Distributed Palletizing using a Cam Driven Multi Track Material Handling Device

Stephen J. Derby
Rensselaer Polytechnic Institute
Flexible Manufacturing Center
Mechanical Engineering Dept
Associate Professor
110 8th St
Troy, NY 12180
518-276-6991
derbys@rpi.edu

John McFadden
Distributed Robotics LLC
CEO
35 Creek Rd
Wynantskill, NY 12198
518-286-3014
john@distributedrobotics.com

ABSTRACT

A novel palletizing/material handling device has been created. This Patented design was developed by assessing the needs of many industrial companies. This device trades the unlimited flexibility and position addressibility of standard servo driven robots and material handling machines for a limited set of palletizing locations, by use of a multi track cam plate. The resulting combinations of reduced complexity degrees of freedom result in a less expensive and more usable in a distributed palletizing implementation.

PALLETIZING

What is palletizing? It is a process, needed by many manufacturers, that takes a single stream of boxes or cases and places them on a pallet for shipping. Humans, robots or dedicated automation can perform palletizing. Boxes may be placed by 1) moving them one by one, 2) forming a row in the automation system and depositing the row as an entity, or 3) forming an entire layer within the automation system and then depositing it on the pallet.

Manual palletizing is still commonly found in many of today's factories. Some general sources estimate it to be used by over 100,000 firms if one includes all of the smaller "Mom and Pop" companies. Manual palletizing requires very little training, not being a job requiring human intuition or skill. The proposed (and then rescinded) OSHA regulations would have made a large impact on human palletizing due to the repetitive motion injuries palletizing can cause. Case weights and speed would be impacted. Worker Compensation claims are still an active issue, however. Workers performing palletizing are generally among some of the lowest paid in a factory's workplace.

Robot palletizing works well for medium speed and throughput applications. Robots can move one or more cases at a time. They have the most flexibility when it comes to changing palletizing packing patterns, and have quick changeover ability for handling different size cases. They can even handle mixed case lot palletizing. Robots can only reach a limited number of pallets without a pallet highway, in which empty pallets are moved in to replace filled pallets. Some palletizing robots have grippers that can move an empty pallet into place. Robots for palletizing can range in cost from $90,000 to $150,000, depending on options. Fig. 1 and 2 show two examples among many.

Automated palletizing is achieved with three basic approaches: moving a single case, forming a row and moving the entire row as a unit, or forming an entire layer and depositing the layer on the pallet. Single case palletizers can give cost effective solutions for the small producer, starting at $40,000. Fig. 3 shows one type.

Midrange row formers cost from $60,000 on up. Fig. 4 shows a layer forming unit. Most of these work on one pallet at a time, though some units such as the one in Fig. 5 have a rotary table that services 5 pallets at once.

High-speed palletizers can also have an infeed or input conveyor at a higher level than other designs. In this method, the cases are at the maximum pallet height already, thus reducing overall system motion, as in Fig 6.

Fig. 1 Palletizing robot (7) fits into tight spaces while maximizing work envelope (Columbia/Okura)

Fig. 2 4-axis palletizing robot [4] handles heavy payloads (Samsung)

Fig. 3 Case palletizer [8] lifts boxes with flexible suction cups (Stackbot(tm))

Fig. 4 Palletizer machine [7] forms an entire layer, then deposits it on a pallet (Columbia)

Fig. 5 Rotary palletizer [6] services multiple pallets (Priority One)

At the higher speed end, dual layer forming palletizers can achieve 14 layers per minute (Fig. 7), but at a higher cost . This is often the right answer for big producers.

FACTORY PALLETIZING OPTIONS

If any given factory has more than one production line, there may be an overall factory floor plan. The word "may" is important, since many factories are not started from a clean sheet of paper, but rather evolve as products come and go. Some of the following discussions are more often found in factories where a complete redesign is not cost justified.

A generic sketch of a 3-line factory is given in Fig. 8. This sketch represents a great number of actual factories visited by the author. A star marks the end of each production line. One could argue that this layout is by definition illogical, but as the authors have seen during these site visits, not uncommon. A production manager has several options for palletizing:

Fig. 6 High-speed Palletizer [5] has high-level infeed or input conveyor (Kettner)

Fig. 7 Dual palletizer [5] has two pallet loading areas (Kettner)

Option 1: One could have a person manually palletize at the end of each line. Depending on the rate of case output and the length of accumulating conveyors, the manpower needed can range from 1 person per line to 1 person walking back and forth to cover all 3 lines. The latter approach is usually unlikely. When a pallet (located at each of the 3 stars) is filled, a forklift is needed to move it to the shipping area. A path wide enough for pallets is needed (Fig. 9).

A sub-option here is locating several pallets in the end of the line area, so that the operator does not have to wait for a forklift to change pallets. One is able to keep palletizing on a neighboring pallet. To wait would require an accumulator, and the operator would have to be able to work fast enough to catch up to the production rate.

