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- Meet the CIO – Mr Manesh Patel, Sanmina
- Overcoming Inspection Challenges with True 3D AOI Technology, Koh Young Technology
- The Pathway to Greener Electronics, Electrolube

AN INTERVIEW WITH MANESH PATEL, CHIEF INFORMATION OFFICER AT SANMINA

BY SMT TODAY EDITOR

Machine utilization, throughput, yield and inventory management are just some of the many metrics that are critical to the success of any SMT manufacturing operation. Sanmina operates 500 SMT lines in 75 facilities worldwide, sometimes placing over 25 million components per hour. Recognizing this complexity ten years ago, Sanmina began a digital factory transformation, and have now connected over 25,000 pieces of manufacturing equipment in the cloud.

Our editor met Sanmina's Chief Information Officer, Manesh Patel, to learn how their cloud-based Manufacturing Execution System and IT strategy created an ecosystem to enable more efficient, robust manufacturing results.

Q. Can you give our readers an introduction to Sanmina and your career?

A. Sanmina is a tier one Electronics Manufacturing Services provider producing over 130 million PCBAs per year. In our SMT manufacturing operations, we face complex challenges in a range of industries including the communications, computing, storage, industrial applications, medical, automotive, defense and aerospace markets. The complexity is a result of very high volumes, placement density or unique and new technology. Some examples include class III medical PCBAs manufactured in volumes of 20 million per year, leading-edge communications PCBAs requiring as many as 20,000 component placements and innovative automotive technology that requires sophisticated custom placement methods.

I began my career in information technology more than 30 years ago, working for a well-known global automotive OEM. That experience made me realize the advantages that IT and automation can bring to a world-class manufacturing organization. In the 1990s, I moved to Silicon Valley and applied this experience at a number of early stage semiconductor and advanced electronics companies. In 1997, I joined Sanmina and realized that, as the complexity of products increased, so too did complexity in manufacturing.

Q. What impact did increasing product complexity have on your automation and IT strategy?

A. It drove a requirement for increased sophistication in automation and manufacturing IT systems. As Sanmina's Electronic Manufacturing Services business expanded, our requirements outgrew the capabilities of commercially available Manufacturing Execution Systems (MES). Sanmina also acquired several

Sanmina has 75 factories and 25,000 pieces of manufacturing equipment connected to the cloud, giving executives real-time manufacturing and supply chain visibility, anywhere in the world.

companies in a short period of time. With those acquisitions came many different and incompatible MES systems. This experience allowed us to evaluate a significant number of MES systems and develop a deep understanding of their benefits and shortfalls. A major drawback that we identified was that many solutions focused on the automation of specific functions within the factory. We needed a connected system to reflect the cross-functional nature of work within an SMT factory and to enable robust management of manufacturing processes required to produce the most complex systems in the world.

With the acquisition of SCI Corporation in 2001, another world-class EMS company, we also acquired the MES system they had designed in-house. The system was more powerful and flexible than any other solution we had seen in the market. It became the foundation for what we now refer to as 42Q, our cloud-based MES platform.

Q. Tell me about the impact of big data and Industry 4.0 on your strategy?

A. In the early 2010s, technologies such as the Internet of Things (IoT) and Industry 4.0 were emerging. Customers were designing increasingly sophisticated products. These products required levels of quality, efficiency and advanced automation far beyond anything we had seen in production at the time. At the same time, we were under pressure to lower the cost of ownership of our manufacturing I.T. and MES systems, enable faster time to market and start up manufacturing in multiple locations around the world. Our manufacturing operations needed to be able to:

- Implement engineering change orders faster than ever before.

- Consolidate operations, materials, engineering and quality data from ERP, PLM and other systems.

- Integrate SMT equipment, robotics, automatic optical inspection machines, in-circuit systems and other testers.

- Duplicate production and transfer it efficiently from one location to another.

- Provide high levels of flexibility for product and forecast changes.

- Comply with increased regulatory requirements for the medical, automotive and aerospace industries.

We realized that a cloud-based advanced manufacturing platform would provide a common, shared operating environment that could cover most of these requirements and provide flexibility to scale and change as necessary. As a result, 42Q was developed as

we know it today. Over time, equipment suppliers began to provide connectivity by adopting Industry 4.0 and IIoT techniques. Any gaps in connectivity were closed with the multiple APIs offered on the 42Q platform.

Q. So now you have the cloud-based 42Q MES system and 25,000 devices connected to it. What benefits are you seeing from a business perspective?

A. Let me give you three examples of how we have used connected devices working together in our cloud- based MES to improve component replenishment, manage manufacturing process flow and provide global real-time data visibility.

Firstly, component Replenishment using Autonomous Vehicles

Sanmina can build over 37,000 PCBAs every hour. Keeping SMT lines fed with components is critical. A stock out on the SMT line triggers immediate downtime, resulting in lower line utilization. A typical SMT line costs five million dollars. In a factory with dozens of these lines, downtime results in significant financial impact — and an opportunity for cost avoidance.

A closed loop system was implemented to ensure components are available as required by SMT machines. Our cloud-based MES solution, machine-to-machine connectivity and machine-to-human communication enabled a new approach.

