VirtualArc®

Transforms welding from ‘black art’ to practical science

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The concept of the traditional welder at work in his smithy is being replaced by a more high-tech view of the craft. Who isn’t familiar with pictures of robot welders at work on production lines? Designers and manufacturers take precise and clean mass-produced welds for granted. But teaching a robot to weld isn’t as easy as it may seem.

Whereas a human welder draws on experience and intuition in choosing the correct welding technique and settings, a robot welder must be instructed in every detail of the procedure. Despite the availability of considerable theoretical knowledge, a series of test runs are often required to determine the correct settings. Such runs waste test materials and block robots that could otherwise be seeing revenue generating use. The costs and time involved mean that the number of test scenarios must be limited and the optimum can easily be missed.

ABB has developed a software tool enabling programmers and process engineers to reliably determine the result of a weld. VirtualArc® permits a rapid yet detailed evaluation of scenarios. The reduced need for test runs cuts costs whilst optimizing productivity and quality.

‘Black art’

For many years, welding using the MIG/MAG process has been considered a ‘black art’. Most people know that welding is the process of joining two metal parts together, but very few understand the parameters involved and their bearing on the result.

This ambiguity does not just confuse ordinary people: It is said that when ten welding engineers or welders are asked how a given task should be approached, ten different parameter settings are suggested – all of them achieving the same result!

Complex process

The MIG/MAG process is very complex. To fully understand the theory behind it requires in-depth knowledge of arc physics, fluid dynamics, material science, arc-electrode interaction, amongst others. Very few people in the world have all this knowledge, and of those that do, it is unlikely that any have any practical hands-on welding experience.

On the other hand, many very skilled welders in the industry perform perfect welds without any special knowledge of arc physics and the science behind it. Rather, their choices are guided by so-called ‘feeling’ for the process itself. Such knowledge can therefore be found only in the ‘head’ of each individual welder.

Unfortunately, the number of such skilled welders will most certainly decrease in the future, making it increasingly difficult for the welding industry to be successful.

