trucks (94.1% efficiency) and a consequent reduction in cycle time to 19.62 hours, reflecting a 91.6% decrease from the baseline of finished units during the same timeframe. The strong correlation between the third model's output and OptQuest projections further corroborated the optimization results.

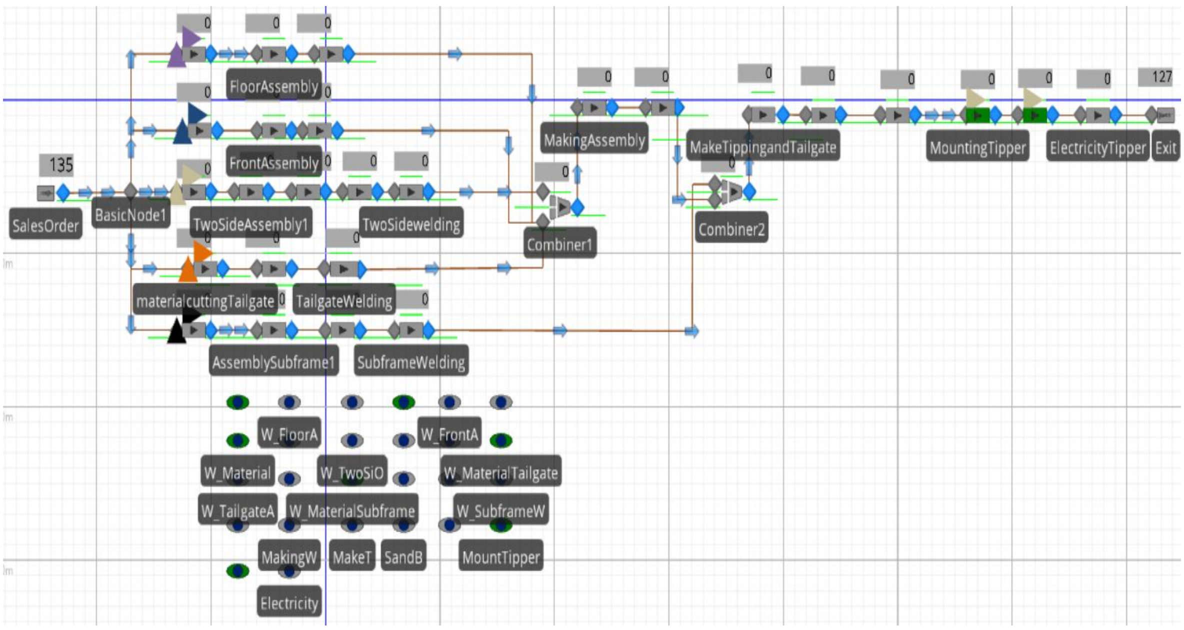

Figure 5.5: Run Model (Model3)

The optimized model configuration, derived from time and motion research with Simio, resulted in significant and motivating enhancements in overall production performance. The targeted

Journal of Information Systems Engineering and Management
2025, 10(51s)
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https://www.jisem-journal.com/
Research Article

modifications led to a substantial decrease in the total cycle time per unit, hence reducing time waste and improving operational efficiency throughout all phases of the production process. The enhancements resulted in a significant rise in production throughput, illustrating the system's improved capacity to manage greater demand levels without necessitating extra resources or substantial infrastructure modifications. A notable effect was the enhanced equilibrium in workload allocation among different workstations. This facilitated the reduction of idle times and mitigated disparities between production regions, resulting in a more streamlined workflow and a synced production rhythm.

Conclusion and discussion

Time and motion studies in production assess tools, minimize lost time, and allocate personnel to suitable positions, thereby enhancing operational efficiency. Awareness of time and accurate measurement of production phase duration are also required. Investigations employed Simio and simulation software. A time motion analysis was employed to create an accurate representation of products based on data from Arab Company for Metal Industries Ltd. Working hours indicate that Simio produces 68 items. Arena duplicated the outcomes. Simio exhibited systematic distribution irregularities. Optquest seems to have restructured numerous stations. Repetition with Opt Quest and the station crew resulted in 119 tippers out of 135. It was reiterated for efficiency and time conservation. The Opt Quest team assisted us in retrieving 127 tippers out of 135 within 468 hours over a span of 26 days, conducting two nine-hour sessions. In conclusion, Simio has transformed time and motion studies from manual observation into a full analytical system with precise production line specifics. This illustrates the research. The second approach use ERP to automatically link work orders, substituting human labor with automated technology and self-regulating processes, hence improving accuracy and efficiency.

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