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A Study on Modeling and Optimization of The Production System in the Hino FG8JPSB Truck Body Assembly Workshop

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ABSTRACT:
This paper presents a study on modeling and optimizing the production system in the HINO FG8JPSB truck body assembly workshop, aiming to enhance productivity and reduce operational costs. In the context of increasing demands for production efficiency, establishing an optimized production system based on calculation, simulation, and evaluation is essential. The study employs a methodological approach combining theory, quantitative analysis, and numerical simulation to develop a production model, determining key factors such as equipment, manpower, floor space, and production processes to support an annual output of 270 truck bodies.
The design process is conducted methodically, starting from task analysis, determining the required number of equipment and workers, evaluating space requirements, to designing transportation flow and selecting optimal layout solutions. A simulation model is utilized to assess operational efficiency, identify bottlenecks, and propose improvements, such as layout rearrangement or adjustment of resource allocation. Among several layout scenarios, the optimal solution is selected based on criteria such as total travel distance or lowest material handling cost.
The results demonstrate that modeling and optimizing the production system significantly improve equipment utilization, reduce idle time, and enhance labor productivity in the workshop.
Keywords: *System modeling, production system optimization, numerical simulation, workshop layout design, truck body assembly, equipment layout, material flow analysis.*

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I. INTRODUCTION

The production system in the HINO FG8JPSB truck body assembly workshop plays a vital role in manufacturing high-quality products that meet the stringent technical standards of the automotive industry. Truck body assembly not only requires coordinated operation among various departments but also demands an optimized production process to increase productivity, minimize costs, and ensure workplace safety. To achieve these goals, the application of production system optimization and assembly process simulation methods is essential for improving operational performance and product quality [1], [2].

Within the HINO FG8JPSB assembly workshop, each stage—from assembling truck body components to quality inspection—is executed through a structured and systematic process. Machines, equipment, and labor resources are allocated effectively across different production phases to ensure flexibility and operational efficiency. However, optimizing individual stages remains a challenging problem, especially when striving to minimize downtime, enhance coordination among departments, and improve the distribution of resources in the production process [3], [4].

To address these challenges, the application of system modeling and numerical simulation has proven to be an effective method for analyzing and optimizing the production system in the HINO FG8JPSB truck body assembly workshop. Previous studies indicate that the use of mathematical models and optimization algorithms can identify bottlenecks in the assembly process and propose improvement solutions such as equipment reallocation, enhancement of material flow, and layout optimization. These improvements not only help reduce production costs but also contribute to product quality enhancement and timely delivery [5], [6].

By applying optimization techniques, simulations, and advanced technologies, the HINO FG8JPSB truck body assembly workshop can improve operational efficiency, reduce risks, and strengthen competitiveness in the automotive industry. Production process optimization not only brings economic benefits but also contributes to the sustainable development of the overall automotive manufacturing system [7], [8].

II. CALCULATION, DESIGN, AND OPTIMIZATION OF THE HINO FG8JPSB TRUCK BODY ASSEMBLY SYSTEM

2.1. Design process and production organization for the truck body assembly workshop

The design task begins with an analysis of production capacity, with the truck body dimensions set at 7,160 x 2,340 x 800/2,150 mm and a designed capacity of 270 units per year. The workshop operates 247 days annually in a single-shift system, achieving an average output of one truck body per day.

The production plan and technological process are established accordingly. The truck body is fabricated using stainless steel, galvanized square steel tubes, aluminum sheets, and aluminum profiles. The production includes seven main stages and thirty-five sub-stages: machining of components (such as the internal skeleton, front wall, rafter frame, rear grille, and bending operations), sub-assembly of components, initial assembly before mounting onto the base chassis, post-mounting assembly, polishing and finishing, final painting, and final assembly with quality inspection before delivery.

Material selection and quantity are calculated based on the consumption norms for one truck body and multiplied for the annual target of 270 units. The primary materials used include stainless steel, galvanized steel tubes, aluminum sheets, and aluminum profiles.

