Industry Interaction Session 2021

Applicable Automation & I4.0 Technologies
(for the Malaysian Rubber Industry)

by the Automation Expert Panel:

- EP Chairman: Mr. Lee Boon Teck
- EP Member : Mr. Tiong Khe Hock
- EP Member : Assoc Prof Ir Dr Chang Yoong Choon

Outline

A. Basic Automation technologies

B. Basic I4.0 technologies

C. Summary of Applicable Technologies

D. Case studies

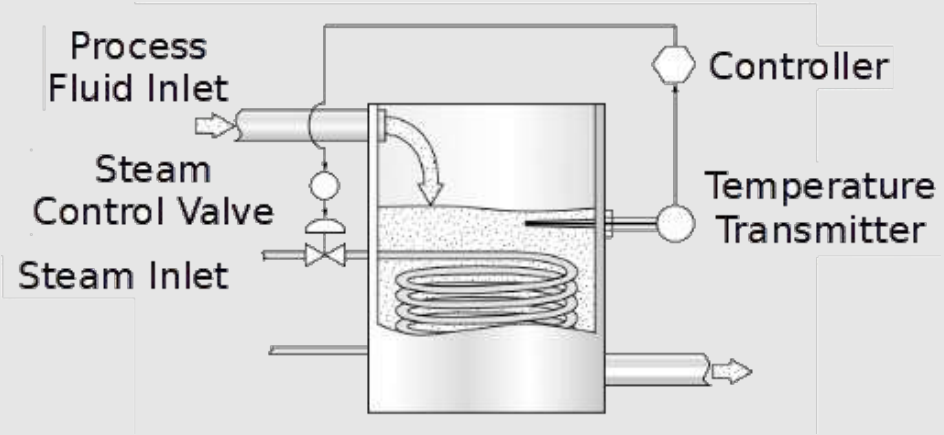
FA – Pick-and-Place by robotic arm

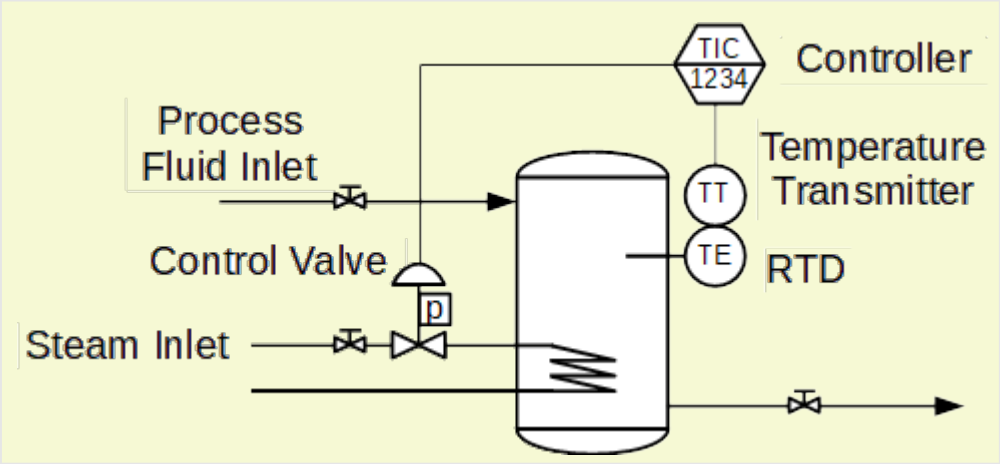
FA - Sequence control of conveying belt system.

A. Basic Automation & Applicable technologies

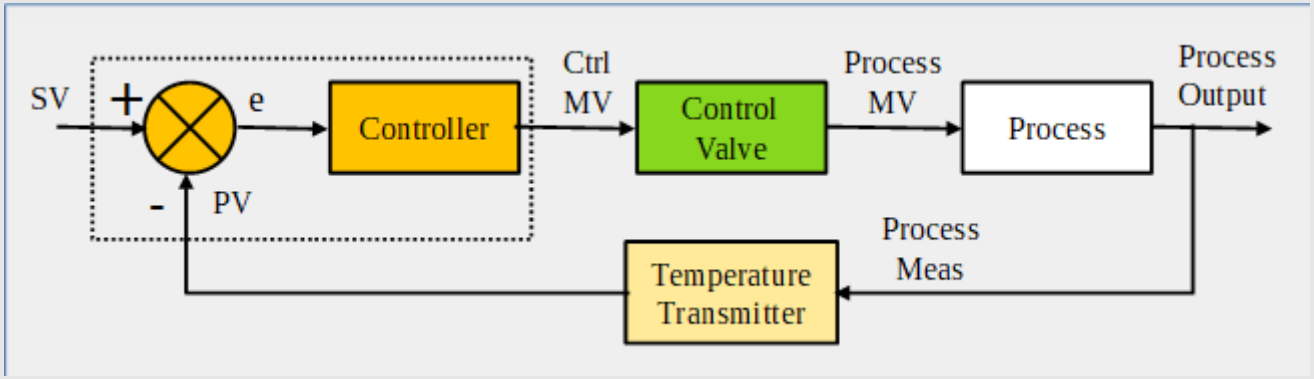
Documentation: Process, P&ID, Loop diagram

- **Process: vs Process & Instrument Drawing (P&ID):**



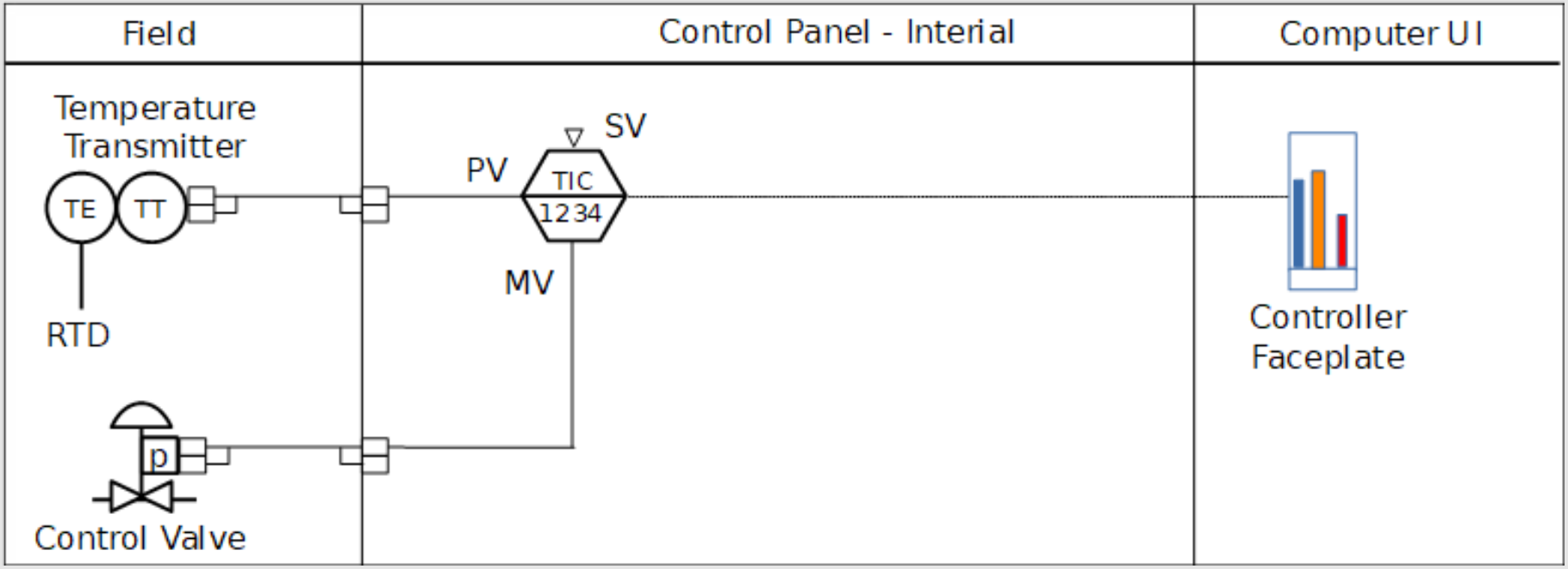


- **Control Loop Block Diagram:**



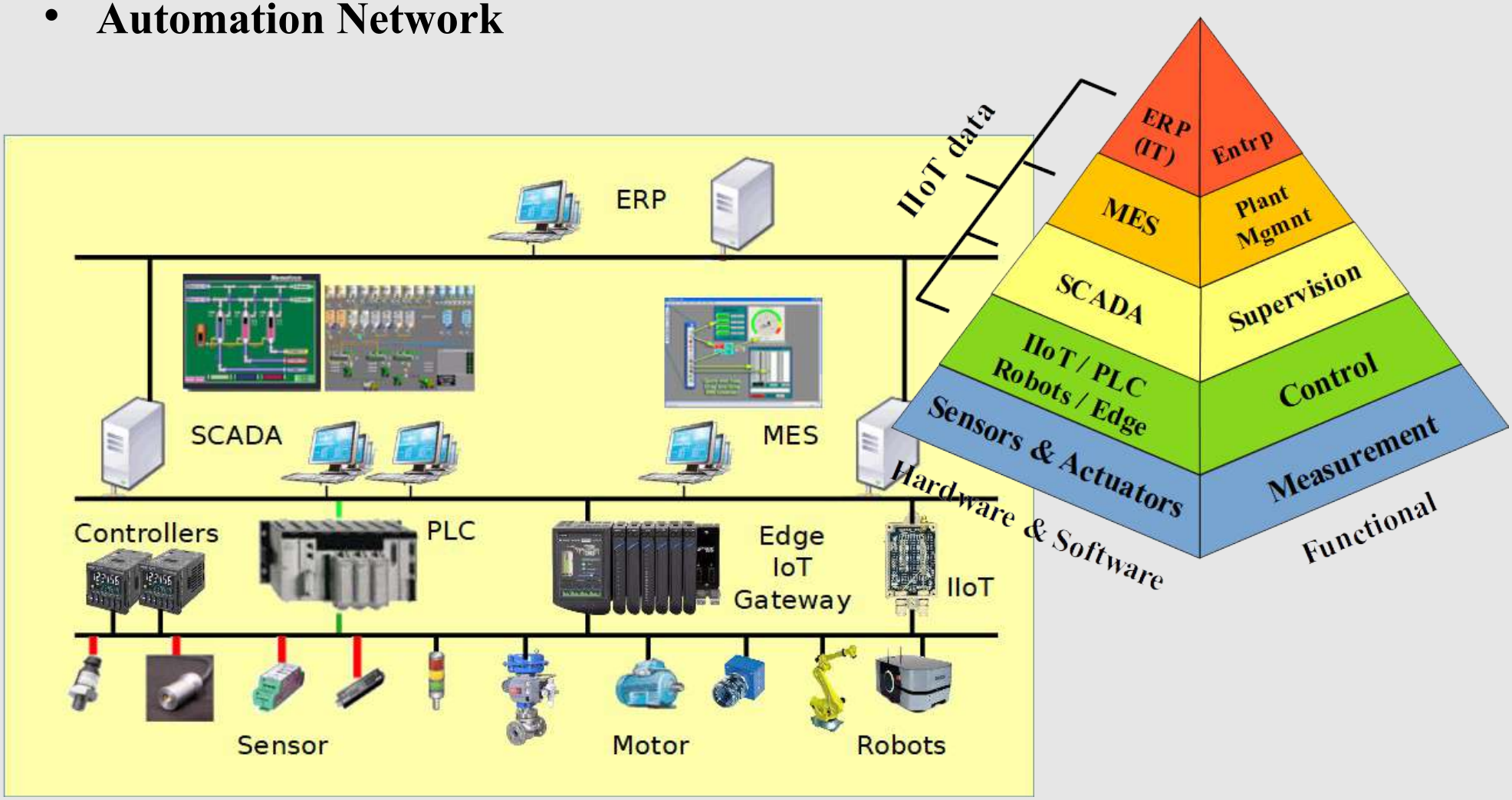
A. Basic Automation & Applicable technologies

