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(54) **Title**: A RADIO FREQUENCY IDENTIFICATION SYSTEM FOR TRACKING AND MANAGING MATERIALS IN A MANUFACTURING PROCESS

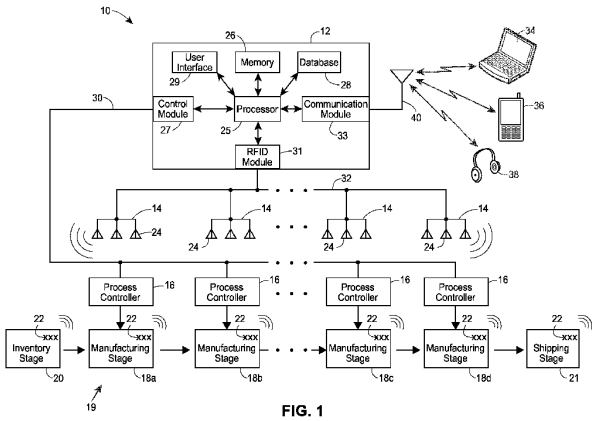

FIG. 1

(57) **Abstract**: A process management system uses a radio frequency identification (RFID) detection system in the form of, for example, a phased array antenna based RFID detection system to track and manage material storage and flow in a manufacturing process or plant. The process management system operates in conjunction with the various machines that implement manufacturing stages or steps of the manufacturing process to assure that the correct materials and processing procedures are used at or on the various production machines of the process to produce a particular product as defined by a job number or job order. The process management system is thereby able to increase the efficiencies of the plant and to increase the quality of the plant production by reducing or eliminating waste, manufacturing errors and shipping errors in the production facility.

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A RADIO FREQUENCY IDENTIFICATION SYSTEM FOR TRACKING AND MANAGING MATERIALS IN A MANUFACTURING PROCESS

Related Applications

[0001] This application claims the benefit under 35 U.S.C. §119(e) of U.S. Provisional Patent Application Serial No. 61/607,406, entitled "Automation Project," filed March 6, 2012 and U.S. Provisional Patent Application Serial No. 61/708,518, entitled "A Radio Frequency Identification System for Tracking and Managing Material Flow in a Manufacturing Process," filed October 1, 2012, the entire disclosures of which are hereby expressly incorporated by reference herein.

Technical Field

[0002] The present disclosure generally relates to using radio frequency identification (RFID) technology to advantageously track, manage and control the flow and or positions of material, such as inventory items, within a manufacturing process or an inventory storage facility, to make the tracking and retrieval of inventory items more automatic and efficient.

Background

[0003] Many manufacturing processes today are highly automated. However, in some industries, manufacturing processes still require manual operation and/or human intervention. An example industry with manually intensive manufacturing processes is the corrugated packaging industry, which typically produces corrugated boxes, point-of-purchase displays, and other kinds of paper based protective and distribution packaging.

[0004] In a typical corrugated plant, the manufacturing process can be generally divided into four stages. In the first stage, rolls of paper material, called rollstock, are received and stored in a rollstock inventory area. In the second stage, the paper rolls are transferred to a wet end area of a corrugator or corrugation machine where the rolls are converted into a continuous corrugated board by gluing multiple layers of paper together in some manner, such as gluing a layer of corrugated paper with one or two layers of smooth paper. At the end of the corrugator machine, the

corrugated board or paper is cut into sheets which are stacked before being placed in a work in process (WIP) area to wait for further processing. In the third stage, the stacks of corrugated sheets are delivered from the WIP area to a finishing area where machines typically called folders and gluers convert the sheets into boxes and other packaging or display products through operations such as die-cutting, printing, stapling, folding and gluing. During this stage, the boxes or other packaging and display products may be printed using, for example, printing plates or may be painted to provide graphics on the products. In the fourth stage, finished goods coming off the finishing area are banded and are palletized to get these finished goods ready for either storage in a warehouse or dispatch and delivery to customers.