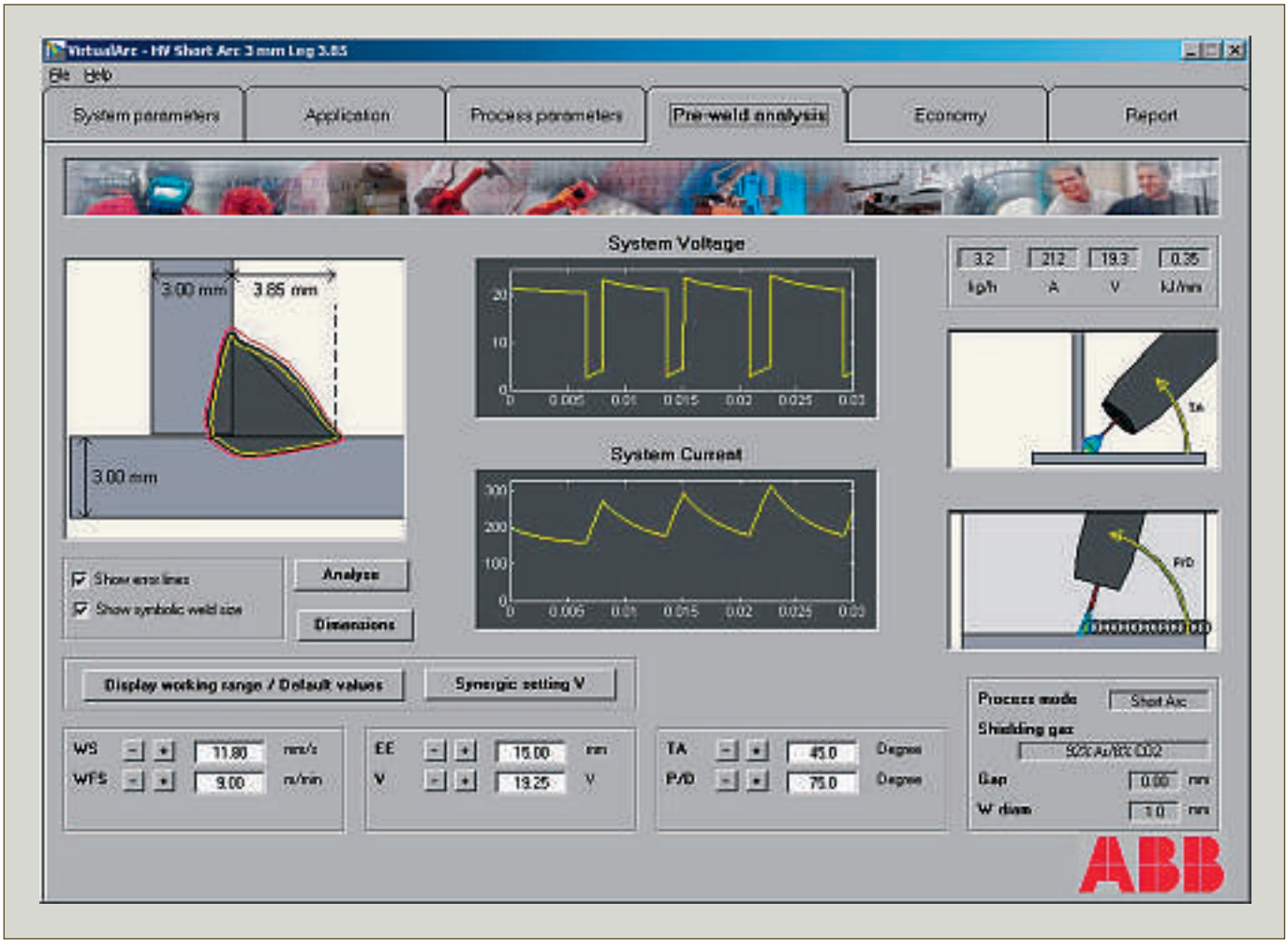
The challenge

Welding equipment suppliers must combine the science behind the MIG/MAG process with practical expertise: Welding must evolve from today’s ‘black art’ to a modern fully controllable manufacturing process.

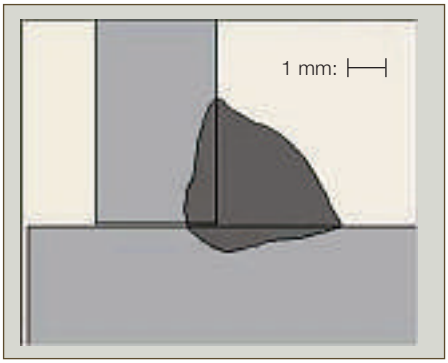
The welding industry itself is interested in raising cost efficiency by using simulation tools as much as possible for production optimization and planning.

ABB have taken up the challenge of serving robot arc welding customers by fulfilling these criteria.

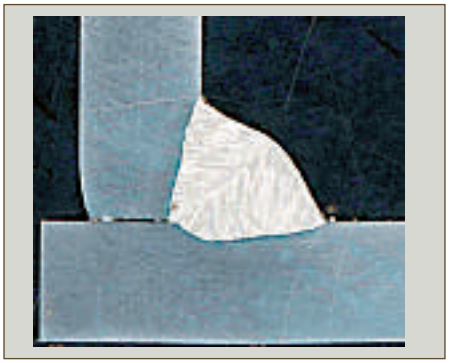
1	VirtualArc pre-weld analysis page. Analysis is carried out using a Bayesian neural network tool.



2 Simulation versus reality



Simulated weld profile



Real weld profile

The product, VirtualArc®

A unique simulation tool called VirtualArc® has been developed to meet the arc welding requirements of customers. VirtualArc® offers robot programmers, operators and welding engineers an 'expert' system providing in-depth analysis of the arc welding process. Its use leads to improvements in process control, final welding quality and productivity.

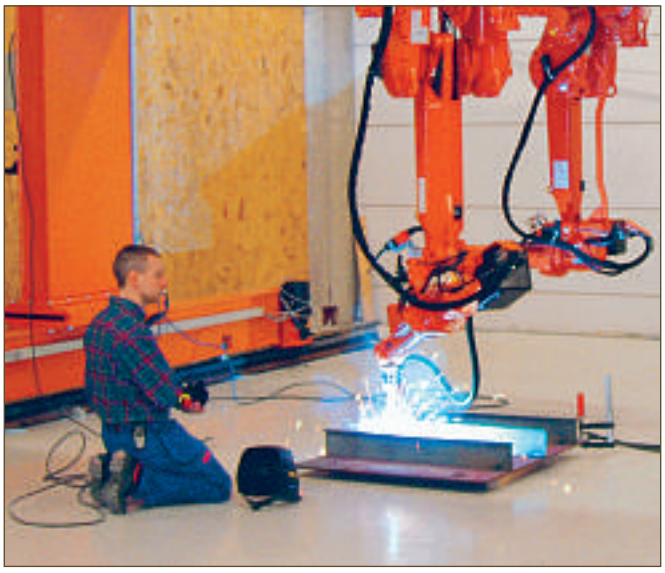
The simulation tool incorporates state-of-the-art technology, facilitating prediction of the dominant phenomena in the weld. Implementation time and costs for automated processes are saved. The robust software package offers a user-friendly interface, which helps minimize process implementation time and hence reduces the costs of automated arc welding.

Arc welding process simulation technology

The technology behind the VirtualArc® software is based on the combination of arc-physics, a self-consistent two-dimensional wire-arc workpiece simulation tool, practical experience with arc welding and experimental results.