- **Documentation: Process, P&ID, Loop diagram**
  - **Loop Drawing (Wiring diagram)**



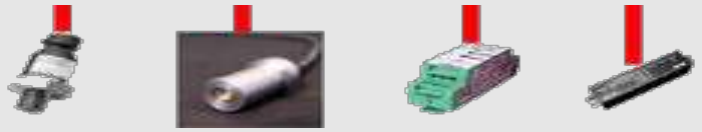
A. Basic Automation & Applicable technologies

- **Automation Network**



1. Applicable Measurement & Actuators

Types of Sensors



- **Proximity Sensors (On-Off)**
  - Opto, Inductive, Capacitive
  - Through-beam, Retro-reflective, Difuse-reflective

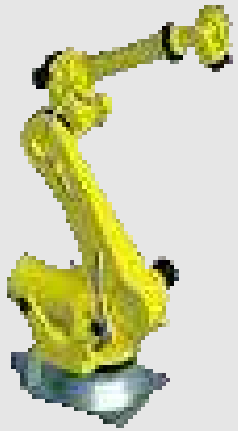
- **Displacement/Distance/Position/Thickness Sensor**
  - Laser, Ultrasonic, Rotary/Linear encoder

- **Level/Pressure/Temperature/Flow transmitters**
- **Force/Loadcell/Weighing indicator**
- **Vision/RFID/Bar-code**

2. Applicable Measurement & Actuators

Types of Actuators & Drives

- Linear On-off Cylinder Actuator
- Linear Positioning Cylinder Actuator
- Damper Actuator
- On-Off motorized Valves (Ball-valve, Diaphragm valve)
- Modulating Control Valves (globe, Ball-valve, needle valve, Butterfly valve)
- Fan (motors)
- Stepper motors
- Servo-drives
- Robots/Co-bots/AMR



2. Applicable Automatic Control

Types of Control Devices

- Dedicated On-Off Controller
- Dedicated PID Controller
- DCS (Distributed Control System)
- PLC (On-Off, Interlock logic, Sequence, PID, Recipe Batch)
- IIoT (On-Off, Interlock logic, Sequence, PID, Recipe Batch)
- Edge Controller/Gateway
- Edge Computers

2. Applicable Automatic Control

Types of Control Functions

- **On-off Control/Gap Control**/Interlock Logic Control
- **Proportional Control**
  - PID Control (feedback control) / Self-tuning control
  - Time-Proportional control/Fuzzy logic
- **Recipe Batch Sequence Control**

Watch out for oscillation response (with increasing amplitude)

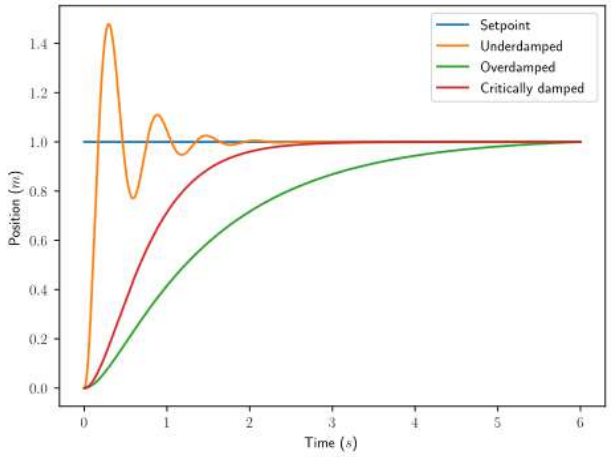
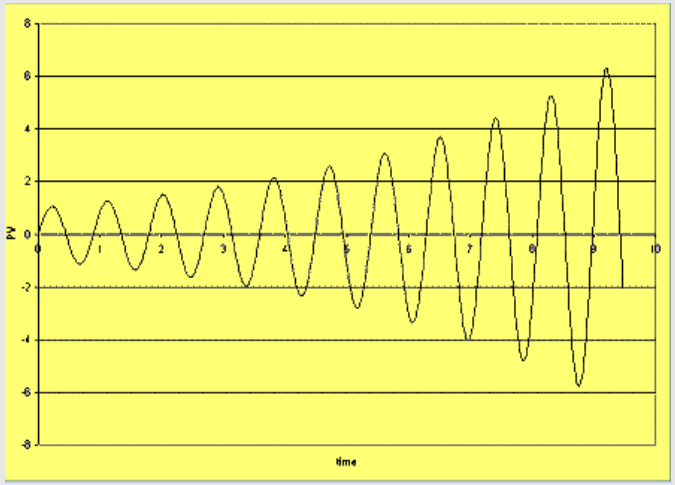


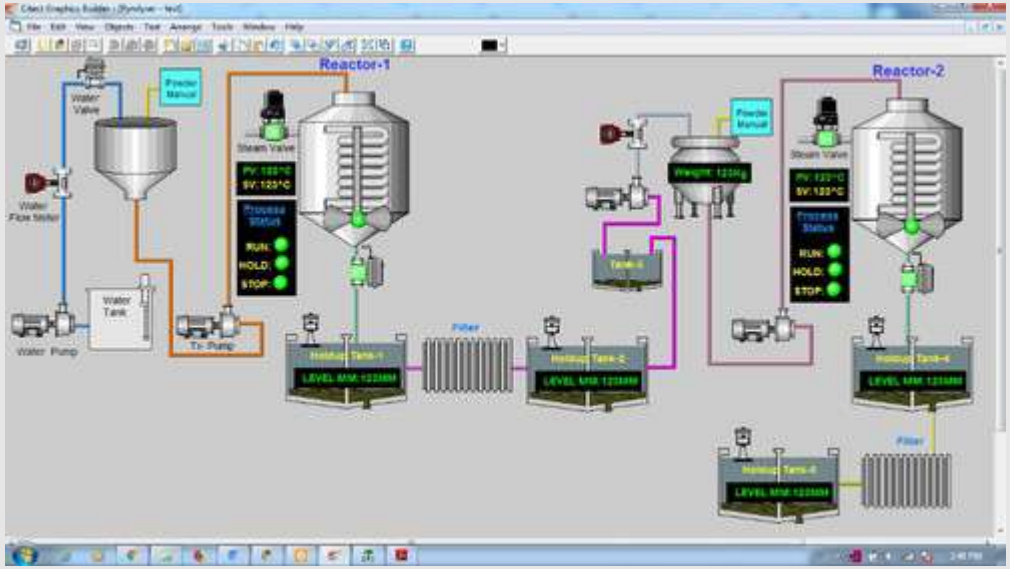
Figure 2.8: PID controller response types



A. Basic Automation & Applicable technologies

3. SCADA (Supervisory Control And Data Acquisition)

Analytics, Visualization, AI & I4.0



4. MES (Manufacturing Execution System)

Production Planning, Analytics, Visualization, AI & I4.0

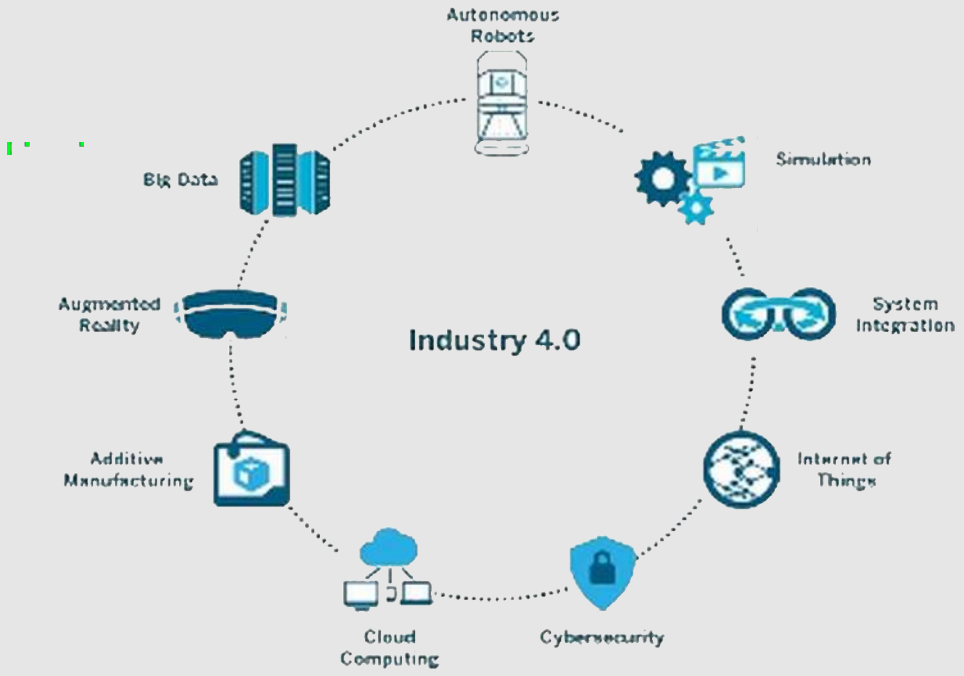
(SCADA & MES offerings are merging)

B. Basic I4.0 & Applicable technologies

What is Industry 4.0

- **German initiative in 2011 (10 years has passed by)**
  - Seamlessly combine Hardware, Software & Cyber Space (Internet) as a whole
- **Digitalization / Digital Transformation of manufacturing/production**

The 9 Pillars of I4.0	
1.	IoT
2.	Cloud/Edge Computing
3.	Universal System Integration
4.	Autonomous Systems
5.	Big Data
6.	Cyber Security
7.	Additive Manufacturing
8.	Augmented Reality
9.	Digital Twin/Advanced Simulation



I4.0: Industrial Internet of Things (IIoT)

- Industrial IoT is an essential part of an I4.0 implementation

What is an IoT / IIoT

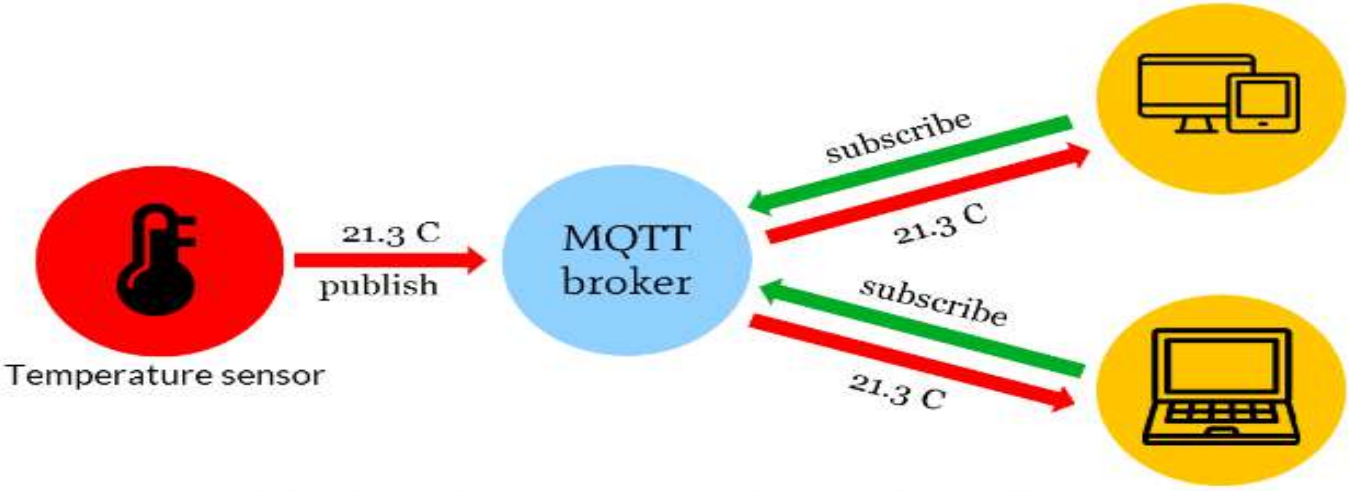
- A device that contains **embedded controllers**