[0005] In each stage of the manufacturing process, various manual operations are typically performed. These manual operations are labor intensive and are generally prone to human errors, thereby creating many problems and inefficiencies in the corrugated plant. Such problems occur in inventory management where each received roll must be manually labeled to be registered in the rollstock inventory. The location of a roll in the rollstock area needs to be recorded so that the whereabouts of the roll can be tracked. However, if a worker forgets to record the location of a roll or makes an error in the recording of the location of a roll, then the roll may become lost in the inventory. Poor inventory management may also cause a worker to transfer a wrong roll from the rollstock area to the wet end area of the corrugator machine. If the error is not recognized, then the wrong roll will be used in the manufacturing process resulting in the production of the wrong type of corrugated material or paper, increased cost and poor quality. If the error is recognized, then the worker must go back and spend additional effort to manually search for the correct roll. Moreover, if the correct roll cannot be found, then the worker may be forced to make a management decision by choosing a different roll. As a result, costly unauthorized upgrades may occur in which a more expensive roll is used to make a final product than is needed or called for by a particular manufacturing job.

[0006] Moreover, in many cases, it is difficult to track and manage partial rolls, which are rolls that have been used for one or more jobs, but which still contain paper material thereon. In particular, operators typically know the approximate

amount of paper on a particular roll within the rollstock area when the roll has never been used or when the roll is first added to the inventory. However, after use, in which some of the paper from a particular roll is removed, the roll is removed from the corrugator machine and is returned to inventory. In these cases, it is necessary to record the amount of paper used from the roll during a particular manufacturing job, which is typically a manual process. If this record keeping is not performed or is performed inaccurately or inconsistently, operators generally do not know how much paper is on a roll or do not trust the records of how much paper is on a roll. In these cases, operators typically opt to use a new (previously unused roll) for a job instead of a partial roll which may or may not have sufficient paper thereon for the job, to assure that the job can be completed without running out of paper on the roll. This procedure leads to the existence of many partial rolls in inventory, which take up space and increase manufacturing costs of the plant because these rolls never get used, or are not matched correctly to the size of the job, thereby creating wasted material.

[0007] Other problems can be found in process flow management of processes where procedures require workers to manually track or label intermediate products and finished goods so that the products can be located and delivered to the next processing stage. For example, intermediate products such as stacks of corrugated sheets must be manually labeled with proper job order numbers in the WIP area to ensure proper delivery to proper work stations in the finishing area. Likewise, finished goods coming off the finishing area must be manually labeled with proper banding sequence numbers so that workers can employ proper banding sequences in the banding machines. However, mislabeling or failure to label the intermediate products may cause considerable downtime or delays in the manufacturing process. Furthermore, errors in manual labeling, may result in costly consequences if the products go missing or the wrong products get made, for example, by having the wrong intermediate products delivered to the work stations in the finishing area or by having the intermediate or finished products get banded using an incorrect banding procedure because a wrong product number or banding sequence number was used to activate the banding sequence.

[0008] Further problems exist in shipping management where the banded finished goods must be manually documented in a loading bay so that a driver can find and

ship the correct products to customers. Due to time constraints, this type of manual documentation is rarely performed. As a result, many times, the needed product is not at the correct location so the driver or loader has to spend a great deal of effort to look for the product in the loading bay. Once the driver finds the correct product and finishes loading the truck, the driver must account for any under/over amount against a customer shipping order. Errors and omissions in the manual documentation process can lead to a myriad of shipping-related problems such as loading the wrong products on a truck, recording the wrong products as being shipped, not recording the products that are shipped, having under/over shipment of products, etc. These problems affect the overall business by making customers feel dissatisfied and distrustful, as well as increasing costs.

[0009] Many corrugated plants have adopted the use of barcode technology to address some of the abovementioned problems. A barcode is an optical machine-readable representation of data relating to an object that is attached to the barcode. While the use of barcodes offers an improvement in accuracy over manual labeling, manual operations are still needed because human operators must place barcode readers in a direct line-of-sight to the printed barcode in order to register a read. Thus, many problems still exist in corrugated plants that use barcodes. For example, problems exist in inventory management where each received roll is registered in the rollstock inventory by manually or automatically placing and scanning a barcode on the roll, and a barcode on the side, or the ceiling, of an inventory aisle where the roll is placed. However, if workers forget to scan both barcodes when storing a roll, or when barcode readers fail, then the roll becomes lost in the inventory. Thus, despite the use of a barcode system, the location of a roll in the rollstock still typically needs to be manually recorded. Moreover, if a needed roll cannot be located in the rollstock, then manual searching and scanning must be conducted in order to determine the whereabouts of the roll. Problems also exist in process flow management procedures that use barcodes. In particular, currently, workers must manually scan the barcode on the products or rolls before moving the rolls or finished product to the next processing or delivery stage where another manual scan takes place to validate the movement. Time constraints and barcode reader failures often compel workers to forgo such scans, which may result in costly errors in the manufacturing process. Furthermore, in locations where outdoor

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