All set for a digital future

Smart Plant.

Dr. Michael Kellner* discusses digitisation, emissions and artificial intelligence in glass manufacturing.

Dr. Michael Kellner was born in Jena and had already come into contact with glass as a student through an internship at Schott Glas.

"Glass - that's what it exactly should be" he says in retrospect, having studied building materials and process engineering with a focus on glass in Weimar.

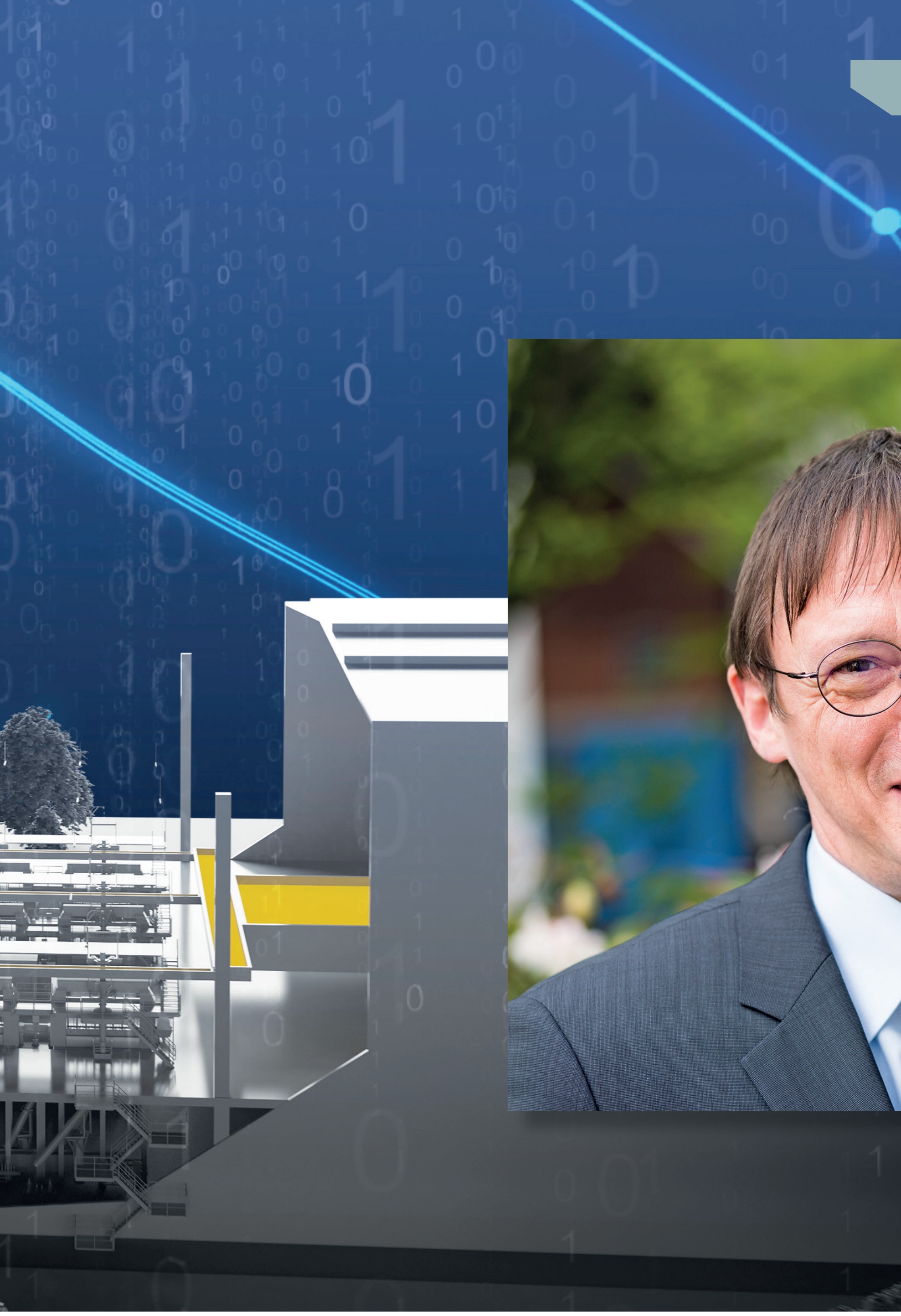
As early as 1986, he was involved with the first image processing cameras and their use for inspecting glass.

"The theory was there, but the technology was not yet powerful enough for the glass industry," he says.

During his doctorate on automation and image processing technology in glass production, Dr Kellner began working at Schott Glas.

