Battery Submodule Assembly Line

PURDUE UNIVERSITY | School of Industrial Engineering

Drew Whiteaker, Holly Courtney, Wayne Chen, Yohith Reddivari

Client Introduction

Photon Automation utilizes high-performance automation and advanced manufacturing process to solve manufacturing tasks for its diverse customer base. The company was established in 2000 and has headquarters in Greenfield, IN. Some of Photon's operation machines include:

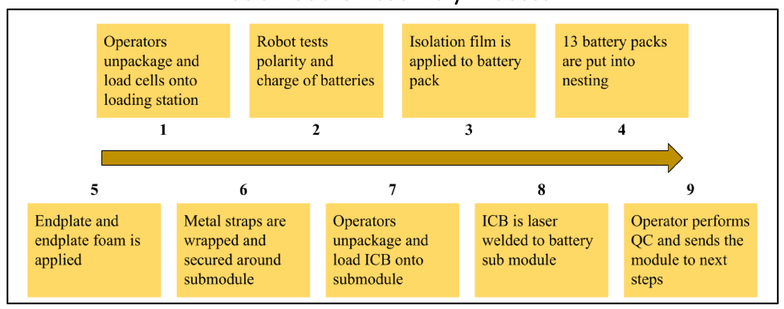
- Welding Lasing System s
- Robotic Assembly Arm s
- CT Scanner Inspection Systems

Photon's work spans several industries including automotives, battery manufacture, pharmaceuticals and healthcare.

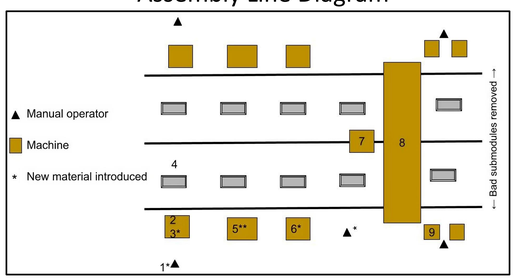
System Model

Photon Automation's current project is to design and construct an automated assembly line that can output a high-capacity battery pack every two minutes. The company has already created a plan for the line layout and major components of the assembly but has yet to build any physical systems yet. The battery packs are comprised of 4 submodules that each weigh over 200 pounds and contain 13 individual battery cells, endplates, and an interconnection board.

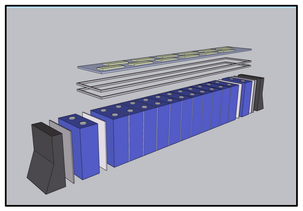
Submodule Assembly Process



Assembly Line Diagram



Battery Submodule



Discussion

Much of our work can form the foundations of future planning, testing, and evaluation of the assembly line. Through this project, the team has gained understanding of the form and function of assembly line creation. We have gotten to see the level of detail and breadth required to create successful designs that consider every aspect of the process.

Protect operators → Optimize station layouts → Calculate dunnage usage

Problem Statement

Our team has been assigned the task of optimizing the submodule assembly process, with a focus on spool replacement, raw material and dunnage presentation, individual battery cell loading, and machine layout improvements. We will evaluate worker safety, recommend material flow and machine layout improvements, conduct changeover rate analyses, optimize raw material presentation and manpower logistics, and reduce assembly time while considering labor costs. By improving the assembly process, we hope to ensure the assembly line's effectiveness, improve worker safety, and recommend the most efficient strategies to build the battery packs.

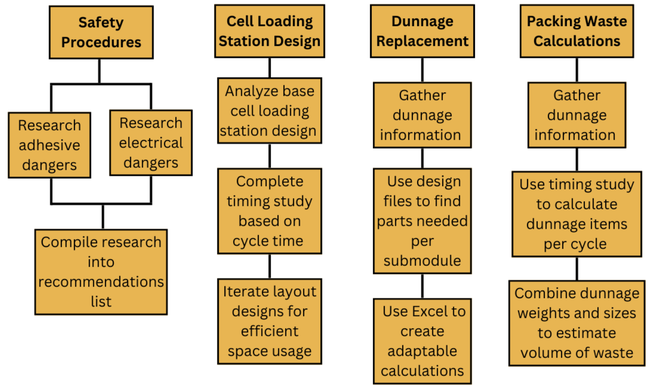
Methodology

Safety procedures- Some hazards of adhesives and voltages used in the assembly include fumes, irritation on contacts, electrostatic discharge, and arc flashes. Safety procedures are based mainly on OSHA standards and chemical safety sheets.