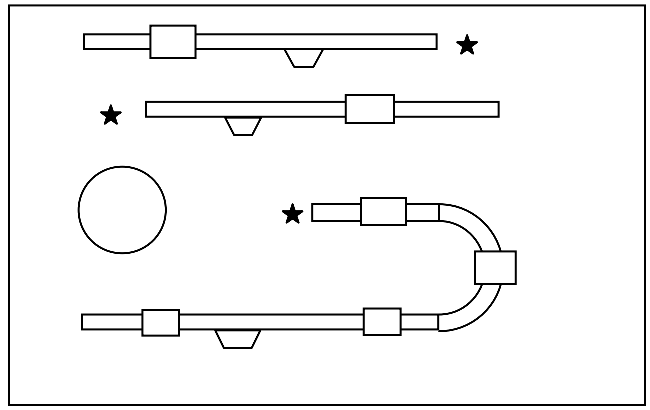

Fig. 8 Generic factory floor – stars mark ends of lines

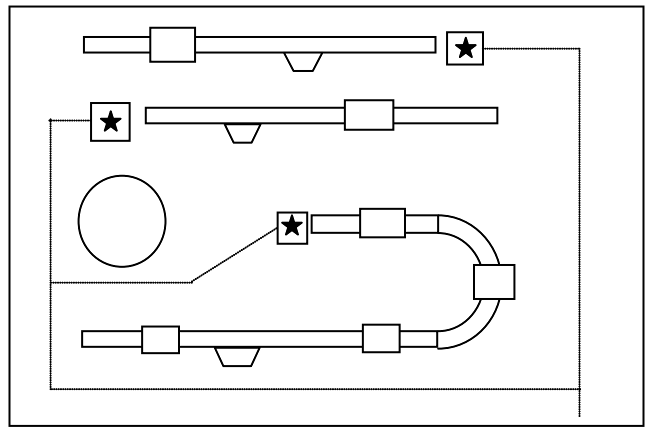

Fig. 9 Pallet locations and forklift paths (dashed lines)

Option 2: A second option is to install a conveyor system that takes the output of the 3 lines and either elevates them to a second floor material handling suite, or moves them to a neighboring room. The authors have seen both approaches used. Fig. 10 represents the conveyor system with the paths marked by dashed lines.

A third option also represented by Fig. 9 is the use of a palletizer.

The material handling suite would contain some buffers for accumulation of product, a tracking system if the product becomes mixed as implied in Fig. 10, or a set of buffers if each line output is kept segregated. A high-speed palletizer (or two) would be used to create a pallet load of each product upon receipt of a pallet's worth. A standard robot system would not necessarily have the required throughput.

Option 3: A third option would be represented again by Fig. 9, where a palletizer is placed at the end of each line, around the marked star. This approach becomes practical when the price of the appropriate capacity palletizer is cost effective. This factor depends a great deal on the rate of product production, and the size of the product.

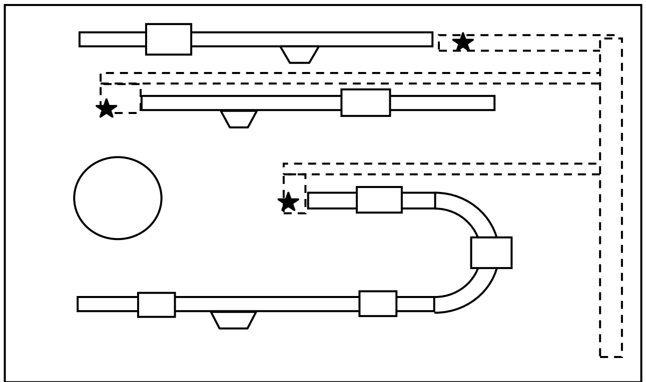

Fig. 10 Conveyor system (dashed lines) moves products to a material handling suite located on another floor or in another room

This product could be a small baked good that is first placed in a carton, and then multiple cartons placed into a case. Or it could be a personal health or beauty item, which again is relatively small. In these situations, the resulting case packing is performed at a reasonably slow rate. These rates may not justify a standard robotic system.

The same sub-option as in manual palletizing is then available; that is, using a large accumulator (if needed) for a buffer, so as to switch out filled pallets for empty ones. Or, does one use a pallet highway? Or a palletizer that itself can actively handle two pallets?

Use of the third option does define what "Distributed Palletizing" means. Several factories that had implemented a complete material handling suite (Option 2, Fig. 10) have removed the complex system due to operational difficulties. Though one plant was not willing to publicly give all of the reasons, it was stated that it "was not worth the operational costs and the headaches". This plant had reverted to Option 1, manual palletizing at the end of each line.

It is reasonable to assume that a centralized system such as Option 2 should be able to operate successfully and cost effectively, so one has to wonder what the other contributing factors were. However, Option 2 does create a complex system that requires a great deal of product tracking and accumulating.

