Automated Component Storage – Key to the Automated Warehouse for Industry 4.0

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Introduction

With the growing interest in industry 4.0, many OEM and EMS electronics equipment manufacturers are making steady progress towards the goals of “smart factories” and “lights out manufacturing”. One of the key requirements for achieving these goals is streamlining the material flow between the warehouse and the production floor, assuring that all components reach the production lines accurately and at the proper time. In recent years, the Automated Component Storage System has come to play a major role in improving productivity and efficiency for many electronics OEM and EMS companies.

Combined with a comprehensive database of all materials, processes, and procedures necessary to manufacture these products and the software systems which must work together to successfully achieve their manufacturing goals, these Automated Towers are providing a powerful tool for both volume manufacturing and high mix environments both. While most companies use an ERP (enterprise resource planning) system to help manage the business, they may in addition be using an MES system (manufacturing execution software) on the factory floor. In addition, the many pieces of equipment used in the manufacturing lines may have their own operating software, maintenance software, individual machine controllers, and line controllers.

The integration and management of these systems is a challenging task. Perhaps the first important requirement to achieving this integration is to have accurate and complete data in the database of materials, processes and procedures. In this paper we address the growing field of automated component storage and retrieval, and its exciting impact on the link between the warehouse and the production floor. In Part I, we’ll examine the different types of component storage towers, and their various features and benefits. In Part II, we will explore the integration of Component Storage Towers with the other hardware and software systems in the factory environment. Finally, in Part III we will discuss the use of automated transport, such as AIV’s (Autonomous Intelligent Vehicles), to collect the materials from the Component Storage Towers and distribute them to the proper locations on the factory floor.

Part I – The Automated Storage Tower

About 15 years ago, the first component storage systems specifically designed for SMT components began to appear in the marketplace. Of course, other types of storage, such as vertical carousels, had been adapted to store SMT reels, sticks, and trays, but systems dedicated for these parts arrived in about 2005. These units deliver the reels or trays in the order called for, and lend themselves to increased traceability and control. Pulling a kit from ordinary shelves, or from a bin in a vertical carousel, involves a person reading the part number, and pulling the correct component for each line item. Human error can and does occur. An Automated Component Storage System automatically reads the bar code on the component reel or tray, and always pulls the correct part, preventing errors. The fact that pulling the wrong component for a kit can result in hundreds or even thousands of misplaced parts resulting in a

huge amount of costly rework, the Automated Component Storage system can pay for itself with this feature alone.

Fig. 1 ISM 3600

The early SMT storage systems held a few hundred parts at most. Today, units holding up to 4,000 reels are very popular. Let's examine the types of systems in the marketplace today.

Fig. 2 Reel in a case

Cases or No Cases?

There are two basic types of SMT storage systems, those who handle bare reels, and those which use cases to hold the reels that are stored in the system. Let's examine the pluses and minuses of both types.

Bare Reel Systems

The bare reel type has the advantage of simplicity. No case is needed, the system just grasps the reel and puts it on a shelf. When the reel is needed, the system grasps the reel through the center hole, and delivers it to the access door. But what possible drawbacks can this method have? The reel must be in good condition. Reels are generally made of plastic, but some are made of cardboard. A chipped reel, cracked reel, warped reel, broken reel, or in the case of cardboard, a floppy reel, can result in an unsuccessful transfer of the reel to or from the door of

the machine, causing a jam and requiring manual intervention. Components in Jedec trays are also subject to the condition of the tray. A warped tray can often cause a jam.

Case Based Systems

In these systems, each component reel or tray is housed in an ESD safe case. This simplifies the handling of the components by the storage systems, as each case has exactly the same dimensions, and the condition of the reel or tray inside does not affect the reliability of handling. Also, the handling robot never touches the reel, tray, or the components inside. It only touches the exterior of the case, so no damage can ever occur to the components.

Fig. 3 Robot Handling a Case

Flexible Case Design

The clever design of the case allows the basic 8 mm 7” or 15” case to handle up to 88 mm thick reels or tray stacks. Expansion strips with quick-turn fasteners allow a base 8 mm case to be a 16 mm case by adding one strip, up to 88 mm in 8 mm increments. This way the customer can adjust the case mix to match any component mix as it changes throughout the year, without needing to purchase different size cases.

Fig. 4 Case with expansion strips

Kits or One at a Time?

The bare reel systems deliver the components one at a time. After the bill of materials for the kit is transmitted to the system, each reel is delivered to the front door, and must be removed before the system delivers the next reel. So, it is necessary that an operator be at the machine during the pulling of each kit. The same is true when loading components back into the Storage System. One reel at a time is placed at the entrance by the operator, who must the wait for the machine to take it before placing the next reel there.

Here the case system has a huge advantage. When the bill of materials for the kit is transmitted to the machine, the system will pull and stack up to 54 reels, without any operator present. When it is finished, it sounds an alarm to notify the operator to come and remove the kit. The operator opens the door and removes the whole stack at one time. The cases make this possible, as they form a neat and even stack, something not possible with bare reels. If more than 54 items are in the kit, the system will resume and pull a second stack of parts. When loading parts into the system, the operator simply stacks the cases, places the stack into the machine, pushes a button and walks away.

The case system requires only 10 seconds of operator time to pull 54 reels, while the bare reel systems requires at least 15 minutes of operator time. If the customer is comparing manual pulling of kits to the case system, over an hour of operator time is needed while the case system still needs only 10 seconds. The Automated Storage System using cases has considerable labor savings over the bare reel system, and huge labor savings over manual pulling of kits from shelves.