SMT machines provide a supply and usage status of all components loaded on the machine. When a component needs to be replenished, the machine automatically sends a signal to the MES. The MES forwards a replenishment order to the warehouse picking system. The warehouse system prioritizes the pick, an operator locates the component in the warehouse and triggers the replenishment procedure in the inventory management system. The component is then placed at a collection station and an autonomous vehicle collects and transports it to the SMT line where it is needed.

When the robotic vehicle leaves the stockroom, a text alert is sent to a technician, so that he or she is ready at the SMT line to load the material when the guided vehicle delivers the reel of components to the line.

> "AS SANMINA'S ELECTRONIC MANUFACTURING SERVICES BUSINESS EXPANDED, OUR REQUIREMENTS OUTGREW THE CAPABILITIES OF COMMERCIALLY AVAILABLE MANUFACTURING EXECUTION SYSTEMS (MES). SANMINA ALSO ACQUIRED SEVERAL COMPANIES IN A SHORT PERIOD OF TIME. WITH THOSE ACQUISITIONS CAME MANY DIFFERENT AND INCOMPATIBLE MES SYSTEMS."

Next is a Digital Factory, Process Compliance and Forced Routings

This second example ensures that every PCBA built in our factories is manufactured according to the required manufacturing process flow.

Think of an SMT manufacturing process with 15 steps. Five may involve inspection or testing.

Sanmina produces over 100 Million PCBAs per year on 500 SMT lines worldwide.

If the PCBA fails an inspection or a test, it is routed out of the main process flow and is repaired. Then boards are reinserted in-line at the point just before the failure occurred. This practice ensures that each repaired PCBA passes the test it originally failed. Now think about managing the flow of product through the defined manufacturing process at a rate of one PCBA per second. That's the requirement when the volume increases to more than 10 million units per year. The number of permutations of valid process paths that could occur as a result of pass/fail results for an individual PCBA is enormous.

Connecting scanners and equipment to the 42Q cloud-based MES system ensures that each product is manufactured using pre-defined processes. The defined physical manufacturing and test process flow is replicated in the cloud-based MES, and pre-programmed rules validate all activity. At every step of the manufacturing process, each product is scanned and the MES forces it through the defined process flow, ensuring process compliance.

Lastly, global Real-Time Data Visibility and Pro-Active Intervention

The two examples I just described happen within the four walls of a factory. However, Sanmina employs 44,000 people who operate 500 SMT production lines in 75 factories worldwide. Many of these lines operate 24 hours a day. Managing and analyzing the high volume of data generated from facilities in different regions that are manufacturing hundreds of different products is extremely complex. In addition, our executives and plant managers travel frequently to meet with customers and suppliers. We needed a system to streamline the entire process and ensure that the right people had the data they needed to proactively address issues or solve problems as they occurred on our SMT lines.

We developed a cloud-based system that converts data from the MES into a virtual representation of the factory and production. This provides supply chain managers and operations executives with access to a virtual factory floor via laptop, enabling them to view information on the status of component inventory, production problems and delivery schedules in real time.

Data generated throughout the manufacturing and test process is collected in the cloud-based MES and is used to measure and manage yield, throughput, WIP ageing, labor efficiency and productivity. MES data is then converted by the system into visual signals that provide real-time status at product, workstation, production floor, plant, regional and global levels. The system monitors yield, throughput, work-in-process (WIP) ageing, labor efficiency and productivity against predefined targets. If an issue causes an interruption to production or yields fall below target, the system sends real-time alerts to technicians. If a problem is not solved within a defined time period, automatic text and email escalation messages are initiated. Using a cloud-based MES platform enables more efficient and cost-effective management of complex manufacturing processes, with real-time data visibility from anywhere in the world.

Q. Those are very impressive examples. So what do you think is the next major advancement in IT and automation of SMT production?

A. Big data and IIoT technology have matured to the point where they no longer pose barriers to what you want to achieve. Today, it's a matter of deciding what you want to accomplish and applying the right technology to realize your objectives.

In some cases, however, specific technology applications have become very advanced but are not used because of regulatory compliance. For example, we now have the ability to extract data from a solder paste inspection machine on an SMT line that measures the accuracy of solder paste deposition. Automatic analysis of this data could detect when activity is moving towards pre-defined limits so that the paste printer could be immediately adjusted without operator intervention, eliminating the possibility of inaccurate paste application. Because this type of innovation changes the manufacturing process, it goes outside of the rules set forth in regulated markets such as the automotive or medical industries. Finding ways to capitalize on the benefits of technology innovation in highly regulated industries is a unique and compelling challenge, worthy of more focus.

Beyond our SMT production lines, use of a cloud-based MES platform can extend beyond a manufacturer's own operations to third party suppliers that agree to use it, providing insight into the status of their operations and component availability. While still in early stages at Sanmina, broadening the scope and use of our cloud-based MES platform to more suppliers automates the flow of critical data to us in real time, providing comprehensive global supply chain visibility that allows us to react and adjust to potential problems at our suppliers.

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