IME 411 - Facility Layout and Material Handling

Course Project

Submitted By

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1. Introduction

This semester for our project, our aim was to make a specialized facility layout and material handling system for manufacturing plastic bottles intended for various cleaning detergents. Our focus is on developing an optimal system that not only supports the manufacturing of diverse bottle types but also ensures operational efficiency through strategic layout planning. The project explores the application of a batch production system, ideal for managing the customization demands of the cleaning products industry, with an emphasis on modular and cellular layouts to enhance flexibility and responsiveness in production operations.

Key components of our design include a product coding system that aids in the tracking and management of inventory, facilitating ease in the assembly and quality assurance processes. This coding system distinguishes different parts of the bottles, such as bodies, caps, and nozzles, by material type and color, enabling precise control over the production flow.

The layout is strategically planned to minimize material transit times and streamline the process chain from injection molding through assembly to packaging. Equipment and workstations are arranged in a cellular layout to foster a smooth workflow, grouping similar processes together to maximize efficiency and reduce cycle times. This setup is designed to allow for quick changes in the production setup to accommodate different product designs, thereby reducing downtime and enhancing productivity.

Material handling is addressed through the integration of conveyor systems that facilitate the efficient movement of components between different stations. This system is designed to handle the rigors of moving large volumes of plastic parts, ensuring that components are delivered safely and timely to each production station.

The project is tailored to create a highly efficient production environment that can quickly adapt to changes in product demand and specifications, supporting the facility's goal of leading in efficiency, quality, and flexibility within the competitive market of cleaning product packaging.

2. Product Name and Production System

1.1. Selected Product

Plastic Bottles for Cleaning detergents.

1.2. Industry Scale and Variety

- **Quantity:** High, as the demand for plastic bottles for cleaning solutions remains consistent across multiple product types (e.g., laundry detergent, toilet cleaner, multi-purpose cleaner).
- **Variety:** Moderate to high, given the need for different shapes, colors, and closure types to suit various cleaning solutions.

1.3. Facility Layout Options

- **Process Layout:** Suitable for moderate quantities with higher customization needs. This layout allows for flexibility in producing different bottle shapes or customizing features based on product variations.
- **Product Layout:** Efficient for high quantities with standardization, particularly for producing a large volume of a single type of bottle.

1.4. Production System:

- **Batch Production System**

Justification: Batch production allows for efficient switching between different bottle types and sizes, supporting variety while meeting demand across multiple cleaning product lines.

3. Product Design

3.1. Product Coding System for Plastic Components

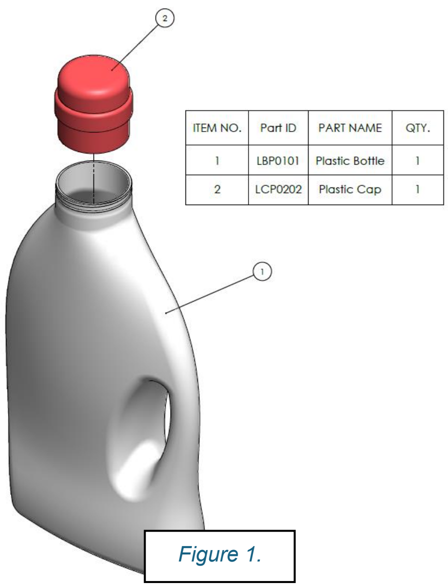
Code Component	Description	Example
1st Letter	Product Code	**L** for Laundry Detergent, **T** for Toilet Cleaner, **M** for Multi-Cleaner
2nd Letter	Component Code	**B** for Body/Bottle, **C** for Cap, **P** for Piston, **L** for Plunger, **T** for Trigger, **N** for Nozzle/Nozzle Valve, **S** for Spring, **U** for Tube, **R** for Spray Container, **I** for Pin
3rd Letter	Material Code	**P** for Polypropylene, **H** for HDPE
4th & 5th Digits	Unique Identifier	**01**, **02**, etc. (sequential number for each component)
6th & 7th Digits	Color Code	**01** for White, **02** for Red, **03** for Transparent, **04** for Stainless, **05** for Blue

Table 1. Product Coding

Note: Part codes may differ from the Exploded Assembly Drawing in color, material, or design. These can be customized per customer requirements; the products shown are examples of factory production.

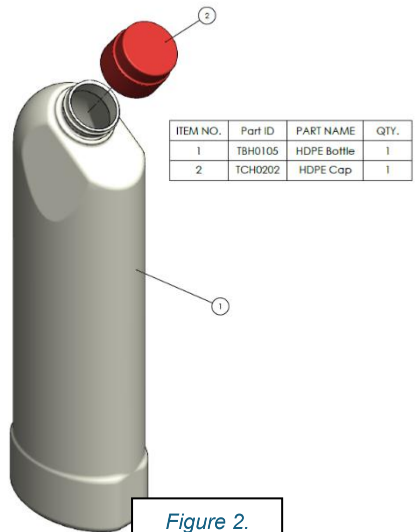
3.2. Exploded Assembly Drawing

The Exploded Assembly Drawing provides a detailed visual representation of each product. Figure 1 shows the assembly for the plastic bottle and cap designed for laundry detergents,



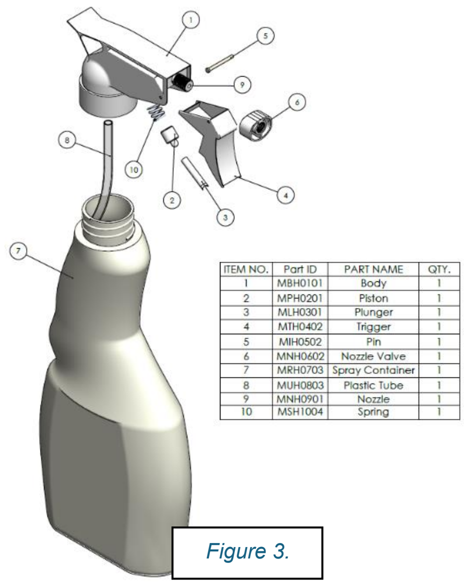
ITEM NO.	Part ID	PART NAME	QTY.
1	LBP0101	Plastic Bottle	1
2	LCP0202	Plastic Cap	1

Figure 1.



ITEM NO.	Part ID	PART NAME	QTY.
1	TBH0105	HDPE Bottle	1
2	TCH0202	HDPE Cap	1

Figure 2.



