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:
• “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
<table>
<thead>
<tr>
<th>Cart/Material Movement</th>
<th>System/Station Control/Work Stream</th>
<th>Process Machine Auto Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Move cart to AS/RS L/UL - 1</td>
<td>System checks full/empty/partial Cart ID/Lot ID transmitted to A via RFID or barcode (BC)</td>
<td>Cart connector contacts USB and recharges.</td>
</tr>
<tr>
<td>AS/RS Loads cart contents</td>
<td>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</td>
<td>Lock/Unlock validates the tray quantity</td>
</tr>
<tr>
<td>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</td>
<td>MCS waits for arrival at tool entity 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 SC validates correct lot to process</td>
<td>Battery high current charge, USB connection to MCS computer</td>
</tr>
<tr>
<td>Cart door opened by operator to access lot Input material loaded from the cart to the process machine</td>
<td>Local machine station controller reads RFID and assigns the output material to that cart number</td>
<td>The machine process material</td>
</tr>
<tr>
<td>A second cart is staged in the output position</td>
<td>Lot number scanned by BC at lot setup sent to MCS resends signal back to SC 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</td>
<td>Update LCD color screen with Lot number and package color attribute previously downloaded to memory</td>
</tr>
<tr>
<td>Operator always maintains watch on priority display or LEDs as the lot is transported to locations - Machine entity updated, if anomaly</td>
<td>Operator Process lot finished</td>
<td>Upon AS/RS unload, BC cover tray scanned for bin number and how to store material</td>
</tr>
<tr>
<td>If Test Bins Material finished processing Operator transports completed material cart to AS/RS</td>
<td>AS/RS unloads material from cart to storage</td>
<td>Cart Locked by closing doors on cart</td>
</tr>
<tr>
<td>Find Cart Operator pages a particular lot number or cart number from the MCS/SC/WS terminal Operator resets LEDs/pager when found</td>
<td>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</td>
<td>Pager on the specific cart flashes and LEDs illuminate</td>
</tr>
</tbody>
</table>

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.