BATTERY PACK ASSEMBLYLINE

A PROJECT REPORT

Submitted by

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In partial fulfillment for the award of the degree of

BACHELOR OF ENGINEERING

IN

ELECTRICAL AND ELECTRONICS ENGINEERING

PANIMALAR ENGINEERING COLLEGE

(An Autonomous Institution, Affiliated to Anna University, Chennai)

MAY 2024

BONAFIDE CERTIFICATE

Certified that this project report **"BATTERY PACK ASSEMBLY LINE"** is the Bonafide work of **ALICE VARSHA.E (REG NO: 211420105005), GAYATHRI.J (REG NO: 211420105024)** who carried out the project work under my Supervision.

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INTERNAL EXAMINER **EXTERNAL EXAMINER**

ACKNOWLEDGEMENT

We would like to express our sincere thanks to our respected Chairman and Chancellor, Sathyabama University **Dr.JEPPIAR M.A., B.L., Ph.D.,** for being in the vanguard of scientific progress in our college.

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We also express our sincere thanks to our Directors **Mrs.C.VIJAYARAJESWARI** and **Dr.C.SAKTHI KUMAR,M.E., Ph.D.,** for providing us with necessary facilities for completion of this project.

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ABSTRACT

The project training was provided by TITAN ENGINEERING AND AUTOMATION LIMITED from 01.02.2024 to 28.02.2024 for an effective period of 1 month (60 Hours). During this 1 month of project training, we learnt about the B2B kind of business that TEAL delivers. We are trained with Safety Lessons that everyone has to know to ensure a safe and secure workplace. This project training exposed us to the realm of assembly engineering, various types of assembly lines and the equipment used to perform those assemblies. We also gained the knowledge of how automation is being implemented in the assembly lines, which proves to reduce the cycle time of the assembly line significantly. Apart from this, we got a clear view in the design process of each of the components of the assembly line according to the project requirements. The art of project management followed in the company was an excellent takeaway for us. We were able to observe how SAP facilitates information flow and data processing across all parts of the company. Along with the core domains, we explored the other subsidiary departments like Quality Control, Logistics and Inventory. This gave us a wholesome experience of the real engineering business that happens in the company. This overall period of project training has been a great learning for us.

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(DIN 47100) WIRES AND CABELS DESCRIPTION & SHORT NAME

S.NO	DESCRIPTION	SHORT NAME	S.NO	DESCRIPTION	SHORT NAME
1	WHITE	WH	30	YELLOW/PINK	YEPK
2	BROWN	BN	31	GREEN/BLUE	GNBU
3	GREEN	GN	32	YELLOW/BLUE	YEBU
4	YELLOW	YE	33	GREEN/RED	GNRD
5	GREY	GY	34	YELLOW/RED	YERD
6	PINK	PK	35	GREEN/BLACK	GNBK
7	BLUE	BU	36	YELLOW/BLACK	YEBK
8	RED	RD	37	GREY/BLUE	GYBU
9	BLACK	BK	38	PINK/BLUE	PKBU
10	VIOLET	VT	39	GREY/RED	GYRD
11	GREY/PINK	GYPK	40	PINK/RED	PKRD
12	RED/BLUE	RDBU	41	GREY/BLACK	GYBK
13	WHITE/GREEN	WHGN	42	PINK/BLACK	PKBK
14	BROWN/GREEN	BNGN	43	BLUE/BLACK	BUBK
15	WHITE/YELLOW	WHYE	44	RED/BLACK	RDBK
16	YELLOW/BROWN	YEBN	45	WHITE/BROWN/BLACK	WHBNBK
17	WHITE/GREY	WHGY	46	YELLOW/GREEN/BLACK	YEGNBK
18	GREY/BROWN	GYBN	47	GREY/PINK/BLACK	GYPKBK
19	WHITE/PINK	WHPK	48	RED/BLUE/BLACK	RDBUBK
20	PINK/BROWN	PKBN	49	WHITE/GREEN/BLACK	WHGNBK
21	WHITE/BLUE	WHBU	50	BROWN/GREEN/BLACK	BNGNBK
22	BROWN/BLUE	BNBU	51	WHITE/YELLOW/BLACK	WHYEBK
23	WHITE/RED	WHRD	52	YELLOW/BROWN/BLACK	YEBNBK
24	BROWN/RED	BNRD	53	WHITE/GREY/BLACK	WHGYBK
25	WHITE/BLACK	WHBK	54	GREY/BROWN/BLACK	GYBNBK
26	BROWN/BLACK	BNBK	55	WHITE/PINK/BLACK	WHPKBK
27	GREY/GREEN	GYGN	56	PINK/BROWN/BLACK	PKBNBK
28	YELLOW/GREY	YEGY	57	WHITE/BLUE/BLACK	WHBUBK
29	PINK/GREEN	PKGN	58	BROWN/BLUE/BLACK	BNBUBK

DEVICE IDENTIFIER LIST

zzzzz

-A

PLC & I/O MODULES
CAMERA
HMI
PCB,S
PC MONITOR & CPU
INTERFACING MODULE
MAGNETIZER
CPV VALVE KIT

-B

TRANSDUCERS
ULRASONIC TRANSDUCERS
ENCODER
TORQUE TRANSDUCERS
LOAD CELL
PRESSURE SENSOR
TEMPERATURE SENSOR

-C

CAPACITOR

-D

DELAY & STORAGE DEVICES
TIMER
COUNTER

-E

COOLING FAN
EXHAUST FAN
AC
HEATING ELEMEMTS

-F

FUSE'S
SAFETY CIRCUIT BREAKER

-G

BATTERY
GENERATOR

-H

PANEL LAMPS
MACHINE LAMPS
POWER LAMPS (FOLDING TYPE)
PILOT LAMPS
BEACON LAMPS
LEDS
BUZZER
TOWER LAMP

-K

RELAYS
CONTACTORS
MULTIFUNCTIONAL RELAYS
SAFETY RELAYS
PHASE MONITOR RELAYS
SSR MODULE

-L

CURRENT TRANSFORMER
CHOKE

-M

MOTOR

-N

TEMPERATURE CONTROLLER
LOADCELL INDICATOR
SPEED CONTROLLER
AMPLIFIER
NPN - PNP CONVERTER
DRIVE
SIGNAL CONDITIONER
NUT RUNNER CONTROLLER

-Q

MAINS ISOLATOR SWITCH
MCCB'S
RCCB
MPCB'S
MCB'S

-R

LVDT
RESISTOR

-S

PROXIMITY SWITCHES
REED SWITCHES
PUSHBUTTONS
SELECTOR SWITCHES
CAM OPERATED SWITCHES
KEY OPERATED SWITCHES
LIGHT REFLECT SWITCH
LIMIT SWITCHES
MULTI POSITION SWITCH
PHOTO ELECTRIC SWITCHES
PULL SIWTCH
TOUCH SENSITIVE SWITCH
PRESSURE SWITCH
ULTROSONIC PROXIMITY SWITCHES
SAFETY CURTAIN

-T

TRANSFORMER

-U

BLOCK BOX
JUNCTION BOX
HMI PENDENT BOX
PUSH BUTTON BOX
MIMIC BOX

-V

POWER SUPPLY
SMPS
RECTIFIER
AC FILTER
OPTO COUPLER
MEASURING TRANSDUCER
MEASURING INSTRUMENT
DIODE

-W

CABLE
TRANSMISSION PATH

-X

TERMINAL CONNECTORS
QUICK CONNECTORS
POWER SOCKET
SPIKE BUSTERS
PLUG CONNECTORS

-Y

MAGNETIC VALVES
VALVE COILS
BRAKE

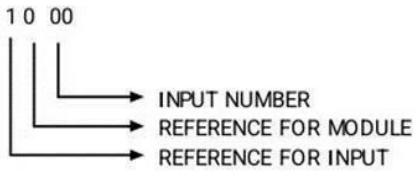
DEVICE TAG NUMBERS

-Q1,-Q2,-Q3----	→	3 Phase (or) 1 Phase (MAINS ISOLATOR SWITCH , MCCB, MCB, RCCB, MPCB)
-F1 TO -F20	→	AC CONTROL FUSES (M/C LAMP, COOLING FAN------)
-F21 TO -F40	→	DC CONTROL FUSES (PLC, HMI, INPUTS ------)
-K0	→	PHASE MOINTER RELAY
-K1 TO -K20	→	POWER CONTACTORS
-K21 TO -K30	→	SAFETY RELAYS
-K31 TO -K50	→	SAFETY CONTACTORS
-K51 & ABOVE	→	CONTROL RELAYS
-S1 & -S50	→	SWITCHING DEVICES IN POWER & CONTROL CIRCUIT
-S51 & -S100	→	SWITCHING DEVICES IN SAFETY CIRCUIT
-S101 & ABOVE	→	DIGITAL INPUTS

FERRULE NUMBERS

1 TO 50	→	AC POWER
51 TO 100	→	AC CONTROL
L+ (24V DC) M (0V)	→	DC POWER (24V DC) SMPS 1
L1+ (24V DC) M1 (0V)	→	DC POWER (24V DC) SMPS 2
L2+ (5V DC) M2 (0V)	→	DC POWER (5V DC) SMPS

1000,1001,1002----	→	DIGITAL INPUTS
2000,2001,2002----	→	DIGITAL OUTPUTS
3000,3001,3002----	→	ANALOG INPUTS
4000,4001,4002----	→	ANALOG OUTPUTS
5000,5001,5002----	→	COUNTER INPUTS



Single Wire Colour Details

PE/Earthing :

EARTH Conductors are marked in GREEN/YELLOW.