ITEM NO.	Part ID	PART NAME	QTY.
1	MBH0101	Body	1
2	MPH0201	Piston	1
3	MLH0301	Plunger	1
4	MTH0402	Trigger	1
5	MIH0502	Pin	1
6	MNH0602	Nozzle Valve	1
7	MRH0703	Spray Container	1
8	MUH0803	Plastic Tube	1
9	MNH0901	Nozzle	1
10	MSH1004	Spring	1

Figure 3.

highlighting its ergonomic

design. Figure 2 depicts the HDPE toilet cleaner bottle, showcasing its unique shape for easy handling. Figure 3 represents the multi-cleaner bottle, illustrating its versatile design suitable for various cleaning applications.

3.3. Component Part Drawing

The Component Part Drawing provides detailed dimensions and specifications for each component. Figure 4 illustrates some components, offering a comprehensive view of their measurements and design features, ensuring clarity for production and quality assurance processes.

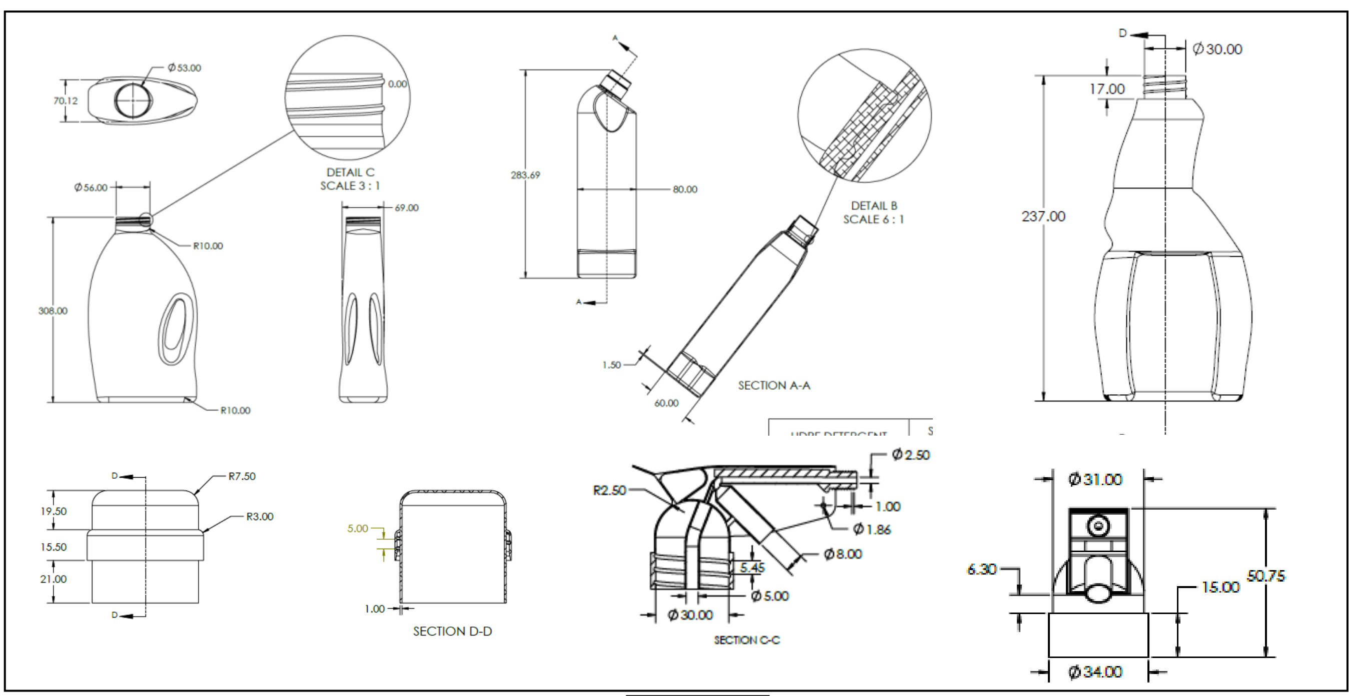


Figure 4.

Note: The Exploded Assembly Drawing and Component Part Drawing provide clearer and more detailed information and can be found in a separate document titled "**Product Design**".

4. Process Design

4.1.Parts list

The following table provides details for each part, including the part number, part name, drawing number, quantity, material, size (in mm), and sourcing information. This ensures clarity regarding the specifications and whether the part is made in-house or purchased.

Company	____________________	**Prepared by**	________
Produce	Laundry Detergent Bottle	**Date**	________

Part no.	Part name	Drwg. No.	Qty	Material	Size(mm)	Make or buy
LBP0101	Plastic Bottle	1001	1	PP	329×181.29	Make
LCP0202	Plastic Cap	1002	1	PET	56×58	Make

Company	____________________	**Prepared by**	________
Produce	Toilet Cleaner Plastic Bottle	**Date**	________

Part no.	Part name	Drwg. No	Qty	Material	Size(mm)	Make or buy
TBH0105	HDPE Bottle	1003	1	HDPE	283.69×80	Make
TCH0202	HDPE Cap	1004	1	HDPE	23.15×35	Make

Company	____________________	**Prepared by**	________
Produce	Multi-Cleaner Plastic Bottle	**Date**	________

Part no.	Part name	Drwg. No	Qty	Material	Size(mm)	Make or buy
MBH0101	Body	2001	1	HDPE	92.11×20	Make
MPH0201	Piston	2002	1	HDPE	12×8	Make
MLH0301	Plunger	2003	1	HDPE	21.84×4	Make
MTH0402	Trigger	2004	1	HDPE	45.69×15	Make
MIH0502	Pin	2005	1	HDPE	20.90×1.86×2.86top	Make
MNH0602	Nozzle Valve	2006	1	HDPE	_	Make
MRH0703	Spray Container	1006	1	HDPE	237×114.55	Make
MUH0803	Plastic Tube	1007	1	HDPE	_	Make
MSH1004	Spring	2007	1	HDPE	_	Buy

Table 2. Parts List

4.2.Bills of materials

The table below presents the product's Bills of Material (BOM), detailing each component's level in the assembly. This BOM provides a structured overview of each part necessary for assembly and production.

