Freddy Müller, Siemens Switzerland AG, explains the importance of wire saw management which could significantly improve yields quickly.

Successful investment in alternative energies takes relevant innovations into account – not only of the energy technology itself, but also of the procedures in component and plant engineering. The best example of this is an innovative wire sawing machine: Significantly improved yields in wafer production, faster processing and minimized consumption of materials have reduced the unit costs to such a degree that competition and market action are influenced with lasting effect – this is underscored by the latest sales figures.

The lion’s share of unit costs of a photovoltaic wafer is represented by the raw material of silicon and the diamond cutting wire that is used to slice the silicon brick into wafers with a thickness of between 100 and 180 μm. The main approaches to improving productivity and lowering costs in wafer production, therefore, are to increase the yield for each brick of silicon, for each working shift and for each machine, as well as reducing the consumption of diamond wire.

One company has significantly further developed wire saw technology in the past few years: The Swiss company of Meyer Burger, one of the world’s leading suppliers of solutions for the manufacture of PV components and systems. Its portfolio covers all phases of production: From the sawing and grinding of the still round silicon ingots into rectangular “bricks”, to the manufacture of finished PV modules and ready-to-install PV systems for integration into roof structures or facades.
Leap in productivity as a result of consistent further development

Meyer Burger has been devoting its attention to the particularly cost-sensitive production of silicon wafers for a considerable time. The most important innovative advances in the last few years were the switch from slurry to diamond wire, the diamond wire management systems developed (and now patented) specially for this purpose, the optimization of process technology, and an automation concept consistently optimized for wire sawing. The first machine, in which all of these aspects have been implemented, is the “DW288 Series 3" diamond wire saw equipped with Siemens technology.

More and thinner wafers in a shorter time and with a lower consumption of diamond wire: Meyer Burger’s DW288 Series 3 diamond wire saw combines a patented wire management system, optimized distances and diameters of the wire guiding rollers, and a consistently optimized automation, to create a highly productive overall package with a secure future.

20 percent saving of wire: Meyer Burger’s diamond wire management system (DWMS) improves the service life by reducing wear in the winding area and permits an optimization of the drive technology. The expensive wire remains sharp for considerably longer and can be guided more dynamically during the sawing process.
Wire management saves 20 percent of the diamond wire

Meyer Burger’s patented diamond wire management system (DWMS) is based on a clear separation of the winding areas into a “wire storage area” and a “working area” used for cutting. This winds the section of wire currently in use in a single layer. This means that the very abrasive diamond wire, which is wound in and out during sawing, no longer comes into contact with any adjacent wire, thereby eliminating the wear caused by wire-to-wire contact during the winding processes. The effect is striking: Using Meyer Burger’s DWMS wire management system, the service life of the extremely expensive cutting wire is extended by more than 20 percent.

Capable of using the thinnest wires: more wafers due to narrower cuts

With their perfected, low-wear wire guidance and optimum spacing and diameters of the wire-guiding rollers, the DW288 Series 3 wire saws can productively use the thinnest cutting wires for industrial purposes. With a 70 μm wire, a precise and clearly defined cut is possible on the machine in a secure and high-performance process as standard; even the first 60 μm wires are already successfully in service. To give some idea of what this means:

The cutting wires currently in standard use are in the range between 80 and 120 μm, which means they are barely thicker than a human hair. The possibility now of being able to use a considerably thinner wire reduces kerf loss and makes even more efficient use of the expensive raw material: A 10 μm narrower cut represents a material saving of about USD 100,000 per year per machine.

High-performance control – on the basis of standard industrial components

The synergetically optimized drive technology makes a considerable contribution to the great thin-wire capability of the machine. “Because the working wire is wound in a single layer, the diameter of the winding always remains the same. This simplifies the regulating task of the
winder and means that more of the regulating dynamic is available for maintaining a constant wire tension,” explains Christoph Eggimann, Product Manager Wafering, who is responsible for wire sawing at Meyer Burger at its facility in Thun, Switzerland. “Together with Siemens, we have drawn up an automation concept optimized for this purpose. Controller, drive controller and the servo motors of the wire winder and also the peripheral systems thus form one integrated system from a single source,” explains Eggimann.

