# Advanced Bonding &

**As automotive electronics evolve thanks to the rise of electromobility and high-performance power systems, advanced bonding and welding technologies have become critical for reliable, high-efficiency production**

WORDS **KARL VADASZFFY**

Over the past 30 years, Hesse Mechatronics has emerged as a global leader in the field of wire bonding and welding technologies, developing innovative equipment that meets the increasing demands of the automotive industry. Originally rooted in classical fine wire bonding using wedge-wedge configurations, the company has seen its capabilities expand to address evolving technological needs and re, notably in electromobility, hybrid electronics, and high-frequency applications.

The company's early success was anchored in fully automatic fine wire bonding machines, which are capable of handling aluminium, gold, and copper wire with precision. These machines offer not just speed but also configuration versatility, supporting ball-wedge bonding, fine ribbon processing, and deep access configurations. Here, flexibility combines with large working areas and best-in-class placement accuracy.

As the demand for power electronics has increased in recent years, Hesse Mechatronics has introduced heavy wire bonding machines. These systems offer the same core advantages to thicker wires and ribbons, including high accuracy, speed, and flexibility, and are capable of processing materials such as aluminum and copper in multiple dimensions with exceptional reliability. A major milestone during this evolution was the launch of PiQC, the German manufacturer's proprietary inline quality monitoring system. "This set a benchmark for zero-defect manufacturing," says CEO Dr. Hans Hesse.

While traditional ultrasonic metal welding machines offer the capability of welding very large cross sections and bonding areas with high ultrasonic power in the kW range, _ admits they lack the precision and speed that are essential for modern, high-efficiency production lines. "So," he comments, "the next logical step was the combination of both machine technologies to form our smart


welding machines." This merged the strengths of wire bonding systems – flexibility, speed, and advanced process control – with the power that is required for large cross-section welding, ideal for things like power terminals, pins, copper rivets, and sleeves.

Dr. Hesse continues, "This can be ideal for power electronics, such as pulse-controlled motor inverters or traction control modules, and another advantage of this technology is the ability to connect different material combinations, like aluminum and copper, or even bonding aluminum onto steel when, for instance, connecting cells in EV battery packs."

When designing the ultrasonic system for the smart welders, balancing the high-power output and rugged 24/7 performance with the low mass and dynamic speed needed for modern production was a major challenge. "These requirements are contrastive," comments Dr. Hesse. But the result is a powerful and robust, yet fast and sensitive system. "The sensitivity in this context is related to the touchdown of the tool tip onto the welding partners. The mechanical stress during touchdown is determined by the dynamic impulse, which is defined by the mass and speed."

He describes how the low mass of the ultrasonic system, in combination with sophisticated touchdown sensing and very precise, dynamic contact force control, enable outstanding performance.

The company's latest technological advancement is the Hesse Laserwelder, which Dr. Hesse calls "the logical next step in our continuous R&D towards higher power and performance." He reveals that with the industry moving toward cylindrical battery cells of larger diameters, there is the need for welding larger cross sections, particularly aluminum and copper busbars.

"The integrated supply of shielding gas and the extraction of welding spatter is essential for process reliability," he explains. "This is ensured in the machine's welding head, which uses a hermetic hold-down tool to create zero gap between the joining partners." For tolerance adjustment, he details, an image recognition system is used prior to the welding process in order to react to tolerances found in previous production steps."

"A high cycle rate is required for the economic efficiency of the process. This is significantly impacted by the dynamics of the Laserwelder. To maximize the cycle rate, it has a laser welding optic with a significantly lower mass compared to products from other manufacturers."

The Hesse Laserwelder is engineered with a 1.5kW infrared laser, capable of focusing energy

# Welding Solutions


into a spot under 50µm. It features spatial and temporal modulation of the beam, with kHz-range frequency control and linear scanning at speeds exceeding 1,000mm/s. This enables heat management and improved joint quality. Forces of up to 200N can be generated to obtain the zero gap, which is applied by means of force-displacement monitoring.

All machine functions are managed through the company's proprietary software, which simplifies integration into modern MES environments and high-throughput assembly lines. Dr. Hesse comments, "The process data that is obtained can be transferred to the customer's MES systems via standard interfaces such as OPC UA. The laser welder can also be integrated into existing line control systems via fieldbus systems such as Profinet."

"This set a benchmark for zero-defect manufacturing"

Dr Hans Hesse, Hesse Mechatronics CEO


Early on, the company recognized the significant role that can be played by the incorporation of intelligent systems and AI, which remains a feature of ongoing R&D. Current work in this area includes monitoring bonding quality in an intelligent way, assisting the operator in setting up the production process, and intelligent production line synchronization and management.

Observing the industry more widely, Dr. Hesse observes that "the greatest challenge is certainly the technological and financial pressure from competition in the Far East." As such, he suggests that stable framework conditions are required in Europe, free from bureaucratic constraints, while enabling fair conditions in international competition. "Improvements to these framework conditions must be ensured by policymakers," he stresses. "Fair competition will enable us to successfully assert ourselves in the demanding semiconductor and automotive markets. Nationally driven protectionism is detrimental to the long-term economic success of all countries in the world."

Looking ahead, he adds that the push toward decarbonization, energy storage, and electrification will clearly dictate future demands. "The developments and improvements in these areas will also drive the developments and trends in joining techniques," Dr. Hesse says, suggesting that further developments toward higher ultrasonic power for the company's smart welders will be on the agenda.

"Another trend for ultrasonic wire bonding and smart welding will be the offer of fully customized tools and systems, adapted and optimized to the customer's specific application and process." This, he says, includes higher ultrasonic power outputs, customized bonding tools, and more intelligent systems tailored to specific customer needs. "For example, planar and embedded contact technologies in power modules are gaining traction and could supplant traditional interconnection methods."