New integrated manufacturing system boosts fab productivity

At Modulight, all the manufacturing steps and their supporting processes in product development and production have been integrated into a single relational database. The new system has led to an increase in productivity through better manufacturability and support for rapid decision making, write **Seppo Orsila and colleagues**.

Fig. 1. The new database-centered manufacturing system from Modulight consists of a database server, desktop and hand-held PCs, and production equipment.

Modulight, an optoelectronic component maker based in Tampere, Finland, has integrated all of its manufacturing facility's functions into a database-centered manufacturing system. The database stores all data related to production and product development, and helps Modulight to manage and monitor operations in real time. This can also be performed remotely. The system has improved the level of operations in almost every sector, including maintenance, sales, management and customer service. This article discusses the practical benefits of introducing rigorously defined database-centered manufacturing to a production environment.

The Web interface

Modulight's system has been built around a single relational database, which operates on a standard multiprocessor IBM server running Microsoft SQL Server. The production equipment is directly connected to the database (figure 1), and primary access to the system is realized via an integrated Web-based user interface. Some of the specific elements of the access part have been realized by developing stand-alone programs with a graphical user interface using industry-standard software development tools such as Labview and Visual Studio. All of these systems communicate with the database and store all data and parameters in the database itself.

The use of a Web interface makes the system independent of operation systems and it can therefore be used from any PC or hand-held device that has a standard Web browser and a network connection. Most of the system's functions are also designed to work well with the small screen of a Compaq IPAQ portable hand-held device. This has allowed paper-based process notepads to be completely replaced, resulting in lower costs, improved efficiency and increased process monitoring accuracy.

Web access also makes it significantly easier to allow wider access to employees (and eventually to other interested parties) via properly designed extranets. Engineers with secure connections can also access the system from home, allowing fab engineers to work remotely for perhaps the first time in the industry's history.

The Web interface does not need any special client-side software, so updating it can happen solely at the server side, without disturbance to the users. Also, version control of the user interface is simple and the introduction of upgrades that do not interfere with production to the production system is uncomplicated. Upgrades simply appear to users the next time they access the upgraded functionality or resource.

The platform and development tools have allowed Modulight to focus on the system itself rather than the practical implementation. We have found it very easy and cost effective to rapidly improve the system based on the requirements specified by technical personnel.

These days, when outsourcing is in and internal development is out, one might wonder whether the benefits of developing a custom-made system match the efforts required. But when the project is periodically analyzed, combining customer feedback, resources spent and the improvement in operations, the conclusion reached is that the development of the system is an essential part of improving operations when compared with a normal software development program.

A system for every business sector

When a process technician starts working and connects to the database, the system suggests a suitable process step to be performed. This suggestion is based on the competence of the technician, the availability of equipment and the priority level of the various processes in

Production personnel interact continuously with the database as the product is being manufactured and as it passes through various quality control steps.

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Equipment periodic maintenances to come

Equipment	Equipment periodic maintenance type	Due date		
Ultra-1	Change water	2-Oct-2002 09:00	Do maintenance	Omit
Ultra-2	Change water	2-Oct-2002 09:00	Do maintenance	Omit
Surface profiler	Vertical calibration	2-Oct-2002 10:00	Do maintenance	Omit
Vacuum packer	Check the oil level	3-Oct-2002 08:00	Do maintenance	Omit
PL mapper	Clean the unit surface	3-Oct-2002 09:00	Do maintenance	Omit
Epitaxy-2	Daily maintenance for Epitaxy-2	3-Oct-2002 17:00	Do maintenance	Omit
LN2 separator	Check the oil level	4-Oct-2002 09:00	Do maintenance	Omit
LD-production tester	Cleaning	4-Oct-2002 09:00	Do maintenance	Omit
DI water system	Change purification pack	7-Oct-2002 10:00	Do maintenance	Omit
Scriber&Cleaver	Cleaning	7-Oct-2002 09:00	Do maintenance	Omit
RIE	Visual inspection	7-Oct-2002 09:00	Do maintenance	Omit
Mask aligner-1	Visual check	7-Oct-2002 09:00	Do maintenance	Omit
PECVD	Visual inspection	7-Oct-2002 09:00	Do maintenance	Omit
Expander	Cleaning	7-Oct-2002 09:00	Do maintenance	Omit

Fig. 2. Automated maintenance and calibration can be scheduled by the database-centered manufacturing system.

progress. Once the technician has accepted the process step, the database gives instructions for performing that step, i.e. what equipment and input parameters should be used and any process-specific instructions given by the engineers. While running the process step, the processing/quality control equipment and/or the technician feed data to the database. When one process step is complete, the database suggests which step to perform next.