AC Power Wire :

- All LIVE Supply wire circuit must be marked in ORANGE Colour
- The Line Supply 1 (L1) Supply wire circuit must be marked in BLACK Colour
- The Line Supply 2 (L2) Supply wire circuit must be marked in BLACK Colour
- The Line Supply 3 (L3) Supply wire circuit must be marked in BLACK Colour
- The Neutral wire circuit must be in LITE BLUE Colour

DC Control Wire

- The 24V (+) Supply wire circuit must be marked in DARK BLUE Colour
- The 0V (-) Supply wire circuit must be marked in DARK BLUE Colour

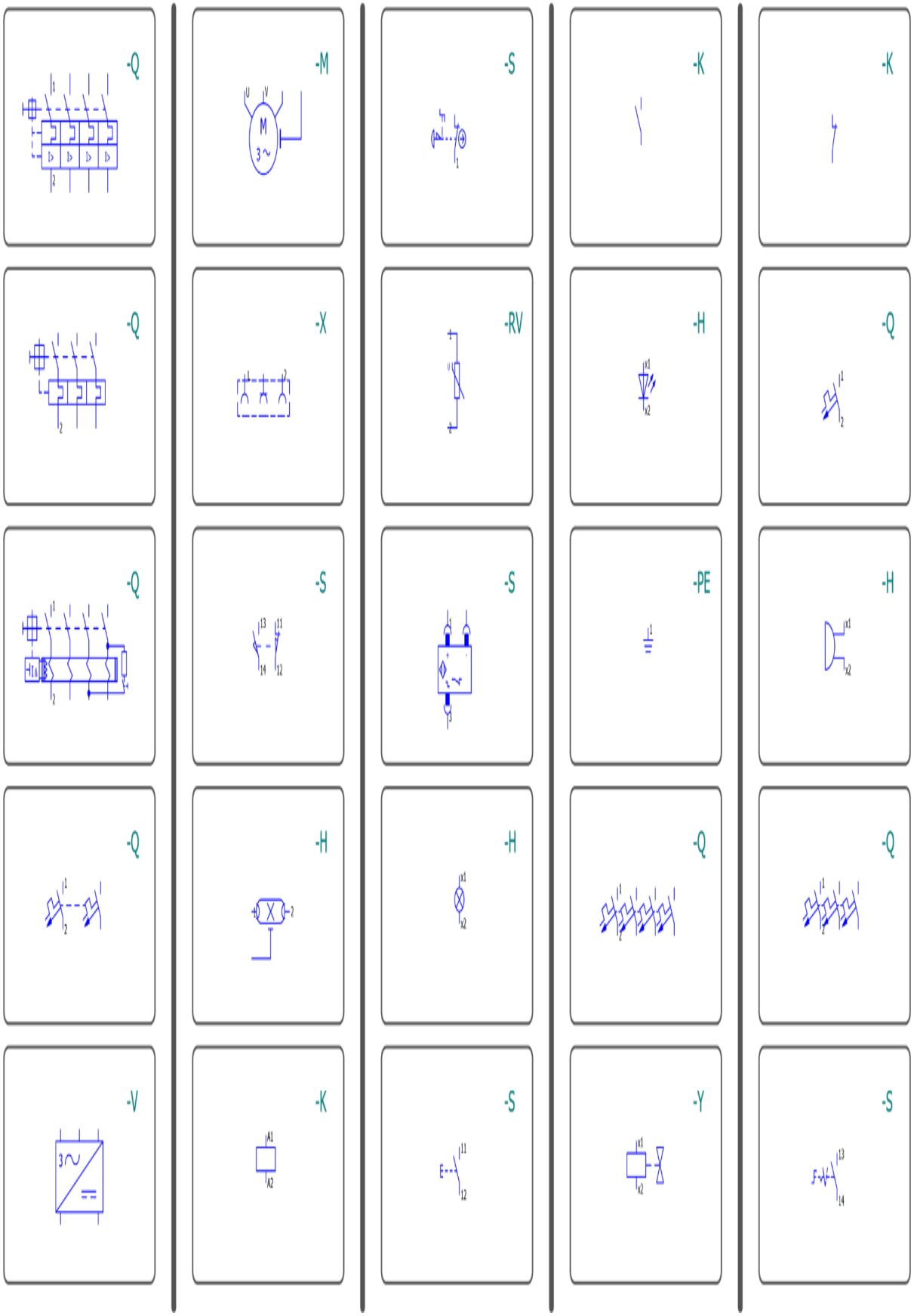
PLC Input/Output

- The PLC Input wire circuit must be marked in DARK BLUE Colour.
- The PLC Output wire circuit must be marked in DARK BLUE Colour.

SENSOR CABLES:

- BROWN : 24V SUPPLY
- BLUE : 0V SUPPLY
- BLACK : SIGNAL FROM/TO THE DEVICE
- WHITE : SIGNAL FROM/TO THE DEVICE

Symbol Identification



CHAPTER 1
COMPANY PROFILE

TITAN ENGINEERING AND AUTOMATION LIMITED

Titan Engineering and Automation Limited (TEAL), is a wholly owned subsidiary of Titan Company Limited, A TATA Enterprise. This diversified business group includes Titan Watches, Tanishq Jewellery, Titan Eyeplus Eyewear, Fastrack and many more personal accessories. Born as an in-house engineering team dedicated to high precision component manufacturing and designing, manufacturing automation machines, TEAL has augmented into realms beyond the initial setup.

Born as an in-house engineering team dedicated to high precision component manufacturing and designing, manufacturing automation machines, TEAL has augmented into realms beyond the initial setup. The team now boasts of full-fledged machine building and automation and component manufacturing businesses catering to the global markets

TYPE OF INDUSTRY: Assembly Line Manufacturing COMPANY SIZE: 501-1000 Employees

TYPE: Privately held

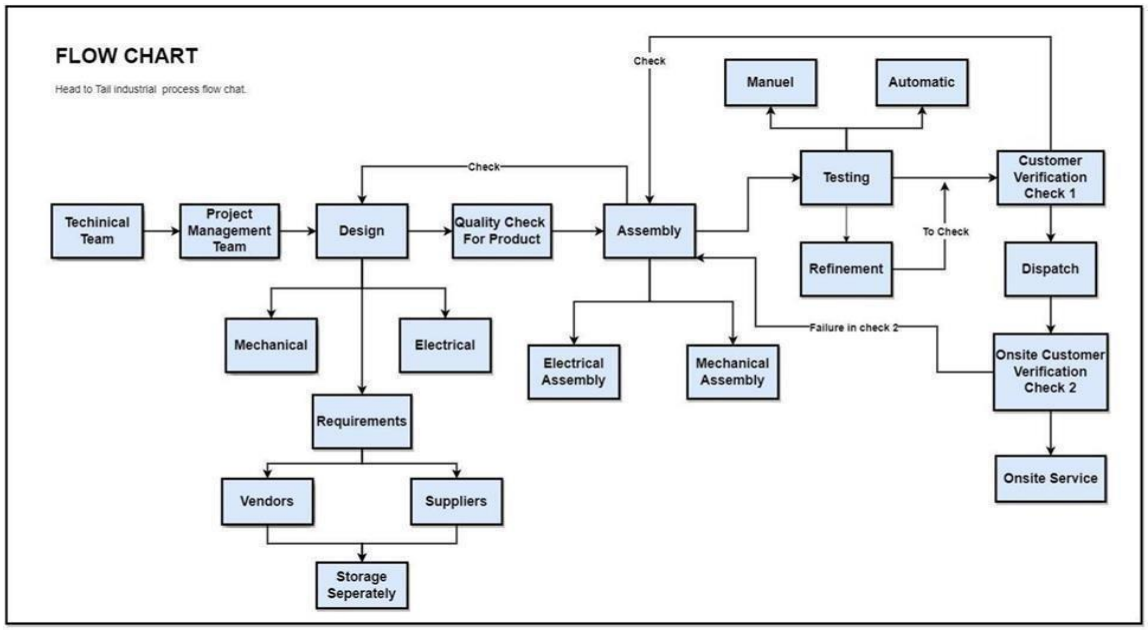
WEBSITE: https://www.titanteal.com/

CHAPTER 2

BUSSINESS FLOW

A business process is a collection of linked tasks that find their end in the delivery of a service or product to a client. A business process has also been defined as a set of activities and tasks that, once completed, will accomplish an organizational goal. The business process flow of Titan Engineering and Automation Limited is shown below:

These are some of the fundamental business processes that TEAL typically have. The Companies uses business process management (BPM) tools and methodologies to streamline and optimize these processes for efficiency and effectiveness. SAP (Systems, Applications, and Products in Data Processing) is a significant part of the business processes in the company. SAP is a leading enterprise resource planning (ERP) software solution that helps companies manage various aspects of their business operations.