Company	________________	**Prepared by**	______
Produce	Laundry Detergent Bottle	**Date**	______

level	Part no.	Part name	Drwg. No.	QTY	Make / buy	Comment
0	A -0	The Bottle	0001	_		
1	LBP0101	Plastic Bottle	1001	1	Make	
1	LCP0202	Plastic Cap	1002	1	Make	

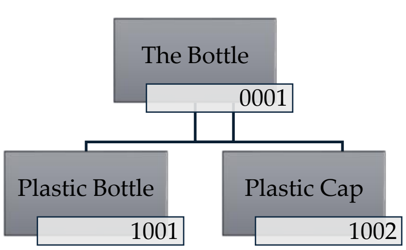
Company	________________	**Prepared by**	______
Produce	Toilet Cleaner Plastic Bottle	**Date**	______

level	Part no.	Part name	Drwg. No.	QTY	Make / buy	Comment
0	B- 0	The Bottle	0002	_		
1	TBH0105	HDPE Bottle	1003	1	Make	
1	TCH0202	HDPE Cap	1004	1	Make	

Company	________________	**Prepared by**	______
Produce	Multi-Cleaner Plastic Bottle	**Date**	______

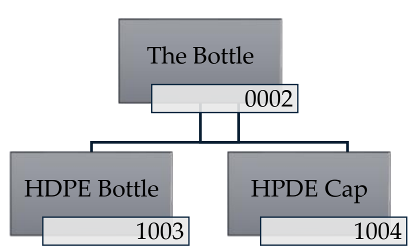
level	Part no.	Part name	Drwg. No.	QTY	Make / buy	Comment
0	C- 0	The Bottle	0003	_		
1	SA-1	Trigger Assembly	1005	1	Make	
2	MBH0101	Body	2001	1	Make	
2	MPH0201	Piston	2002	1	Make	
2	MLH0301	Plunger	2003	1	Make	
2	MTH0402	Trigger	2004	1	Make	
2	MIH0502	Pin	2005	1	Make	
2	MNH0602	Nozzle Valve	2006	1	Make	
1	MRH0703	Spray Container	1006	1	Make	
1	MUH0803	Plastic Tube	1007	1	Make	
2	MSH1004	Spring	2007	1	buy	

Table 3. Bill of Materials



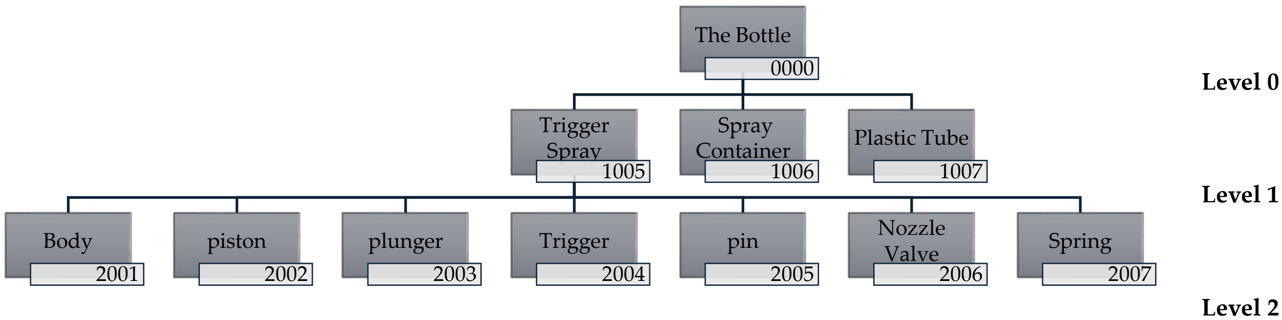
Level 0

Level 1



Level 0

Level 1



4.3.Route Sheet

The Route Sheet provides a detailed overview of the manufacturing process, specifying each step required to produce the product. The table below ensures efficient workflow planning and precise resource allocation for each stage of production.

Company	______________	**Part name**	Plastic Cap	**Prepared by**	______
Produce	Laundry Detergent Bottle	**Part number**	LCP0202	**Date**	______

No.	Operation Description	Machine type	Tooling	Set-up T	Operation T	Materials
01	Material Preparation: Polypropylene is melted, mixed with red colorant, and prepared for molding.	Material Blender	Dryer Moisture Analyzer	15 to 30 minutes	15-30 minutes per batch	PP
02	Injection Blow Molding: Injection Station: PP is injected into a preform mold, forming the initial shape. Blowing Station Ejection Station	Injection Blow Molding Machine	Thermocouples Mold Release Agents	30 minutes to 2 hours	5-15 seconds per cap	_
03	Cooling and Solidifying: Cooling helps to solidify the plastic and maintain dimensional accuracy.	Injection Blow Molding Machines Cooling Systems	_	30 minutes to 2 hours	10-30 seconds	_
04	Trimming: Removes excess plastic (flash) around edges for a smooth finish.	It can be done manually.	Deburring Tools Compressed Air Gun	_	5-10 seconds	_
05	Inspection and Quality Control: Ensures each cap meets quality standards for dimensions, color, and strength.	Visual Inspection System	Quality Gauges Calipers and Micrometers Tension and Compression Tester	15 to 30 minutes	1-2 seconds per cap	_
06	Packaging: Caps are organized, counted, and packed for distribution. Count and organizes caps, place them into boxes, and prepares them for shipment.	Automatic Counting and Packaging Machine	_	20 to 45 minutes	5-10 seconds per batch	_

Table 4. Route Sheet

Note: The route sheet in this assignment provides an example for only one part. Full data for each part is available in a separate file titled Route Sheet.

4.4.Sequencing the Required Process

4.4.1. Assembly Chart

The Assembly Chart illustrates the sequence of operations required to assemble the product, including key inspection points. This chart provides a clear visual of each step in the assembly process, showing the order in which components are added, combined, and inspected. It guides efficient workflow, ensuring each part is assembled and checked in the correct sequence to achieve the final product.

