A COMPREHENSIVE LOOK AT PALLET HANDLING ROBOTS

Warehouse automation is changing the way supply chain managers control inventory processes. From inventory management to pallet handling, robots are taking center stage to batch-pick, sort, and ship products, thus exceeding customer expectations. Inventory optimisation is changing at a record pace thanks to automation. This whitepaper aims to highlight the latest trends, technologies, regulatory standards, and challenges surrounding the supply chain industry after the pandemic and the way ahead for automated robots in global logistics networks.

EXECUTIVE SUMMARY:

Palletising emerged as a major trend in the 1950s, changing how people work by loading products on wooden bases. **The MHI-2016 standards** define pallets as rigid, composite platforms offering solid bases for storing, stacking, loading, and transporting goods. The significant advantage of palletising is that it provides the scope for efficient loading and unloading, optimally organising goods.

Whether it's a truck or a warehouse, pallets slot the goods, offering drainage and aeration for perishable products. The quicker sorting enhances employee workflow, giving them improved flexibility and freedom to manage the inflow and outflow of goods.

Traditional palleting systems are now being combined with smart robotics to act and respond in a human-like fashion. Gartner predicts **75%** of large enterprises will adopt robotic automation in the next 3 to 5 years. The shift in automation is driven by companies researching newer avenues to increase their logistics capacity and address the severe labour shortage.

The surprising element is that robots have low entry barriers and can be scaled incrementally in the long run. This chapter highlights the rapid dynamics of logistics robots, delving into how they are transforming the palletisation landscape. We'll look at major players and gain a bird's eye view of the industry, keeping in mind the regulations, challenges, and associated risks.

THE DANGERS OF MANUAL PALLETISING

Wooden structures have been around for a long time, acting as bases for bags, allowing companies to load products faster. An interesting observation is that this relies on manual labour and the practice is still relevant today. However, the inherent risks pose severe credibility issues, plaguing the warehouse industry. Heavyweights carried by workers cause back strain even after following all the necessary SOPs and protocols. The same is true for repetitive motion, which causes stress on the muscular tissues.

The dangers extend beyond muscle strains; workers are prone to severe injury risks causing splinter wounds especially when they work quickly to meet performance targets. In the United States, the Mine Safety and Health Administration(MSHA) database records 217 palletising injuries during the 2007-2011 forecast period. The peak days lost were 10047 days with a median of 17 days per injury. Overexertion was the significant accident type(70%).

The back and spine were the most affected, followed by the shoulders, hands, and legs. The influence of pallet positioning on spinal loading creates biochemical reactions related to occupational **low back disorder(LBD).**

THE NEED FOR AUTOMATED ROBOTIC SOLUTIONS

Automated palletising was developed to counter the growing problems of manual stacking, storage, and transfer. Standardized in the 1970s, it combined conveyor belts and industrial equipment to arrange containers into preset patterns. However, the only drawback was they required the product to be identical in weight, size, and volume, reducing flexibility.

This limitation paved the way for palletising robots to enter the global logistics industry. Articulated robotic arms have the potential to handle packages without changing the physical equipment. These robots have advanced to the point where mixed palletising is a reality, allowing them to be reprogrammed to accept mixed orders without losing productivity. Several automated solutions have popped up in the last few decades in the warehousing industry. Some of the prominent ones include:

INTERNAL TRANSPORTATION:

Autonomous mobile robots move like normal lift trucks within the warehouse area with zero routes and installation limitations.

PICKING AUTOMATION:

Intelligent robotic arms with vision/grip sensors map the entire area, dropping products in totes on a passing conveyor.