CHAPTER 3

TYPE OF BUSINESS (B2B)

Business-to-business (B2B) is a transaction or business conducted between one business and another, such as a wholesaler and retailer. B2B transactions tend to happen in the supply chain, where one company will purchase raw materials from another to be used in the manufacturing process.Titan Engineering and Automation Limited, as a B2B player in the engineering and automation sector, excels through its niche specialization, delivering tailored engineering and automation solutions to its carefully segmented target market of manufacturers and industrial facilities. With a relentless commitment to innovation and quality, Titan builds strong client relationships based on trust and reliability. They offer not just products or services, but also comprehensive technical support, ensuring clients receive the highest value throughout their journey.

B2B Logistics	B2C Logistics
Orders are larger in quantity and lower in volume.	Few items in an order that is delivered directly to individual customer doorsteps.
Buying decisions are based on cost, quality, reliability and supplier relationships.	Buying decisions are based on convenience, availability, brand reputation, and customer reviews.
Shipping methods are complex and can involve multiple modes of transportation.	Shipping methods are simple and may involve parcel carriers as well as local delivery services.
The focus is on building long-term relationships, maximizing cost-efficiency and cost-effectiveness.	The focus is on providing fast, reliable and cost-effective delivery.
Pricing is based on the current requirements of the receiving business.	Pricing and transactions are made on standard prices.
The cost of shipping is high, and orders take longer to reach the destination.	The shipping cost is low, and the order arrives within a few days, weeks, or hours of the placement.

CHAPTER 4

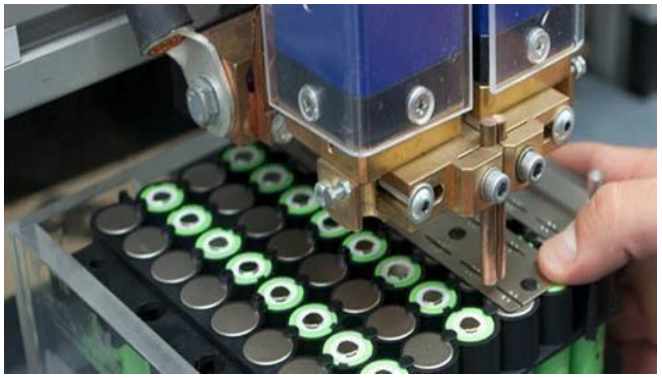
ASSEMBLY LINE

OBJECTIVE:

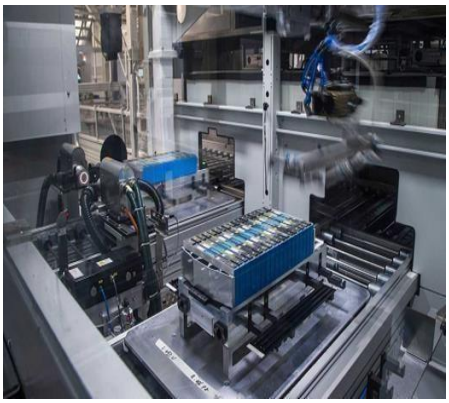
The objective of this assembly is to produce the battery packs for BMW bikes by assembling individual Li-ion cells in series and parallel configurations.

4.1 DESCRIPTION:

Li-ion battery technology has become the preferred technology in many battery storage applications due to its relatively high energy and power density, better volumetric densities, and low maintenance. The battery packs for BMW bikes were produced by TVS company and the manufacturing of the Battery pack assembly line was carried out by TEAL Titan Engineering and Automation Limited. To deliver the required power and energy for the application, individual Li-ion cells must be assembled in series and parallel configurations to form a Li-ion battery pack. A single battery pack contains 65 lithium-ion batteries arranged in 5 rows, with 13 in each row. These battery modules are then stacked to form a battery pack that can deliver the required



power. Once the battery pack has been designed, the assembly is carried out carefully to deliver the performance.



4.1.1 BATTERY AGING TEST :

Batteries are charged and discharged several times and their capacity is recorded at each charge and discharge to detect the battery discharge protection and its efficiency.

4.1.2 CELL SORTING :

The process of identifying and grouping the cells with similar parameters and characteristics so that they perform similar operations efficiently. The lithium- ion batteries were grouped depending upon the amount of voltage and internal resistance so that consistency and stability of the whole battery pack are ensured during its life. They were carried down in three types of conveyor belts A, B, and C, and a group of 13 cells were taken by the pick and place unit and arranged in a series module.

4.1.3 BOTTOM AND TOP COVER THE HOUSING STATION :

The bottom and the top cover of the assembly pack were set out separately in two stations. The laser marking process was carried out in another station.

4.1.4 LASER MARKING STATION :

The cover housing was labeled with the specification of the product and the company's logo using a laser marker. The battery cells taken through the conveyor belt were stacked up into modules and arranged in series and parallel lines.

4.1.5 THERMISTOR PASTING STATION :

The thermistor is placed at three different positions on the stacked battery module using a thermistor paster. The top cover carried out in a separate line was placed over the battery module.

4.1.6 BUFFER STATION :

A buffer station where no operations are carried out and battery modules are kept halted for entering into the next following workstation. The buffer station is also used to change the sequence of the modules from one line segment to another. Here the battery pack is rotated to 180 degrees as per the design specification and carried into the next station.

4.1.7 MODULE TIGHTENING STATION :

The battery modules were tightened together for the given required torque usingan automated robotic tightening module.

4.1.8 INTERCONNECTOR ASSEMBLY STATION :

Each electrochemical cell contains a terminal. The interconnector plate is coupled to the circuit and the terminal of one of the electrochemical cells. Two high-power copper interconnector plates were placed at the terminal batteries which provide electrical conductivity between all the cells.

4.1.9 PLASMA CLEANING STATION :

The plasma cleaning process relies on the activation of plasma ions to achieve the purpose of removing dirt on the surfaces. This method can effectively remove the dirt and dust from the end face of the cell pole in advance of the battery welding to reduce defective soldering. The gas phase plasma is etched on the surface of the interconnector in a sequenced pattern and also the plate is removed to clean the cell surface using plasma.

4.1.10 RESISTANCE WELDING STATION :

Resistance welding is a highly efficient easily monitored process to pass the electric current and the strip gets melted by the resistance heat generated. The welding zone's temperature distribution gradually stabilizes after every welding point by passing cooling air. After welding one point, the electrode will move to another point for welding, there should be a certain distance between the two adjacent points and limited resistance heat provided for proper welding.

4.1.11 ACIR INSPECTION STATION :

AC-IR inspection measures the internal resistance of the battery cell by passing a large amount of current and measuring its voltage drop. ACIR has become a very standard method for accessing the resistance of Li-ion battery cells. To measure, an AC is passed through the battery cell and the voltage response of the cell is measured.

4.1.12 MODULE STACKING STATION :

The cells and interconnector plates must be first aligned in a defined position and two battery pack modules were placed one

over the another with a single plate placed intermediate between them to prevent short-circuiting between the positive and negative poles. Integrated 3D camera systems and scanners are fixed in every station for ensuring the proper arrangement of battery cells .

4.1.13 TOP COVER SUBASSEMBLY STATION :

The power supply unit and charge plug and all other charge balancing circuit connections are assembled and placed on the top cover housing. Proximity sensors are fixed in every station to detect the presence of components in the assembly line segment.

4.1.14 OVERHEAD PALLET TRANSFER SYSTEM :

Overhead pallet transfer systems are designed to move the stacked batterypallets to the following next workstation.

4.1.15 DAMPERS & DOWEL ASSEMBLY STATION :

Dampers reduce the severity of vibration and shock on the battery components which is important for all automotive applications. The stacked battery pack is covered by two shells on both the top and bottom sides. The damper shells are made up of aluminum and they are kept together using dowel pins.

4.1.16 GAP FILLER DISPENSING STATION :

Dispensable gap fillers are used to fill large and uneven gaps in assemblies, and little to no pressure is transferred between interfaces. Gap fillers combine high thermal conductivity and low viscosity with the ability to maintain insulating properties. Gap fillers are filled between the two shells by an automated dispensing mechanism.

4.1.17 LIQUID SEALANT DISPENSING SYSTEM :

Liquid sealants are thermally-conductive gap-filling liquid materials to avoid any humidity entering the battery which drastically decreases the battery performance and causes damage to the battery system and delicate cells. Semi- automatic dispensing tools are used to apply liquid sealant material directly to the target surface, resulting in efficient use of material with minimal waste. Sealing the gap between the shells using liquid sealant prevents the entry of dust and dirt into the battery pack module.

4.1.18 LASER MARKING AND PCB ASSEMBLY STATION :

The damper shells are labeled with encoded machine-readable data matrix codes using an automated laser marker. Battery Protection Circuit Board protects the battery packs from overcharging, discharging, over-current, cell balancing functions, and short circuits during battery charging. When battery packs are fully charged, it can cause a short circuit. In case there is an overcharge or Under voltage, the PCM detects it and ensures a balanced voltage between the battery cells.

4.1.19 BMS ASSEMBLY STATION :

The battery management system monitors the battery in real time and transmits data through designated software. The components of the BMS include a control module, a management system, a wireless communication module, a display module, and a collection module. The collection module funcions as a site for collecting information about the battery.