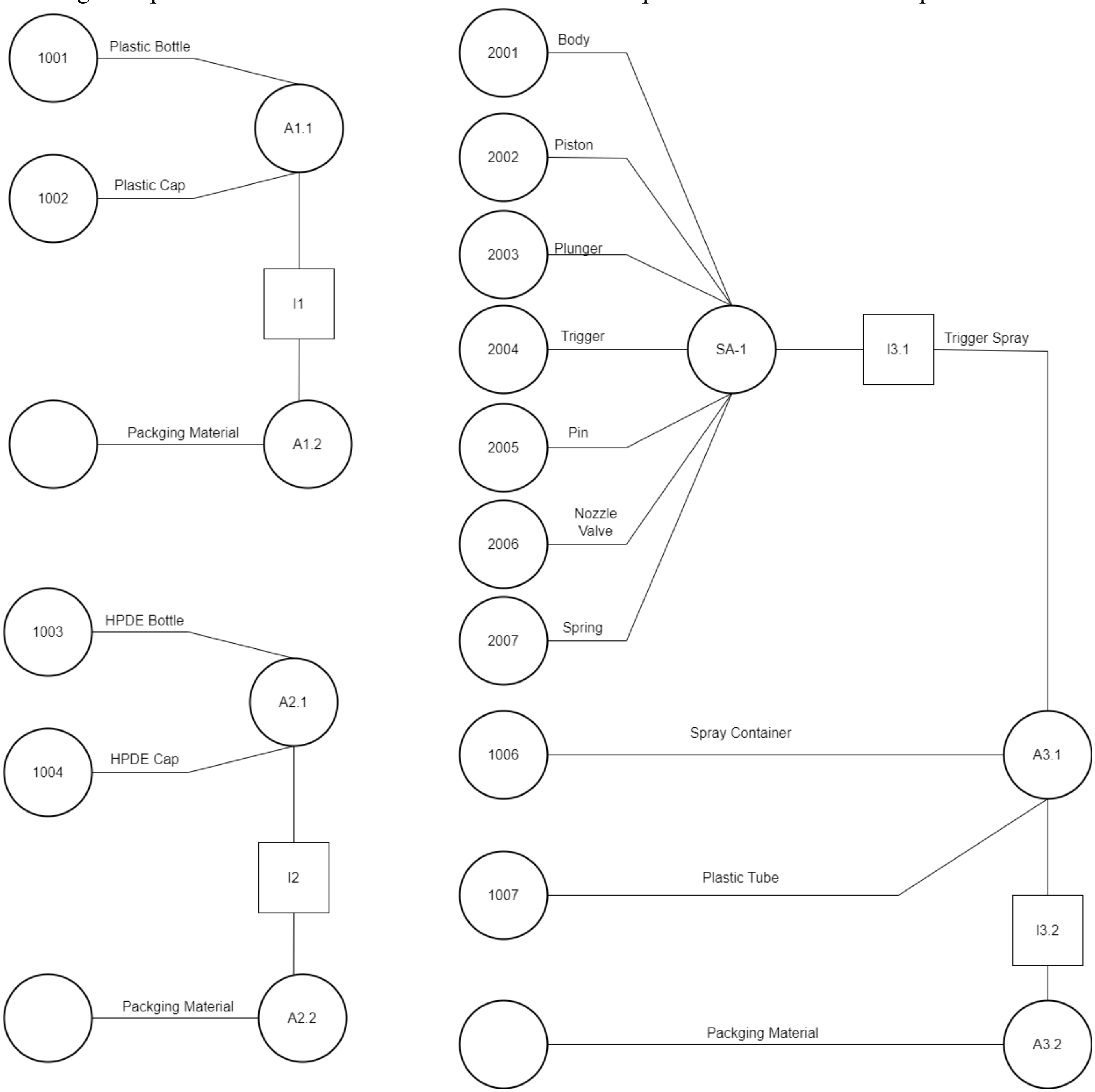


Figure 5. Assembly Chart

4.4.2. Operation Process Chart

The Operation Process Chart maps each step in manufacturing and assembly, including all operations and inspections. It provides a clear view of the workflow, helping to optimize efficiency, identify bottlenecks, and maintain quality control throughout production.

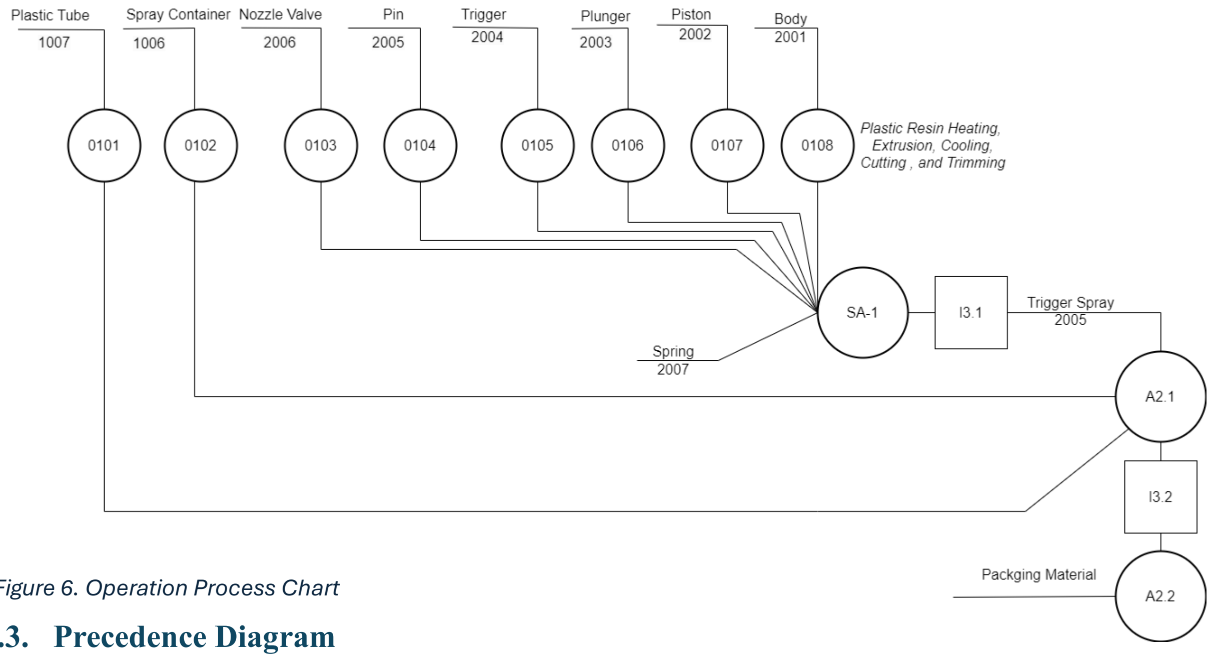


Figure 6. Operation Process Chart

4.4.3. Precedence Diagram

The Precedence Diagram illustrates the sequence and dependencies of each operation in the production process. This chart highlights the order of tasks, helping to streamline scheduling, optimize task flow, and minimize delays.