  Includes:
  - I/O connection to Sensors & Actuators
  - Local Data Collection & Data Analysis
  - (may include Sensors, Local Control and/or AI
- **Standard and Open communication protocol (eg. MQTT)**
  - data exchange with other devices/systems over the Internet
- **Usually supports wireless communication**

I4.0: Industrial Internet of Things (IIoT)

The MQTT communication protocol

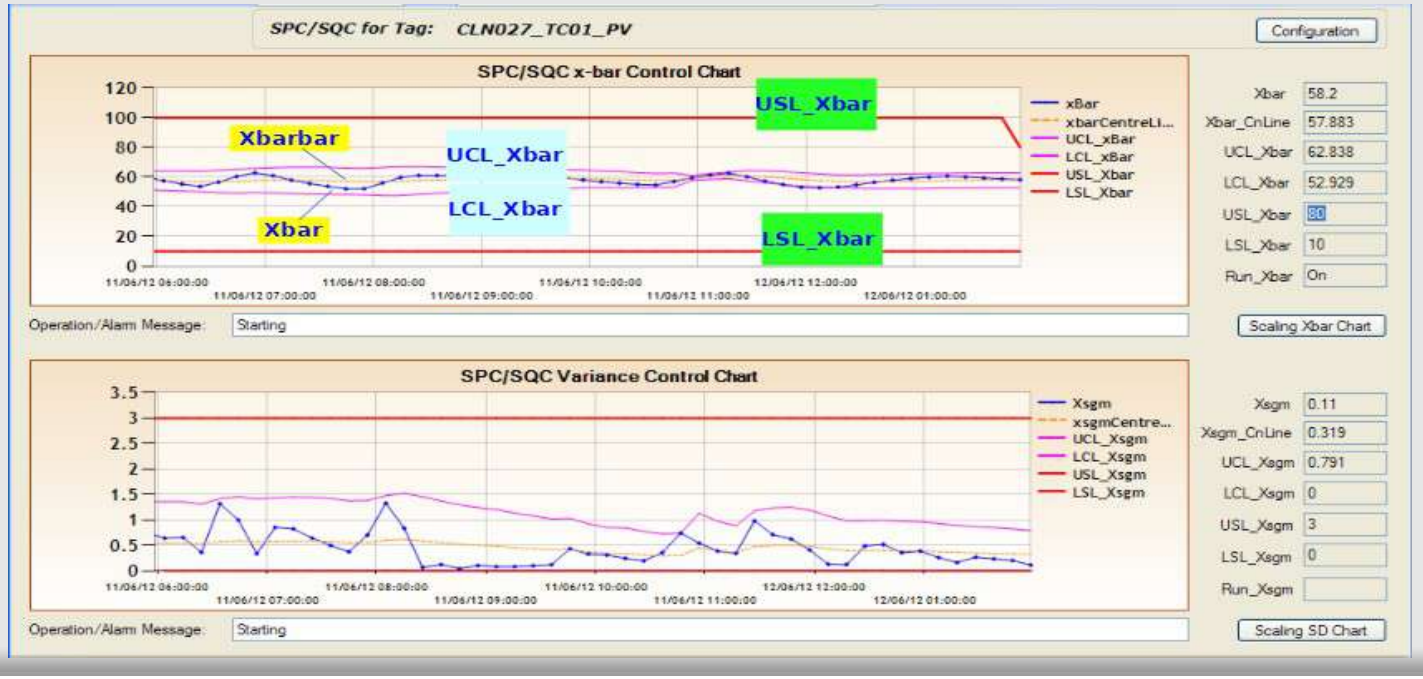
- MQTT stands for **M**essage **Q**ueuing **T**elemetry **T**ransport.
- Open Standard (OASIS standard and **ISO recommendation**).
- Protocol usually runs over TCP/IP
- Protocol is **Lightweight**
- Based on **Publish-Subscribe** network model (**efficient**)
  - data is **Pushed** by Publisher (instead of **Polling** by clients, such as OPC)



Schematic data flow from sensor (machine) to devise (machine)

I4.0: Applicable Analytics:

- **Real-time SPC/SQC**
  - Generate statistical point based on a group of SAMPLE POINTS
  - x-bar Chart: Plots of sample AVERAGE
  - s-Chart: Plots of sample Std. Dev. (SD)
- **Benefits of SPC/SQC**
  - Notify on: Process RUN & OFF-SPEC conditions
  - Generate: Process Control Limits & Process Capability C_{pk}



I4.0: Applicable Analytics:

Real-time OEE

OEE = Availability x Performance x Quality

- Single machine OEE plus Line OEE

- **Benefits of real-time OEE**
  - **Insight** into line **Bottle-neck** and **Spare capacity**
  - **Notify on: Low** OEE, Availability, Performance & Quality

I4.0: Applicable Analytics

Real-time OEE – Challenges:

- Availability = (Real Run Time) / (Available Time)
- Performance = (Real Cycle Time) / (Ideal Cycle Time)
- Quality = (1st. time Good Products) / (Total Good Products)

Available Time = (Total Time) – (Planned Downtime)
Run Time = (Available Time) – (Unplanned Downtim

- **Challenge 1: How & When to incorporate Planned Downtime?**
- **Challenge 2: What is the time period of measurement**
- **Challenge 3: How to plot a trend of real-time OEE**

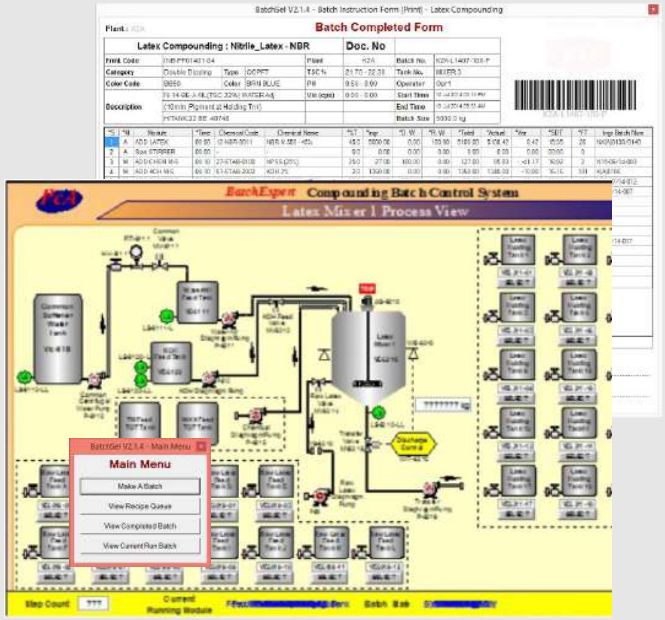
C. Summary of Applicable Technologies

Rubber Glove Manufacturing:

Compounding

Recipe Batch Control

- **Unlimited Master Recipe available**
- **Improves Throughput & Quality**
- **Reduce Manpower**
  - Weighing/Temperature control
- **Recipe Security**
  - Automatic recipe Encrypt/Decrypt
- **Batch Traceability**
- **Real-time Management Reports**
  - Raw Material consumption report
  - OEE & Trending:
    - Run time
    - Production throughput
    - Quality analysis



C. Summary of Applicable Technologies

Rubber Glove Manufacturing:

Production Line Monitoring & Control

Production Counting

- Chain Speed control (Geared Motor, Servo-drive, VSD-drive)
- Motor Running Hr & performance monitoring
- Production throughput with Glove Size analysis & monitoring
- Former Analysis
- Former Bypass Synchronization
- Trending & SPC/SQC::
  - Process measurement
  - OEE

C. Summary of Applicable Technologies

Rubber Glove Manufacturing:

Production Line Monitoring & Control

Former Preparation, Dipping Tank Control & Drying

- Former Brushing (Brush, Motor, Servo-drive, VSD-drive) control
- automatic Level / Temperature / flow control
- pH / TDS measurement

Beading

- Brush, Geared Motor, Servo-drive, VSD-drive) control

Vulcanization

- Temperature control / Air flow control

Glove Stripping (Removal)

- Automatic Air Purching control
- Automatic Glove Stripping
- Automatic Glove Pulling & Stacking

C. Summary of Applicable Technologies

Rubber Glove Manufacturing:

Production Line Monitoring & Control

QA/QC

- Automatic QA check on Water-leak test

End-of-line packing

- Automatic Glove Packing
- Inner box packing
- Carton box packing

Utilities

- Water, Gas, Energy Consumption Monitoring
- Energy generation
- Boiler Control
- Solar Energy

C. Summary of Applicable Technologies

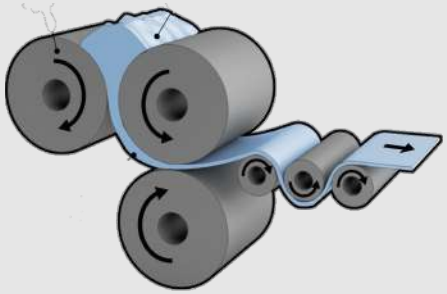
Dry Rubber Manufacturing:

Compounding

- Automatic Small Chemical Compounding - Recipe Batch Control
- Computer guided semi-auto weighing & feeding control

Production Monitoring & Control

- **Production throughput analysis & monitoring**
  - OEE / Temperature / Pressure
  - Trending & SPC/SQC
- **Conveyor belt control (Geared Motor)**
- **Calendering Roller Gap Monitoring & Control**



- **Molding & Vulcanization**
  - compression molding, transfer molding, injection molding
  - Pressure / Temperature / Timing control
- **QA/QC**
- **Utilities**

C. Summary of Applicable Technologies

- **Matrix of Applicable Technologies:**

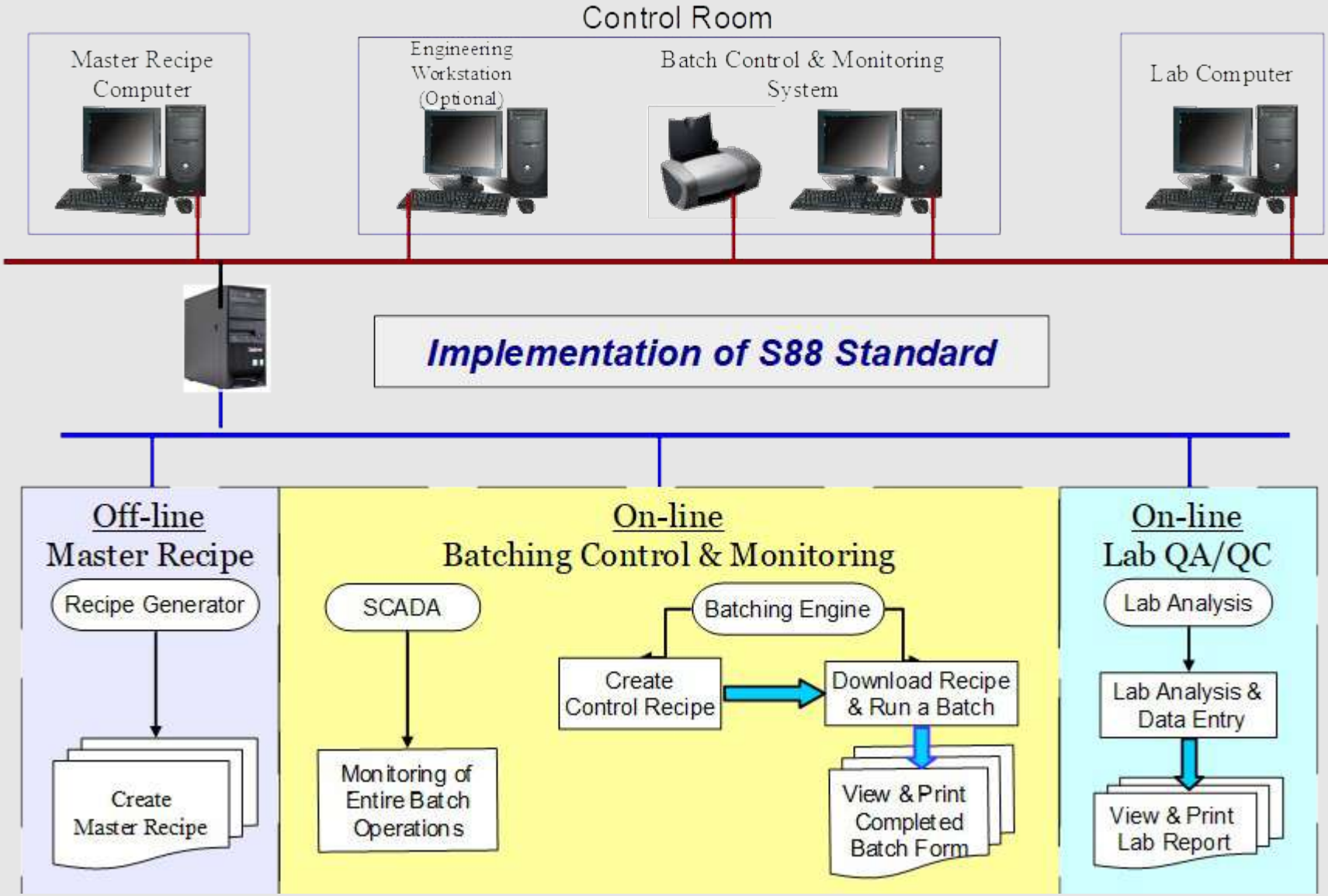
List of Automation Systems & Technology for the Malaysian Rubber Industry

