



Towards intelligent GMAW

African Fusion talks to Paul Kah: President of the Cameroon Welding Association (CWA); a delegate of IIW's Technical Commission XII for Arc Welding Processes and Production Systems; Professor in welding technology at University West in Sweden; a journal reviewer for *Welding in the World*; and the author of a new book: *'Advancements in Intelligent Gas Metal Arc Welding Systems; Fundamentals and Applications'*.

Paul Kah is from Cameroon. He studied there to become a teacher, graduating in 2001. He did a professional Master's degree in science and technology teaching, a five-year in-service programme sponsored by the Cameroon Government, which he completed while teaching in high schools with some part time work at the University of Cameroon.

He then applied to continue his studies overseas and received positive offers from universities in Finland, Denmark and Germany. "I chose Finland and, in 2005, I started my second Master's degree at Lappeenranta University of Technology (LUT) in Finland, this time in Science in Technology. I graduated in 2007 and was intending to return to Cameroon, but my supervisor invited me to continue my research for a PhD, which I started at LUT in 2007. I was then working on hybrid GMAW/laser welding, which involved using state-of-the-art equipment and control features in both of these complex welding processes," Kah tells *African Fusion*.

He finally submitted and

graduated in 2011 and was immediately offered a post-doctoral research and teaching post. After another five years, he applied for a position as an assistant professor. "I was then re-evaluated and promoted to associate professor, so I stayed in Finland until 2020. Then, while applying for a full professorship at LUT, an opportunity opened up at University West in Sweden, so I applied and was awarded a post as a full professor in welding technology," he relates.

As well as having written over 100 technical papers in his career, many in the field of advanced welding process monitoring and control, Kah's most recent publication is a book on Gas Metal Arc Welding (GMAW) that he began to write back in Finland in 2017. "Scandinavia is very strong in modern welding equipment with advanced sensing, digital and software capabilities to control welding processes. To come to grips with these technologies, though, I felt there was a need to understand the underpinning fundamentals of the welding arc the complex interactions between

arc plasma, metal transfer, weld pool dynamics and the solidification behaviour of different materials, which is influenced the simultaneous

interplay of material in the liquid, plasma, gaseous and solid states," he explains.

Called *'Advancements in Intelligent Gas Metal Arc Welding Systems; Fundamentals and Applications'*, the book was finally published in June this year. "I came to Sweden in February of 2020 and, because my first year was less intense and my family was still in Finland, I took the opportunity to focus intensively on completing the book.

From experimental studies of GMAW welds, numerical models have been developed to examine the complex phenomena in a GMAW process, which include electromagnetics, heat transfer, fluid flow, metal transfer, microstructure evolution and thermal and mechanical effects. The studies and models have significantly improved our understanding of the welding physics and have enabled improved optimisation of welding process parameters and more reliable prediction of microstructure evolution and as-welded properties.

'Intelligent systems', he says, while capturing the general nature of modern digitally controlled equipment, also suggest the link to Industry 4.0 manufacturing technologies, which are fast becoming entrenched in across Europe. "Artificial Intelligence is arriving and with the combination of sensors, monitoring software, analytics and process control via online

and/or offline technologies, it is already being adopted in parts of the welding industry," he says.