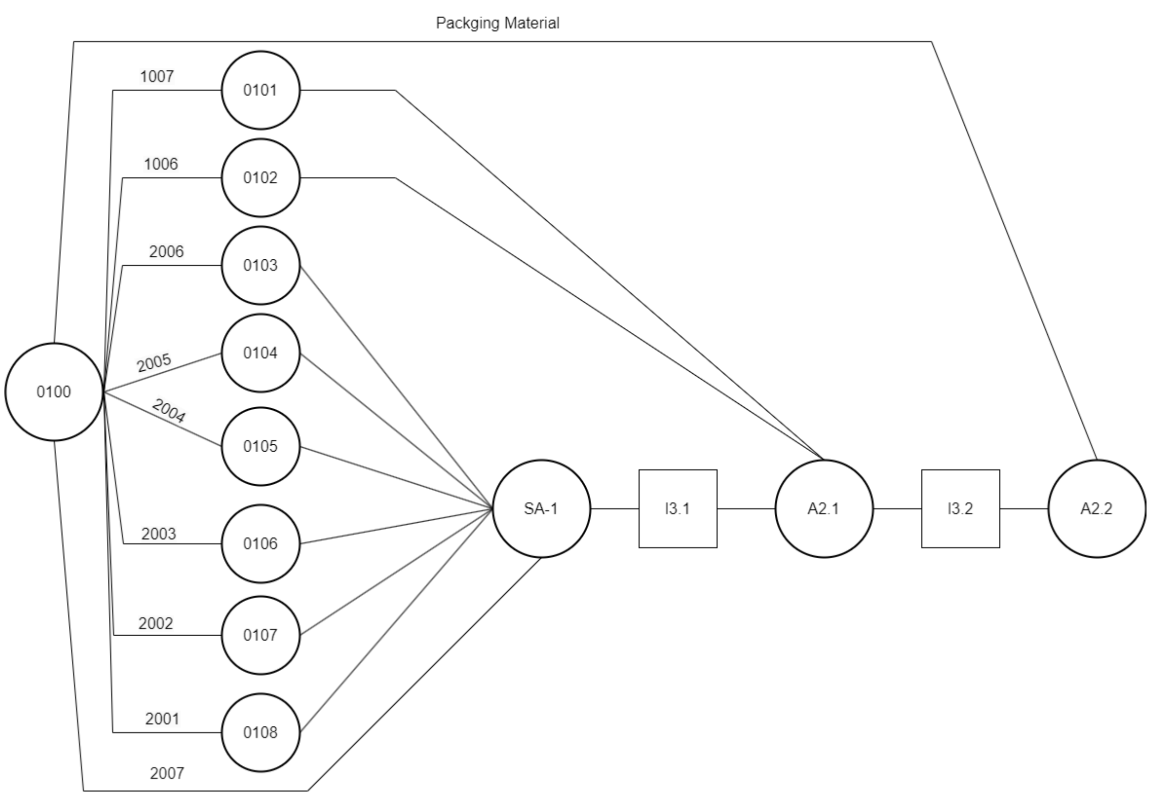


Figure 7. Precedence Diagram

5. Schedule Design

5.1.Marketing Information

The following table summarizes market analysis for our products covering demand variability over the next 10 years, alongside associated probabilities and confidence levels.

Year	Product	Demand State	Probability	Volume/Unit	Confidence Level/%
1st Year	Laundry Detergent	Pessimistic	0.2	8,400	90%
		Most Likely	0.6	10,000	
		Optimistic	0.2	12,000	
	Toilet Cleaner	Pessimistic	0.25	5,880	
		Most Likely	0.55	7,000	
		Optimistic	0.2	8,400	
	Multi-Cleaner	Pessimistic	0.15	6,720	
		Most Likely	0.65	8,000	
		Optimistic	0.2	9,600	
2nd Year	Laundry Detergent	Pessimistic	20	8,820	80%
		Most Likely	60	11,025	
		Optimistic	20	13,230	
	Toilet Cleaner	Pessimistic	0.25	6,174	
		Most Likely	0.55	7,350	
		Optimistic	0.2	8,820	
	Multi-Cleaner	Pessimistic	0.15	7,056	
		Most Likely	0.65	8,400	
		Optimistic	0.2	10,080	
5th Year	Laundry Detergent	Pessimistic	0.2	9,950	70%
		Most Likely	0.6	12,763	
		Optimistic	0.2	15,315	
	Toilet Cleaner	Pessimistic	0.25	6,961	
		Most Likely	0.55	8,933	
		Optimistic	0.2	10,719	
	Multi-Cleaner	Pessimistic	0.15	8,028	
		Most Likely	0.65	10,205	
		Optimistic	0.2	12,246	
10th Year	Laundry Detergent	Pessimistic	0.2	5,000	55%
		Most Likely	0.6	10,000	
		Optimistic	0.2	15,000	
	Toilet Cleaner	Pessimistic	0.25	3,500	
		Most Likely	0.55	7,000	
		Optimistic	0.2	11,000	
	Multi-Cleaner	Pessimistic	0.15	4,500	
		Most Likely	0.65	8,000	
		Optimistic	0.2	13,000	

Table 5. Market Analysis & Demand Over 10 Years

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5.1.1. Information to be obtained from Marketing

1. Who are the Consumers of the Product?

- **Industries Served:** Major players in the cleaning supplies industry, packaging suppliers, and companies needing given bottle designs.
- **Target Audience**: Manufacturers of household cleaning products, including both multinational and local companies
    1. Multinational Companies like Procter & Gamble, known for brands like Tide and Mr. Clean.
    2. Local companies like El-Nasr for Plastic and Chemicals (NPC), and Pioneer Plastic Industries may contact us for Private Labeling or Co-Packing.

2. Where are the Consumers Located?

- **Primary Locations**: Most manufacturers are in or around urban industrial zones in Cairo, Alexandria, and Giza. Key distribution should focus on these industrial hubs.
- **Distribution Needs**: Facilities will be strategically located near urban centers to reduce shipping costs and time. (e.g., Abu Rawash, industial zone, Alexandria dessert road).

3. Why Will the Consumer Purchase the Product?

- **Product Quality and Design:** Consumers prioritize bottles that are durable, fit for purpose, and designed to reflect their brand. High quality in terms of material as we use HDPE, PP manufactring our products.
- **Customization:** We are looking forward to meeting specific branding or functional needs, such as size, shape, and color.

4. Where Will the Consumer Purchase the Product?

- **Sales Channels:**
    1. **Direct Orders:** Bulk ordering via direct sales to manufacturers and distributors.
    2. **B2B Platforms:** Some companies might order through online B2B marketplaces for convenience.
- **Distribution Strategy:** Facilities should be close to major client facilities or logistic hubs to minimize transportation costs.

