Innovative automation technology optimizes production systems for photovoltaic industry

Material handling technology meets IT

As the prices of photovoltaic (PV) products fall, the demand increases. This places the industry under enormous cost and innovation pressures. Reducing production costs and increasing competitiveness requires efficient and highly available production facilities in which the automation platform is of critical importance. Therefore ACI-ecotec, specialists in production systems for crystalline and thin-film photovoltaic modules, depends on Beckhoff control technology.

ACI-ecotec, located in St. Georgen, Germany (relocating to Zimmern in winter 2009), was formed in 2004 by the strategic takeover of Ecotec Automation by the ACI-group. In the process, the company redirected its focus towards the photovoltaic and automotive supply industry. In the photovoltaic product division, ACI-ecotec is a worldwide market leader thanks to innovative developments in the area of material handling technology and contacting, including thin-film modules. ACI-ecotec also works with its partners to develop turnkey solutions.

**PC Control replaces conventional PLC technology**

While focusing on the photovoltaic industry, ACI-ecotec’s heritage of precision engineering and production plant construction has proven to be highly fruitful. The best example of this is the ecoTrans transfer system developed by the company. Originally, this patented transfer system was used in the construction of assembly lines. Now the refined version, ecoTrans Solar connects the process stations in the production of silicon-based and thin-film solar modules. ACI-ecotec is currently installing its material handling technology in a 30 MW thin film solar production line. ACI-ecotec’s supply program encompasses 144 trades which take up around half of the 500 m long production line. ecoTrans Solar integrates a variety of process steps including marking and identification systems, measurement technology and thermal processes as well as special handling tasks such as contacting and dispensing to solar modules. ACI-ecotec uses identification- and laser-marking systems from bo-
raldent, another member of the ACI-group. raldent uses Beckhoff control technology in its products.

"It is one of my jobs to ensure optimum incorporation of Beckhoff control technology at ACI-ecotec," reports Ralf Berger, Software Manager at ACI-ecotec and responsible for overall coordination of the automation and software strategy. The handling system is divided into 14 processing islands. Each segment is equipped with a C6920 Industrial PC as the control computer and a 12-inch CP6901 panel as the user interface, both from Beckhoff. There are additional floating operating panels that can be connected to any point on the production line as required for servicing and maintenance purposes. As soon as the operating panels are plugged in, they are integrated into the emergency-stop circuits of the handling system via the Beckhoff TwinSAFE Terminals.

EtherCAT is an integral element in the automation concept and is used as the primary fieldbus system. The Equipment-to-Equipment communication is via either EtherCAT or PROFINET interfaces, which are operated on the EtherCAT Couplers as a secondary fieldbus. Communication with the various subsystems integrated into the handling system is via ADS, Ethernet, other fieldbuses or RS232 interfaces depending on the manufacturer.
Handling system with highly efficient IT and communication interfaces

“In reality, the ecoTrans Solar handling system is a massive IT project that succeeds thanks to highly effective communication interfaces,” explains Ralf Berger. “The transportation is closely linked to various sub-processes such as identification and inspection. Measurement and image-processing systems in various forms, x-ray inspection systems and our "ecoFlasher" systems with integrated measurement technology all have to be integrated into the handling system." Information technology is becoming ever more important in these processes. “We have standardized the horizontal flow of information from machine to machine (Equipment-to-Equipment),” comments the automation expert. “In addition, we had to take into account the vertical flow of information from the equipment, including the handling system and all its integrated subsystems to the MES level.” The MES is the work of ACI-ecotec’s sister company, acp-IT and meets the SEMI standards applicable to the photovoltaic and semiconductor industry. It permits expansion of any stage, from data collection to full remote control of the production line by the MES as well as coupling with ERP systems from different manufacturers, e.g. SAP. Together with acp-IT, ACI-ecotec has developed a product which it is using for the connection of handling technology and process machinery to the MES. This MES interface adapter enables the control systems of the related machinery and systems to connect to the MES. This product uses the standardized SECS interface protocol and satisfies, as does the MES itself, the valid SEMI standards. Therefore, this product can be operated on the MES of any manufacturer provided it meets the required standards. The MES interface software communicates with the related control system via Ethernet and the TCP/IP protocol. Along with TwinCAT PLC, it also supports PLC controllers from other manufacturers. "These flexible communication interfaces," says Ralf Berger, "have never before been available in this concentrated form in photovoltaic production. With conventional control technology it would have been simply impossible to implement within the time and budget available to us."

