Method for a manufacturing WIP cart for integrated factory automation systems

Disclosed is a method for a manufacturing work-in-progress (WIP) cart for integrated factory automation systems. Benefits include improved functionality and an improved manufacturing environment.

Background

Conventionally, inventory held on WIP carts utilizes paperwork tickets (paper lot travelers) to document the material contained in the cart. It does not provide any real-time information on the machine being assembled or the direction the cart should proceed in on the floor. No real time dispatching is possible. As a result, finding a particular lot or cart is difficult, which causes delays in material delivery.

Locking carts use standard pad locks.

Paper tickets are posted on each cart to provide lot numbers and a route to move material. A material handler (person) assigned to the area moves from cart to cart looking for the lot by reading the paperwork attached to the cart. This problem is conventionally solved by centralizing the automated storage and retrieval system (AS/RS) to and from each process machine. The route assigned to the lot is adjusted each time the lot/cart returns to the storage system. While in transit, the lot is reassigned by sending an in-plant handler to a particular cart/lot. A liquid crystal display (LCD) downloads the priority information.

Pad locks to maintain high-volume inventory (HVI) control are managed though standard controlled lock keys. Some control is in place to deal with keys, but they can easily be passed person to person, lost/stolen, or used without verification.

The communications implemented for the disclosed method are standardized by several specifications, including the following”

- “Radio frequency identification for item management -- Part 6: Parameters for air interface communications at 860 MHz to 960 MHz”, designated as ISO/IEC 18000-6:2004, dated August 31, 2004, and released by International Organization for Standardization.
- “Universal Serial Bus Specification”, Revision 2.0, dated April 27, 2000, published by USB Implementers Forum, Inc.
- “ZigBee specification”, version 1.0, dated December 2004, published by ZigBee Alliance, Inc. ZigBee is a trademark of the ZigBee Alliance, Inc.

General description

The disclosed method is integration of low cost, off-the-shelf components to create a manufacturing WIP system linked to a factory automation backbone for standard transport carts. The method includes a dispatch tool that provides an operator on the shop floor with the

transport information. Links enable cart lock/unlock and authorization to a specific person for HVI control. The ZigBee™ wireless protocol and active radio frequency identifier (RFID) technology enable the storage retrieval system to guide the manufacturing activity.

The key elements of the disclosed method include:

- Digital picture frame, including an liquid crystal display (LCD), memory, and a USB port
- Boost capacitors or equivalent portable source to provide high capacity battery life with short duration charge
- Digital in-house pager, ultra-bright light-emitting diodes (LEDs), and a reset button
- Wireless ZigBee module for lock actuation using a short range wireless shop floor system, solenoid actuator, locking hardware, including a cart door and operator validation for access
- Active RFID wireless tag with a factory locate feature and an RFID antenna at each work station
- Custom cart parking mat on the production floor

Advantages

The disclosed method provides advantages, including:

- Improved functionality due to providing a manufacturing work-in-progress (WIP) cart for integrated factory automation systems
- Improved manufacturing environment due to eliminating paperwork tracking
- Improved manufacturing environment due to integrating material supply, AS/RS, dispatch, and work-stream systems

Detailed description

The disclosed method is a manufacturing work-in-progress (WIP) cart for integrated factory automation systems. The cart can be located in the factory by RFID or paging. An active RFID tag connects carts/lots to a wireless antenna network that triangulates the location and updates the position on the factory floor. The location information is made available to users on a workstation display (see Figure 1).

Alternatively, the cart/lot location is available by paging the lot (issuing a locate page). The user scans an area and look for the flashing LEDs (locate beacon) on the cart. When flashing, the user can extinguish the page with the reset button.

The digital picture frame includes an LCD display, memory, and a USB port. The frame presents a large color display containing basic lot information and where to transport the lot.

The cart location is detected using a custom cart parking mat on the production floor. The mat contains a flat laminated conductor antenna for reading RFID passive labels when the cart is parked over the label, which is secured by a pressure sensitive adhesive (see Figure 2).

During movement to a machine or process location, the cart and transport information is updated in near-realtime. Lots are dispatched from the AS/RS directly to and from each process tool (see Figures 3 and 4).

The disclosed method prevents the cart paperwork from being misplaced or switched. The MIP carts and workstations are linked to the factory automation system. Color visual information indicates the package type. Electronic validation provides secure HVI control using wireless actuation. Material can be rerouted if the destination machine is disabled while the WIP cart is in transit. The method provides the lot location of all material, all carts at machines, and all lots spontaneously by way of RFID or in-house paging. The disclosed method provides status information for material control, scheduling, and dispatch.