Main equipment selection includes: 1 crane, 3 electric welding machines, 3 TIG welding machines, 3 MIG welding machines, 1 bench drill, 5 handheld drills, 1 plasma cutting machine, 1 Φ350 cutter, 8 Φ125 multifunction machines (cutting, grinding, polishing), 1 painting equipment set, 1 silicone gun, 1 rivet gun, and 6 mechanical toolboxes.

Supporting tools, spare parts, and necessary jigs are also selected, including welding tools, assembly jigs, personal protective equipment, and accessories accompanying the main machines to ensure efficiency and safety during processing and assembly.

Internal transportation requirements are determined with the use of cranes and mechanical support equipment to transport materials, parts, and assemblies within the production area.

Human resource planning includes 23 personnel: 1 workshop director, 2 technical and quality inspection staff, 1 accountant/warehouse/cashier, 17 fabrication and assembly workers, and 1 service staff. Labor costs are calculated for each job title accordingly.

The production area covers 1,339.9 m², with equipment arranged in a logical production line layout to optimize operations and internal transport. Auxiliary and administrative areas are also arranged: director's office (35.5 m²), technical room (42.6 m²), accounting office (39.95 m²), shared office (220.1 m²), materials and semi-finished goods warehouse (176.9 m²), locker room (16.5 m²), and restrooms (63 m²).

Energy requirements are identified for the entire system, including electricity for all mechanical equipment and lighting, compressed air for pneumatic tools and systems, and water for cooling, equipment cleaning, and workshop hygiene.

Occupational safety and technical hygiene measures are implemented, including personal protective equipment, fire prevention systems, ventilation, exhaust, and dust extraction systems, as well as cleaning equipment for the workplace and environment.

The overall workshop layout is optimized with functional zones arranged according to the production process. The layout flowchart is designed to minimize internal transport distances and maximize operational efficiency.

The production management system is organized with a structure consisting of the workshop director, technical and inspection staff, accounting and logistics personnel, and the skilled worker team. An organizational chart is established to define the management and operational relationships among departments within the workshop.

2.2. Optimization of the Production Area Layout System

Optimizing the production workshop layout is a crucial step to enhance productivity and reduce costs throughout the manufacturing process. Conducting a thorough evaluation and selecting the optimal layout plan prior to implementation ensures overall efficiency for the system. The specific steps undertaken are as follows:

Step 1: Developing alternative workshop layout plans

During the layout design process of the production workshop, developing multiple layout alternatives is essential to identify the most optimal arrangement. Each alternative is designed by rearranging the positions of production areas with equivalent sizes or those closely linked in the technological process. The relocation must comply with production organization principles, avoid disrupting the flow of materials and semi-finished products, and ensure functional and spatial efficiency. In this study, three layout alternatives were proposed by varying the positions of the main departments in the truck body assembly line, including the material preparation area, machining area, assembly area, inspection area, and dispatch area. Developing multiple options provides a basis for comparison, evaluation, and selection of the most suitable layout according to actual conditions and production requirements.

Step 2: Determining the area and dimensions of each department in the alternatives

After proposing the layout plans, the next step is to determine the specific area and dimensions for each functional zone within the workshop. The required area for each department is calculated based on the planned production capacity, equipment layout standards, worker operation radius, and safety, operational, and maintenance requirements. In addition, determining the dimensions also depends on the specific production model (batch production, assembly line, or unit production), the number of machines in each department, and potential future expansion. Each layout must allocate sufficient space for the material warehouse, truck body frame machining area, floor-roof-wall assembly area, quality inspection zone, and the final dispatch area. Accurate area planning ensures smooth material and product flow and facilitates later cost and spatial efficiency analysis.

Step 3: Analyzing distances and movement frequency between departments

One of the key factors affecting the efficiency of a production system is the distance of material movement between departments. This distance is analyzed by identifying the centroid of each functional area in the layout and measuring the rectilinear (Manhattan) distance between them. At the same time, the frequency of material and semi-finished product transfers between areas is determined based on the technological process and the planned output—in this case, 247 units per year. The analysis reveals which departments have high movement frequencies, allowing for strategic placement of these departments in close proximity to reduce transportation costs and waiting time. This is a vital preparatory step for the next phase of internal transport cost calculation.

