BIG DATA IN WELDING TECHNOLOGY

White Paper

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SUMMARY

The collection, storage, and processing of vast quantities of data, as summarized by the term “big data”, is assuming an increasingly important role in the production sector. Detailed information on the individual stages of production can help companies to organize their manufacturing operations in a more flexible, efficient, and cost-effective manner. Big data is also a basic requirement for digitally networking production and logistics into so-called smart factories.

Data processing and analysis are also gaining ground in welding technology. Modern welding systems collect information about current, voltage, or wire speed, welding speed, time, and job numbers. These data can be used in various ways: such as for optimizing welding processes, recording the steps to make them traceable, or for intelligent production monitoring.

In welding technology, big data has significant advantages for users from various industries: whether for efficiently manufacturing large quantities, meeting obligations with regard to documentation and supporting evidence, or ensuring a consistently high product quality. Data collection and analysis by a central documentation and management system can be machine-based for individual welding systems, or component-based. Industrial users with numerous power sources find this particularly helpful for improving their manufacturing performance, making it more cost-effective and transparent.

This white paper examines the applications and benefits of big data in welding technology, as well as the challenges that companies face.

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1 TERM CLARIFICATION AND CATEGORIZATION

1.1 THE IMPORTANCE OF BIG DATA FOR INDUSTRIAL MANUFACTURING

Comprehensive digitization and networking is in full swing throughout the industrial manufacturing sector. This trend – known as Industry 4.0[1] – fundamentally changes the way medium-sized and large companies work across all industries. Individual processes are no longer viewed in isolation, but are regarded as part of complex and company-wide value-creation networks. Within these networks, machines and plant, commodities and components, packaging and charge carriers, as well as many other components, are combined into so-called cyber-physical systems, communicating globally via the Internet of Things. This produces intelligent factories, in which the control of all processes by powerful sensors is becoming increasingly autonomous and decentralized. The objective is fast, efficient, and flexible manufacturing – from mass production to batch sizes of one.

One of the key technologies for this epoch-making transformation is commonly known as big data. The term originally described quantities of data that are too large, too complex, too fast-moving, or too weakly structured for them to be evaluated by manual and conventional processing methods. But now big data is also a collective term for digital technologies that are being made responsible for a new era of communication and data processing. In connection with Industry 4.0, this mainly means the collection, storage, and analysis of the vast quantities of information generated during the individual stages of production. This can include sensor data, status data, transaction data, or RFID data.[2]

By continuously collecting and evaluating process-relevant data, companies can configure their production operations more flexibly, and use their resources more efficiently – making sure that machinery capacity is utilized uniformly, for example, or that consumables are available as and when required. The availability of machines and systems can also be significantly increased, along with the stability of the individual processes, by introducing proactive maintenance and servicing measures, or permanent limit monitoring, for instance. Companies can react more quickly to customer requests and requirements, and implement targeted improvements to their products and services. The result is not only cost-effective manufacturing, even of small batches, but also the emergence of totally new business models. One such example is the development of products and services that are individually customized on the basis of customer and user data. There can be no doubt that big data is already playing a crucial role in company competitiveness, and that this trend will gain even more momentum in future.

1.2 WHY BIG DATA IS OF INTEREST TO WELDING TECHNOLOGY

The pioneers of big data usage were primarily the big internet players such as Google or Amazon, and social networks such as Facebook or Twitter. The enormous success of these internet giants spectacularly illustrates just how valuable the resource of data is today. The online platforms also generate a colossal amount of information: every day, Facebook users create four petabytes of new data[3] – that is 4,000 terabytes or four million gigabytes. The calculated total hours of playback time on YouTube are one billion per day[4], and on Google, approximately 3.8 million search requests are placed in a minute, which equates to around 5.5 billion every day[5]. Storing and processing as large a range of user data as possible is an essential part of the business model for these companies, as well as the foundation for profits amounting to billions[6].

But other industries can also benefit from the potential of big data to improve their own value creation – the production sector, for instance. Just like online retailers who draw on user data to analyze the behavior of their customers and optimize their business strategies accordingly, manufacturing companies can also use data analysis to improve the performance of their individual machines and systems, their entire production lines, or complete value creation chains, making them more flexible and efficient. At virtually every step of modern industrial production, process-relevant data can now be obtained, collected, and evaluated – and the ideal way to do this is with a central system that uses this information to universally control and optimize the entire supply chain.