The system also uses a customer-specific IFP1500 Touch Panel, an IPC427D Microbox, on which the convenient operating program and a fail-safe SIMATIC WinAC RTX-F 2010 run, which also controls the safety responses of the machine. The drive controller has been programmed with Drive Control Chart (DCC) directly in the drive controller of the SINAMICS S120 type. The sensitive wire is guided precisely by 1FK7 servo motors. The sensors and actuators required for this process are integrated via the ET200SP I/O system with IP20 degree of protection and ET200ecoPN with IP65/67 degree of protection, which simplifies the construction of the machine and contributes to the slim design of the system.

The entire communication uses the high-performance PROFINET, which also promotes the simple and swift diagnosis of the machine. Ultimately, the decisive factor is that, even with the thinnest wires, the sensitive control reliably maintains the extremely fine line between optimum yield and the risk of a wire break: the wire
tension remains constant up to 0.5 N. Without exerting any additional stress on the wire, the cyclic acceleration and braking processes can be configured more dynamically and in addition, a higher cutting speed can be maintained – up to 30 m/s.

“The machine operates at the very limit of what is technically feasible today,” explains Thomas Weber, TPC Manager in Thun. “The consistent automation technology is therefore a key element for ensuring maximum process reliability.” And the concept is bearing fruit: The machine has the lowest quota of wire breaks on the market.

The faster change of cutting direction and the higher cutting speed considerably increase the throughput of the new generation of machines. A 650 mm long brick can be cut in less than two hours into thousands of high quality wafers with a total thickness variation (TTV) of less than 10 μm.

Highly productive – and equipped for the future

The degree of development undergone by wafer manufacture over the past view years is illustrated by a comparison between the DW288 Series 3 diamond saw with the slurry-based DS271 wire saws still widely in use today, in which the cutting particles are applied to the cut not by the wire itself, but by a fluid. For an annual production capacity of 500 MW, 50 slurry wire saws are required. The same output is achieved today by 17 of the DW288 Series 3 machines – and without the enormous cost of storing and recycling large quantities of used slurry. In addition, the amount of kerf loss is minimized by reducing the width of cut from 150 μm to less than 90 μm.

Therefore, the PV manufacturers who switch from slurry-based sawing procedures to the diamond wire technology can make considerable profits by using the latest Meyer-Burger wire saw. In addition to the massive increases in productivity, they also gain confidence in the future, which is urgently needed in the solar energy sector. This is because the trend is clearly toward high-efficiency, thinner wafers. In the case of monocrystalline n-type wafers, for example, the switch to the 100 μm technology is already foreseeable. With the new wire saw from Meyer Burger, PV production is well-equipped for these tasks. A manufacturer of PV components prepared in this way can respond quickly to advances in technology and secure their market shares at an early stage.

Background knowledge: Wafering

THE MOST IMPORTANT ELEMENT of a photovoltaic cell is the wafer – a very thin slice of extremely pure silicon. Wafers are cut from blocks or “bricks” of silicon using wire saws. The extremely thin (and very expensive) cutting wire is guided numerous times over two wire guide rollers, so that it forms a narrow field of wire. Oscillating movements of the rollers make this wire grid a “reciprocating saw” for silicon.

There are two cutting methods, one using a rather smooth wire and one with diamond-coated wire. When sawing with smooth wire, the abrasive particles are applied to the cut by means of a fluid (slurry). These slurry-based procedures now only have a limited competitive value due to their cutting performance: The diamond particles in the slurry “roll” at only half the speed of the wire through the cut in the material. Diamond-coated wires, on the other hand, generally achieve more than twice the cutting speed. In addition, slurry-based cutting procedures involve additional high costs for storing, preparing, and recycling the fluid.

The aim in wire sawing is to cut as many functional wafers from one brick as possible. The critical variables therefore are the cutting accuracy and the width of the cut. The surface of the cut wafer must be left in perfect condition for the following texturing cut. The minimum achievable thickness of the wafer is also dependent on the cutting precision. The width of the cut in turn is an indicator for the proportion of silicon shaved off, in other words wasted, during the cutting process – narrower cuts mean more wafers per brick. The cutting of one brick can take several hours, during which time the cutting wire is stressed to its limits – but the process must not be put at risk by a broken wire. To achieve high productivity, therefore, the reliability of the process as well as the cutting speed is decisive.