Step 4: Creating From-To charts and calculating total travel distances and transport costs for each layout alternative

Based on the analyzed distances and movement frequencies, Step 4 involves generating From-To charts for each layout alternative. These charts present the distance and number of transfers between departments, thereby allowing the calculation of total material movement distances per day or per year. Using the total distance, the internal transportation cost is estimated by multiplying with the cost rate per meter (2,000 VND/meter in this study). The results provide the total internal transportation cost for each layout option. The From-To chart not only supports economic evaluation but also serves as a visual tool to detect inefficient flows (e.g., unnecessarily long, tangled, or intersecting paths). In this study, the three proposed layouts are directly compared in terms of total travel distance and transportation cost, forming the basis for selecting the optimal layout.

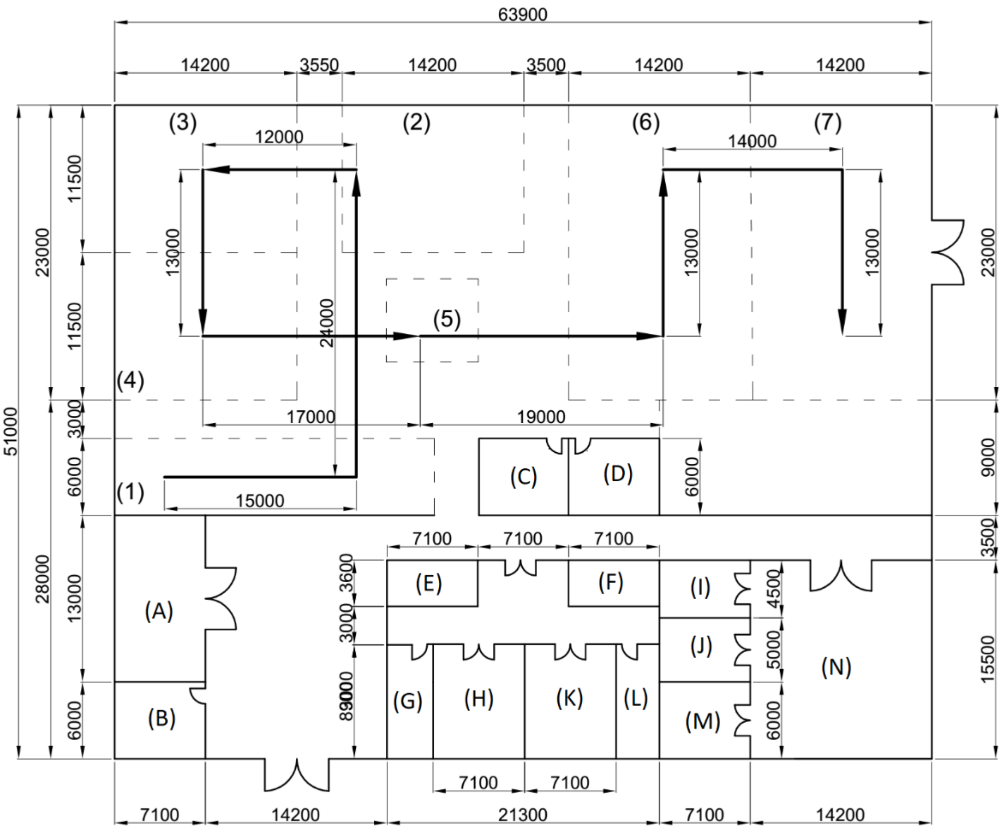

Figure 1. Material Flow under Layout Option 1

Layout Alternative 1: This option follows the material flow diagram as shown in Figure 1.

Symbols for the workshop layout areas in Figures 1, 2, and 3 are as follows: 1. Detailed Component Processing Area; 2. Front Chassis Assembly Area; 3. Rear Chassis Assembly Area; 4. Floor Assembly Area; 5. Polishing Area; 6. Finishing (Painting) Area; 7. Inspection and Dispatch Area; A. Raw Material Warehouse; B. Warehouse Keeper's Room; C. Production Tools Storage; D. Inspection Tools Storage; E. Men's Locker; F. Women's Locker; I. Accounting Office; J. Director's Office; G. Men's Restroom (WC); H. Men's Shower and Changing Room; K. Women's Shower and Changing Room; L. Women's Restroom (WC); M. Engineering Office; N. Workshop Office

The transportation distance between departments is calculated using the rectilinear method by drawing perpendicular lines between the centers of the departments.