AUTOMATED STORAGE/PICKING SOLUTIONS:

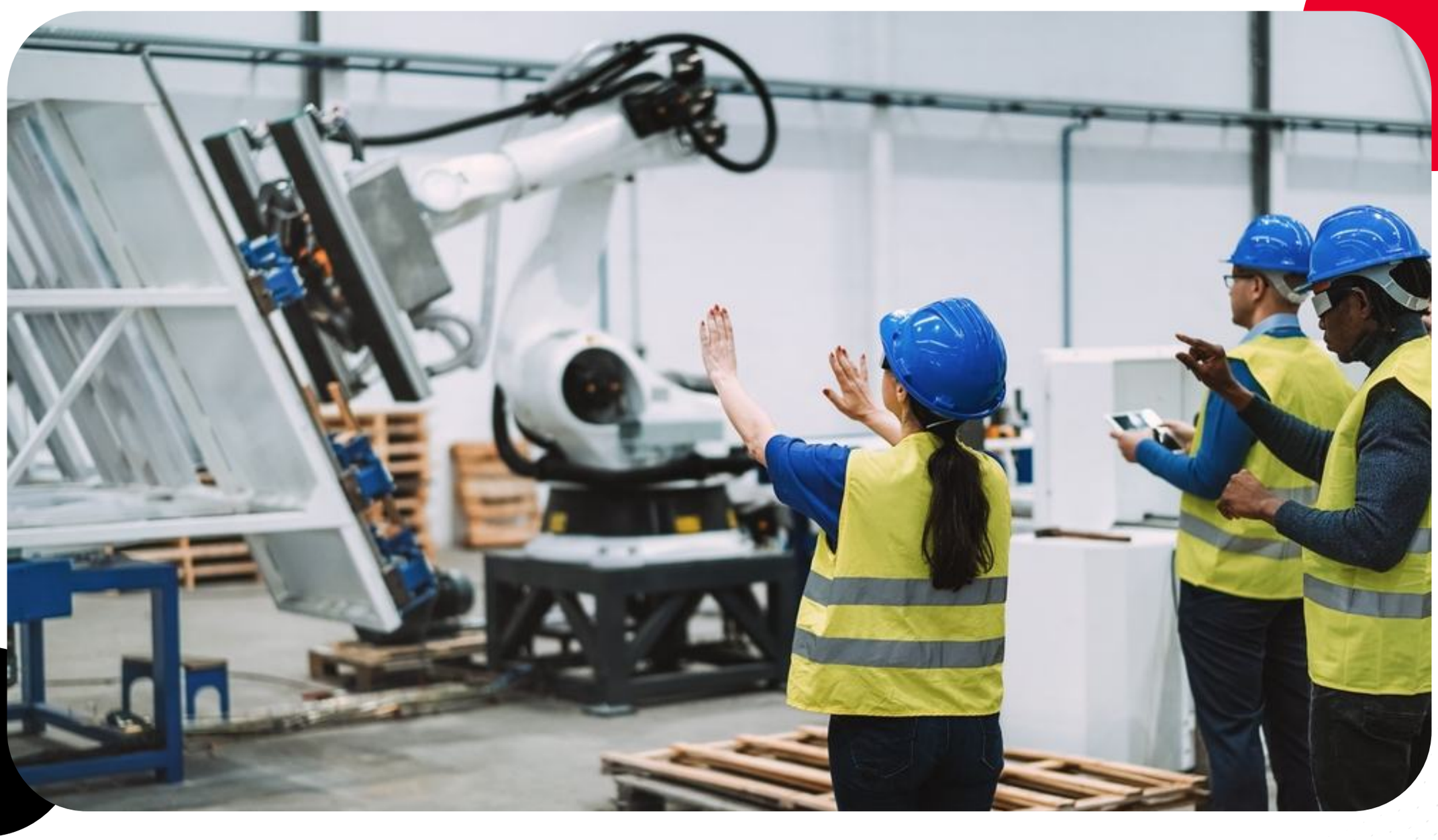
The goods-to-robot model employs engineered robotic systems with multiple cobots working within a grid to bring storage bins and shelves to packaging stations.

3D LIGHT DETECTION - LIDAR TECHNOLOGY

The supply chain industry in Japan has developed autonomous forklift pallet-handling systems. The machine detects the pallet through deep-learning object identification via an image. Based on the 3D light detection technique results, the system estimates the distance between the forklift and the pallet. The vertical LIDAR scans the pallet for precise fork adjustment, requiring zero human intervention.