The disclosed method can be implemented using the following steps:

1. Install a locking door, solenoid, and latch mechanism to a cart to receive the output of the wireless ZigBee module, and install a local computer module to a station control or work-stream terminal.
2. Attach a standard RFID label with a bar code as a cart license plate.
3. Optionally, use an active RFID tag for a plant antenna matrix to read and triangulate cart position within the factory.
4. Mount an LCD digital picture frame, batteries (capacitors), pager unit, LED, and USB download connector. Connector docking should be achieved as the cart moves to the load/unload position.
5. Install the ZigBee wireless module.
6. Install wiring and verify all connections.
7. Perform software modification as required to enable cart features, such as in plant locating and dispatch.

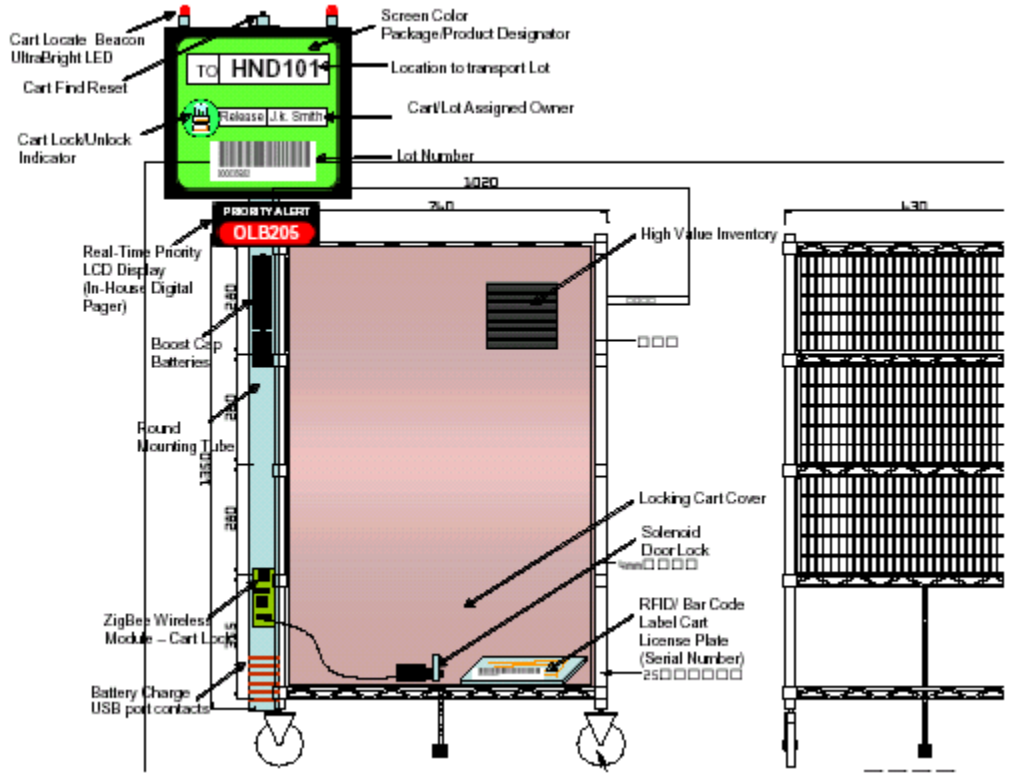

Fig. 1

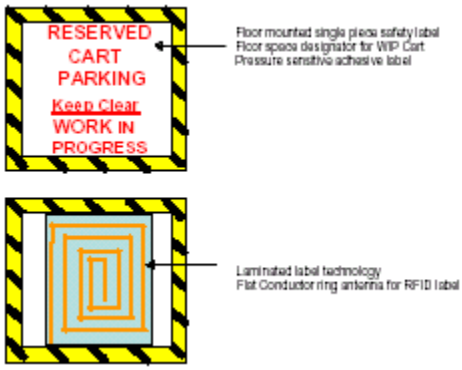
RESERVED
CART
PARKING
Keep Clear
WORK IN
PROGRESS
Floor mounted single piece safety label
Floor space designator for WIP Cart
Pressure sensitive adhesive label
Laminated label technology
Flat Conductor ring antenna for RFID label