The unit transportation cost is 2,000 VND per meter.

Table 1. Transportation Distance and Cost under Layout Option 1

Material Flow	Transportation Distance (meters)	Transportation Cost (VND)
1-2	39x6	468000
2-3	12x4	96000
3-4	13x6	156000
4-5	17x5	170000
5-6	19x6	228000
6-7	40x3	240000
Tổng	679	1358000

The order-based assembly workshop is projected to produce 247 products per year. Therefore, the total transportation cost for 247 products under Layout Option 1 is calculated as:

Total Cost = Total Distance × Unit Transportation Cost × Number of Products
T = 679 × 2,000 × 247 = 335,426,000 VND

Thus, the total transportation cost under Layout Option 1 is 335,426,000 VND.

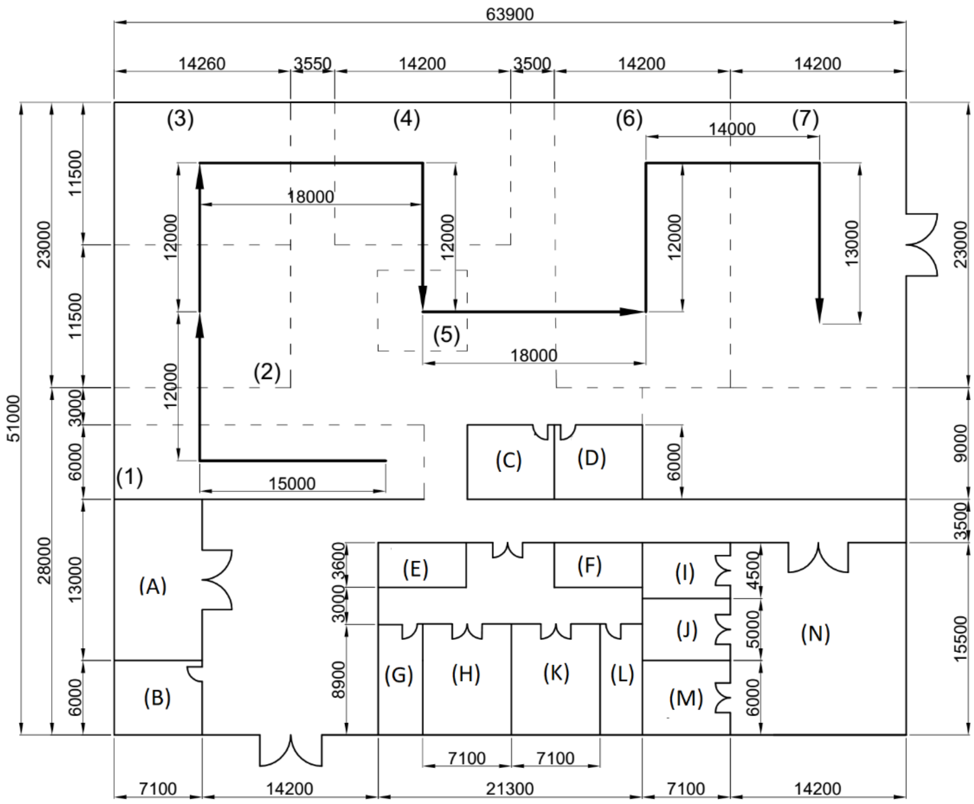

Figure 2. Material Flow under Layout Option 2

Workshop Layout in Option 2:

In this option, the positions of the Pre-Chassis Assembly Area (2) and the Floor Assembly Area (4) are swapped. This rearrangement is made due to their similar sizes and close proximity. As a result, the new material flow is shown in Figure 2.