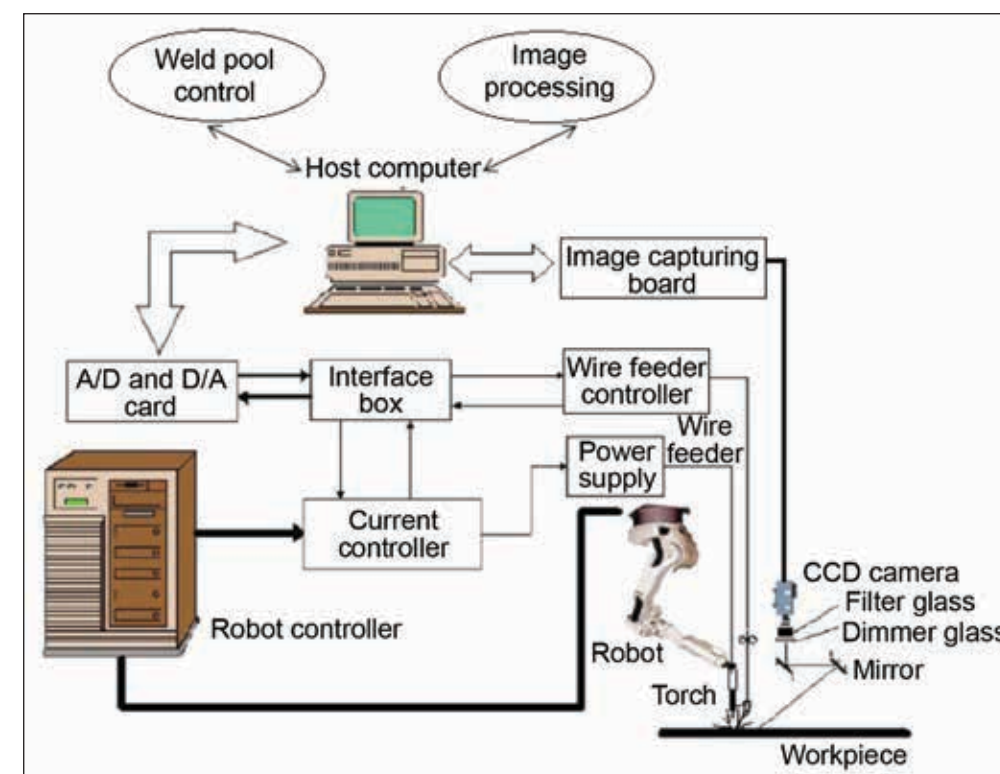
Describing the fundamental welding process control strategy for GMAW, he says that the key focus is on the wire feed rate, the current waveform and the associated voltage: the idea being to optimise droplet transfer efficiency. "This helps us to establish process stability and consistency and, via continuous monitoring, we can track and react to disturbances and rebalance the key parameter to restore stability. This relates well to Industry 4.0, which, at the state-of-the-art, is now being advanced to Industry 4.5.

In support of the need for this book, Kah points to an estimate that over 50% of global domestic and engineering products contain welded joints: "GMAW is currently the most commonly used fusion joint method in product manufacturing, due to its many advantages: applicability for most common industrial metals; suitability for all weld positions; the potential to produce for high-quality welds: its high welding speed; and the fact that it is ideally suited to automation.

"Although GMAW has been used for many decades, the importance of further advancements in GMAW cannot be underestimated," he continues. Fabricators are all looking for more efficient production strategies, resource savings and quality improvements," he notes.

Paul Kah's book provides an overview of the various aspects associated with GMAW, starting from its theoretical basis and ending with the characteristics of industrial applications and control methods. Additional sections cover ancillary processes associated with welding and welding control, such as fuzzy logic, artificial neural networks, and others.

"In view of the increasing industrialisation and urbanisation of modern society, the future looks promising for welding, and it will continue to be an important, productive, and cost-effective manufacturing method. However, steps must be taken to attract skilled personnel into the industry. In addition, changes must be made to accommodate the changing demands of modern society and working life, most notably with respect to the expanded use of welding automation. The welding indus-



A real-time weld pool control system of a welding robot with computer vision. The integration of robotic science, sensor technology, monitoring and control systems, artificial intelligence and other relevant technologies in practical welding applications gives automated systems the ability to make human-like decisions.

try, particularly in Africa, must embrace all modern-day technological tools to keep pace with the rest of the world," he believes.