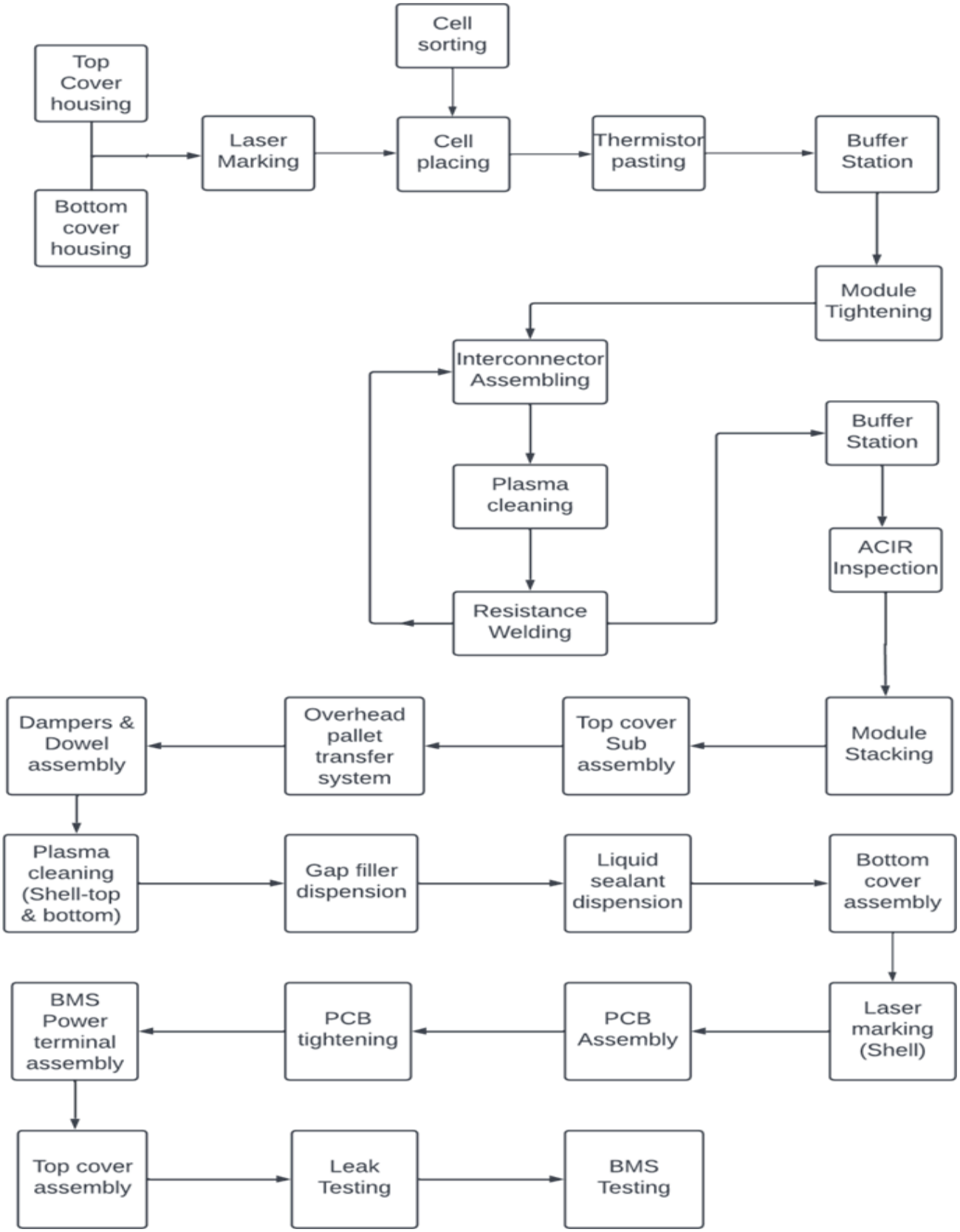
4.1.20 LEAK TESTING STATION :

Leak testing is a fundamental operation in the battery pack assembly process, to check the hermetic seal of the battery pack, to prevent the entry of humidity, dust, or other external contaminants, which could cause a short-circuit on the high-voltage components contained inside.

4.1.21 BMS TESTING STATION :

The BMS test system optimizes the control algorithm and accurately simulates the required sensors as well as measuring, collecting, and processing the digital and analog outputs produced by the BMS system to ensure reliable.

4.2 FLOW CHART OF THE ASSEMBLY LINE



CHAPTER 5

CE DESIGN - SEQUENCE OF OPERATION

5.1 COMPONENTS INVOLVED:

- Battery cell
- Lower Cover
- Camera for placing OK Confirmation
- Laser marking
- SR1000 Scanner

5.1.1 BATTERY CELL:

An electric battery is a source of electric power consisting of one or more electrochemical cells with external connections for powering electrical devices. When a battery is supplying power, its positive terminal is the cathode and its negative terminal is the anode.[2] The terminal marked negative is the source of electrons that will flow through an external electric circuit to the positive terminal. When a battery is connected to an external electric load, a redox reaction converts high-energy reactants to lower-energy products, and the free- energy difference is delivered to the external circuit as electrical energy.

5.1.2 LOWER COVER:

A lower cover for a battery is a protective casing or cover that fits around the battery to protect it from damage, dust, and moisture. Lower covers are typically made of durable materials such as plastic, metal, or rubber. They may be designed to be removable for easy battery access, or they may be a permanent fixture on the device. Lower covers are an important accessory for any electronic device that uses a battery, as they help to ensure that the battery stays safe and functional.

5.1.3 CAMERA FOR ORIGIN:

Cameras play a crucial role in industrial manufacturing, especially in quality control and safety monitoring. They are used to inspect products, track assembly lines, and monitor worker productivity. There are different types of cameras used in industrial settings, including smart cameras, machine vision cameras, and handheld cameras. These cameras are designed to handle the harsh conditions of a manufacturing environment, such as extreme temperatures, humidity, and vibrations.

They also come with special features such as image capture in dark or low-light conditions, optical zoom, and Bluetooth connectivity**.**

5.1.4 LASER MARKING:

Laser marking refers to the process of adding text, graphics, or other designs to a surface using a laser beam. It is a popular and efficient way to customize products, from clothing and jewelry to furniture and industrial equipment. The process works by exposing the surface to a high-intensity laser beam, which melts or etches the material, creating permanent, high-quality marks or designs. Characterized by its precision, speed, and versatility, laser marking is widely used in various fields, including entertainment, marketing, healthcare, and education.

5.1.5 SR1000 SCANNER:

An SR1000 scanner is a type of barcode scanner that is specifically designed to scan barcodes with 1D and 2D symbology. It is a reliable and fast scanner that is often used in industries such as retail, logistics, and warehousing. The SR1000 scanner is equipped with a USB interface and supports various operating systems, including Windows, Mac, and Linux. It also offers features such as batch scanning, data capture, and data processing**.**

CHAPTER 6

SORTING

Cell sorting is the process of arranging data inside cells of a spreadsheet in a specific order based on certain criteria. It can be done manually or automatically in Microsoft Excel, Google Sheets, and other similar programs. There are several ways to sort cells, including in ascending or descending order, by rows, by columns, or by multiple criteria at once. It is a useful function for organizing and analyzing large datasets, and it can save time and improve data accuracy when working with complex information.

Cell sorting can be used to obtain a homogeneous cell population from mixed samples. It can also be used to isolate rare stem cell populations, and for research that requires a very pure stem cell population.

Some techniques used for cell sorting include:

Panning

Fluorescence activated cell sorting (FACS)

Magnetic cell sorting (MACS)

The average sort takes about an hour of instrument setup time, up to 15 minutes for setting sort regions, and about 15 minutes of post-sort analysis.

Cell sorters can cost anywhere from $35,000 for used, outdated machines, to close to $500,000 for new, top-of-the-line devices.

It is also a process that separates a specific cell type from other cells in a sample. It involves identifying and selecting cells, and then separating them based on their properties. These properties can include size,

morphology, viability, and protein expression. The cells are being sorted based on their measurements, weight and magnestic resonance.

6.1 PROCESS INVOLVED IN CELL SORTING:

1. COLLECTING
2. PRE-SORTING
3. MANUAL-SORTING
4. MAGNETIC SORTING
5. MECHANICAL SORTING
6. AUTOMATIC SORTING
7. RECYCLING

6.1.1 COLLECTING:

Small numbers of cells should be collected into small tubes for best recovery. Consider collecting directly into plates or lysis buffer when cell numbers are low. Coat tubes with protein to improve viability. Collecting in cell sorting refers to the process of accumulating data in a cell and then sorting it. This is often used in data analysis and can be done using various software programs, such as Microsoft Excel or Google Sheets. The process involves selecting the data you want to collect, entering it into a cell, and then using the sorting function to arrange the data in a particular order. This can be useful for tasks such as organizing large datasets or comparing specific data points.

6.1.2 PRE - SORTING:

A crane empties the barrels into a large container. From here, a conveyor belt takes them for manual pre-sorting. Along this conveyor belt, staff remove large packs such as batteries from computers, drilling machines, laptops, phones, etc. from the flow of waste. Those packs are sorted into

4 tidy groups based on their composition: rechargeable lithium, alkaline, lead and nickel cadmium. Strange but true: cans, food scraps, paper, and even nappies, light bulbs, sharp objects and injection needles sometimes end up among the batteries. They are all removed and sorted according to the rules of the game. We all have a part to play, please use the barrels only to dispose of used batteries.