Table 2. Transportation Distance and Cost under Layout Option 2

Material Flow	Transportation Distance (meters)	Transportation Cost (VND)
1-2	27x6	324000
2-3	12x4	96000
3-4	18x6	216000
4-5	12x5	120000
5-6	18x6	216000
6-7	39x3	234000
Tổng	603	1206000

The order-based assembly workshop is projected to produce 247 products per year. Therefore, the total transportation cost for 247 products under Layout Option 2 is calculated as:

Total Cost = Total Distance × Unit Transportation Cost × Number of Products

T = 603 × 2,000 × 247 = 297,882,000 VND

Thus, the total transportation cost under Layout Option 2 is 297,882,000 VND.

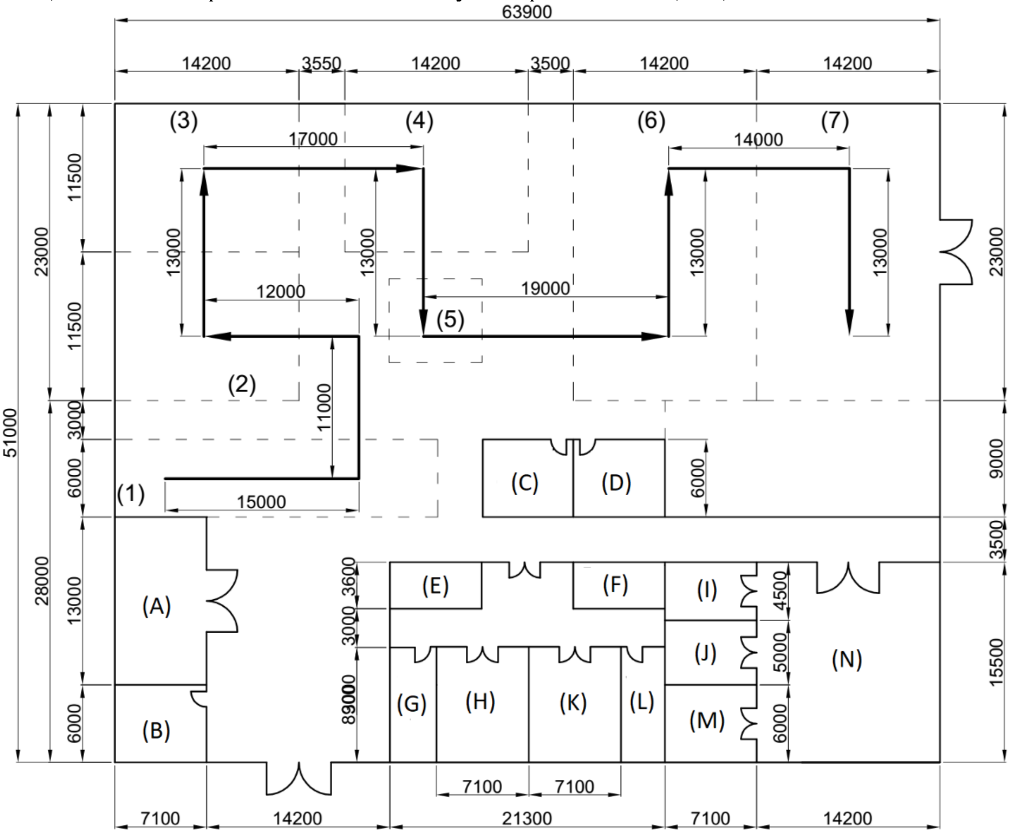

Figure 3. Material Flow under Layout Option 3

Workshop Layout in Option 3:

In this option, the positions of the Pre-Chassis Assembly Area (2) and the Floor Assembly Area (4) are swapped again, and the direction of the material flow is changed accordingly. The resulting material flow is shown in Figure 3.

Table 3. Transportation Distance and Cost under Layout Option 3

Material Flow	Transportation Distance (meters)	Transportation Cost (VND)
1-2	38x6	456000
2-3	13x4	104000
3-4	17x6	204000
4-5	13x5	130000
5-6	19x6	228000
6-7	40x3	240000
Tổng	681	1362000

The order-based assembly workshop is expected to produce 247 products annually.

Therefore, the total transportation cost for 247 products under Layout Option 3 is calculated as:

Total Cost = Total Distance × Unit Transportation Cost × Number of Products

T = 681 × 2,000 × 247 = 336,414,000 VND

The total cost for Option 3 is 336,414,000 VND.