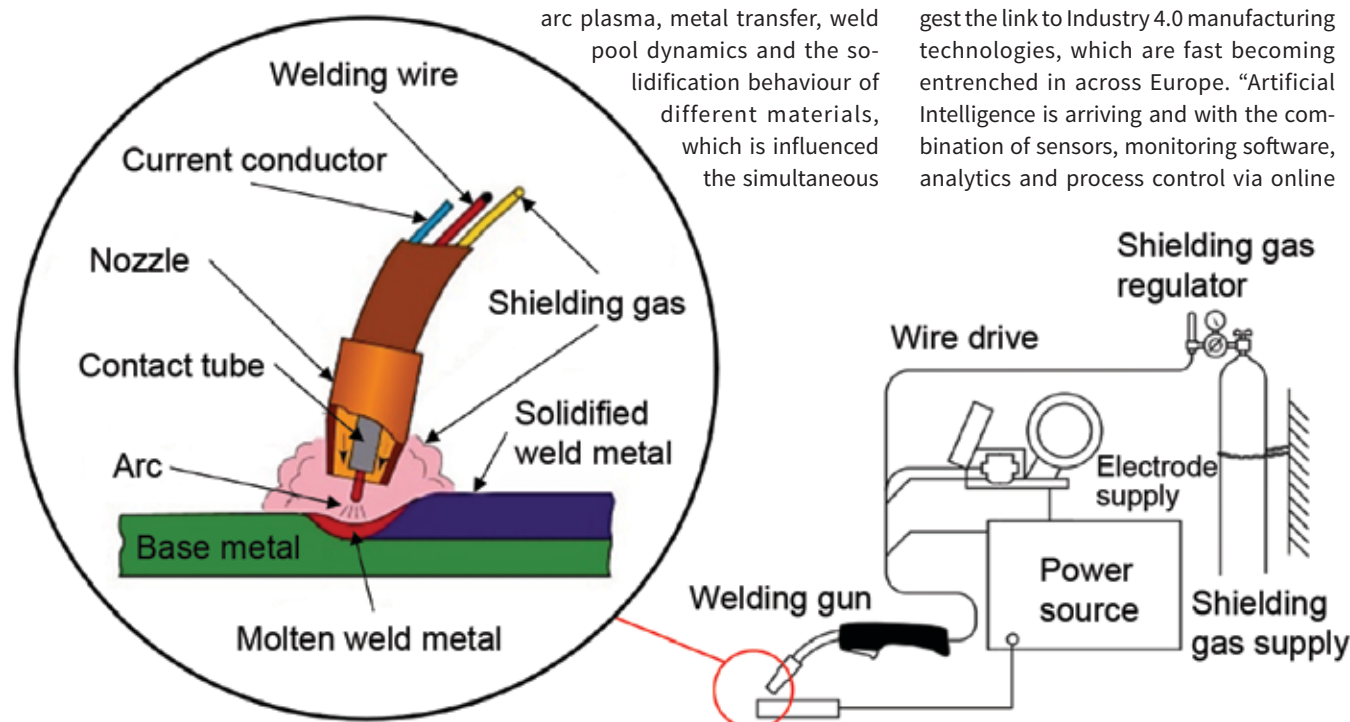
Advancements in Intelligent Gas Metal Arc Welding Systems covers recent advances in the development of gas metal arc welding and experimental studies of GMAW processes, sensing and control of GMAW processes, process optimisation and new applications of GMAW. Readers can gain knowledge across a comprehensive range of welding issues.

Written to be directly useful to welding professionals, the book is also ideal for professionals in the field looking to identify and solve GMAW-related problems: topics and chapters can be accessed and read in any order.

"As modern manufacturing shifts towards automated technologies, research in the field of intelligent robots with the ability to make human-like decisions has been a topic of much interest. This has led to investigations into the integration of robotic science, sensor technology, monitoring and control systems, artificial intelligence and other relevant technolo-

gies in practical applications of intelligent robotic welding. Using computer vision, for example, important information can be gathered about the overall behaviour of a welding system.

Professionals, welding and manufacturing engineers, materials scientists and researchers in the fields of manufacturing engineering, welding, joining, materials science, metallic materials and welding require knowledge of this area of modern welding practice, as do engineers studying for the IIW IWE certificate and students at Bachelor, Masters and Doctoral levels, who represent the future of our welding industry," Kah concludes. ■



A schematic diagram showing some of the complex interactions involved in the GMAW process.



To find out more about Paul Kah's book or to order a copy, scan this QR code.