After the doctorate, he started as a trainee at the former company Heye-Glas, an innovative, medium-sized enterprise. Initially, he was the link between production and development for introducing automation solutions in glass production. In 1992, he was responsible for testing the first image processing applications based on image processors at Heye, and shortly afterwards he began to develop PC-based image processing solutions. "Experts at the time thought that image processing could never work with a PC," says Kellner. "What a mistake". The 'process engineer' with a doctorate left the company in 2000, but returned to Heye in 2006 as head of development.

Since 2019, he has been responsible for the development of digital systems, a field in which Heye has been involved since the 1990s. It introduced a PC-parameterisable, electronic timing system



Dr. Michael Kellner.

for controlling the IS-machines and the hot end reject system, including the evaluation of pushing glass containers from the dead plate on to the machine conveyor by means of pushers.

The complete hot end process was converted to servo technology, i.e. from gob forming to ware handling.

"This was a huge step into the future, as the motion sequences were now matched and followed by the feedback generators according to the given motion curves," he states.

Shortly afterwards, the first servo motors were also used in the IS-machine to make critical process sequences reproducible and to avoid container defects.

An important component in light glass production is certainly the introduction of the Heye Process Control, which digitally records and visualises the pressing process by recording the plunger positions.

Hot end gob camera

In 1998, Heye worked on a hot end gob camera for recording the cut of gobs.

But the resolution of the cameras and the performance of the PCs was not sufficient enough.

The experiences gained were important to build up the skills for the following years. When the first grabber cards were available, the new Terra computers were bought and a camera-based mould number reader and a camera-based sealing surface tester developed.

The company has converted complete machine platforms because the market has tended to triple and quadruple gob operation.

"Consequently, we made all the hot end equipment 'fit for the future'. Today we offer the complete technology platform for all applications. The further development of sensors and actuators has created new opportunities. Since the introduction of industry 4.0, we are raising the bar higher."

For example, the new IS-machine, the Heye SpeedLine is the first machine that is fully bus capable.

The next development goal was to create areas in the IS-machine where sensors, actuators, the necessary cables and the processor technology could be installed safely and reliably. Safe and reliable means, in this context, protection against heat, oils, oil vapours, water, water vapour, dirt and glass.

"We have succeeded with the

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Smartline2 Cold end inspection machine.

SpeedLine because we have conceived the design differently. The cable routing was first designed and tested where the sensors must be mounted and how we can technically protect them to ensure long-term stability.

"Operating sensors without failure in a 1000°C hot environment is not so easy. Thanks to the bus system, all systems in the machine are networked together and a large number of sensors can be managed.

"This naturally brings with it new possibilities and products, for example the intelligent lubrication interval control - the Heye Multi-Circuit Central Lubrication - which saves oil and increases the lifetime of the components. Also the inline measurement of pressures and temperatures of the equipment should only be mentioned here.

"With this machine, we have taken a giant step into digitisation. There is now a 'Communication Tower' that combines all network components, computers and servers in one cabinet.

"The components are interconnected and communicate with each other. SpeedLine is a platform technology in which components such as robots or measuring and control systems can be easily integrated."

Via the Communication Tower there is also a gateway to the outside, i.e. to the customer.

The Application Programmable Interface Heye SmartLink provides the customer with the data of the manufacturing process for individual data analysis.

"Most of the software is developed by us, especially in the key technical areas.

"The hollow glass industry is a relatively small and special market segment. It is difficult to explain the processes to external companies. There are a few components that we buy, such as sensors. However, the suppliers then work for the glass industry in the long term and are therefore aware of the requirements."

Decarbonisation

The most topical issue at the moment is the CO_2 footprint or decarbonisation. If you took energy consumption and leave the compensation models aside, then it is essentially about the sensible use of energy and the avoidance of energy waste.

"For us as a machine manufacturer, two different directions are relevant when it comes to emissions.

"On the one hand, it is a matter of minimising losses, which means producing as much as 100% of the glass bottles possibly without defects. Then you don't have to throw away glass bottles, don't waste the energy needed to make them and have a better CO_2 footprint.

"On the other hand, the focus is on equipment availability. It is best to operate the machine 24/7 and produce glass bottles without any defects. This also includes minimised job change times.

"To avoid emissions, it is important that errors are found and eliminated as soon as possible. This is why it is important to reduce the gap between cold end information gathering and hot end information processing. To increase efficiency, we use the PlantPilot information system, which records the efficiency situation and messages deviations to those points where corrections need to be made."

This results in an improvement in equipment availability and an increase in yield by reducing transport and quality losses. Efficiency increase and CO_2 reduction are therefore closely related.