Automation Technology Matrix (for Latex Products)

Station	Processes / Operations	Key Parameters	Automation Technology (IT/OT)																			
			Process Measurement		Automatic Control			Statistical Control	Machine vision	Mechanical Automation		Robotic			Identification & Labeling			Big data		Control Hardware		
			Realtime measurement	Operator Alert	Continuous Control	Discrete Control	Batch control	SPC/SQC		Mechanical Cam	e-Cam	Traditional	Collaborative	Mobile (AGV/AMR)	Barcode, 2D barcode	RFID	Blockchain	Predictive maintenance	AI & Data Mining	IoT	PLC	PC-based
1	Compounding (Dilution/Mixing)																					
	Raw material handling													Advanced	Proven	Advanced	Advanced					
	Batch Control																					
		Weighing Temperature	Proven	Proven			Proven	Recommended							Proven	Advanced	Advanced	Advanced	Advanced	Advanced	Proven	Outdated
	Mater Recipe generation, Control Recipe generation, Control Recipe Execution	Raw Material consumption, Production throughput, Quality Analysis, OEE calculation	Proven	Proven															Advanced			
2	Production Lines																					
	Overall Operations																					
	Data analysis	consumption, Production/ Glove Size throughput, Former Analysis, Quality Analysis,	Proven	Proven															Advanced			
	Chain Speed control (Geared Motor, Servo-drive, VSD-drive)	Motor Control, Running Hr.& performance monitoring	Proven	Proven	Proven	Proven												Advanced		Recommended	Proven	Outdated
	Former Cleaning																					
	Acid, Alkaline, Coagulant Dipping & Rinsing	Level, Temperature, TSC, pH	Proven	Proven	Proven			Proven												Recommended	Proven	Outdated
	Former Bypass Synchronization		Advanced			Advanced														Advanced	Advanced	Outdated
	Mechanical Brushing (Brush, Geared Motor, Servo-drive, VSD-drive)	Motor Control, Running Hr.& performance monitoring	Proven	Proven	Proven	Proven												Advanced		Recommended	Proven	Outdated
		Brush & Former surface QA							Advanced										Advanced	Advanced	Advanced	Outdated

Latex Product | Dry Rubber Products

D. Case Study – Recipe Batch Control



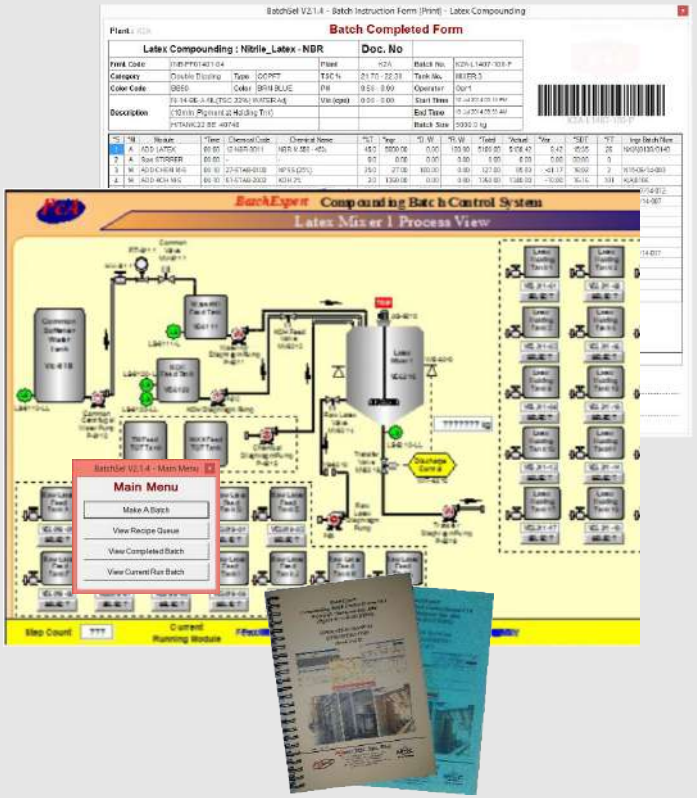
D. Case Study – Recipe Batch Control

Rubber Glove Manufacturing:

Compounding Recipe Batch Control (ANSI-SP88 Std.)

Benefits:

- Master Recipe for unlimited Methods & Formulation
- Automatic recipe encryption (protection)
- Traceability for every batch
- Dynamic weighing error correction
- improves:
  - Management control & accountability
  - productivity
  - Consistency, Acuracy & Quality
- Eliminate reworks
- Reduces Manpower & Wastage



Thank You

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Next Presention
to follow ...

Vision Inspection Systems in Manufacturing

Ir. Dr. Chang Yoong Choon
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Traditional Manual Quality Inspection