6.1.3 MANUAL SORTING:

After the manual pre-sorting, the batteries thunder on down a conveyor belt for manual sorting. A laser counts the number of batteries racing past, so that the conveyor belt can maintain a pace that is comfortable for the employees. Four people take care of the next stage of sorting:

They remove any remaining objects: plastic, ink cartridges, medicines, etc. Here they cut open the well-known Bebat bags and store them separately for the monthly tombola.

They take alkaline, nickel-cadmium (NiCd), nickel metal hydride (NiMH) and rechargeable lithium batteries off the conveyor belt. They pluck out button cell batteries with an aluminum or stainless steel casing.

6.1.4 MAGNETIC SORTING:

Magnetic sorting is a process for sorting cells in various imaging and laboratory techniques based on their magnetic properties. In cell sorting, magnetic particles are attached to certain cells in a suspension, forming clusters of cells with similar properties. These clusters can then be separated and sorted using a magnetic field for further analysis or manipulation. Magnetic sorting is used in several cell biology applications such as gene expression analysis and stem cell research.

Magnetic-activated cell sorting (MACS) is a cell separation technology that uses magnetic beads conjugated to monoclonal antibodies. The beads are incubated with a cell suspension, and then the cells are passed through a column within a magnetic field. MACS, also known as immune magnetic cell separation, involves targeting cells for selection or depletion using antibodies or ligands directed against specific cell surface antigens.

MACS can be used to separate apoptotic sperm with high proportions of fragmented DNA from the rest.

Magnetic cell sorting is a bulk enrichment technique that can be highly specific. It can ensure isolation of the desired cell populations with purity as high as 90%.

However, MACS has poor overall specificity when only one antibody is used. It also has suboptimal separation efficiencies for cell-based therapies.

6.1.5 MECHANICAL SORTING:

Mechanical sorting is a process that separates the parts of a mixture based on properties like color, particle size, and shape. It's often used in material recovery facilities (MRFs) or in mechanical–biological treatment (MBT) facilities to separate waste materials.

Mechanical sorting is a method of sorting elements in a list or data set using mechanical or electromechanical means. It involves the use of machines, such as sorting tables, conveyor belts, and hydraulic or pneumatic systems, to move and position items in a specific order based on certain criteria, such as size, shape, or color. Mechanical sorting is commonly used in a variety of industries, including manufacturing, packaging, and distribution, to automate and improve the efficiency of

sorting processes.

6.1.6 AUTOMATION SORTING:

Automated sorting refers to the use of machines and computer programs to sort items based on specific criteria such as size, color, weight, or numerical values. It is sometimes called automated reordering or automated classification. This process is commonly used in industries such as logistics, warehousing, and retail, where a large volume of items need to be sorted and organized quickly and efficiently. The most common types of automated sorting systems include conveyor sorting, magnetic sorting, and Optical Character Recognition (OCR) sorting. These systems can be integrated with other technologies, such as artificial intelligence and machine learning, to improve their accuracy and functionality.

6.1.7 RECYCLING:

Recycling in cell sorting is the process of reusing existing cells instead of discarding and replacing them with new ones. It can significantly reduce the amount of electronic waste generated and lower the carbon footprint associated with cell manufacturing. Additionally, recycling can help conserve natural resources and reduce the environmental impact of mining operations. Several methods are used for recycling cell phones, including refurbishment, recycling of components, and thermal destruction. Common components that can be recycled include batteries, metals, plastics, and LCD screens. It's worth mentioning that not all cell phones can be recycled, so it's always best to check with the manufacturer or a local recycling center for specific details.

PROCESS INVOLVED:

1. **PROCESS OF 130 CELLS WITH SAME GRADE IN TO MODULE**
2. **LASER MARKING**

PROCESS OF 130 CELLS WITH SAME GRADE IN TO MODULE:

This means that all of these cells have an equal level of proficiency or performance in the specific topic being assessed. In other words, they have reached the same level of understanding or mastery of the material covered in the module. It suggests that these cells have been assessed and have demonstrated similar capabilities. It is possible that these cells have been taught in a similar way or that they have been exposed to similar resources that have helped them achieve the same level of performance**.**

Cell Sorting:

The first step is to sort the 130 cells with the same grade. This involves ensuring that all cells meet the required specifications for the module assembly process**.**

Module Design:

Engineers design the module layout based on the specifications of the battery pack. This includes determining the arrangement and connection of cells within the module**.**

Module Assembly:

The cells are then assembled into modules according to the predetermined design. This can involve various techniques such as welding, gluing, or mechanical fastening to securely hold the cells together.

Electrical Connection:

Once the cells are physically assembled into modules, electrical connections are made between them to ensure proper functioning of the battery pack**.**

Testing:

Quality control procedures are implemented to test the modules for performance, safety, and reliability. This can include electrical testing, thermal testing, and vibration testing, among others.

Packaging:

Finally, the modules are packaged for shipment to customers or for further assembly into larger battery packs, depending on the requirements of the application**.**

CHAPTER 7

SEQUENCE OF OPERATION, CELL LOADING, PNEUMATIC CYLINDERS

7.1 SOP:

7.1.1 SEQUENCE OF OPERATION – RE ORIENTATION

STEPS INVOLVED:

1. Reset process complete
2. Re orientation servo 1 moves pick position
3. 7 cylinder pick the 7 cell with position orientation
4. Re orientation servo 1 moves place position
5. Re orient servo 2 moves pick position
6. 6 Cylinder pick the 6 cell with position orientation
7. Re orient servo 2 moves place position
8. Set process complete

7.1.2 SEQUENCE OF OPERATION – CELL SCANNING START

STEPS INVOLVED:

1. Reset process complete
2. Lifter cycle up
3. Cell rotation motor on and scanner trigger continues
4. All data recieved
5. Cell Rotation motor off and store data to respond position
6. Lifter cycle down
7. Set process complete

7.1.3 SEQUENCE OF OPERATION 2 (INDEXING)

PLC STEPS INVOLVED:

1. Cell sorting Pc & Cell Scanning PC & Re orientation PC
2. Set Indexing Start In Indexing Servo To position
3. IP NC & Servo PC
4. Check Slot Sensor Nc & Start Servo Jog
5. Stop Servo After Slot Sensor Sense
6. Reset All PC (Cell sorting, Cell scanning, RE orientation)
7. Process Indexing Complete

REWORK AND REJECTION SEQUENCE (CELL SCANNING)PLC

The only step involved in this process is if one cell not scanning or grade Issue then all cell need to be reject all inside cell sorting and find the issue.

REWORK AND REJECTION SEQUENCE (CELL PLACING)

To ensure Cell placed correctly the camera will detect after placing & if not placed correctly need to generate Alarm & Instruct operator Need to come manually

MASTER SEQUENCE

STEPS INVOLVED:

1. Pallet Receive from Previous Station
2. Pallet Presence On
3. Part Presence On Move to next Step Or move to Step 34
4. RFID Tag Presence
5. RFID Read On
6. RFID Read complete
7. Lifter Up

8. PP Y & X Moves To camera Origin Position
9. Camera Trigger
10. Check Previous master Stored Program With Current master Pallet
11. If master Coordinated Ok & If Not Move Step 13
12. Master Sequence OK
13. Select HMI buttom To re Teach or Reject with X & Y Changes values
14. Operator Need to Acknowledge If teach
15. PP Y & x to camera Origin Zero Position & Makes Master Position
16. Process Complete

DEVICES:

1. Proximity Sensor
2. Retro reflect sensor
3. RFID

PROXIMITY SENSOR:

A proximity sensor is a device that detects the presence or absence of an object within a certain range without any physical contact. It works by emitting an electromagnetic field or a beam of electromagnetic radiation and then measuring changes in the field or beam caused by the presence of an object.

A proximity sensor often emits an electromagnetic field or a beam of electromagnetic radiation (infrared, for instance), and looks for changes in the field or return signal. The object being sensed is often referred to as the proximity sensor's target. Different proximity sensor targets demand different sensors. For example, a capacitive proximity sensor or photoelectric sensor might be suitable for a plastic target; an inductive

proximity sensor always requires a metal target.

RETRO REFLECT SENSOR:

A retro reflective sensor is an electronic component that measures the amount of light retro reflected from reflective markings on a surface. Retro reflective sensors are commonly used in collision avoidance systems in vehicles, where they detect the presence of yellow or white lane markings in low-light conditions. They work by illuminating the surface in question with a beam of light, and then measuring the amount of light that is reflected back toward the sensor. The resulting data can be used to determine whether a vehicle is on the right course or headed for a collision.

RFID:

Radio-frequency identification (RFID) uses electromagnetic fields to automatically identify and track tags attached to objects. An RFID system consists of a tiny radio transponder, a radio receiver and a transmitter. When triggered by an electromagnetic interrogation pulse from a nearby RFID reader device, the tag transmits digital data, usually an identifying inventory number, back to the reader. This number can be used to track inventory goods.