IDENTIFYING TWO KEY PALLET TECHNOLOGIES

Pallet handling equipment mainly includes manually operated hydraulic trucks or electric/fuel-driven forklifts. When the goods are delivered, the operator monitors the loading and unloading, requiring massive labour investment. However, in recent years, Automated Guided Vehicles(AGVs) have transformed the pallet transportation logistics inside the factory.



Separate parallel mobile robots are receiving the spotlight in smart factory logistics. These intelligent systems contain two sub-robots - primary and secondary–that perform synchronous pallet-lifting actions. Navigation is enhanced through external sensors, software modules, and power scheduling to meet unmanned logistics requirements. Compared to traditional AGV forklifts, mobile robots are compact, have high expandability, and can carry larger payloads.

Each robot is connected via a non-linear control system to obtain optimal speed and full motion control. The dual robotic solution was invented to solve the problems of its predecessors. In early 2015, the forklift company, Jungheinrich, launched a forklift AGV with a single steering wheel. However, the attached wheels couldn't achieve zero wheel rotation, requiring larger working space. Similarly, in 2007 a dual-pronged robotic solution named the **Doppelkulfen System** was made by Professor Manuel Weber of the University of Stuttgart, Germany.

Later versions combined the robotic solutions to perform palletising with zero-radius rotation and omnidirectional motion. The only catch was the pallet had to be placed on a custom-height pallet rack in advance. To adapt to the changing workspace needs, parallel intelligent robots entered the fray. The two sub-robots can fulfil linear, oblique linear, and zero-radius turns through high-gain observers controlling the speed limits.

Another major technological boost is Freight Urban Robotic Vehicle(FURBOT). The automated forklift installed on FURBOTS is powered by hydraulics, using a fixed displacement pump to change the motion speed in real time via pressure sensor tracking. A control algorithm is implemented in the processing unit to control the motor speed driving the pump. The selection of hydraulics is due to two reasons - to boost power under limited space/mass and to make the vehicle cost-effective, enhancing its commercial viability.

WAREHOUSE MACHINERY REGULATORY STANDARDS

Recent technological advancements have created the need for strict regulatory standards in India. Many warehouse compliance programs are grouped into docking equipment(dock seals, shelters, and levellers) and storage equipment (pallet racks, long bins, and multi-tier shelves). Standards for specification, stability, testing, and other transport handling equipment are prescribed by the Bureau of Indian Standards(BIS).

IS 15640	IS 15634	IS 8790-2
IS 4357	IS 15611-1	IS 13971
IS 6876	IS 15611-2	IS 13302
IS 7309	IS 15488	IS 12726
IS 7525	IS 15487	IS 11757
IS 7570	IS 14770	IS 11683
IS 7617	IS 13971-2	IS 10312
		IS 10517

SPECIFIC PALLET STANDARDS

- **IS 3971 – Pallets for material handling**
- **IS 5325 – Box pallets for the transition of goods**
- **IS 11982 – Design rating and safe working load for flat surface pallets**

POSSIBLE FRAMEWORK FOR AI IMPLEMENTATION

The growing dominance of artificial intelligence is reshaping the regulatory system, prompting relevant stakeholders to seek consensus to designate a digital supply chain leader. This initiative will help launch multiple pilot programs with sufficient funding opportunities. The arrival of smart sensors has created the first family of robots operating inside a warehouse.

For example, kitting is a mini-assembly operation where SKUs of predefined volumes are packed into designated packages via a computer vision solution, minimising fatigue-related accidents. Robotics-as-a-service companies offer robotic arms, picking, heavy carriers, and autonomous forklift systems to boost inventory accuracy and product shipment.

INDUSTRIAL USE CASES OF ROBOTIC PALLETIZING

Robotic palletisers are reaching the warehouses of multiple companies worldwide. They help reduce labour costs by **50-95%** compared to manual palletisers. Here's how companies are reaping benefits from this modern technology.