Then, ideally, the measurements would have to take place at the Hot End.

"This is not easy, however, because many of these measurements are contacting measurements. And when I contact a hot bottle with a measuring tool, it deforms and becomes unusable.

"We still do not have a solution to how it might work to turn a hot bottle and, for example, to measure the wall thickness. That is not realistic at the moment. Today, we want to measure the parameters of the forming process directly and keep them constant within narrow limits.

"We use infrared cameras at the hot end to identify deviations in the process more quickly and, above all, not to exceed or fall below the limits and to take countermeasures immediately."

This technology is called Hot End Closed Loop. Ideally, non-contact sensors control and regulate the process.

Control loops

Different sensors are also used at different locations for the different process sections. They are then used to influence

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parameters of the gob, the parison or the bottle.

If you start with the gob forming, you use a gob camera to adjust and control the gob shape and gob weight. Also, the gob temperatures can be measured to influence the spout temperature in the feeder. On the blank side, the gob delivery into the blank mould can be detected and adjusted. The tool temperatures on the blank side (blank mould, neck ring and plunger) can also be measured and controlled. Infrared cameras on the machine conveyor are already frequently used today to measure wall thickness distribution and detect global errors. Optical cameras are planned on the machine conveyor for measuring and controlling the container geometry and for detecting glass defects.

The manufacturing process is completed when the glass container passes the annealing lehr. The cold end does not deal with controlling the process.

However, what should be mentioned, is to check automatically whether the inspection machines are set correctly by using sample containers.

However, downstream processes, such as printing or surface treatments for increasing the strength, can also be measured and controlled.

Weight and shape

In the 1990s, a price war broke out for disposable packaging. To save on raw material, energy and transport costs and also to reduce the charges to the dual system for disposable bulk items, projects were launched to reduce the weight of glass containers – that means, to produce with thinner wall thickness.

Heye has an advantage with its experience from H1-2 technology and was able to transfer this to IS-machine technology. A relic of these times is the famous Paderborner beer bottle.

It was shown that the shape has an immense influence on the weight of the container while maintaining its strength. Today, a compromise is sought between an individual bottle shape, volume and weight with sufficient strength.

"If we want to become more ecological, then we will have to compromise on the individual bottle shape in favour of the container weight," he states.

Many machine components and HI products, which were already developed for light glass technology at the time, are now standard in industry. Starting with the Process Control, through axial cooling and hot end transport – all of them components that can be used with know-how for the production of lightweight containers.

Lightweight glass challenges

The characteristic of simple light glass is that it breaks quickly. You can fix this problem with thermal or chemical post-processing, but it will increase unit costs. No one would probably pay a deposit of several Euros for a gorilla milk glass bottle.

For the future, a technology must be developed that is based on the current hollow glass production and is efficient.

"Anyone who manages to increase and maintain the glass surface strength in the production of lightweight glass will be at the forefront in the future.

"I see the big emission savings in the glass industry globally in the recycling of cullet from the market (waste glass collection and processing), because for a glass bottle production from cullet, much less energy is needed than for a production from raw materials.

"Energy savings through heat recovery from the forming processes and in the annealing lehr have further potential. The ecological approach follows the economic approach: If you save energy, you also save money. This is a strong incentive. The biggest cost factor in glass production is energy."

Remote maintenance

For remote access via the Internet, it is essential to consider security. Cyber criminals are lurking everywhere, and so companies are increasingly sealing themselves off. This means service providers cannot get into the company networks to connect to the machine and provide support from there without considerable effort. Solutions must be found in consultation with the IT departments of the customers.

Artificial intelligence

"AI is currently high on the agenda. I am now in the third wave: The first was in the 1980s, the second in the 1990s and the third is rolling now. You can certainly do a lot with artificial intelligence.

"But, you have to keep the boundaries in mind: Artificial intelligence is determined on the basis of learned information from the past.

"To learn a corresponding neural network, a large number of good and bad example objects are needed – we talk about 500 to 5,000 information. Gaining and learning these examples is a huge effort. And when new objects appear, the neural network cannot begin with them."

There are AI applications, the decision is already working very well. In the glass industry, on the other hand, this only works for simple applications, such as reading mould numbers in the seven-segment code. Glass defects, on the other hand, become more difficult because they always look different.

If new information is added that the trained system does not know, AI will not get any further. There are basically no two exactly the same checks.

"Perhaps a combination of imaging processes and neural networks can help, but that is still a dream for the future." ■

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Heye SpeedLine IS machine