Step 5: Analysis and Selection of the Optimal Layout Option

After obtaining the total distances and transportation costs for each option, the final step is to analyze, compare, and select the optimal layout. The evaluation criteria include: lowest total transportation cost, shortest material flow distance, ensuring a logical and uninterrupted material flow without crossing paths, and minimizing waiting time. Additionally, supplementary factors such as future expandability, flexibility to accommodate product changes, labor safety, and conditions for ventilation and lighting may also be considered as needed.

In this study, according to Table 4, Option 2 has the lowest total transportation distance (603 meters) and the lowest total cost (297,882,000 VND/year), while still ensuring a logical, continuous, and non-overlapping flow of materials. Therefore, Option 2 is selected as the optimal layout for the HINO FG8JPSB truck assembly workshop.

Table 4. Total Transportation Distance and Cost Comparison

Option	Total Transportation Distance (meters)	Total Cost (VND)
Phương án 1	679	335,426,000
Phương án 2	603	297,882,000
Phương án 3	681	336,414,000

III. NUMERICAL SIMULATION AND RESULTS EVALUATION

To verify the effectiveness of the optimized layout option, the research team conducted numerical simulations using Tecnomatix Plant Simulation — a powerful tool for analyzing, evaluating, and optimizing production system operations. The simulation process allows visualizing material flows, resource allocation, and identifying bottlenecks in the production line, thereby providing reasonable improvement solutions.

3.1 Simulation Process

The simulation was carried out sequentially through the following steps:

Step 1: Set model run time:

First, the user sets the simulation period — typically one production cycle such as a day, week, month, or year — to ensure that the output results accurately reflect the actual system operation.

Step 2: Build the overall workshop framework:

Within the software, the factory space is created by arranging blocks representing specific areas, machines, or production stages. This step establishes the physical foundation of the model.

Step 3: Connect blocks to form the production flow:

After building the framework, these blocks are linked using the software’s Connector tool, describing the product flow from input to output stages. This sequence must strictly follow the real production process flow.

Step 4: Input information for each block:

At this step, the user configures detailed data for each block, including processing time, material movement methods in/out, defect rates, processing costs, stage names, etc. These data are crucial to the accuracy of the simulation model.

Step 5: Set input materials:

The source of raw materials and their supply cycle are established to ensure sufficient inputs for production. This setup helps evaluate the system’s production capacity under continuous operation.

Step 6: Run the simulation:

Once the setup is complete, the model is run to check material flow, productivity at each stage, and phenomena such as bottlenecks, waiting times, or idle times.

Step 7: Collect and analyze results:

Finally, the software provides statistics such as average waiting time, working efficiency at each stage, overall productivity, etc. These data are compiled to support the analysis and evaluation of the model’s effectiveness.

3.2 Simulation Results

Target production: 270 units per year

The simulation results, including product quantities, waiting times, working efficiencies, and idle efficiencies at each stage, are summarized in Table 5.