Passive tags are powered by energy from the RFID reader's interrogating radio waves. Active tags are powered by a battery and thus can be read at a greater range from the RFID reader, up to hundreds of meter

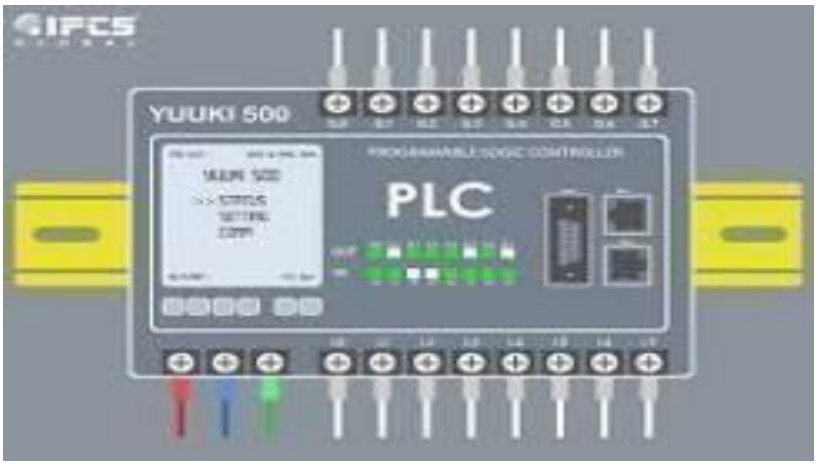
RFID tags are used in many industries. For example, an RFID tag attached to an automobile during production can be used to track its progress through the assembly line,[citation needed] RFID-tagged pharmaceuticals can be tracked through warehouses,[citation needed] and implanting RFID microchips in livestock and pets enables identification of animals.

PLC (PROGRAMMABLE LOGIC CONTROLLER)

PLC:

PLC stands for programmable logic controller. It is a small, modular computer that is used to manage electromechanical processes in industrial settings. PLCs are used to automate common industrial operations, such as assembly lines, machines, robotic devices, and other activities that require high reliability.

PLCs are programmed to activate an electrical circuit, relay, or other input/output device at a predetermined time set by the operator. They can be programmed with customized instructions for performing a particular task. PLCs have largely replaced mechanical relays, drum sequencers, and cam timers Ladder logic is a programming language used with PLCs. It is primarily used to develop software for PLCs used in industrial control applications.



STEP INVOLVED:

1. Pallet Receive From Previous Station
2. Pallet Presence On
3. Part Presence On then Move to next Step Or Move to Step 13
4. RFID tag Presence
5. RFID Read On
6. RFID Read complete
7. Lifter Up
8. Laser Marking Trigger station
9. Laser Marking Done Feedback
10. Lift Cyl Down
11. RFID Tag Presence
12. RFID Write On
13. RFID write Complete
14. Wait For Next Station Pallet Face
15. Stopper Down
16. Pallet Moves TO Next Station

7.2 CELL LOADING

At present, most battery pack assembly lines adopt semi-automatic and

fully automated production lines. Considering the cost and construction site, the SHINHOP assembly line is designed and manufactured based on the principle of practicality, simplicity, and efficiency. The production line process requirements are as follows:

1- The cell loading adopts robot automatic loading or manual loading. Incoming materials can be manually delivered to the designated location, and this station is used as a reserved station.

2- The accuracy of battery cell scanning and identification must reach 100%.

3- Regarding the size (height, length, width, and height of the cell pole) and weight of the incoming battery cells, the battery cell thickness measurement tool must be equipped with a pressure sensor, the pressure is ≦4000N, and the thickness needs to be clearly displayed on the equipment. The thickness interval parameters are adjustable.

4- The voltage and internal resistance are tested and selected according to specified standards. The battery cell voltage detection accuracy requires 0.1mV, and the resistance detection accuracy requires 0.xn--001m-jpd. When the battery cell OCV is detected, the battery cell code is automatically paired with the battery cell voltage and internal resistance. The voltage and internal resistance interval parameters are adjustable, and there is a corresponding operation interface on the touch screen. (The expected voltage range is 3-5V, the accuracy requirement is 0.001V, the internal resistance is expected to be in the range 0.1-0.xn--5m-fcc, and the accuracy requirement is 0.001 mΩ). The equipment is automatically classified and removed the unqualified product to the NG area and retrieved manually.

5- The battery cells in the module are connected in series, and the module code is laser printed on the end plate. The module code is printed on the end plate. The coding range of the coding machine is ≥ 300mm*300mm. The coding accuracy rate must reach 100%, and the coding position deviation should be controlled within ±1mm.

6- The module consists of end plates on both sides, battery cells and two steel strips.

7- The maximum stacking number of modules is 16 cells. After stacking, the height difference of the poles is less than 0.05mm. The accuracy requirements of the robot are: movement accuracy ±1mm and static accuracy 0.5mm.

8- When the steel strip is placed on the module, the pressure on both sides is ≦8000N. The pressure on each cell is between 300-500N. The overall length of the module is ≦1200mm. The module size equipment can be accurately controlled, and the overall length error of the module is ±0.5mm.

9- After the module is formed, conduct insulation testing on the individual cells. Testing equipment for insulation testing needs to be purchased from high-quality well-known brands. The testing tooling must be well-insulated and well-designed to be compatible with multiple products.

10- The qualified module battery poles terminal are laser cleaned, and after completion, the module flows into the bus bar welding station. The gap between the bus bar and the poles is less than 0.2mm.

11- Bus bar welding requirements: the pulling force is greater than 1400N, and the welding station needs to realize automatic laser welding and automatic dust collection.

12- After the bus welding is completed, the module flows into the post-welding inspection station.

13- Insulation withstand voltage test on the module. The insulation test requires (conductive part to insulating layer) 500VDC level, insulation value ≧1GΩ, the withstand voltage test requirement (conductive part to insulating layer) 4400VDC level, withstand voltage value ≦100μA.

14- Conduct bus bar welding inspection on the module, use DCIR current detection, fast charge and discharge of the module, and voltage internal resistance test. It is necessary to add safety protection and equipment emergency safety accident handling plans (equipment self-protection).

15- The PACK line is basically a manual work station, including: cabinet on-line, cabinet pre-processing; module loading into the cabinet; module fixing; BMS installation; wire harness installation, module connection; top cover; chassis Insulation withstand voltage testing, PACK offline testing; chassis offline.

16- The module fixing station is a manual station. The module fixing screws are manually tightened with a tightening gun, and the torque is uploaded to the MES system.

17- EOL testing, RGV is used as the transport carrier to complete the transport of PACK boxes, and isolation design is required in this area.

STEPS INVOLVED:

1. Pallet Receive From Previous Station
2. Pallet Presence On
3. Part Presence On Move to next Step Or Move To Step 34
4. RFID tag Presence
5. RFID Read On

6. RFID Read Complete
7. Lifter Up
8. Scanner Trigger To Scan the Laser Marked Data
9. PP Y&X Moves TO Camera Origin Position
10. Camera Trigger & Origin Correction Factor Finds
11. Origin Correction Moves to PPY & PPX
12. Counter makes 0
13. Check Ready feedback from orientation Sequence
14. PPY & X Moves to the 1st Pick position & Camera Check Placing Pos Empty
15. PPZ Moves Down To Pick position
16. Vaccum On
17. Vaccum Feedback Checking
18. Magnetic Cylinders Move Home
19. PPZ, PPY, PPX Moves to 2nd Pick position
20. Vacuum On
21. Vacuum feedback checking
22. Magnetic Cylinders move home
23. PPZ moves Home
24. PPY and X moves to the place position
25. PPZ moves down to place position
26. Vacuum off and counter increase
27. PPZ moves home
28. Check count >= 5 move to next step otherwise move Step 13
29. Lifter cyl down
30. RFID Tag presence
31. RFID write on
32. RFID write complete
33. Wait for next station pallet free
34. Stopper down

35. Pallet moves to next Station

DEVICES USED:

- SERVO
- VACCUM GENERATOR
- REED SWITCH

7.2.1 SERVO:

Servomechanism, or servo, is a device used to provide control of a desired operation through the use of feedback AI servo, an autofocus mode

Electrohydraulic servo valve, an electrically operated valve that controls how hydraulic fluid is ported to an actuator

Servo drive, a special electronic amplifier used to power electric servomechanisms Servomotor, a rotary actuator that allows for precise control of angular position

Servo (radio control), is a small, cheap, mass-produced actuator used for radio control and small robotics Servo bandwidth, the maximum

trackable sinusoidal frequency of an amplitude Servo control, the use of pulse width modulation to remotely control servos

Servo tab, is a small hinged device installed on an aircraft control surface to assist the movement of the control surface.

7.2.2 VACUUM GENERATOR:

A vacuum generator, also known as a suction pump or ejector, is a device that creates a partial vacuum by removing gas and air molecules from a sealed volume. They can also move fluids from one area to another.

Vacuum generators use compressed air to create a low-pressure

zone, which allows them to create a vacuum for various applications such as suction or filtration. They can be created using either electrical or pneumatic means.

Vacuum generators are compact and relatively simple machines that generate a vacuum very quickly. They are typically used together with vacuum suction cups, which are connected to the vacuum generator's outlet and attached to the object being handled.

7.3 PNEUMATIC CYLINDERS

A pneumatic cylinder, also known as an air cylinder, is a mechanical device that uses the power of compressed gas to produce a force in a reciprocating linear motion.