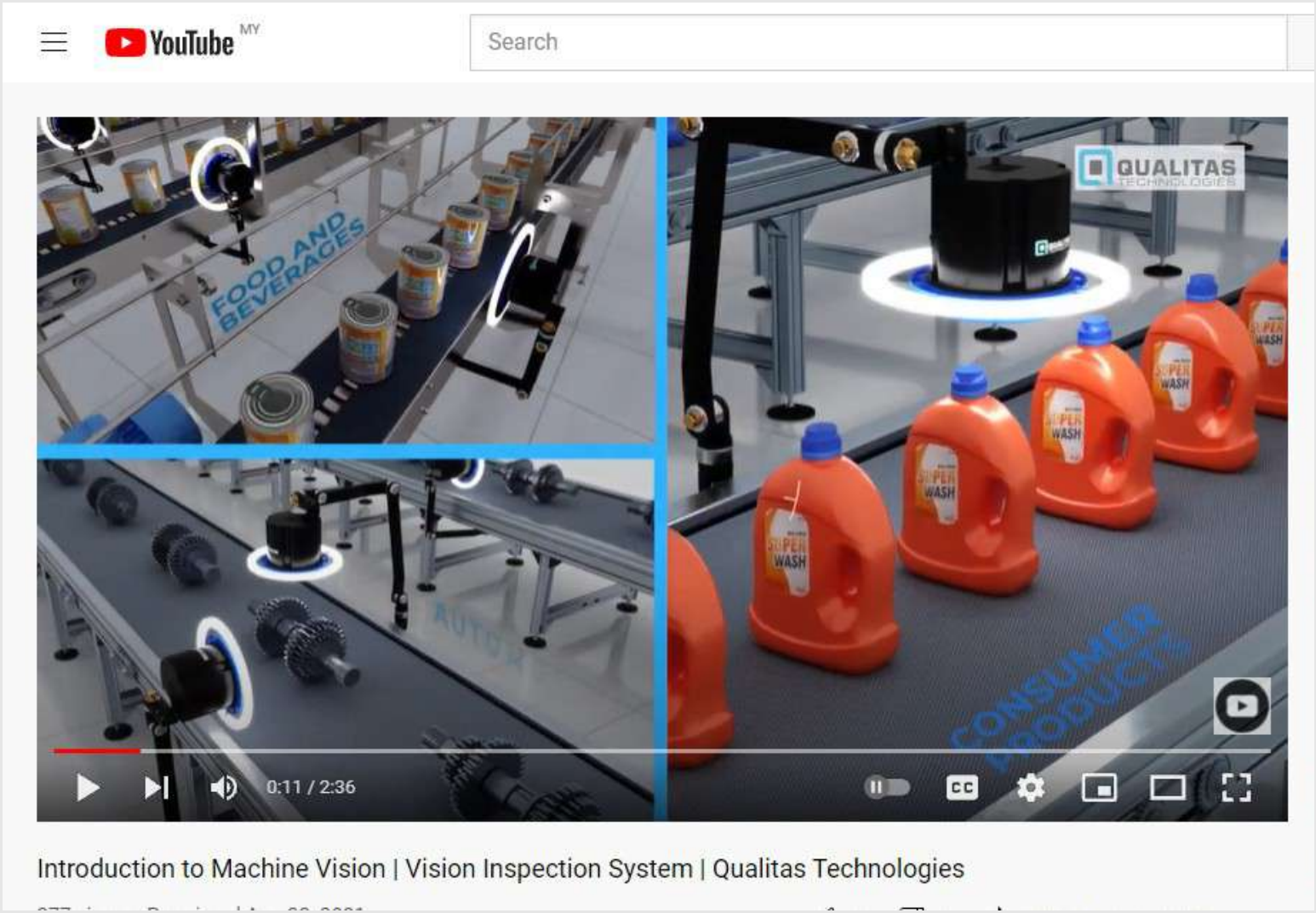
Traditional Manual Quality Inspection

Challenges of Manual Quality Inspection

- Work fatigue

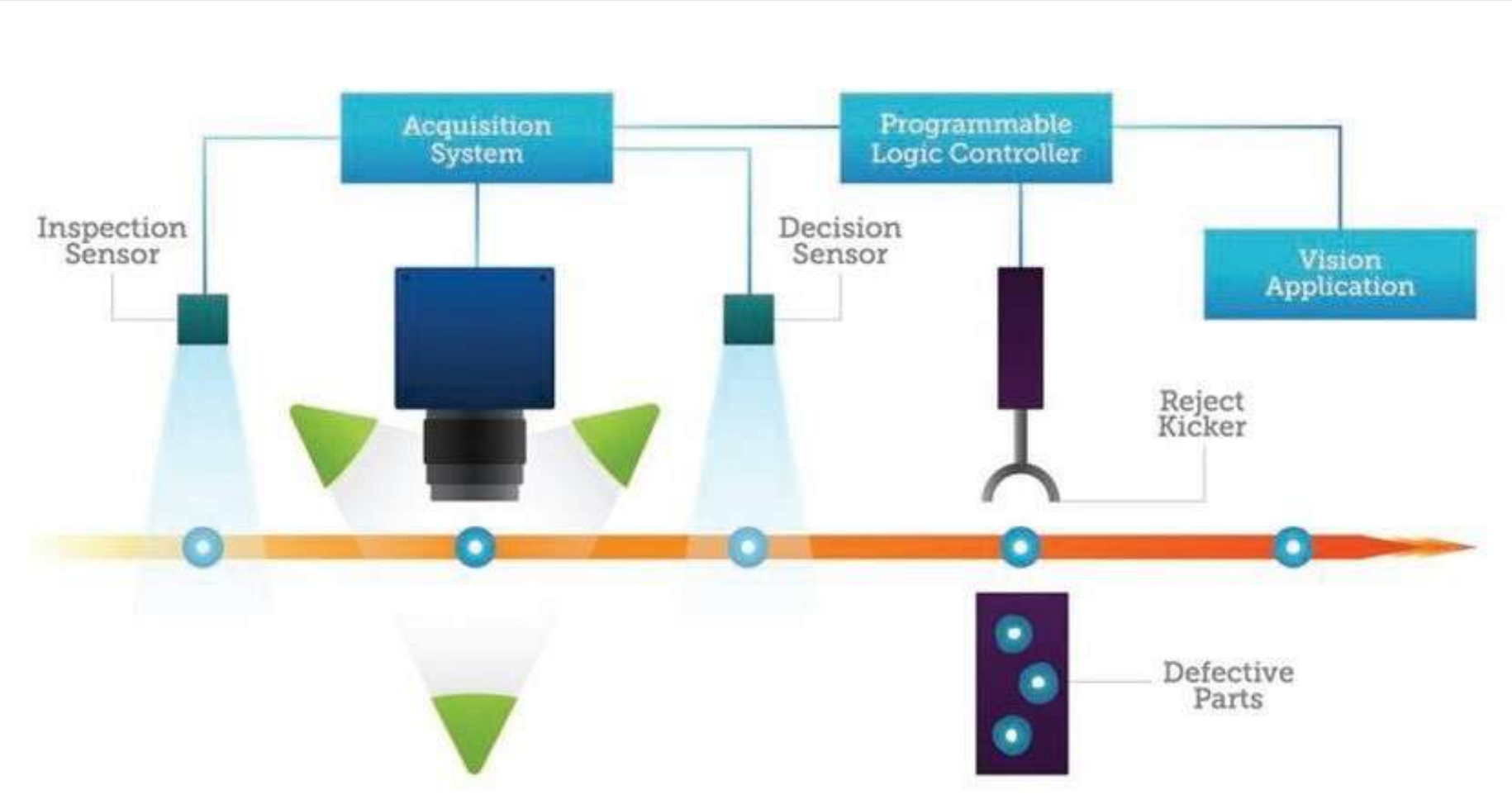
- COVID restrictions (social distancing, lockdown, etc)

Vision Inspection System (Video)

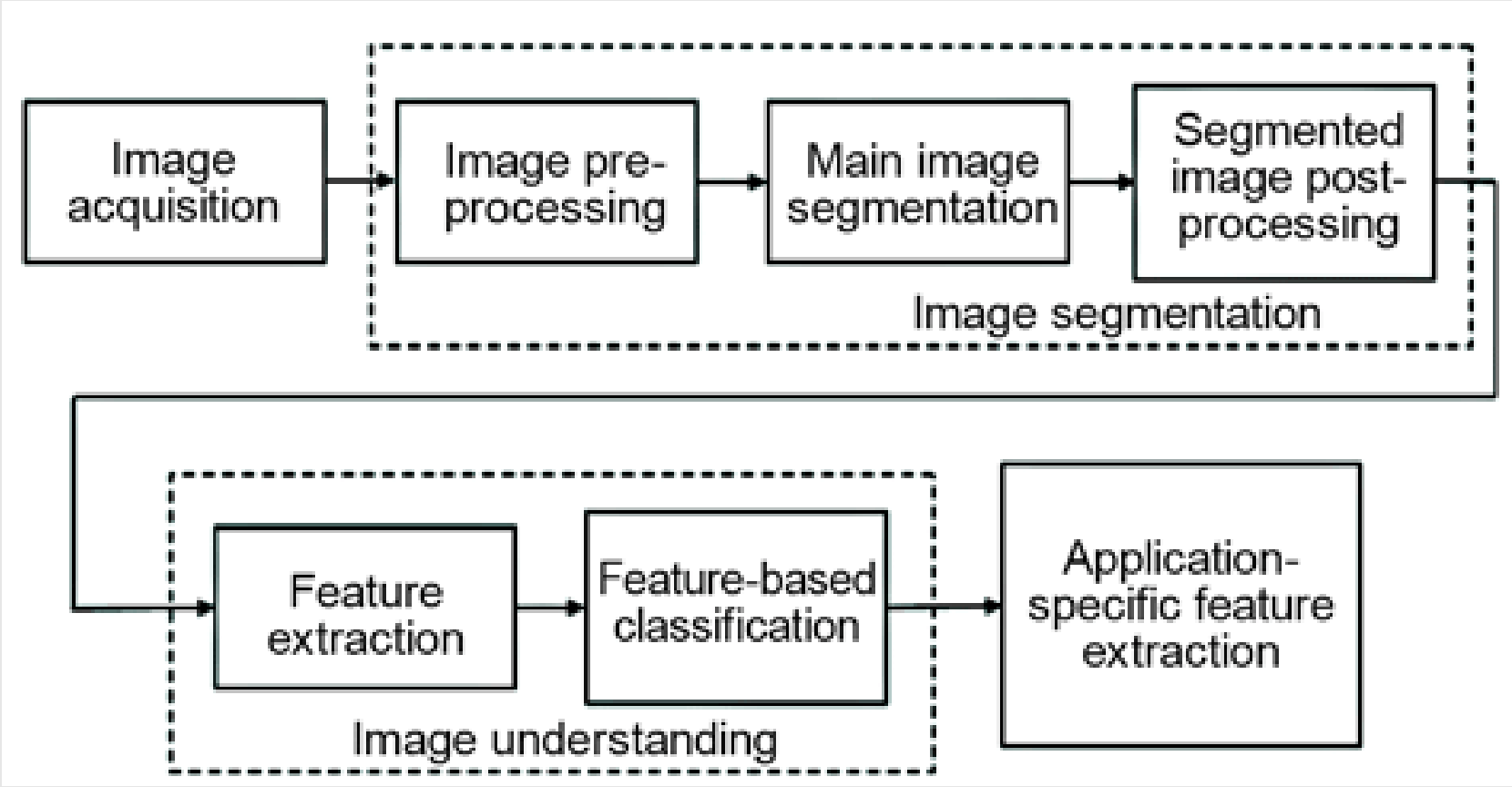


Vision Inspection Systems

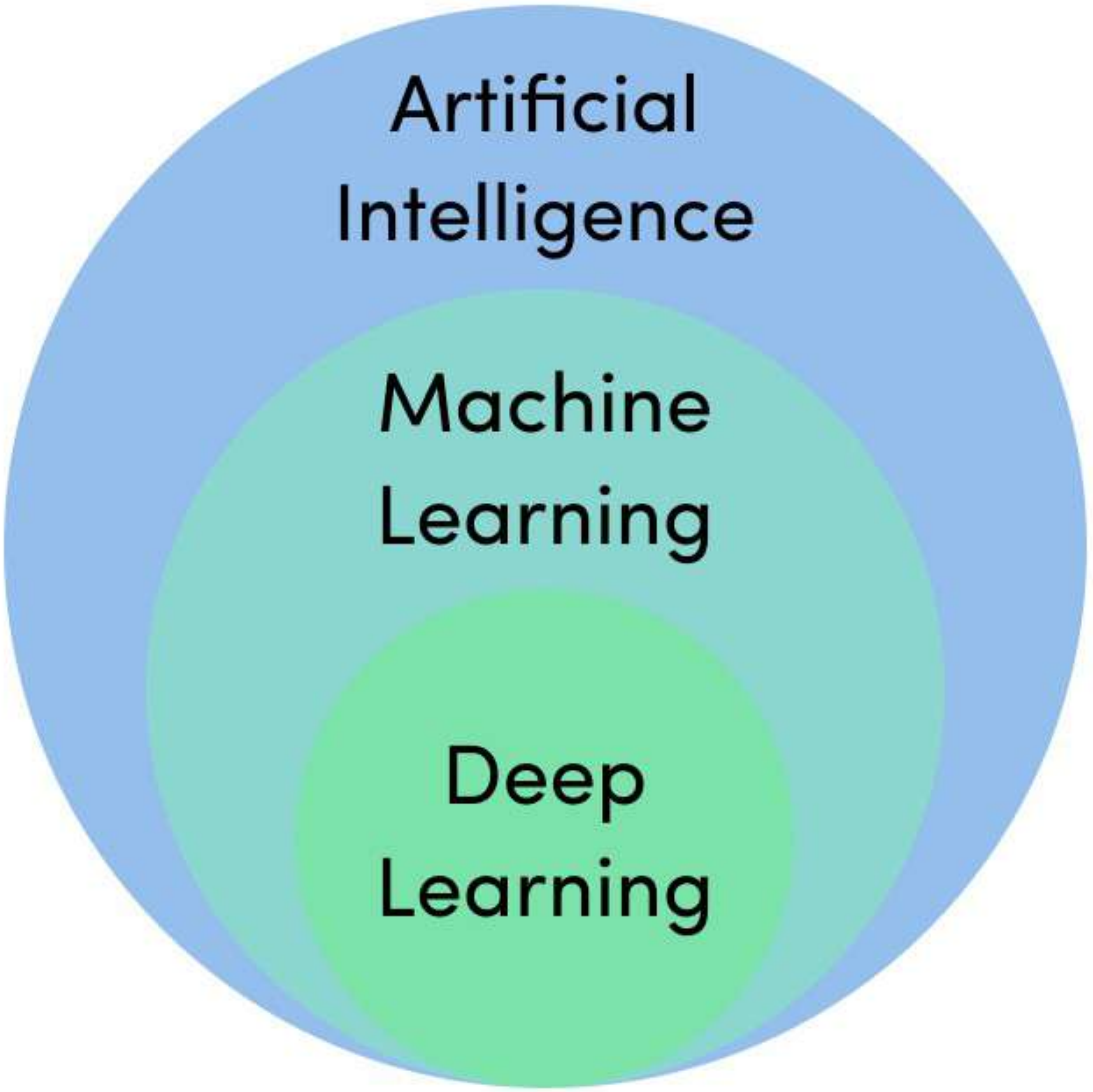
Vision Inspection System



Vision Inspection Technique



AI in Computer Vision Techniques



AI vs Machine Learning vs Deep Learning

- AI: Technique which enables a machines to mimic human behaviour

Computer Vision Techniques

- From Machine Learning to Deep Learning
- Increase of dataset (increase of storage space)
- Increase of GPU computational power (Moore's law)
- Increase of Internet bandwidth (data rate)

Vision Inspection Systems: Advantages

- Consistent quality, not affected by work fatigue
- Increased manufacturing throughput
- Up to 99% accuracy (provided sufficient samples)
- Minimal impact by COVID restrictions
- Industry 4.0 ready with data analytics (e.g. reject rate, inspection throughput, etc)
- Potential ROI in 2 years

Thank You

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Next Presention
to follow ...