Welding technology is a central component of numerous value creation chains and plays an important role in this development. Here too, data processing and analysis are gaining ground. The traditional joining method was transformed into a forward-looking high-tech process no by the time the welding process was digitized in the 1990s.[7] Modern welding systems consist of several microprocessors networked by bus systems, and have ultra-fast data communication channels both within the machines and outside. They are also already capable of storing massive amounts of information – one of the basic requirements for big data. What makes data analysis in welding technology so interesting for manufacturing companies is that it offers several advantages at the same time.

2 BIG DATA APPLICATIONS IN WELDING TECHNOLOGY

2.1 PROCESS OPTIMIZATION

Big data in welding technology has great potential for process optimization. This is especially important for industries where welded joints have to be produced in large numbers, and maintaining standards for their quality and appearance also puts them under high cost pressure. A prime example of this is the automotive industry, with its highly automated production lines. Here, the work of the welding systems is often robot-assisted, and in many cases, the systems specialize in just a single task. Complex challenges such as joining different materials and demanding geometries are on the agenda here.[8] At the same time, the weld seams produced must also be able to withstand high dynamic loads when used later by the end customer and – at least in visible areas – be spatter-free and unblemished.

It is also crucial to the success of the company that cycle times are reduced as much as possible, and that the cost per unit is kept as low as possible. Every second and every gram that can be saved in the production process is relevant to the total when large numbers are involved. For welding technology, this demands not only ever higher welding speeds, but also a minimal error rate and, ideally, sparing consumption of filler metals and energy – coupled with excellent results, of course. This is made possible firstly by high-precision digital control of modern welding systems, but secondly, by the continuous optimization of the welding process on the basis of the data generated.

2.2 SUPPORTING EVIDENCE AND DOCUMENTATION

A further major advantage of collecting and processing welding data is that it creates transparency and traceability for the individual steps. Which welding system processed which component? Which welding process was used for that? How high was the welding speed, the current, or the wire speed? All these questions are particularly important in industries where quality has to be fully substantiated – in steel construction, for example, or for manufacturers of construction machinery and commercial vehicles, the so-called yellow goods. A strict documentation requirement is in place here – meaning that every step of production must be traceable down to the last detail.[9] If a construction or a machine component then malfunctions or exhibits signs of a defect, the cause is usually quickly identified. This saves time and cost and helps to avoid corresponding errors in the production sequence in future.

With big data, industrial users can collect and document all the necessary data from their welding processes. It is then possible to determine in detail which component has been fabricated in which way – an important criterion for compliance with the strict legislation that exists in many industries. It is essential, especially when the safety of individuals and the environment is at stake, to make every effort to exclude production errors by having full documentation – and should an error still arise, to quickly localize and eliminate it. Intelligent and continuous analysis of the welding data also plays an important part in this.

2.3 PRODUCTION MONITORING AND QUALITY MANAGEMENT

It does not matter which industry is involved: manufacturing companies are usually confronted with high customer demands for quality in their manufactured products. It is therefore crucially important to use specialized monitoring and test systems to permanently ensure this. It is irrelevant whether quality assurance is controlled by standards and regulations, such as in steel, power plant, and pipeline construction, or whether it is the responsibility of the manufacturer, as in the automotive industry.[10] What does matter is that certain characteristics of the finished product meet the specific standard of requirement from which their quality is derived. In the case of welded joints, this includes the geometry of the weld surface, pores and inclusions, surface cracking, strength, leaks, penetration, and hardening characteristics.[11]

All these criteria can be monitored by means of product testing – although this is time-consuming and expensive, especially when large numbers are involved. Ultimately, to ensure perfect quality, all the characteristics of every single part must theoretically be tested by means of various processes. What is more, some criteria, such as penetration or strength, can only be determined by destructive testing processes. This therefore only occurs indirectly, during welding process qualification. Although production sample testing can reduce the remaining uncertainty about whether finished products comply equally with these characteristics, it cannot totally exclude it.