5. What Percentage of the Market Does the Product Attract, and Who is the Competition?

- **Market Share:** The demand for plastic bottles for cleaning products is significant due to high household consumption of these products.
- **Competition:** Key competitors include other plastic packaging manufacturers within Egypt, and international suppliers if they offer innovative or cost-effective solutions. We will work on differentiation in design, bulk pricing, and quality of materials can provide a competitive edge.

6. What is the Trend in Product Changes?

Trends:

1. Our facility will shift toward sustainable packaging, where we will be using recyclable or biodegradable plastic.
2. Increased demand for ergonomic and custom-shaped bottles that enhance product appeal is one of our main upcoming features.

Consumer Awareness: Manufacturers may increasingly seek eco-friendly packaging options as end-consumer awareness grows, so we are considering eco-friendly options.

5.1.2. Facilities Planning Issues Impacted by This Information

1. **Packaging**:
   Our facility will be equipped to produce versatile bottle designs and potentially accommodate eco-friendly materials in the future.
2. **Susceptibility to Changes in Marketing Strategies**:
   - Flexibility in mold changes for custom or ergonomic designs.
   - Adaptability to incorporate new materials as market trends shift towards sustainability.
3. **Method of Shipping**: Efficient handling and bulk shipping capabilities are essential to meet manufacturers' large order demands reliably.
4. **Warehousing System Design**: Warehousing will facilitate storage of bottles in bulk quantities and be adaptable to handle different designs and sizes.
5. **Seasonality and Sales Variability**: Storage and production capacity will account for fluctuations in demand, especially around major retail seasons.

Future Trends and Growth Potential: We will plan for growth in demand for eco-friendly bottles and new materials, allowing flexible production to keep up with industry changes.

5.1.3. Volume-Variety Chart (Pareto's Law not Applicable)

Product	Projected Volume (Most Likely)	Variety (No. of Components)
Laundry Detergent	10,000	2
Toilet Cleaner	7,000	2
Multi-Cleaner	8,000	10

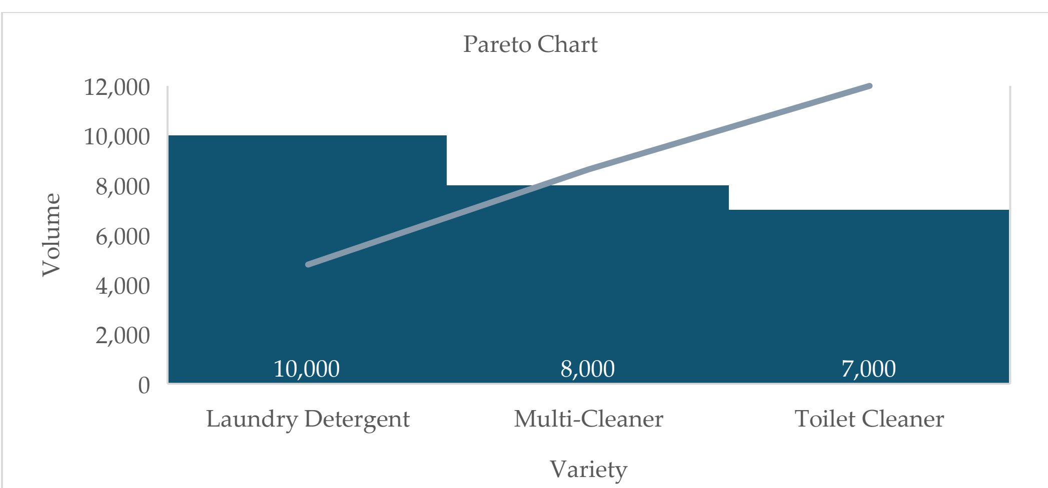
Pareto's Law (80/20 Rule) Applicability

Pareto's Law might apply if the majority of the demand (about 80%) comes from a minority of products (about 20%).

Volume Distribution:

- Laundry Detergent has the highest volume, followed by multi-cleaner and then Toilet Cleaner.
- If one or two products account for the bulk of demand, Pareto's Law applies.

Given this distribution, Laundry Detergent and Multi-Cleaner are likely to cover a significant share of total volume, supporting Pareto's Law, as these products are likely to generate around 80% of the demand.



4.2. Process Requirements

Chart 1. Pareto Chart

4.2.1. Production Volume Estimation

Using the marketing information with probabilities and confidence levels, we calculate expected production volumes for each product by taking the weighted average.

Expected Volume = $(P_P * V_p) + (P_m * V_m) + (P_o * V_0)$

Where P is the probability and V is the volume for each demand state.

Product	Year	Expected Volume
Laundry Detergent	1st Year	10,080
	2nd Year	11,025
	5th Year	12,711
	10th Year	10,000
Toilet Cleaner	1st Year	7,000
	2nd Year	7,350
	5th Year	8,797
	10th Year	6,925
Multi-Cleaner	1st Year	8,128
	2nd Year	8,534
	5th Year	10,286
	10th Year	8,475

Table 6. Production Volume Estimation

4.2.2. Production Requirements

We calculated production requirements for each assembly process using the formula: $I = \frac{O}{1-d}$

Where I is the input quantity, O is the output quantity, and d is the defect rate at that stage.

After each stage of production, the number of good (non-defective) units decreases due to defects that occur in the manufacturing process. The Defects are assumed to be critical (e.g., major leaks, unsafe products) The action taken will be recycling the plastic to be a more environmentally friendly disposal.

	Node	Process	Required Output	Defect Rate	Required Input
Multi-Cleaner	1	Inject Molding for Body	8,164	0.05	8,594
	2	Assembly of Trigger and Piston	8,164	0.03	8,417
	3	Nozzle and Valve Installation	8,164	0.04	8,504
	4	Final Assembly and Packaging	8,000	0.02	8,164
Laundry Detergent	1	Plastic Bottle Molding	10,959	0.05	11,536
	2	Injection Blow & Molding	10,520	0.04	10,959
	3	Cooling & Trimming	10,204	0.03	10,520
	4	Cap Installation & Packaging	10,000	0.02	10,204
Toilet Cleaner	1	Plastic Bottle Molding	7,440	0.04	7,750
	2	Injection Blow Molding	7,216	0.03	7,440
	3	Cooling &Trimming	7,071	0.02	7,216
	4	Cap Installation & Packaging	7,000	0.01	7,071

Table 7. Production Requirements

4.2.3. Machine Requirement

We used hypothetical values for machine cycle time and availability:

- **Cycle Time per Unit**: 2 minutes
- **Machine Availability**: 8 hours per day (480 minutes per day)
- **Working Days per Year**: 250

Capacity per Machine per Day = 480/2 = 240 Units

Using the formula: Machined Required = $\frac{Total\ Production\ Volume}{Machine\ Capacity\ per\ Day * Working\ Days}$

Assuming **250 working days per year**, then for each process we will need approximately 1 machine.