Fig. 2

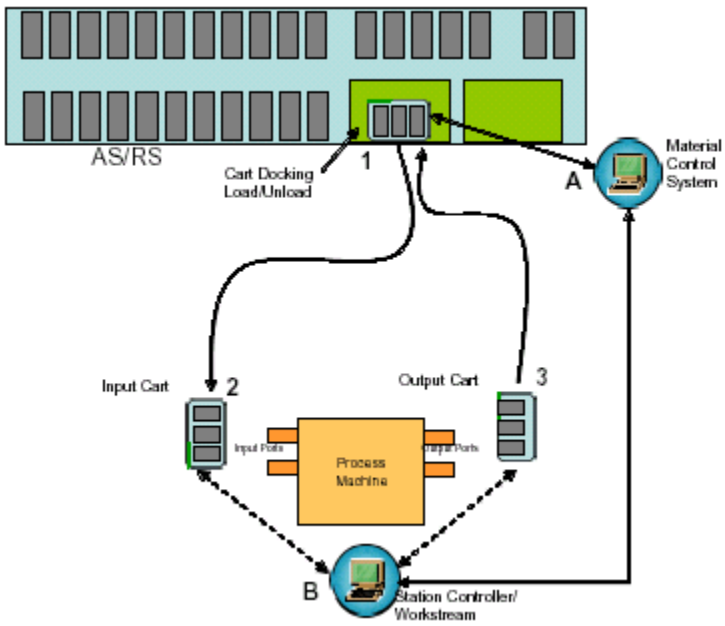
AS/RS
Cart Docking
Load/Unload
1
A
Material
Control
System
Input Cart
2
Output Cart
3
Input Ports
Output Ports
Process
Machine
B
Station Controller/
Workstream

Fig. 3

Cart/Material Movement	Material Control System/Station Control/Work Stream	Process Machine Auto Actions
Move cart to AS/RS L/UL - 1	System checks full/empty/partial Cart ID/Lot ID transmitted to A via RFID or bar code (BC)	Cart connector contacts USB and recharges.
AS/RS Loads cart contents	MCS and dispatch engine determines lot/or material schedule based on product route and tool availability LCD picture frame downloads lot number, location to transport the lot, list of acceptable operators assigned to cart to enable unlock	Lock/Unlock validates the tray quantity Battery high current charge, USB connection to MCS computer
Cart ready - transport cart to tool/entity number - 2 Cart set over RFID parking zone label/reader on the production floor next to process tool	MCS waits for arrival at tool entity	RFID label decoded by reader
	RFID label tells SC the lot has arrived because of cart serial numbers	
	Operator signs into WS computer by name and PIN number	
	MCS/SC/WS validates operator can access the lot Bar code scan the lot number on the LCD display	Unlock ZigBee wireless signal sent from local SC computer to the local cart
	SC validates correct lot to process	
		Unlock solenoid fires to unlock cart - LCD photo show Unlock
Cart door opened by operator to access lot		
Input material loaded from the cart to the process machine		
A second cart is staged in the output position	Local machine station controller read RFID and assigns the output material to that cart number	The machine process material Output cart receives digital page from MCS - Priority LCD display provides location to move the cart - ASRS next stop
Operator always maintains watch on priority display or LEDs as the lot is transported to locations - Machine entity updated, if anomaly	Lot number scanned by BC at lot setup sent to MCS resends signal back to SC	Update LCD color screen with Lot number and package color attribute previously downloaded to memory
If Test Bins	Operator scans Lot Number - scans cover tray bar code label and scans BC describing Bin 1, 2 x to assign Bin to a specific cover tray stack	Upon AS/RS unload, BC cover tray scanned for bin number and how to store material
Material finished processing	Operator Process lot finished	Cart Locked by closing doors on cart
Operator transports completed material cart to AS/RS	AS/RS unloads material from cart to storage	
Find Cart Operator pages a particular lot number or cart number from the MCS/SC/WS terminal	MCS/SC/WS will know position of all carts that are in-use at each location - input/outputs to each tool as read by RFID license plates	Pager on the specific cart flashes and LEDs illuminate
Operator resets LEDs/pager when found	RFID location with active tags also update	

Fig. 4

Disclosed anonymously
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Notes from the Tech Writer

- This disclosure contains references to several standards/specifications. Please review them to verify that the item listed is the exact standard and version to which the disclosed method complies.
- When standardized protocols are referenced in a disclosure, the protocol title, publication date, and owning organization must be stated to meet the legal requirements. I could not find the exact title for the ZigBee specification. So, I put in a partial entry in the Background. When I have written “ZigBee specification” in the bulleted list item, the exact title must be inserted between the quotation marks. Otherwise, all references to ZigBee must be removed and replaced with a generic description.