For this reason, it makes sense to monitor not only the quality of the product, but also the quality of manufacturing: after all, production facilities and manufacturing processes have a measurable quality that is closely linked to the end product. Operators can clearly determine whether manufacturing is proceeding correctly or whether there are faults, by means of different parameters. In welding systems, for example, these are voltage, current, wire speed, or welding speed. If all the values observed are within the defined tolerances, the manufacturer can assume that production is error-free. It is then also highly probable that the product quality is perfect. On the other hand, if the values that occur during the welding process are outside these limits, it is highly unlikely that the finished part will meet all the quality criteria in the end.

Big data makes it possible to observe these parameters continuously, in the system cycle time. Because all the process-relevant data are available, the user has the opportunity to configure production monitoring in a way that is ideal for the particular application. The user then has the flexibility to determine which criteria are tested, and how tight the tolerances will be. Manual or automatic intervention options can easily be integrated into the production sequence, to detect and suppress any faults. The only products delivered are those with production parameters within the pre-defined limits – as this suggests that it is extremely likely that the product will be of the desired quality. In many cases, production monitoring can replace expensive product testing. The two methods can also be combined to meet exacting demands – making quality management as reliable as possible for customers and manufacturers alike.

3 THE CHALLENGE OF USING BIG DATA

3.1 DATA SECURITY

To take full advantage of big data in production, all the relevant information must be present in digital form and the stations involved must always be available – even beyond company and site boundaries. Security is an important aspect here: after all, we are dealing with sensitive corporate data, which must never be allowed to fall into the wrong hands. But a certain amount of risk is involved both in local storage and cloud computing.

It is therefore important that welding technology manufacturers pay special attention to data protection when developing new hardware and software products. Various methods are suitable, one of which is using the latest cryptography to encrypt and authenticate the data. Ideally, data transmission should be based on the end-to-end principle, where the sender encrypts the information in a trustworthy environment with a system that can only be decoded again by the receiver in an environment that is also protected. Certificates to verify that the data and the sender are genuine can also be used.[12]

The potential risk of unauthorized access to sensitive data is still one of the reasons for the great skepticism towards big data in many companies. But this can be virtually excluded with the right precautions. Here however, it is not just the manufacturers who are required to implement correspondingly high security measures in their networks, users must do so as well. This starts by changing standard passwords into state-of-the-art secure passwords. What is more, the process data obtained is in many cases far less useful to competitors than companies usually assume. The benefits of big data usually far outweigh the risks. Once companies have recognized this fact, acceptance of the new technology usually increases too.

3.2 BIG DATA VS. SMART DATA

The potential of processing and using production data to create value within a company is great for optimization, but is also a major expense. The quantity, variety, and speed at which the information is produced often pushes conventional IT infrastructures to the limit. New solutions and concepts are therefore required to master the never-ending torrent of data, and keep track of what is going on in the face of increasing complexity.

Basically, big data in its original meaning – that is, collecting vast quantities of data, like the operations of the major search engine providers – is less interesting for industrial manufacturing. This is why the term "smart data" has become established within this main concept, by way of differentiation. It describes useful, protected, and high-quality data that has been identified from comprehensive data inventories. The advantages of this pre-selection are that the amount of work involved is less and the required storage capacities are much lower. In a manner of speaking, big data is the raw material that has to be processed to realize its full potential.[13] Which information is ultimately relevant to the user differs from application to application. In welding technology, for instance, important insights can come from recording external factors such as humidity and temperature. Linking these to the device and process data and analyzing them together could form the basis for further optimization.

4 PRACTICAL IMPLEMENTATION AND RANGE OF FUNKTIONS

4.1 DATA COLLECTION AND PROCESSING IN THE POWER SOURCE

Most of the information that is relevant to the analysis, documentation, and optimization of welding technology tasks is produced within the welding system. Modern power sources are fitted with high performance processors and high-speed bus systems to enable them to process and store it. Universally digitized welding systems have been conquering the market since the 1990s. One of their advantages is that all the data are already available in digital form, and are therefore easier to use. Not only that, but power sources now provide numerous communication and networking options, such as Ethernet, WLAN, Bluetooth, or NFC (Near Field Communication). These make it possible to accurately depict and control even high-frequency arc processes such as CMT (Cold Metal Transfer)[14] in real time. High-resolution data can also be continuously transferred to connected systems, such as an ERP system or analysis software – the basic requirement for using big data in welding technology.