4.2.4. Cost Estimation

Assuming:

1. **Machine Cost**: $10,000 per machine
2. **Annual Maintenance Cost**: $1,000 per machine

For each product, the cost per year (if 1 machine is needed):

Total Cost = Machine Cost + Maintenance Cost

= 10,000 + 1,000 = $11,000

6. Work Force Requirements

The workforce is categorized into production, support, administrative, and additional staff. The total workforce is 63 employees, distributed as follows:

Category	Role	Number of Employees	Notes
Production Workforce	Operators	9	9 injection machines + 9 surface finish + 3 material blender machines (1 operator per machine).
	Mechanical Engineers	2	
	Industrial Engineers	2	
	Quality Control	4	
	Quality Control Engineer	1	
Subtotal		**18**	
Assembly Workers		26	8 workers per product line × 2 product lines + 10 workers for additional assembly tasks.
Material Handlers		9	1 per cell × 3 cells + 3 for forklifts + 3 between departments.
Warehouses Managers		3	
Packaging		6	Can increase based on production.
Subtotal		**44**	

Category	Role	Number of Employees	Notes
Support Workforce	Maintenance Technicians	5	1 per 3 machines (15 machines total).
	Quality Assurance Staff	9	1 per product line × 3 shifts (3 product lines).
Subtotal		**14**	
Administrative Workforce	HR Staff	2	Managing HR and recruitment.
	Accounting/Logistics	3	Financial and supply chain activities.
	Receptionist	1	
	Supervisors/Managers	3	1 per shift.
Subtotal		**9**	
Additional Staff	Cafeteria Support	2	Facility maintenance.
	Security Personnel	3	1 per shift.
Subtotal		**5**	
Grand Total		**90**	

Table 8. Workforce Requirements

7. Factory Layout and Strategy

Selected Layout Type: Cellular Layout

The cellular layout is particularly advantageous for batch production systems and environments requiring moderate product variety. This layout strategically organizes machinery and personnel by product family, thereby minimizing material handling inefficiencies, enhancing workflow continuity, and providing adaptability to accommodate diverse bottle designs.

Reasons for Selection:

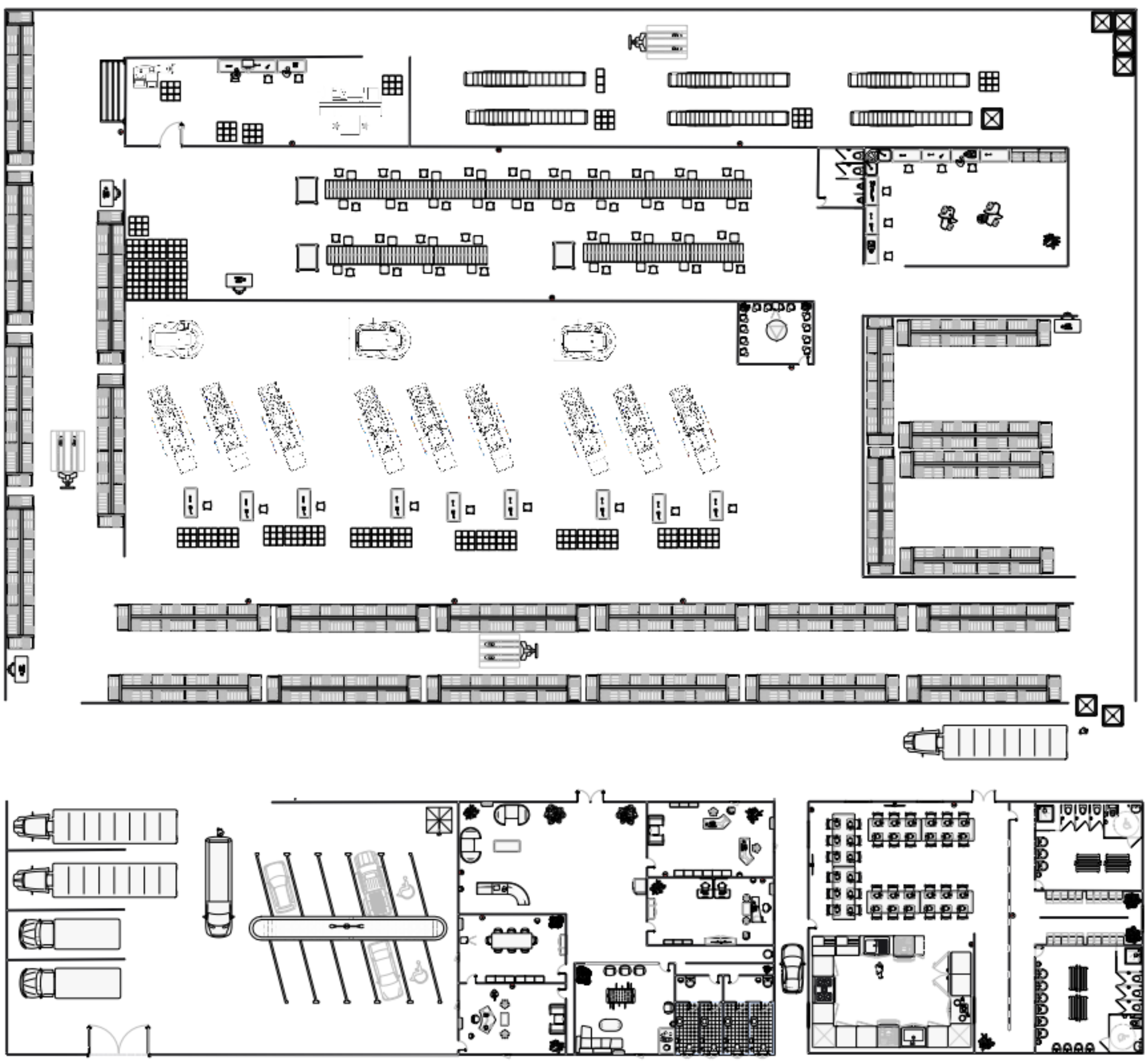
1. Efficient use of space and resources.
2. Faster production changeovers.
3. Scalability to meet varying production demands.
4. Enhanced team collaboration within cells.
5. Simplified material flow and reduced in-process inventory.