The software consists of different modules that are strongly inter-connected with the whole process system, including power source characteristics and connecting cables. Weld profile and quality predications are obtained using Bayesian neural network technology. Predictions from arc simulations, and heat and mass transfer to the workpiece are used as input to the neural network to predict weld quality and profile as well as defects.

3 Robot gantry system during testing and before delivery.



The VirtualArc® software

VirtualArc® consists of different modules with input pages with which the user enters data on the system parameters, the application and the weld process. The first page asks for information on the weld power source, gun, cables and wire feed system. The second asks for the materials, plate thickness, joint configuration, gap, weld geometry and weld class (B, C or D). On the third page details are requested of the wire and gas specifications and whether a short arc, spray arc or rapid arc is to be employed.

Armed with this data, the software then undertakes a pre-weld analysis using a Bayesian neural network tool 1. A further page graphically displays the predictions from the analysis of the weld parameters, the weld profile and the required or default speeds and torch angles. The user can inspect time graphs of current and voltage and a cross section of the weld. The latter shows the depth of weld penetration and profile, enabling the user to assess the quality and knowing the speed, estimate the productivity of the process.
Entering the relevant data literally takes a few minutes. The analysis is completed in seconds. VirtualArc® enables significant time saving by eliminating the need for live weld test runs and the subsequent sectioning of the weld for inspection. In addition to costing time, such live test runs consume components and materials and remove the valuable robots from the production process. VirtualArc® also allows rapid appraisal of 'what if' scenarios. In just a few seconds, the effect of different weld speeds and torch angles can be evaluated, making it easier to find ways of improving productivity and/or weld quality. In addition, there are cost and investment pages that enable the user to accurately and rapidly determine expendi-

ture and justify the application before welding is undertaken.

Simulation versus reality

Whenever software replaces testing, the validity of the results is often in question. Comparison of VirtualArc® predictions with test welding data shows that the simulated weld profile is extremely close to its real weld counterpart 2.

VirtualArc® benefits

Featuring an easy-to-use software interface, VirtualArc® can be operated from a single PC or laptop. It provides users with efficient 'off-line' welding process tuning, which predict a wide range of results including weld shape and penetration, weld quality and possible welding defects.

Predicting such results brings substantial benefits including shorter implementation time, optimised welding productivity and quality, and well documented welding procedures. In turn these considerations contribute to lower production costs.

As well as saving time and money through better production, VirtualArc® is also an efficient training tool for robot operators, programmers and production/welding engineers, and an excellent platform for retrieving and storing arc welding process information for future developments. VirtualArc® is also useful for comparing different weld procedures in cost per metre of weld.

> The welding industry is interested in raising cost efficiency by using simulation tools as much as possible for production optimization and planning.

VirtualArc® in use: the example of Andon Automation

Market pressure is forcing welding equipment users to raise their productivity. One way to do this is by making increased use of equipment; around-the-clock production is no exception. Production stops are costly and must be kept to a minimum.

One company that helps manufacturers meet these goals is Andon Automation. Andon Automation not only provides welding customers with hardware (eg, robots, positioners, robot carriers and welding equipment), but also provides support using advanced software tools.

Two tools from ABB play an important role here: RobotStudio and VirtualArc®. RobotStudio (see textbox) is used to define and create robot programs offline without requiring any real robots to be diverted from their productive activity, and VirtualArc® is used to evaluate and set welding parameters. Both tools eliminate risk and shorten the production time for new programs while maintaining plant productivity.

Göran Bergling of Andon Automation says that 'from a single PC or laptop we can predict close to exact weld configuration, which results in substantial benefits such as short implementation time, optimised welding productivity and quality – all contributing to lower production costs' 3.

VirtualArc® also facilitates cost and investment analysis, enabling Andon Automation to support their customers by providing financial analyses of production scenarios.

Bergling adds that as a supplier of advanced robot systems, Andon sees RobotStudio and VirtualArc® as excellent tools in the application and implementation phases. On top of this, he predicts that customers will benefit from these technologies in years to come.

VirtualArc is a tool that enables quality and productivity to be increased and costs to be cut. Customers are given a head start in a competitive and tough market.

RobotStudio

ABB's RobotStudio software is a tool for simulating the movement of robot arms. Traditionally, robot programming is performed by manually moving the arm of a real production robot through a series of reference positions, which are then recorded. This implies a production break for the robot – a costly and inefficient use of a valuable asset.

RobotStudio offers an alternative by allowing the program to be created on a virtual robot existing only as a model inside the computer. This robot has exactly the same spatial and dynamic properties as the real robot and is controlled by the same program. RobotStudio models the robot in a virtual 3D environment in which potential collisions or spatial constraints can preemptively be recognized. This prevents unpleasant surprises or damage on the real production line later.

RobotStudio can also be used to compare alternative setups or train staff. By reducing programming costs and down time for production lines, this software is helping customers achive higher utilization and productivity on their production lines.

See also ABB Review 3/2001 pp28-30.

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