Modern welding systems collect information about current, voltage, or wire speed, welding speed, time, and job numbers. These can be read on a PC or mobile devices, for example. Numerous opportunities are available to the user: these include viewing, editing, and deleting jobs (defined parameters for a specific welding task), or exporting them in different formats and applying them to other compatible power sources. The user is also able to compare the set and actual values for each task, and react quickly if there are deviations. In this way, ongoing production processes can be continuously improved and supporting documentation provided.

Another function is so-called limit monitoring, that is monitoring limit values. The user defines upper and lower limits for certain parameters. The data are stored in the power source and visualized via a web browser, for instance. Now if the value in ongoing production exceeds or falls below one of these limit values, the welding system issues a warning or automatically stops the process, depending on the setting. This enables companies to implement intelligent and individual production monitoring, which can be relied on to protect the quality of their welding processes.

Data communication between the welding system and the user works in both directions. This means that it is also possible to adapt the range of functions of the power source to changing requirements by upgrading. Modern welding systems are usually suitable for several processes and process variants. This flexibility can be vastly improved by offering new characteristics and software updates. This increases investment security, particularly for companies confronted with frequently changing tasks. A universal security system also ensures data protection for each power source communication. For example, access to the different functions is individually controlled by creating different user profiles.

4.2 DATA COLLECTION AND PROCESSING ACROSS POWER SOURCES

Welding systems that make their data available to the user in digital form and which are fitted with the relevant communication functions can also be integrated into a networked and automated production environment. This holds great potential for further optimization – by using a documentation and data analysis system, for instance. The software can collect and evaluate all the information, not only in relation to each machine, but also in relation to each component. This makes it possible, for instance, to have continuous documentation of set values at component level, so that when working with a certain component, each step is fully traceable – an enormous advantage for quality assurance.

Set values such as job data can also be observed and recorded by the system for the entire service life of a welding system. The user can also create and edit jobs centrally, and transfer them to various devices – thus saving valuable time. All the documented data can be evaluated easily and individually using filter functions. This gives users the best possible overview of their manufacturing, allowing them to target individual processes for improvement. The details of all the connected welding systems and their components are visible at a glance on the central dashboard of the analysis system. If a fault occurs anywhere, the operator is immediately informed and can react quickly. This helps manufacturing companies to achieve high-quality production, and is instrumental in significantly reducing costs. Using a data collection and analysis system across power sources is an attractive proposition, especially for industrial users who have to control and monitor a large number of automated welding systems.

5 CONCLUSION

Although welding has been around for one hundred years, it has always kept up with technological advances and has evolved continuously over the decades. Welding technology has not escaped the current trend towards increased digitization and networking in the sector either – and as part of this, big data is currently one of the most relevant topics for the industry and its customers. Collecting, storing, and analyzing vast quantities of welding data has huge advantages for manufacturing companies – whether optimizing time and cost for their processes, meeting specifications with regard to documentation and traceability, or in quality management.

Big data has also changed the focus of welding technology suppliers. For decades, electricity conversion was the key to success, but today, it is the digitization of the welding process. Communication, real-time data monitoring, data storage, cyber security, and intelligent man-machine interfaces are now the driving forces in development. The role of software tools in optimizing parameters or managing wearing parts, for example, is becoming increasingly important. Weld properties used to be determined by hardware alone. The symbiosis of hardware and software has guaranteed the perfect arc for more than 20 years.

This is why modern power sources are being given more and more networking and communication functions to go with their actual task. High performance processors and high-speed bus systems are a basic requirement. Welding data can then be transferred at extreme speeds and resolutions in real time, ready to be used – both in relation to each machine and to each component. Special documentation and analysis systems collect information from all the connected power sources and process them individually in accordance with the user's requirements. The result is a clear saving in time and cost, as well as higher quality and full transparency in production. For welding technology manufacturers, the future will not just be about creating the perfect arc, it must also be fully integrated into an overall process to ensure optimum component quality.

For many companies, the use of big data initially presents a challenge: existing IT infrastructures must be modified and upgraded, data protection issues resolved. After all, sensitive company data must never be allowed to fall into unauthorized hands. However, the relevant safety precautions, and the creation and introduction of suitable hardware and software solutions for processing and using the data, are an expense that as a rule, more than pays for itself. If used properly, the advantages of big data far outweigh the costs and risks.

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