Table 5. Summary of Key Parameters

Product Quantity at Each Stage (units)		Waiting Time at Each Stage Over 247 Days		Working Efficiency (%)		Idle Efficiency (%)	
Bansilicon	276	Bansilicon	6:38:07.3646	Bansilicon	0.06983805...	Bansilicon	0.93016194...
DanhBongCanHong	277	DanhBongCanHong	4:06:49.4245	DanhBongCanHong	0.42124662...	DanhBongCanHong	0.57875337...
DanhBongKhungBao	278	DanhBongKhungBao	4:35:29.0323	DanhBongKhungBao	0.35172064...	DanhBongKhungBao	0.64827935...
DanhBongOpTru	277	DanhBongOpTru	5:06:54.3885	DanhBongOpTru	0.28036437...	DanhBongOpTru	0.71963562...
DanhBongSan	277	DanhBongSan	4:37:00.8633	DanhBongSan	0.35045546...	DanhBongSan	0.64954453...
GcCanSauCanHong	284	GcCanSauCanHong	0.0000	GcCanSauCanHong	1	GcCanSauCanHong	0
GcKhungSan	281	GcKhungSan	8:00:00.0000	GcKhungSan	0.99595141...	GcKhungSan	0.00404858...
GcVachTrcVachsaukeo...	283	GcVachTrcVachsaukeo...	2:00:00.0000	GcVachTrcVachsaukeo...	0.99898785...	GcVachTrcVachsaukeo...	0.00101214...
GiaCongTru	282	GiaCongTru	4:00:00.0000	GiaCongTru	0.99595141...	GiaCongTru	0.00404858...
HanTig	278	HanTig	3:05:36.7742	HanTig	0.56320850...	HanTig	0.43679149...
KiemTraTongThe	274	KiemTraTongThe	4:11:46.9091	KiemTraTongThe	0.41599190...	KiemTraTongThe	0.58400809...
LapBatChong	279	LapBatChong	5:03:49.2857	LapBatChong	0.28247300...	LapBatChong	0.71752699...
LapBungLenThungXe	279	LapBungLenThungXe	5:03:51.4286	LapBungLenThungXe	0.28238866...	LapBungLenThungXe	0.71761133...
LapCanHong	280	LapCanHong	4:02:31.3879	LapCanHong	0.42519399...	LapCanHong	0.57480600...
LapCanSau	279	LapCanSau	6:03:38.5714	LapCanSau	0.14119433...	LapCanSau	0.85880566...
LapDien	274	LapDien	6:11:20.7273	LapDien	0.13866396...	LapDien	0.86133603...
LapKeoTruocKeoSau	275	LapKeoTruocKeoSau	6:49:38.2609	LapKeoTruocKeoSau	0.04639001...	LapKeoTruocKeoSau	0.95360998...
LapKhungCamKeo	275	LapKhungCamKeo	5:10:00.0000	LapKhungCamKeo	0.27834008...	LapKhungCamKeo	0.72165991...
LapMatSanMangNuoc	280	LapMatSanMangNuoc	5:02:20.9253	LapMatSanMangNuoc	0.28340080...	LapMatSanMangNuoc	0.71659919...
LapNhanInox	275	LapNhanInox	6:54:37.1739	LapNhanInox	0.03479251...	LapNhanInox	0.96520748...
LapOpNgoai	279	LapOpNgoai	6:18:35.3571	LapOpNgoai	0.10589574...	LapOpNgoai	0.89410425...
LapTayKhoaBS	279	LapTayKhoaBS	6:33:32.1429	LapTayKhoaBS	0.07059716...	LapTayKhoaBS	0.92940283...
LapThungLenXeNen	281	LapThungLenXeNen	6:00:38.2979	LapThungLenXeNen	0.14220647...	LapThungLenXeNen	0.85779352...
LapTole	275	LapTole	6:09:46.9565	LapTole	0.13917004...	LapTole	0.86082995...
LapvachTruocTruVachs...	281	LapvachTruocTruVachs...	2:31:22.9787	LapvachTruocTruVachs...	0.63992914...	LapvachTruocTruVachs...	0.36007085...
LapVeCsChanBun	280	LapVeCsChanBun	5:02:20.9253	LapVeCsChanBun	0.28340080...	LapVeCsChanBun	0.71659919...
LapViSau	275	LapViSau	5:39:53.4783	LapViSau	0.20875506...	LapViSau	0.79124493...
PhuBac	274	PhuBac	6:31:16.3636	PhuBac	0.09244264...	PhuBac	0.90755735...
QuetDauChongGi	276	QuetDauChongGi	5:08:15.5957	QuetDauChongGi	0.27979082...	QuetDauChongGi	0.72020917...
SonLotLan1	276	SonLotLan1	6:08:13.8628	SonLotLan1	0.13967611...	SonLotLan1	0.86032388...
SonLotLan2	276	SonLotLan2	6:08:13.8628	SonLotLan2	0.13967611...	SonLotLan2	0.86032388...
SonMau	275	SonMau	5:39:49.1304	SonMau	0.20892375...	SonMau	0.79107624...
TretMalit	276	TretMalit	7:07:01.0830	TretMalit	0.00232793...	TretMalit	0.99767206...
VsBeMat	276	VsBeMat	4:08:39.8556	VsBeMat	0.41902834...	VsBeMat	0.58097165...