The automatic production-control feature significantly reduces the resources needed for production management, and ensures that production capacity is used in the most effective way. The automatic allocation of process steps not only allows a reduction in the time spent by production engineers in guiding process technicians, but also enables much more complex and efficient logic to be used in workflow management. As listed above, a number of different production parameters can be taken into account when deciding the process order.

One example is maintaining worker competency. The system can be defined to ensure that each operator repeats all the process steps for which they are qualified at least once every two months, ensuring that process technicians remain cross-trained. However, if at the same time we want to choose those individuals with the best track records for high-priority processes, we must apply rather complex logic. This example shows how the completeness of the manufacturing database system can effectively support the company's human-resources process by ensuring the continuous development of personnel. This increases productivity and the ability for rapid change management down to the production floor.

Some advantages, such as assigning each process step individually, might only improve efficiency in a small-company environment, but we believe that significant economies of scale also exist. Indeed, some of the benefits will only appear in larger fabs. Due to the holistic approach required to achieve such benefits as rigorous traceability, interactivity in decision making and future support for all

activities, the basic data structure needs to be very robust and complete. This means that all data must be parameterized if possible, even if the present business model or operations do not necessarily require it. In developing the system we adopted this philosophy, and are now receiving some payback. For example, developing the new functionality requested by users is usually just a matter of adding some logic, parameters or making a new database query. We have found the system easy to integrate with conventional MS Office applications and have produced complex reports in a matter of hours or days.

Challenges of the holistic approach

The completeness is, however, also a drawback. The holistic approach that is required certainly makes implementation time consuming, and the benefits only start to appear after a certain maturity. We have found that this is for three reasons:

- early development of the system requires a lot of basic specification and implementation work, which by itself does not produce anything tangible;
- gaining user confidence and acceptance takes time;
- the system needs to be run for some time to produce enough data to support advanced decision making.

However, we also believe that gradual implementation is the best choice because this allows us to tackle the biggest challenge: obtaining user acceptance via constant dialogue and the integration of the development team with the production team.

Practical benefits

The database-centered manufacturing system also provides support for decision making at the daily production level. The system recognizes failed components, thus preventing unnecessary further processing. It can also be taught to evaluate the need for additional process steps, if the targets were not achieved with the pre-defined processing parameters in the previous steps. All this reduces the possibility of human error and frees human resources for more productive tasks.

For engineers, the database-centered manufacturing system provides a great source of production and product development data. All the data that would otherwise be scattered around the factory in various formats and media is now available from any user's PC in a single format, enabling easy access to product and yield improvement through

statistical process control tools.

For maintenance personnel, the system not only provides a complete record of maintenance, service and calibration, but can also be used to schedule future maintenance and calibration (figure 2). This helps the maintenance personnel to keep track of all the required activities. When equipment is designated out of use by a technician who observes a sudden equipment failure, it will automatically be removed from available resources. Process technicians are then automatically forwarded to other tasks (process steps) while the repair task is assigned to fab maintenance personnel.

To emphasize the robustness of the approach, it is worth noting that the general rules and logic which companies need to implement anyway, can in many situations be even more effective when automated and set to run in real time. Compare a situation in which a system automatically monitors a process parameter such as yield or tolerances of lasers. When control values are exceeded, the appropriate activities are halted or corrective action is taken.

For the sales department, in addition to basic information like real-time storage access, the database-centered manufacturing system provides great tools to improve customer service. As the sales team enter customer orders to the enterprise resource planning system, the manufacturing database system can change production priorities for different products automatically, if such a feature is desired. The sales team can also easily extract product verification data from the database for each shipped component, and detailed process information for each particular component can be delivered. The database could also be used as a basis for an extranet that can provide customer access to real-time information regarding their orders.

For the management team, the database-centered manufacturing system provides almost unlimited analytical capabilities to support factual decision making. Up to date production figures or statistics regarding the use of personnel and equipment resources can be displayed with just a few mouse clicks, providing an efficient way to rapidly reassign part or all of the company's resources.

Conclusions

We have demonstrated that database-centered manufacturing can provide access to simple analysis, lead to an improvement in production efficiency and customer service, and support nearly all of the operational processes found in an ISO9001:2000 company. We believe that this is due to the ease of use, as well as the completeness of the implementation. However, it is important to note that some basic time is needed to achieve the first tangible results that will benefit users. Before reaching this point, users will often consider this type of project as unproductive work, and so user confidence must be won if database-centered manufacturing is to be introduced.

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