SCADA and Robotics Applications in Rubber Industry

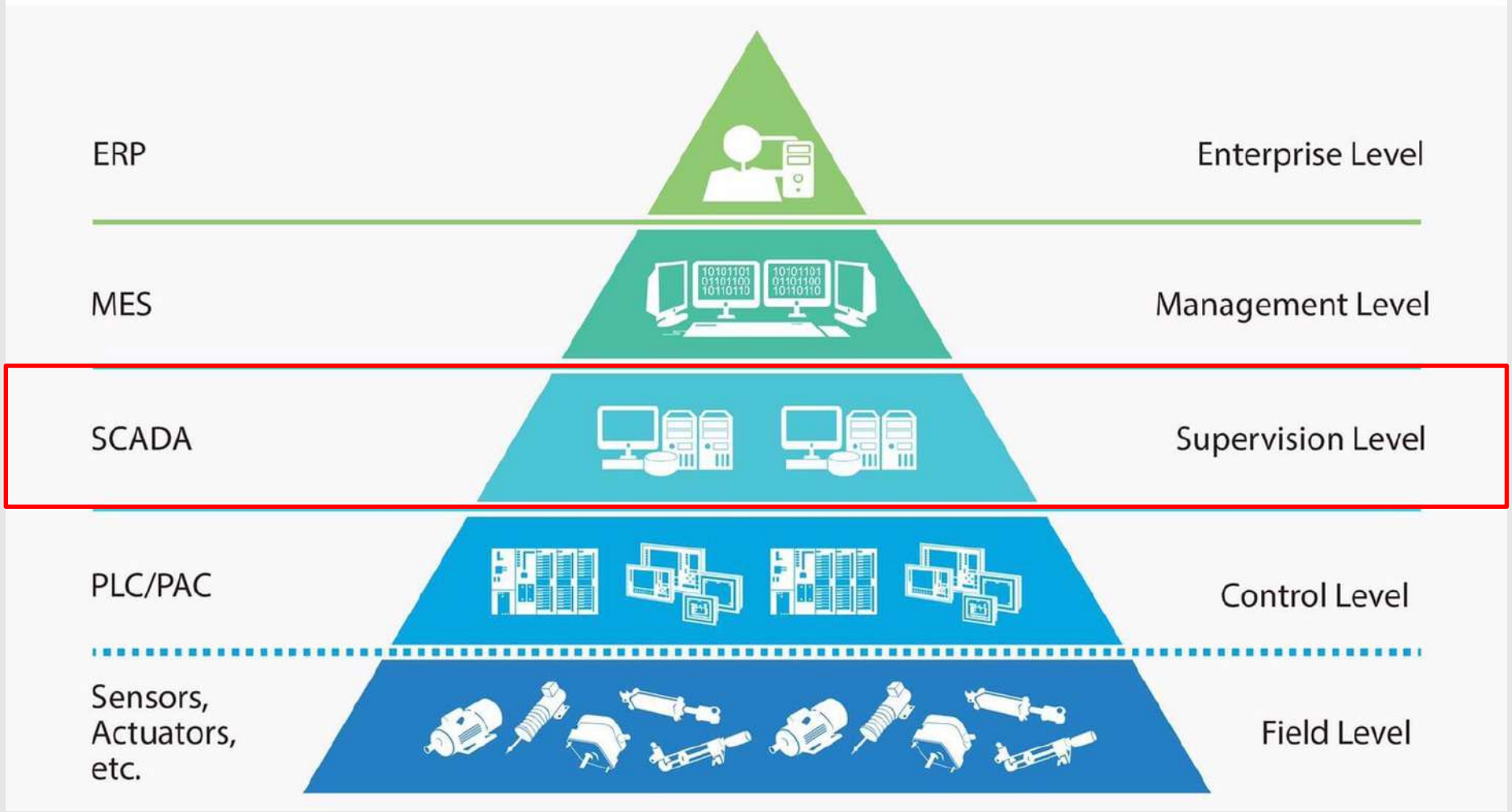
Tiong Khe Hock
President
Malaysia Automation Technology Association (MATA)

Outline

- Automation Pyramid & SCADA
- SCADA Applications
- Robotic Installations in Malaysia
- Robotic Applications

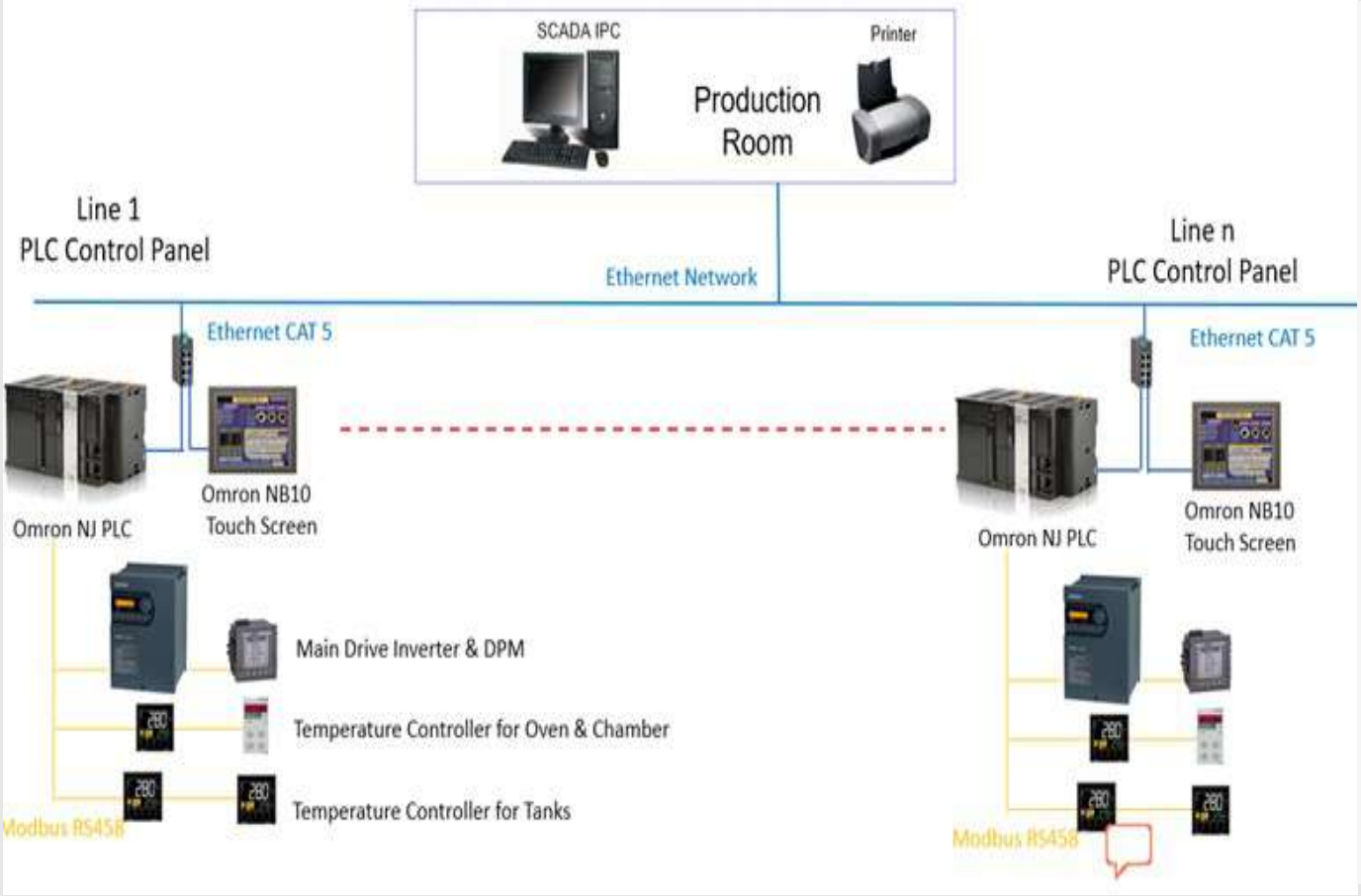
Automation Pyramid & SCADA

Supervisory Control & Data Acquisition (SCADA)



SCADA Applications – Rubber Glove Industry

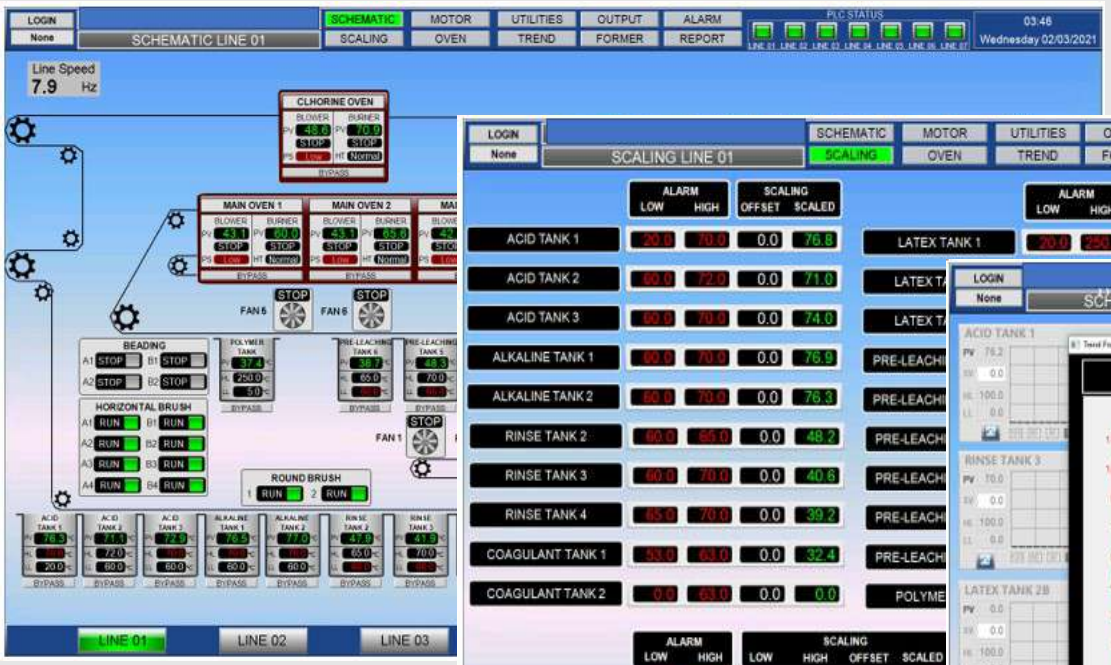
Dipping Line Supervisory Control and Data Acquisition



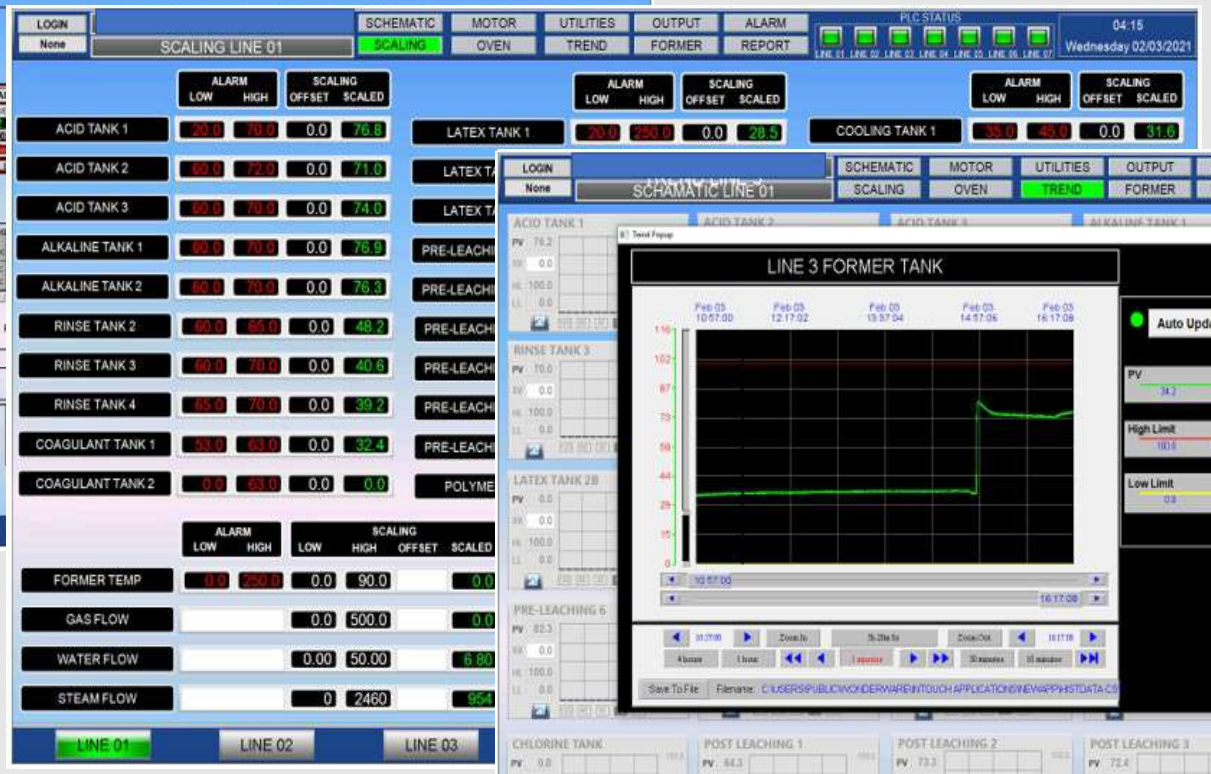
Benefits

- Reduce manpower and eliminate human error during start up.
- Reduce energy consumption at the blower motor.
- Reduce signal wiring between Main panel & fields devices via Fields Bus network.
- Reliable data sending direct to SQL without SQL knowledge.
- Real-time monitoring to quickly identifying waste/performance opportunities.
- Auto- reporting generation for production