Cell loading station design- Based on station layouts produced by the client, we evaluated timing requirements for operators and machines. The team also created several dunnage staging suggestions in order to make the area efficient and accessible to operators and forklifts bringing product in and removing waste.

Dunnage replacement- Several pieces of the submodule are packaged in spools and must be regularly changed out. The amount of material on each spool is not finalized, but the client wanted to get estimates of how long each spool will last. An adaptive Excel sheet was created in case the dunnage changes.

Packing waste calculations- Battery cells are used rapidly at the loading station. An Excel sheet and design files were used to estimate the dunnage waste over time.

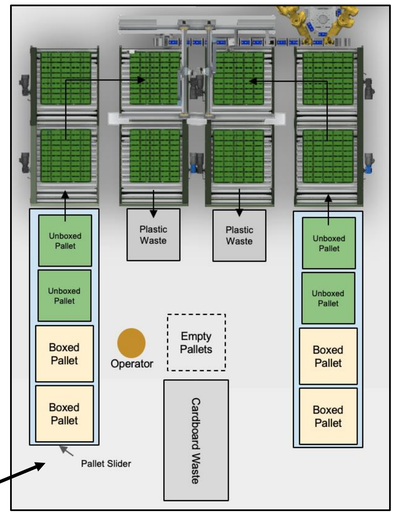


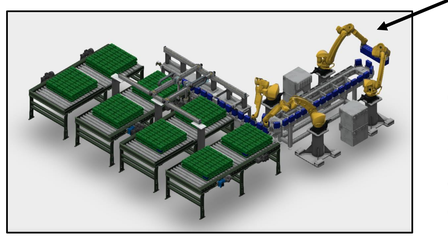
Results

Safety Procedures

- Wear insulated gloves and boots. Add electrostatic mats if possible.
- Wear proper masks and ensure area is well ventilated.
- Insert splash guard shield and wear appropriate gloves

Cell Loading Station Design





Cell Loading Station

1. Pallets of battery cell placed on sliders
2. Operators remove outer box while pallets on the slider.
3. Place outer boxes and emptied pallets to the cardboard waste and empty pallets.
4. Once pallets are unboxed, move onto the elevator.
5. Robotic Arm retrieve cells modules.
6. New pallets refresh onto the line once it is emptied, and empty plastic to waste bins

Dunnage Replacement Frequency

Non-Continuous Dunnage

Part	Use Frequency	Units Used per Hour	Units per case	Replacement Frequency
Battery Cell	4.6 units/sec	780	200	**15.4 min**
End Plate	30 units/sec	120	100	**50 min**
ICB	60 units/sec	60	100	**100 min**
7mm Push-in Rivet	30 units/sec	120	500	**250 min**

Continuous Dunnage

Part	Use Frequency	Length Used per Hour	Length of Roll	Replacement Frequency
End Plate Foam	30 units/sec	25 m	100 m	**4.1 hrs**
Strap	30 units/sec	284 m	2,500 m	**8.8 hrs**
Intercell Isolation Film	5 units/sec	160 m	800 m	**5.0 hrs**

Packaging Waste Calculations

Shift Time (hrs)	8
Pallets used per Hour	4.5

Key: Edit / **Result**

	Carboard				Plastic			
Waste per Pallet	10.97	m^2	118	ft^2	0.022	m^3	0.76	ft^3
Density	0.13	kg/m^2	0.027	lb/m^2	910	kg/m^3	56.8	lb/ft^3
Weight of Waste per pallet	1.43	kg	3.15	lbs	19.65	kg	43.33	lbs
Size of Waste per shift	395	m^2	4252	ft^2	0.777	m^3	27.5	ft^3
Weight of Waste per Shift	**51.4**	kg	**113**	lbs	**707**	kg	**1560**	lbs

Battery Cell Weight	20 lbs
Cells per pallet	200
Cell Weight per pallet	4,000 lbs
Cardboard Weight per pallet	3.1 lbs
Plastic Weight per pallet	43 lbs
Pallet Weight	40 lbs
Total Pallet Weight	4,086 lbs