Like in a hydraulic cylinder, something forces a piston to move in the desired direction. The piston is a disc or cylinder, and the piston rod transfers the force it develops to the object to be moved.[1] :85 Engineers sometimes prefer to use pneumatics because they are quieter, cleaner, and do not require large amounts of space for fluid storage. Because the operating fluid is a gas, leakage from a pneumatic cylinder will not drip out and contaminate the surroundings, making pneumatics more desirable where cleanliness is a requirement. For example, in the mechanical puppets of the Disney Tiki Room, pneumatics are used to prevent fluid from dripping onto people below the puppets.

General

Once actuated, compressed air enters into the tube at one end of the piston and imparts force on the piston. Consequently, the piston becomes displaced.

Compressibility of gases

One major issue engineers come across working with pneumatic cylinders has to do with the compressibility of a gas. Many studies have been completed on how the precision of a pneumatic cylinder can be affected as the load acting on the cylinder tries to further compress the gas used. Under a vertical load, a case where the cylinder takes on the full load, the precision of the cylinder is affected the most. A study at the National Cheng Kung University in Taiwan, concluded that the accuracy is about ± 30 nm, which is still within a satisfactory range but shows that the compressibility of air has an effect on the system.

Fail-safe mechanisms

Pneumatic systems are often found in settings where even rare and brief system failure is unacceptable. In such situations, locks can sometimes serve as a safety mechanism in case of loss of air supply (or its pressure falling) and, thus remedy or abate any damage arising in such a situation. Leakage of air from the input or output reduces the output pressure.

7.3.1 TYPES OF PNEUMATIC CYLINDERS:

Although pneumatic cylinders will vary in appearance, size and function, they generally fall into one of the specific categories shown below. However, there are also numerous other types of pneumatic cylinder available, many of which are designed to fulfill specific and specialized functions.

Single-acting cylinders

A single-acting cylinder (SAC) has one port, which allows compressed air to enter and for the rod to move in one direction only. The high pressure of the compressed air causes the rod to extend as the cylinder chamber continues to fill. When the compressed air leaves the cylinder through the same port the rod is returned to its original position.

Double-acting cylinders

Double-acting cylinders (DAC) use the force of air to move in both extend and retract strokes. They have two ports to allow air in, one for outstroke and one for instroke. Stroke length for this design is not limited, however, the piston rod is more vulnerable to buckling and bending. Additional calculations should be performed as well.

Multi-stage, telescoping cylinder

Pneumatic telescoping cylinder, 8-stages, single-acting, retracted and extended

Telescoping cylinders, also known as telescopic cylinders can be either single or double-acting. The telescoping cylinder incorporates a piston rod nested within a series of hollow stages of increasing diameter. Upon actuation, the piston rod and each succeeding stage "telescopes" out as a segmented piston. The main benefit of this design is the allowance for a notably longer stroke than would be achieved with a single-stage cylinder of the same collapsed (retracted) length. One cited drawback to telescoping cylinders is the increased potential for piston flexion due to the segmented piston design. Consequently, telescoping cylinders are primarily utilized in applications where the piston bears minimal side loading.

Although SACs and DACs are the most common types of pneumatic cylinder, the following types are not particularly rare

Through rod air cylinders: piston rod extends through both sides ofthe cylinder, allowing for equal forces and speeds on either side.

Cushion end air cylinders: cylinders with regulated air exhaust to avoid impacts between the piston rod and the cylinder end cover**.**

Rotary air cylinders: actuators that use air to impart a rotary motion.

Rodless air cylinders: These have no piston rod. They are actuators that use a mechanical or magnetic coupling to impart force, typically to a table or other body that moves along the length of the cylinder body, but does not extend beyond it.

Tandem air cylinder: two cylinders assembled in series

Impact air cylinder: high velocity cylinders with specially designed end covers that withstand the impact of extending or retracting piston rods.

Rodless cylinders

Rodless cylinders have no rod, only a relatively long piston. Cable cylinders retain openings at one or both ends, but pass a flexible cable rather than a rod. This cable has a smooth plastic jacket for sealing purposes. Of course, a single cable has to be kept in tension.[4] Other rodless cylinders close off both ends, coupling the piston either magnetically or mechanically to an actuator that runs along the outside of the cylinder. In the magnetic type, the cylinder is thin-walled and of a non-magnetic material, the cylinder is a powerful magnet, and pulls along a magnetic traveller on the outside.

In the mechanical type, part of the cylinder extends to the outside through a slot cut down the length of the cylinder. The slot is then sealed by flexible metal sealing bands on the inside (to prevent gas escape) and outside (to prevent contamination). The piston itself has two end seals, and between them, camming surfaces to "peel off" the seals ahead of the projecting linkage and to replace them behind. The interior of the piston, then, is at atmospheric pressure.

One well-known application of the mechanical type (albeit steam-powered) are the catapults used on many modern aircraft carriers.

7.3.2 Design and Construction

Depending on the job specification, there are multiple forms of body construction available

Tie rod cylinders: The most common cylinder constructions that can be used in many types of loads. Has been proven to be the safest form.

Flanged-type cylinders: Fixed flanges are added to the ends of cylinder, however, this form of construction is more common in hydraulic cylinder construction.

One-piece welded cylinders: Ends are welded or crimped to the tube, this form is inexpensive but makes the cylinder non-serviceable**.**

Threaded end cylinders: Ends are screwed onto the tube body. The reduction of material can weaken the tube and may introduce thread concentricity problems to the system.

Material

Upon job specification, the material may be chosen. Material range from nickel-plated brass to aluminum, and even steel and stainless steel. Depending on the level of loads, humidity, temperature, and stroke lengths specified, the appropriate material may be selected.

Mounts

Depending on the location of the application and machinability, there exist different kinds of mounts for attaching pneumatic cylinders.

CHAPTER 8

INDUSTRIAL AUTOMATION

Industrial automation uses control systems, usually computers or robots, to handle manufacturing processes and machines to replace human beings. These systems can operate industrial equipment automatically and typically include feedback loops and sensory programs that can adjust operating conditions automatically to meet the desired values based on real-time data.

8.1 TYPES OF INDUSTRIAL AUTOMATION:

8.1.1 Fixed automation:

Fixed automation, or hard automation, is an automation type in which the configuration of the manufacturing process stays fixed. This type of automation is therefore best suited for completing a single set of tasks repeatedly. For instance, if the automation procedure repeats the same tasks with identical units, it is fixed automation. In effect, fixed automation machines are controlled by programmed commands and computers that direct them on what to do, give notifications, and measure production metrics. Fixed automation is generally suitable for large- volume products. The operation in fixed automation's sequence isn't complex and involves fundamental functionalities like rotational or plain linear motion or both.

8.1.2 Programmable automation systems:

Programmable automation systems involve automated or robotic equipment controlled through programming for batch production. The automation is controlled through a program, which is coded in ways that allow it to change its sequence anytime there's a need. This industrial

automation type allows easy product or process changes by modifying the control program. This also allows the implementation of new processes. Programmable automation is most used in systems that produce similar items using the same automated steps and tools. It's ideal for medium-to-high

production volumes and suitable for batch production processes such as factories making food variants. If the product/production needs changing, the machine is reprogrammed. In programmable automation, products are made in batch quantities at a time ranging from a few several dozen to several thousand units. And for each new product batch, the production equipment must be reprogrammed or changed over to accommodate the new or required product style.

8.1.3 Flexible automation:

Flexible automation, also known as soft automation, is an extension of programmable automation with next-to-zero downtime and minimum manual changeover procedure. This means greater flexibility and results in a greater production rate. Essentially, flexible automation allows the production of different product types without the need for complex reprogramming. This allows production to switch between tasks minimizing downtime. Building upon programmable automation, flexible automation systems often involve precise electromechanical controls. Examples are industrial robots and multipurpose CNC machines.

8.1.4 Process automation:

Process automation means using technology to automate manual processes through data and systems integration. It combines all other industrial automation types into one, connecting flexible and integrated automation systems. Process automation is used more in businesses where software programs/apps execute a set of tasks within the modern, digital enterprise.

It manages business processes for transparency and uniformity to increase a company's workflow. Using process automation can help increase productivity and efficiency in businesses. It can also provide new insights into business challenges and suggest solutions**.**

8.2 HYDRAULICS AND PNEUMATICS

Within the field of automation, both pneumatics and hydraulics play crucial

roles, serving as essential foundations. These two systems possess unique advantages that are specifically designed to cater to particular applications. Pneumatics, which involves the utilization of compressed air, demonstrates exceptional performance in situations that necessitate swift and accurate motions. The ideal suitability of this technology for tasks such as robotics and assembly lines stem from its simplicity, rapid response times, and cleanliness. In contrast, the field of hydraulics, which capitalizes on the property of fluids being incompressible, is highly effective in fulfilling the requirements of applications that necessitate substantial force and torque. Hydraulic systems are frequently utilized in the context of heavy-duty assembly lines where the emphasis is placed on the utilization of significant power. The selection between pneumatics and hydraulics is contingent upon various factors, including but not limited to speed, force prerequisites, and the overall characteristics of the automation undertaking. Collectively, these fluid power systems assume a crucial function in enhancing efficiency, accuracy, and dependability in automated lines.