Other sites visited by the authors used a distributed palletizing approach, and selected the sub-option of having an accumulator leading into a palletizer that serviced a single pallet. Forklift operators were on call to keep the pallets rolling. Overall operations seemed efficient.

A distributed palletizing system with units handling two pallets at a time allows for the sub-option of not having a significant accumulator. This is important when there is little floor space available. Forklifts need to be scheduled only when a pallet is full. The servicing window is much larger and thus production can continue smoothly.

Table 1 below summarizes this comparison, pointing out the benefits of a distributed palletizing approach in some factories. It should be noted that, in other factories, each line's output could justify a larger palletizing system.

STACKBOT$_{TM}$ PALLETIZER

Assume that most palletizing will be done with similar size boxes or containers for many hours/shifts without changeover. With this assumption, there are only a limited number of positions in X and Y (parallel to the floor) that the carton must be move to. Why have an expensive piece of automation hardware (servomotors, linear slides, etc.) that allows for unlimited X and Y position access when only a limited number is needed.

The Patented novel concept here (Fig. 3) is to create a device that uses a selectable multiple cam track plate. The cam track plate's function is solely to determine the X and Y position. In the simplest case, it does not carry any of the load of the payload (box or container), or any vertical load of the device itself. It has a mechanical switch that selects which cam track the payload should travel on. The tracks and switch function similar to a railroad train yard, with the various spurs to allow for train car loading or unloading.

A dedicated unpowered arm would support the payload weight and give the overall rigidity. This arm's sole function is for support, even though it may look similar to a powered robotic arm.

Then the XY position along the cam track can be traversed by applying a linear motion. An electric motor, a stepper motor is used to power this linear actuator. There would need to be rotational pivot joint to allow for appropriate motion.

The cam track plate would be removable, so as to allow for different sets of palletizing locations. Exchanging the cam track plates is done manually. Any current manufacturing method produced from CAD database could create the cam track plate. These plates are held in place by quick release pins, so different boxes or containers could be palletized with a small changeover effort.

CONCLUSIONS

By creating a lower-cost palletizing device, it now opens manufacturing floors to reassess the formation of large conveyor systems to move product cases into a high speed palletizing system. By distributing a series of such dedicated palletizing devices, the operation now changes to the feeding of empty pallets and the removal of filled pallets from various factory locations. Factories that currently have manual palletizing now have an alternative.

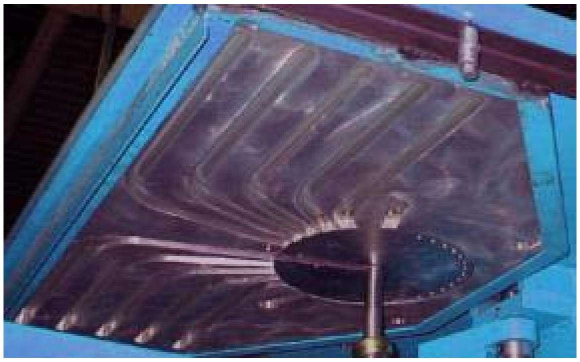

Fig 11 Stackbot Cam Track plate

REFERENCES

[1] "Research in New Material Handling at RPI", S. Derby, Warehouse of the Future Conference, Orlando Florida, pages WOF-4-01 through WOF-4-5 , June 4, 1999

[2] "Novel Palletizer Design", S. Derby, Warehouse of the Future Conference, Atlanta, GA, pages WOF-5 through WOF – 15, May 2000

[3] "Design of the Stackbot$_{tm}$ Cam Track Palletizer/Material Handling Device", S. Derby, N. Kirchner, ASME Mechanisms Conference, Baltimore, MD, pages MECH 14131/1-6, Sept 11-13, 2000

[4] www.apgllc.com/ Samsung Faraman PL2 robot represented by American Productivity Group LLC

[5] www.kronesusa.com/ Kettner Pressant palletizers

[6] www.priorityonepackaging.com/ Rotary palletizer

[7] www.palletizing.com/ Columbia palletizers

[8] www.distributedrobotics.com/ Stackbot palletizer

	Option 1 Manual	Option 2 Centralized	Option 3 Distributed
Palletizing Labor Quantity	High	Minimal	Minimal
Forklift Labor Quantity	High	Moderate	High
Forklift Activity Location	Distributed	Centralized	Distributed
Accumulator Requirements	None If Handles Multiple Pallets	Very Large Depends On Number Of Production Lines	None If Handles Multiple Pallets
Conveyor Requirements	Limited	Very Large	Limited
Floor Space Requirements	Nominal	Need Space For Conveyors And Accumulators	Nominal
Product Tracking Requirements	None	Needed To Keep Correct Product On Correct Pallet	None
Integrated System Control	Only Signal To Get Filled Pallet Removed	Very Demanding	Only Signal To Get Filled Pallet Removed

Table 1 Palletizing Options Requirements Comparison