The working efficiency of the production stages for assembling the HINO FG8JPSB truck body is illustrated in the chart in Figure 4.

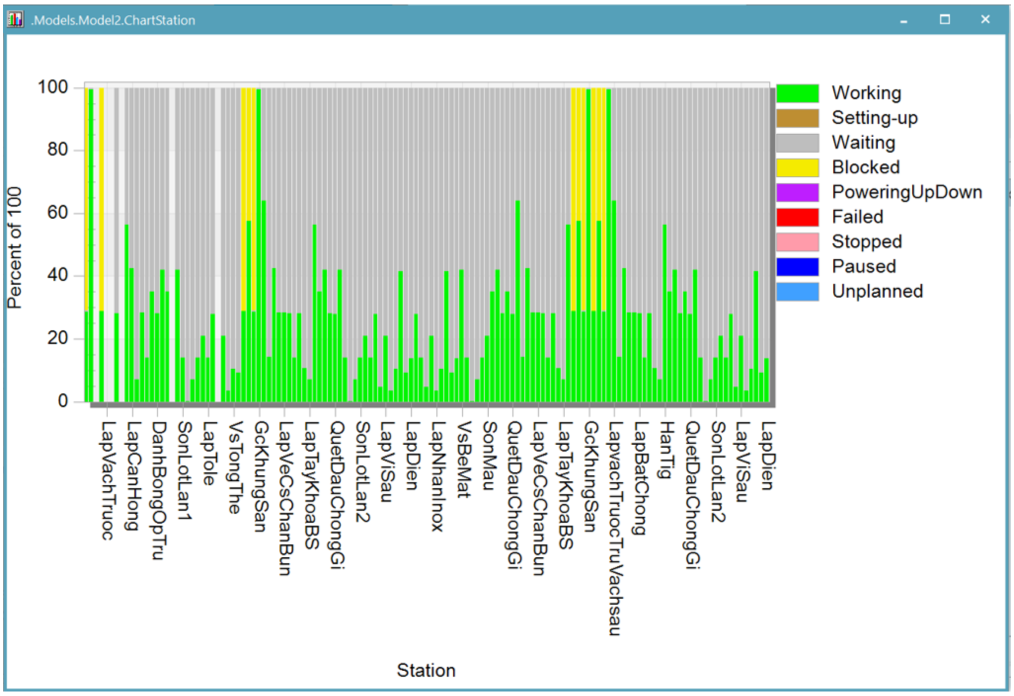

Figure 4. Working efficiency of production stages for assembling the HINO FG8JPSB truck body

4.3 Comments and Improvement Proposals

From the simulation results, especially the chart in Figure 4, it can be observed that some production stages in the system have a working efficiency below 50%. This indicates that these stages are not being optimally utilized, leading to resource wastage and prolonging the production cycle time.

To improve the system's efficiency, the following improvement measures should be considered:

Review the workforce allocation at stages with low efficiency. There may be an excess or shortage of personnel causing imbalance among the processes.

Optimize the working operations and procedures at these stages to reduce processing time per unit.

Reduce waiting times between stages by optimizing the material supply schedule or adjusting the capacity of input/output equipment accordingly.

Reasonable adjustments based on simulation analysis will further refine the layout plan, ensuring its feasibility when implemented in actual production.

IV. CONCLUSION

This paper has presented the research process of modeling and optimizing the production system in the assembly workshop of the HINO FG8JPSB truck body, aiming to improve productivity and reduce operating costs. By applying mathematical modeling methods, numerical simulation, and layout optimization, the study identified key factors affecting production efficiency such as equipment arrangement, workforce, technological processes, and material flow.

The results indicate that developing a production model and selecting an optimal layout plan based on criteria like total travel distance and transportation costs helped minimize equipment idle time, increase labor productivity, and improve the efficient use of production space. At the same time, rational organization of functional areas and appropriate resource allocation contributed to reducing bottlenecks in the assembly process, enhancing product quality, and ensuring delivery schedules.

The study confirms the importance of combining theory, calculation, and practical simulation in designing and optimizing industrial production systems. It also opens up opportunities for broader application of modeling and optimization tools in modern assembly workshops to enhance the competitive capacity of enterprises in the automotive industry.

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