8.3 COMPONENTS OF A HYDRAULIC AND PNEUMATIC SYSTEM:

Both hydraulic and pneumatic systems consist of several key components thatwork together to generate, control, and transmit power. While the basic principles are similar, the choice of components can differ due to the distinctproperties of fluids (liquid in hydraulics, gas in pneumatics). Here are thefundamental components of hydraulic and pneumatic systems:

8.4 HYDRAULIC SYSTEM COMPONENTS:

Hydraulic Pump: Converts mechanical power into hydraulic energy by pressurizing the hydraulic fluid.

Reservoir: Stores hydraulic fluid and helps dissipate heat.

Hydraulic Fluid: Typically, oil-based, it transmits power and lubricates components.

Hydraulic Motor or Hydraulic Cylinder: Converts hydraulic energy back into mechanical energy. A motor generates rotary motion, while a cylinder produces linear motion.

Valves: Control the flow of hydraulic fluid. Common types include directional control valves, pressure control valves, and flow control valves.

Actuators: Hydraulic cylinders and hydraulic motors are actuators that performthe mechanical work in response to the pressurized hydraulic fluid.

Filters: Remove contaminants from the hydraulic fluid to maintain system cleanliness.

Accumulator: Stores hydraulic energy to provide additional power during peakdemands.

Pressure Relief Valve: Prevents system overpressure by releasing excess fluid.

8.5 PNEUMATIC SYSTEM COMPONENTS:

Compressor: Converts mechanical energy into compressed air by pressurizingthe air.

Air Reservoir: Stores compressed air to provide a constant and reliable supply. **Pneumatic Actuators:** Convert compressed air energy into mechanical motion. Pneumatic cylinders are common actuators in pneumatic systems.

Valves: Control the flow of compressed air. Similar to hydraulic systems, there are directional control valves, pressure control valves, and flow control valves.

Filters: Remove moisture and contaminants from the compressed air to maintain system cleanliness.

Regulator: Adjusts and maintains the pressure of the compressed air within the desired range.

Air Receiver: Provides a buffer for fluctuations in air demand, ensuring a steady supply.

Pressure Switch: Monitors the pressure in the system and can activate or deactivate components based on preset values.

Fittings and Tubing: Connect various components in the system, allowing the flow of compressed air.

CHAPTER 9

QUALITY INSPECTION

Due to the growth of precision capabilities in measurement techniques and manufacturing processes, new products have been developed, along with quality improvement routines for old products. As a result, it has become necessary to thoroughly inspect any materials purchased either at the supplier's warehouse (or go down) or at the time goods are received by the receiving department. The main aim of the inspection is to prevent damage. As such, an inspection of materials is of the utmost importance; both quality and quantity must be checked and inspected systematically.

Objectives of Inspection:

- To maintain product quality
- To receive only the correct quantity of materials
- To ensure that suppliers are careful and efficient
- To utilize the money invested optimally

9.1 COORDINATE MEASURING MACHINE:

A coordinate measuring machine, also known as a CMM, is a piece of equipment that measures the geometries of physical objects. CMMs using a probing system to detect discreet points on the surfaces of objects.

9.1.1 Bridge CMM:

Bridge CMMs feature a probing system that moves along three axes: X, Y and Z; these axes are orthogonal to each other in a Cartesian coordinate system. Each axis has a sensor that monitors the probe’s position (in mm) as it moves along an object and detects points on the object’s surface. These points form what is called a point cloud, which “illustrates” the surface area users are interested in inspecting.

9.1.2 Portable measuring arm CMM :

Portable measuring arm CMMs are coordinate measuring machines that can take measurements of parts right on shop floors, allowing for quick results and real-time analysis. As opposed to inspectors bringing components to a lab to be measured, technicians use an articulated arm, with either a six- or seven-axis system, to measure components wherever required; this is particularly useful to analyze parts while still integrated into their fixtures or assemblies.

CHAPTER 10

MATERIAL STORAGE

Materials are received in an organization's storage department where they are stored until issued to the using department. Materials are preserved to protect them from different types of damages, which maintains their original value and quality. Maintaining the original value and quality of materials can improve production quality while reducing storage and production costs. Storage of materials, therefore, is a critical function.

Receiving is important, but storage is still more important because it aims at:

- Keeping materials safe.
- Protecting materials from damage.
- Protecting materials from loss of value or quality.
- Ensuring the availability of materials in a perfect and serviceable condition.
- Ensuring the smooth and efficient functioning of the production department.

10.1 VERTICAL CAROUSEL MODULES:

Vertical Carousel Modules are built with a series of carriers attached in fixed locations to a chain drive. Movement is powered by a motor, which sends the carriers in a vertical loop around a track in both forward and reverse directions. One of the unique and compelling features of a Vertical Carousel is that it utilizes unused overhead space and stores items by stacking them vertically (up to 30 feet). Standard shelving stacks items vertically to just within arms' reach, then they are multiplied laterally taking up a lot of floor space. Storing vertically not only saves a lot of space, but also saves employee time and energy in locating items as they are delivered directly to the operator. With the vertical carousel, items stored high are automatically brought to the operator at an ergonomic height.

ADVANTAGES:

• Increased speed and accuracy of picking operations as items are automatically retrieved and brought to the operator at the touch of a button.

• Eliminate safety issues with forklifts and ladders.

• With the inherent ergonomic design, reduce employee injury from reaching, bending and twisting while retrieving or carrying loads.

• All inventory is centrally located and optional integrated software allows for inventory management processes to improve dramatically.

10.2 VERTICAL LIFT MODULE (VLM):

A vertical lift module (VLM) is an enclosed system that consists of two columns of trays with an inserter/extractor in the center. The VLM inserter/extractor automatically locates stored trays and retrieves trays from boththe front and back of the unit with a push of a button and delivers them to the operator at an ergonomically positioned pick window. Designed to deliver stored items to the operator and eliminate walk and search time, the VLM can increase productivity up to 2/3. Vertical Lift Modules are available in various heights and widths to meet every application. Utilizing the floor to ceiling height and storing trays in height optimized positions allows the VLM to save up to 85% floor space when compared to standard shelving**.**

ADVANTAGES:

• Minimal footprint, saving valuable square footage while maximizing product density.

• High throughout rates from a picking perspective compared to conventional picking.

• Ability to train workers and achieve maximum throughput in a significantly brief period.

CHAPTER 11

KANBAN CARDS AND 5S

A Kanban card is a visual representation of a work item. Translated from Japanese, it literally means a visual (kan) card (ban). It is a core element of the Kanban system as it represents work that has been requested or is already in progress. A Kanban card contains valuable information about the task and its status, such as a summary of the assignment, responsible person, deadline, etc. Indeed, Kanban cards are mainly used for visualizing your assignments' progress from the moment they're requested to the moment they're considered done. They aim to "radiate" information for a single work item so teams can stay on the same page and quickly spot work issues. With the help of Kanban cards, you can:

- Build an information hub for work assignments
- Reduce the need for status-update meetings
- Improve the overall transparency of the work process.

In English, these 5S words have come to be known as:

- Sort: Eliminate that which is not needed.
- Straighten: Organize what remains after sorting.
- Shine: Clean and inspect the work area.
- Standardize: Write standards for 5S.
- Sustain: Consistently apply the 5S standards.

These Quality improvement techniques have been implemented in TEAL to ensure satisfactory services to its customers.

CONCLUSION

In conclusion, our one-month project training experience at TITAN ENGINEERING AND AUTOMATION LIMITED (TEAL) was an

En-lightening and invaluable opportunity. Throughout this short but intensive period, we were exposed to the intricacies of the B2B business world that TEAL operates within. Beyond theoretical knowledge, we were immersed in practical lessons that underscored the paramount importance of safety in the workplace.

The heart of our project training experience lay in the realm of assembly engineering. We delved into the multifaceted world of assembly lines, gaining insights into the diverse equipment used for various assembly processes. One of the most captivating aspects was witnessing the seamless integration of automation technology into assembly lines, resulting in a remarkable reduction in cycle times. This exposed us to the cutting-edge technologies that are shapingthe future of manufacturing.

One of the standout features of our time at TEAL was witnessing how the company leveraged SAP to facilitate seamless information flow and data processing across all its facets. This underscored the significance of technology in modern business operations. In retrospect, our project training at TEAL was a remarkable learning journey. It provided us with invaluable insights, practical skills, and a deeper appreciation for the intricacies of the engineering and automation industry. The experience not only broadened our horizons but also reaffirmed our commitment to pursuing a career in this dynamic and ever- evolving field. We are immensely grateful for the opportunity and look forward to applying the knowledge and skills gained during this internship to future endeavors in the world of engineering and automation.

REFERENCE

[1] In 2013, R.G. Gommes and M.R. de Sousa published "Unmanned Aerial Vehicles for Border Surveillance" in the Journal of Intelligent and Robotic Systems.

[2] In 2021, M. Al-Sulaiman, S. Saeed, and M. Al-Rakhami published "A Review of Battery pack assembly line : Applications, Challenges, and Future Directions" in the Journal of Sensors.

[3] In 2019, H. Al-Ali, M. Al-Sulaiman, and M. Al-Rakhami published "battery pack assembly line " in the Journal of Sensors.

[4] In 2020, J. Rosell-Polo, M. Franch, and J. Llorca will publish "Feasibility Study of a battery pack assembly line" in the Journal of Unmanned Vehicle Systems.

[5] In 2016, A. Patel and H. Patel's article "battery pack : Privacy and Legal Issues" appeared in the International Journal of Scientific & Engineering Research.