- **Napco -** A Chicago-based leading coffee brand has partnered with Robotiq to address labour shortages and employee safety by installing automated palletisers and collaborative robots. The palletisers run two shifts working 18 to 20 hours per day to fill 1,500 cartons totalling 180,000 coffee bean capsules, increasing employee productivity by 15%. The system has significantly decreased production downtime, eliminating employee injuries and high attrition rates. The robots feature force sensing and collision detection technology to work alongside operators, promoting a safe working space.

- **Pepsico -** The leading F&B industry employs robotic solutions at its facilities across the globe. Automation has helped them reduce costs by 50% while boosting product quality by 40%. Shipping payload has increased by a cumulative 25% year on year.

- **Unilever -** The globally renowned brand collaborated with Sidel to install centralised palletising solutions including eight robotic cells, conveyors and packaging shuttles. The modular concept was designed and live-tested using virtual reality glasses by Sidel, followed by quick installation at their factory site to boost packaging lines. The operator selects the production order and detailed info regarding pallet size, and total number of rows/layers, and the label is automatically transmitted to the end of the line setup.

RISK MITIGATION FOR HUMAN-ROBOT COLLABORATION

Certain ISO standards mandate strict guidelines to enable smoother human-robot interaction. Initiatives are underway to boost efficiency and enhance on-ground risk assessment. Studies indicate that operators wear safety vests to improve detection by robotic cameras. Significant constraints are implemented to separate the robot's operating area from human zones. Moreover, ESN standards reduce human contact by reducing force and machine power.

Companies like ABB and SICK are developing robotic sensors that promote safe collaborative practices by reducing hazard exposure. Moreover, cobots are starting to work safely alongside humans, featuring rounded edges, force limitations, and softer materials. They are equipped with automated control systems to slow down or stop when they detect humans, minimising overlap accidents.

On the other hand, voice-activated commands and augmented reality assist in guiding humans in developing intuitive, user-friendly robot interfaces. Additionally, IoT systems provide real-time data on warehouse conditions preventing accidents and unwanted collisions. Several organisations are conducting simulated risk assessment tests to understand the real-life scenarios of human-robot existence. Potential hazards arising out of these tests include:

FAILURE TO PICKUP OBJECTS

The robot doesn't pick the product because it is not present or is stored at an improper place, creating significant time loss.

FAILURE TO PICKUP OBJECTS

The person is standing close to the robot putting him in direct contact with the mechanical gripper. The robot might grip, clamp, and drag the hand while performing the pick-and-drop operations, risking severe hand injuries.

TECHNICAL GLITCH

When multiple robots are moving close to each other, a proximity sensor failure may result in repeated software errors. This might induce collision, and the person standing nearby will suffer significant physical injury.

NAVIGATIONAL ERRORS

The robot navigates the specific warehouse area, and if a worker or a visitor comes nearby, it risks severe collision impact.

PRODUCT/ HUMAN DAMAGE

Industrial robotics can drop packages close to the person, who can get hurt due to the falling impact. The product quality also suffers, impacting the credibility of the firm.

FUTURE SCOPE FOR ROBOT PALLETISERS

The power of AI is no longer optional, and the demand for instant order fulfilment is prompting the shift towards a fully automated warehouse management system. Visual perception, speech recognition, and real-time decision-making abilities are expanding the capabilities of robotic palletisers. Precise examination and capturing data of dock door and inventory visibility power the adoption of automation.

Furthermore, intelligent sorting, warehouse safety, and smart yard docking are areas that can facilitate the expansion of robotics. Warehouses deal with thousands of SKUs requiring precise authentication, sorting, and batching into storage bins. Robots offer the dual benefits of automating SKU pickup and capturing accurate information about each item in their database without manual assistance.

CONCLUSION:

The progress towards pallet handling robots will keep rising as more companies join the AI revolution to cut costs, increase operational efficiency, and boost product quality. The future depends on innovative solutions developed by major industry players, research institutions, and other AI-based companies.

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