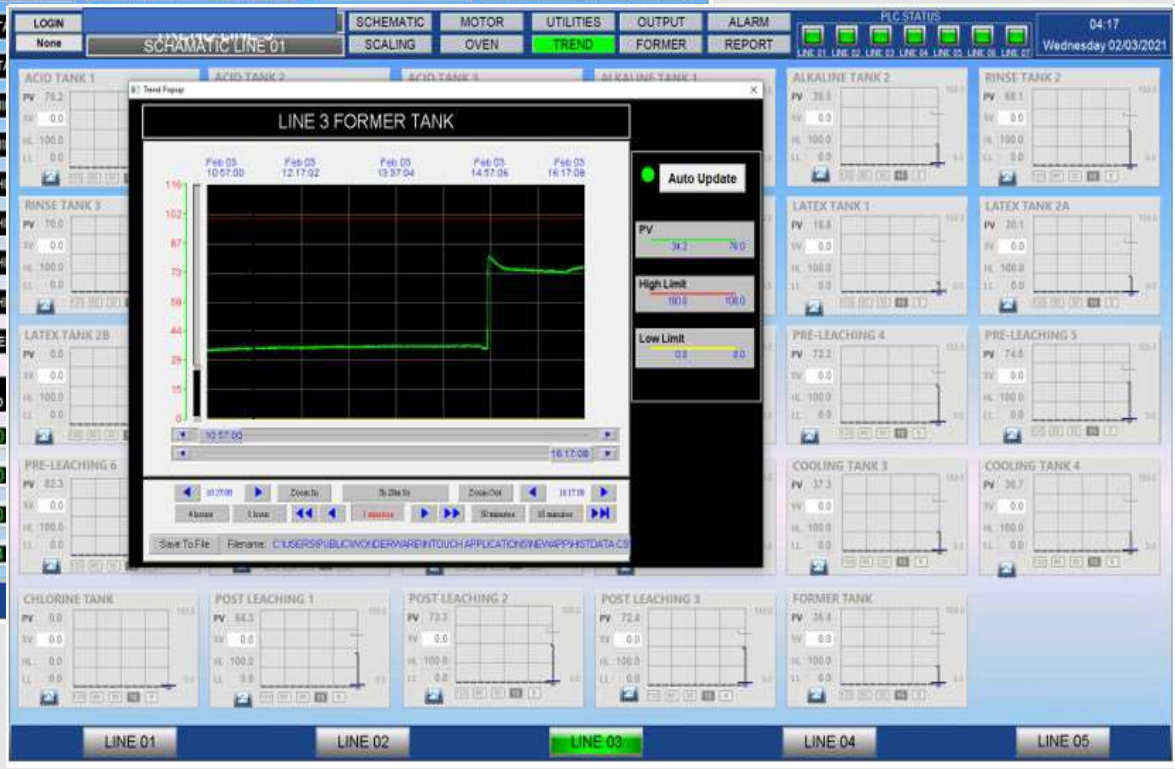
SCADA Applications – Rubber Glove Industry



Overview



Temperature Parameters Setting

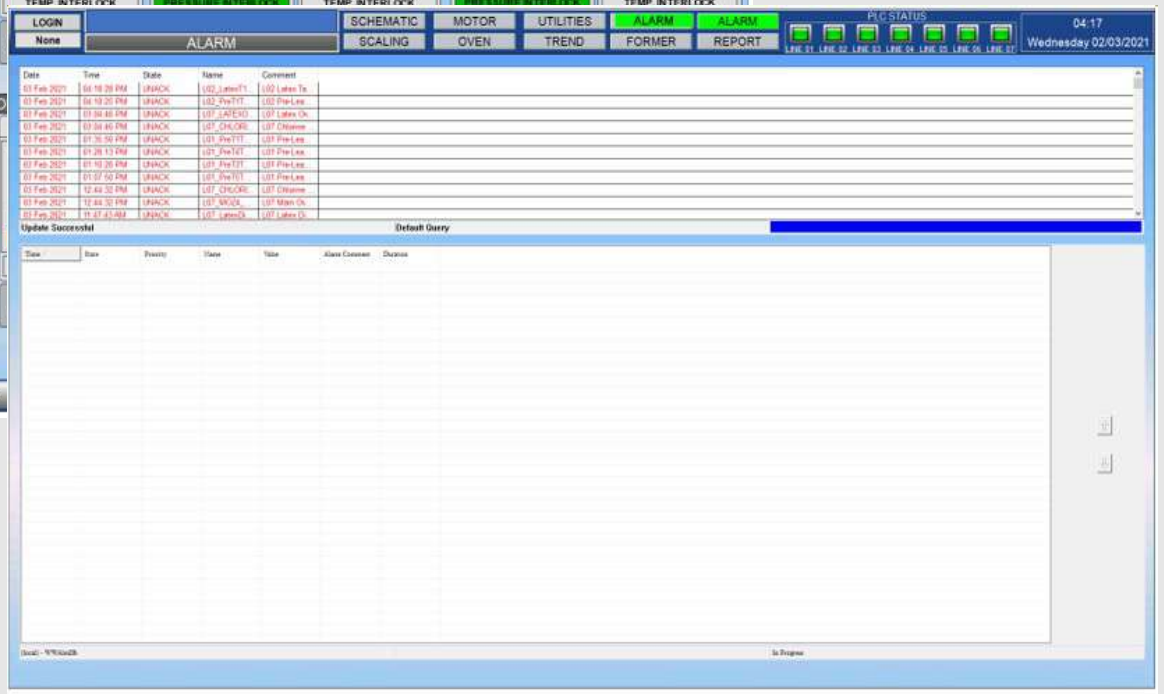


Temperature Trending

SCADA Applications – Rubber Glove Industry

Blower Status Monitoring

Oven Status Monitoring

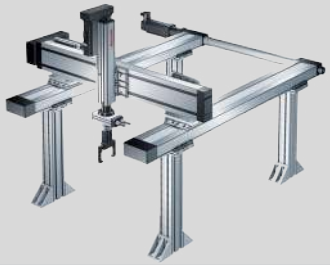


Alarm Logging

Robotics Installations in Malaysia

ROBOTIC INSTALLATIONS BY INDUSTRY

TYPES OF INDUSTRIAL ROBOTS



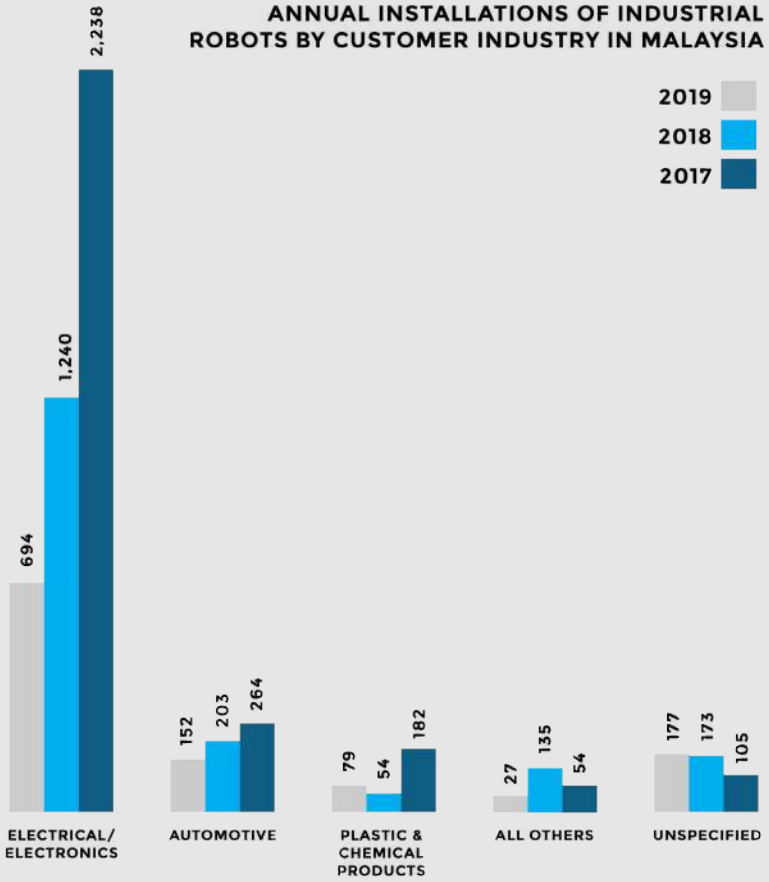
CARTESIAN ROBOT
Built for medium weight loads needing repetitive stacking, improves productivity by freeing-up manpower

SCARA ROBOT
4-axis Scara Robots ideal for mechanical assembly, material handling, packaging, machine tending, and screw driving.

DELTA ROBOT
Four-axis parallel robot achieves high speed and high precision

ARTICULATED ROBOT
6-axis Articulated Robots ideal for mechanical assembly, material handling, packaging, and palletising.

COLLABORATIVE ROBOT
The robot system allows collaborative operation with humans without safety fences



Robotics Applications – Rubber Glove Industry

Automated packaging process for productivity improvement

Issues

Labor Intensive

- Very dependent on workers.
- Manual counting leads to quality issue
- Low efficiency with long working hours
- Process bottleneck.

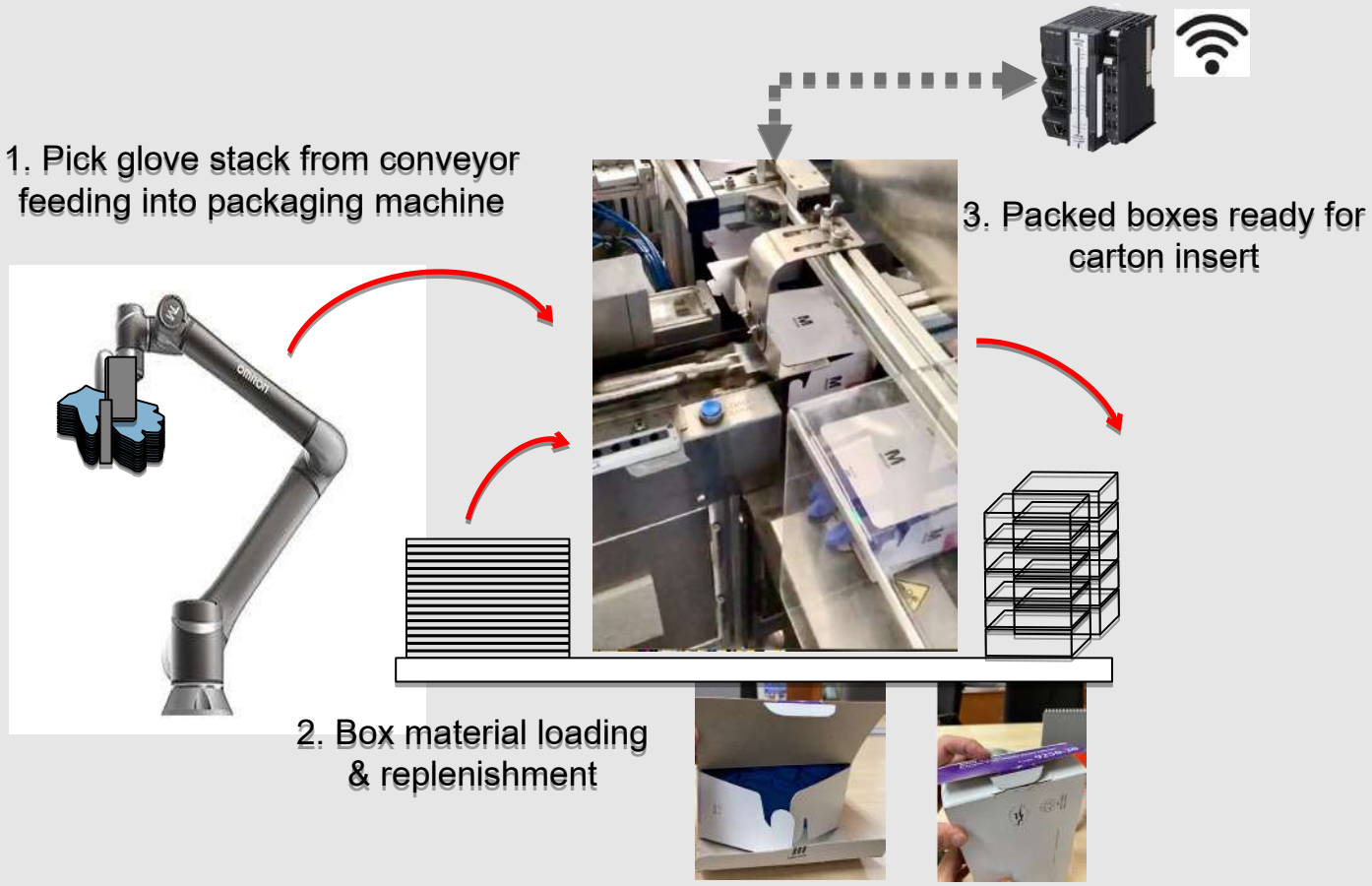
Solutions

Auto-Insertion System with Robotic Picking

- Robotic glove transfer after stacking.
- Mechanical movement with servo control during glove insertion
- Auto case packer system into carton box