8. Departmental Layout and Material Handling

8.1. Layout Strategy

The factory layout emphasizes streamlined material flow and operational efficiency:

Area	Location	Purpose
Raw Material Storage	Near facility entrance	Optimizes logistics and material handling.
Injection Molding Area	Centrally located	Reduces transportation time between processes.
Assembly Zone	Adjacent to the molding area	Facilitates smooth material flow and quick transitions.
Quality Control Section	Near assembly lines	Enables immediate inspection and quality validation.
Packaging Unit	Near finished goods storage	Efficient transfer and storage of completed products.
Administrative Offices	Near main entrance	Accessible for oversight and client visits.
Employee Amenities	Centrally located	Provides easy access for staff during breaks.



Note: Detailed facility design specifications can be found in the Facility Layout Overview and Facility Design documentation.

8.2.Departmental Specifications, Spatial Allocations, and Land Requirements

Department	Area (m^2)	Details
Production	~3000	Includes injection molding, assembly, cooling/trimming, and buffer zones.
Storage/Warehousing	~1200	Allocated for raw materials and finished goods storage.
Administrative Offices	~500	Includes HR, accounting, logistics, and meeting rooms.
Utilities/Maintenance	~200	Power backup systems, maintenance workshops, and water treatment.
Parking/Auxiliary	~700	Space for staff vehicles, visitor parking, and logistics vehicles.
Employee Amenities	~500	Cafeteria and restroom facilities for employees.
Total	~6100	~7800 with buffer zones

8.3.Core Production Departments

The **throughput** and **cycle time** are estimates based on industry standards and typical machine performance. These numbers are used for capacity planning, and machine performance may vary based on operational conditions. The **cooling system** time and throughput depend on the size and complexity of the molded products.

Equipment	Throughput	Cycle Time	Role
Injection Molding Machines	240 units/day	2 minutes/unit	Produces bottles and caps.
Cooling Systems	-	5-10 minutes/unit	Stabilizes molded products for accuracy.
Conveyor Systems	-	Continuous flow	Streamlines assembly and inspection tasks.
Inspection Tools	-	2-3 minutes/unit	Calipers, micrometers, and automated visual inspection.
Packaging Systems	300-500 units/hour	1-2 minutes/unit	Ensures accurate counting and packaging.

Table 9. Production Departments

1. **Injection Molding Area**
   - **Equipment:** 3-4 injection molding machines.
   - **Role:** Produces bottle components (body, caps, and triggers).
2. **Assembly Operations**

Figure 8. Facility Layout

   - **Equipment:** Conveyor systems for assembly tasks.
   - **Role:** Efficient assembly of components.
3. **Cooling and Trimming**
   - **Equipment:** Cooling and trimming machines.
   - **Role:** Stabilizes molded products and trims excess material.
4. **Quality Control (QC)**
   - **Role:** Validates product conformance to quality standards using specialized inspection equipment.

8.4.Ancillary Support Departments

1. **Raw Materials Storage**

Strategically located near the facility entrance for optimal logistics and material flow. Designed with defined pathways for forklifts and categorized storage for HDPE, PP, and other materials. Includes environmental controls to maintain material quality.

2. **Finished Goods Storage**

Positioned near the loading and dispatch area to optimize shipping efficiency. Organized with racks or pallets for easy retrieval and handling seasonal fluctuations in demand.

8.5.Material Handling System

8.5.1. Inter-Departmental Material Handling

- **Primary Equipment:** Conveyor Belts.
    1. Ensures continuous and efficient material flow between production stages.
    2. Reduces human intervention, minimizing errors and labor costs.
    3. Customizable to accommodate fragile, lightweight plastic parts.
- **Supporting Equipment:**
    - Forklifts for bulk transport (e.g., paint drums, finished goods).
    - Automated Guided Vehicles (AGVs) for smaller batches and specialized materials.

8.5.2. Intra-Departmental Material Handling

- **Primary Equipment:** Automated Systems (e.g., Overhead Trolleys, Robotic Arms).
    1. Ensures precision in handling delicate components.
    2. Reduces contamination risks, especially during painting or coating processes.
- **Supplementary Equipment:** Pallet jacks and manual carts for lighter loads and quick adjustments.

9. Additional Considerations for Layout Designing

9.1.Environmental and Safety Considerations

1. **Waste Management:**
    - Proper disposal systems for plastic scraps, paints, and solvents to ensure compliance with environmental regulations.
    - Recycling initiatives for plastic waste to minimize environmental impact.
2. **Fire and Hazard Safety:**
    - Fire extinguishers and suppression systems located in critical areas, such as storage and production.
    - Emergency exits clearly marked and unobstructed.
    - Storage areas designed to separate hazardous materials like paints and solvents.
3. **Ventilation and Air Quality:**
    - Adequate ventilation systems in areas handling volatile materials, such as painting or solvent storage, to ensure worker safety and prevent contamination.

9.2.Scalability and Future Expansion

1. **Provisions for Growth:**

- Reserved space for adding new production lines or expanding storage areas.
- Modular design of the layout to easily adapt to changes in production demands.

9.3.Compliance and Standards

1. **Regulatory Standards:**
    - Factory layout adheres to ISO 9001 for quality management systems.
    - Compliance with OSHA (Occupational Safety and Health Administration) standards to ensure worker safety.
2. **Industry Best Practices:**
    - Utilization of lean manufacturing principles to minimize waste and maximize efficiency.
    - Regular audits and inspections to maintain high standards of operation.

10. Conclusion

The proposed facility layout and material handling system detailed in this project demonstrate a strategic approach to manufacturing plastic bottles for cleaning detergents, emphasizing efficiency, flexibility, and scalability. By choosing a cellular layout and integrating batch production techniques, the facility is designed to meet high production demands and adapt to market changes and consumer preferences efficiently. Our design not only supports the current needs of the cleaning supplies industry but also anticipates future market trends, particularly the shift towards sustainable packaging solutions. The comprehensive consideration of environmental impacts, consumer demands, and production efficiency positions this facility to be a leader in the packaging industry, contributing to both economic and environmental goals. Through meticulous planning and strategic design, we aim to set a new standard for production facilities in the cleaning supplies sector, focusing on operational excellence and sustainable practices.