The cases give one more benefit. The fact that the cases are stackable, allows secure handling of the components outside the machine. Trying to carry a stack of 50 bare plastic reels is difficult and risky. With the cases, the parts can be carried securely, and protected from ESD at all times.

Fig. 5 Case stack vs. bare stack

MSD

One of the features of most Automated Storage Systems is their management of MSD parts. The storage system can automatically maintain its internal humidity below 5% and automatically track the validity time for each individual component. When an MSD listed component leaves the Automated Storage System, the system starts the clock on that component while recording the exit time, internal humidity, and external humidity. When the part returns to the system, the clock is stopped on the part, and the remaining eligibility time is recorded for the component.

While it is out of the Storage System, warnings will be sent as the component approaches expiration, and can be escalated as the expiration time approaches. If the part is baked to restore its eligibility, a supervisor can enter their code and certify the restored eligibility. When an audit occurs, one has only to enter the component part number and unique id, and the system can print out the life history of that component from receipt until all were used. No clipboards or manual entries are needed. The internal tracking system for MSD is also able to share data with any exterior software system, such as MES, to update the status of the MSD components.

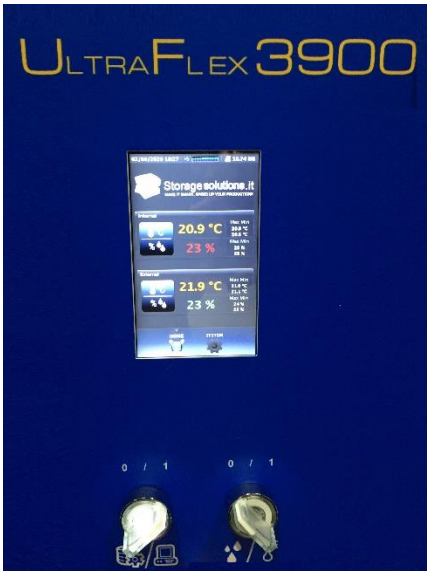

Fig. 6 Humidity display from 3600

Floor Space

One of the additional advantages of Automated Storage Systems is the savings of floor space as a result of the density inside the systems. For space savings, the case-based systems have an advantage here, based on higher internal densities than the bare reel systems. A 3600 reel case based system can save about 70% of the floor space needed by traditional shelving.

Cost Per Reel or Tray

When comparing different Automated Storage Systems prior to purchase, the purchaser should be guided by the principle of cost per reel (or tray), not the cost per Storage Unit. Why is this method important? It is because of the wide differences in capacity between storage systems. A higher cost system may actually be by far the best value, because its large capacity results in a far lower cost per reel stored.

For Example:

Unit F Capacity: 964 reels Cost: $47,500 Cost per reel: $49.27

Unit E Capacity: 3,602 reels Cost: $93,000 Cost per reel: $25.82

So, Unit F has the lower unit cost, but Unit E holds almost four times the number of reels, which results in close to half the cost per reel as Unit F. And it would take almost four of Unit F to equal the capacity Unit E.

UltraFlex

The most popular case-based unit on the market has one more distinct advantage among Automated Component Storage Systems and that is UltraFlex. To understand UltraFlex, we need to review how Automated Storage Systems are put together. Each system is manufactured with a specific configuration. For example, a system could be built with all 8mm shelve spaces, and could only hold 7-inch 8 mm reels. Or it could be configured to hold both 7-inch and 15-inch reels, with a variety of shelf space sizes for 8mm, 16mm, 24 mm, 32mm, 44mm, 52mm, 64mm, 72mm, or 88mm reel thicknesses.

The difficulty with this is that over time the component mix of the customer will change, requiring a different mix of sizes to match the new component mix. This results in two options; Buy an additional storage system with a configuration that when combined with the existing system, meets the customer's new component mix. The second option is to have the manufacturer send a service tech, open up the machine and manually change the shelf size configuration, re-program the system to its new configuration, calibrate the system and close it back up. This can take one to three days to do and will cost several thousand dollars.

With UltraFlex none of this is necessary. Using the adjustable cases previously described in the Case Based System section, cases can be adjusted to meet the new mix. The UltraFlex Storage Unit will accommodate whatever size mix of cases that are fed into it. The space in the machine that is holding a 15-inch 88mm thick case today, can hold three 15-inch 24mm cases tomorrow, and two 15-inch 44mm cases the next day. UltraFlex means that over time, the same unit will adjust to the customer's component mix without the need for modification.

Fig. 7 View of several different height 15-inch cases inside a 3600

Summary

In Part I – "The Automated Component Storage Tower" we covered:

1. **The types and basic features of storage towers**
2. **Bare Reel vs. Cases**
3. **Adjustable Cases**
4. **One component at a time or kit pulling**
5. **MSD component management**
6. **Floor space**
7. **Cost per reel**
8. **UltraFlex technology**

In Part II, we will explore the integration of Component Storage Towers with the other hardware and software systems in the factory environment. These include Pick and Place lines, X-Ray component counters, and both MES and ERP software.

In Part III, we will discuss the used of automated transport, such as AIV's (Autonomous Intelligent Vehicles), to collect the materials from the Component Storage Towers and distribute them to the proper locations on the factory floor. Also, the further steps needed in the quest for the "Lights Out Factory"