Robotics Applications – Rubber Glove Industry

Automated packaging using Servo Control and Collaborative Robots



Benefits

- Reduces manpower dependency during layering process.
- Fully automate process to ensure quality consistency.
- Seamless software integration using EtherCAT for wiring cost reduction.
- Easy Troubleshooting – online to PLC, able to configure, set and tune every motor.
- Simple Proven Integration and allows remote troubleshooting.

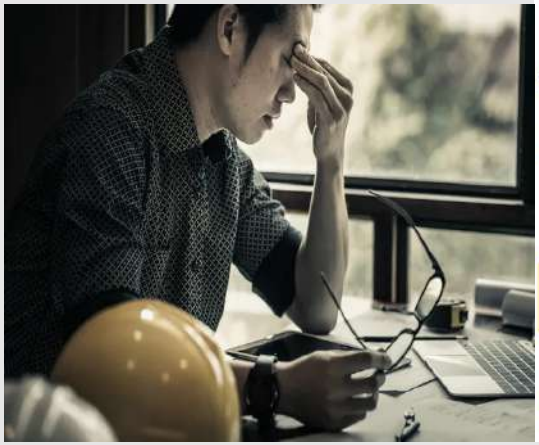
Robotics Applications – Rubber Glove Industry

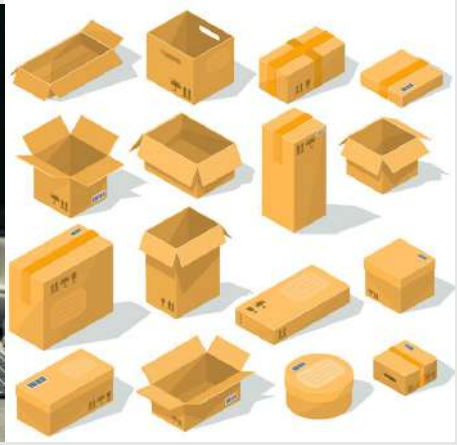
Intelligent Carton Erector using Collaborative Robots

Issues

Labor Intensive & inflexible

- Very dependent on workers.
- Multiple carton sizes – hard to automate.
- Long changeover time (for standard carton erector) – mechanical adjustment is needed.





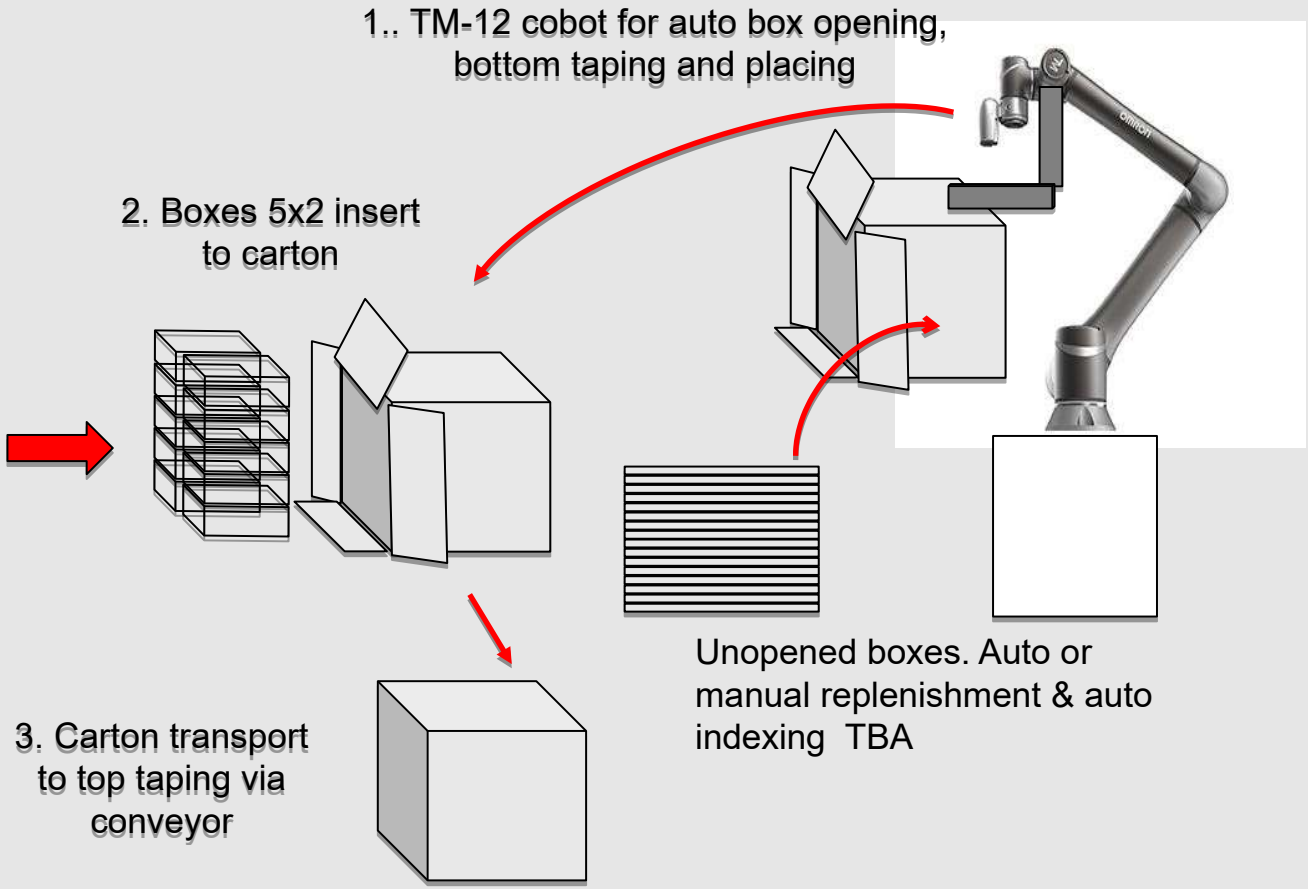
Solutions

Cobot handling for multiple SKU

- Carton erector by using cobot.
- Mechanical design with servo control for inner boxes arrangement.
- Conveyor transfer for finish box.

Robotics Applications – Rubber Glove Industry

Auto Box to Carton Insertion with Collaborative Robots



Benefits

- Flexible, safe & space saving.
- Support wide range of carton size without any mechanical changeover.
- Minimize manual works to reduce human dependency.

Robotics Applications – Rubber Glove Industry

Collaborative Robot Palletizer

Issues

Labor Intensive

- Manual palletizing with heavy load (worker ergonomics)
- Conventional palletizer robot need big floor space to implement

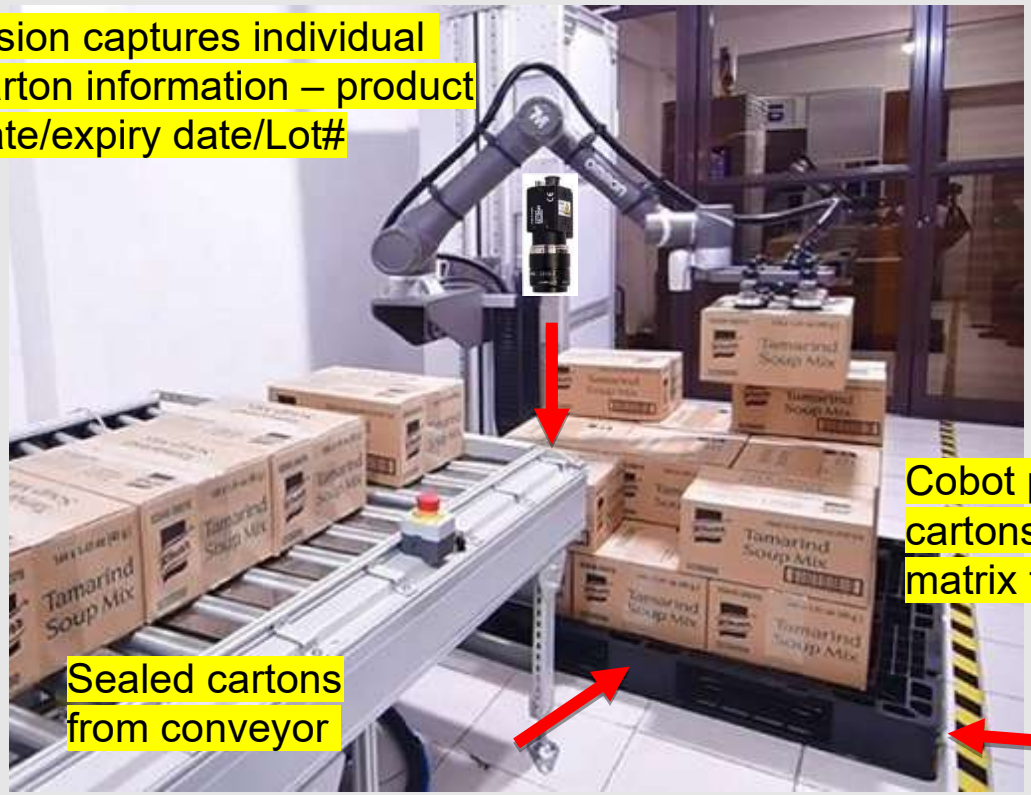
Solutions

Flexible palletizing with proven Cobot

- Provide cobot palletizer which required minimum footprint
- Install stacker system if the reach is more than 1300mm
- Bundling with 2D code or RFID reader for full traceability

Robotics Applications – Rubber Glove Industry

Collaborative Robot Palletizer



Benefits

- Flexible, safe & space saving. (no cage)
- Up to 9 pick per minute
- Integrated vision to detect carton position before pickup
- Minimize manual works
- Collaborative Robots are designed to be easily redeployed to different tasks and applications, making production as flexible as needed

Automated Material Transfer using Mobile Robot

Issues

Manual transport & traceability

- Labor dependent. (pushing trolley / pallet jack / driving forklift in production floor)
- Low efficiency
- Safety concern (Forklift)
- Not traceable

Solutions

Autonomous transportation with traceability

- Adopt Mobile Robot for Carton replenishment or finish goods pallet transfer to storage area
- Full material movement traceability with ID code reader
- Payload up to 1,500 kg with Fleet Manager system can manage up to 100 robots

Thank You

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