Open automation platform permits flexible solutions based on toolbox principle

ACI-ecotec offers its customers a differentiated solution spectrum, i.e. the various photovoltaic production modules are available in different design variants from manual via semiautomated to fully automated MES-coupled operation. To achieve this breadth of variation, ACI-ecotec employs the toolbox principle. For example, a system can be supplied with manual workstations, which can be replaced at a later date with automated processing machinery. ACI-ecotec also offers scalability in terms of equipping the machine modules with special functional features. Otherwise, customers can operate the PV production in an autonomous line without MES connection and retrofit it at a later time. “We don’t need to replace any hardware in the process,” comments Berger. “As long as we are using an Industrial PC from Beckhoff, there are simply no problems when loading and operating the MES interface adapter.” Automation expert Berger rates the Beckhoff I/O system as particularly flexible: “In the ecoTrans Solar we are using EtherCAT as the central bus system and preferably EtherCAT Terminals. We use PROFiBUS to connect
the local handling modules since several of the subsystems integrated into the handling system as well as drives are fitted with PROFIBUS interfaces.

TwinCAT PLC lets you create all types of communication interfaces efficiently and in a very short time. Ralf Berger and his team learned to appreciate this special characteristic of the TwinCAT system when developing the extremely demanding Ethernet-based MES interface adapters. Particularly the fact that TwinCAT runs reliably on any PC with the Windows operating system without requiring any adjustments to the PLC software has proven to be an enormous benefit. “With control systems from other manufacturers,” according to Ralf Berger, “we had to individually test and adapt dozens of hardware configurations with different CPUs and communications modules. You simply don’t have these kinds of compatibility problems or the associated test and development costs with Beckhoff. The EtherCAT fieldbus and the Beckhoff terminal system let us integrate different peripheral devices and subsystems in a very short time whether via secondary fieldbuses or other communication interfaces, such as RS232 or analog interfaces.” The developer team managed to produce a library of software modules in double-time to enable the integration of devices from different manufacturers with extremely varied communication interfaces. “The resulting ‘toolbox’ drastically reduces the development time for follow-up projects,” explains Berger, of the benefits from the open control platform.

Equally convenient is the security aspect of the PV production modules. “Subsequently, retrofitting a plant with additional security modules is not a problem since we decided to use the Beckhoff TwinSAFE security sys-
A particular advantage of the Beckhoff safety solution is that the TwinSAFE Terminals are used throughout the handling system modules rather than centrally and the fieldbuses can be used to transmit the safety-related signals to the control system. This considerably reduces wiring costs and commissioning costs as a whole. As they are programmable, the TwinSAFE Terminals are highly flexible and can be adapted to meet individual site requirements.

Integration of measurement and control systems into the PC controller
For both surface inspection and quality assurance, ACI-ecotec uses image sensors with and without intelligence on-board. Additional measurement tasks typically used in photovoltaic production relate to the insulation and high-voltage measurement of the photovoltaic cells. Particularly in the case of thin-film solar cells, the so-called “flashers” are used for classification. This takes place at the end of the substrate processing and enables the assignment of the substrate to performance classes which determine its ultimate purpose.

ACI-ecotec also uses automation components from Beckhoff in the ecoCure, a new type of machine for curing substrates. “Due to the heating equipment, this involved a great deal of control technology,” reports Berger. “Traditional PLC systems would either collapse under the weight of control loops or would require additional hardware solutions, which would cost substantial amounts of time and money. Beckhoff’s Bus Terminals and TwinCAT software offer huge benefits in this area.”

Achieving high levels of communication and integration
The development of ACI-ecotec from simple machine manufacturer to process and system provider requires the corresponding expertise in communication technology and software. Ralf Berger is delighted that the Beckhoff platform meets all of these requirements: “The PV industry is closely related to semiconductor production so attention is increasingly focused on data-linking between the equipment and the production control level. Against this background, the subjects of software interfaces and data exchange have become immensely important. We are particularly impressed by Beckhoff’s integration of the PC-based control system into the Microsoft world and its easy programming.” The TwinCAT Libraries couple an extensive range of communication systems – whether they be Ethernet, EtherCAT or other fieldbuses – offering variable solution concepts. “ACI-ecotec uses any opportunity to use the functionalities provided in the TwinCAT Libraries,” assures Ralf Berger.

Efficient and successful
The flexibility of the Beckhoff platform offers great benefits in terms of the straightforward connection of peripheral process equipment. However, in the opinion of Ralf Berger: “It is surpassed by the impressive software possibilities and communication options. We also capitalize on the benefits of being able to couple drive technology and the fast I/O terminals. In one project, for example, which involved coupling our handling system with a process module from another manufacturer also fitted with Beckhoff control technology, we came up with an extremely elegant solution to the transfer of the substrates. The challenge was to feed the substrates, which are supplied with specific voids, flush into the process station. For this purpose, we coupled the Beckhoff Controllers via an EtherCAT bridge, then linked in the drive controller of the process station in real-time and controlled the AX5000 EtherCAT Servo Drives from Beckhoff to consistently guarantee flush transfer of the substrates. The problem was solved in just two days both efficiently and successfully.”