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Адреса
ІЕЗ ім. Є.О. Патона НАНУ
03150, Україна, Київ-150, вул. Казимира Малевича, 11
Тел./факс: (38044) 205-23-90
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THE INTERNATIONAL INSTITUTE OF WELDING: 75 YEARS

J. C. Lippold, S. Egerland, R. Shaw, E. Raufelder

Emeritus Faculty, Department of Materials Science and Engineering, The Ohio State University, Columbus, OH, USA.
E-mail: erdmuthe@iiwelding.net

This year, the **International Institute of Welding** (IIW) celebrates its 75th anniversary as the leading international professional organization devoted to the advancement of welding, joining, and allied technologies. This year also marks the 60th anniversary of *Welding in the World* which was established by IIW in 1963 as a mechanism to publish authoritative papers and other articles that represent the work of the technical commissions within IIW. This article provides a brief history of IIW and its relationship to *Welding in the World*.

1 A brief history of the international institute of welding

The following provides a brief history of the International Institute of Welding. For an in depth account, *Joining Nations* by P.D. Boyd is recommended [1]. The book by David Barnett entitled *Linking people, Joining nations* reviews IIW history from 1990 to 2017 [2].

IIW was officially founded in 1948 during a meeting of international welding societies in Brussels, Belgium. The 13 founding countries were Austria, Belgium, Denmark, France, Italy, the Netherlands, Norway, South Africa, Spain, Sweden, Switzerland, the United Kingdom, and the United States. These countries were represented by 21 technical organizations including Institut de Soudure (France), Istituto Italiano della Saldatura (Italy), the Welding Institute (United Kingdom), and the American Welding Society (USA).

An original organizing principle was the establishment of "commissions" to coordinate and conduct the work of IIW. Initially, five commissions were identified dealing with gas welding, electric arc welding, resistance welding, documentation, and education. By the first member assembly held in Delft, the Netherlands, in 1949, a total of 12 commissions had been established and held their first meetings. A list of these commissions and the inaugural chair for each is provided in Table 1. Commissions XIII (fatigue testing), XIV (welding instruction), and XV (fundamentals of design and fabrication for welding) were subsequently established by 1951. Commission XVI (welding of plastics) was established in 1962.

Over the ensuing years, some commissions were merged and new ones established. For example, C-IV, Documentation was merged with C-VII and replaced by High Energy Density Welding in 1985. A complete history of the evolution of the commission structure can be found in the reference texts [1, 2].

The concept of an "Annual Assembly" began in 1950 in Paris with meetings of the commissions separated into Groups A and B to accommodate attendees participating in multiple commissions. Because IIW membership was primarily European, early assemblies were held in London (1951), Göteborg (1952), Copenhagen (1953), Florence (1954), Zurich (1955), Madrid (1956), Essen (1957), and Vienna (1958). The first annual assembly outside of Europe took place in 1961 in New York City.

2 *Welding in the World* and its relationship to IIW

To quote directly from P.D. Boyd…"one of the most vexed problems which the IIW has had to confront throughout the whole course of its existence is that of making its work known" [1]. In 1956, IIW

Table 1 Initial technical commissions established by IIW in 1949

Commission	Topic	Chair
I	Gas welding and allied processes	C.G. Keel (Switzerland)
II	Arc welding	H.E. Jaeger (Netherlands)
III	Resistance welding	US delegation
IV	Documentation	A. Leroy (France)
V	Testing, measurement and control of welds	P. Goldschmidt (Belgium)
VI	Terminology	F.M. van Horenbeeck (Belgium)
VII	Standardization	A. Leroy (France)
VIII	Health and safety	S. Forsman (Sweden)
IX	Weldability	H.G. Geerlings (Netherlands)
X	Residual stresses	R. Weck (United Kingdom)
XI	Stress relieving	W. Soete (Belgium)
XII	Brittle fractures	F. Jonassen (USA)

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established a Publications Committee which was tasked to address this problem. The idea of publishing an IIW journal was initially rejected partly because it was felt a bilingual (French/English) journal was not practical and too expensive to produce. Instead, a *Bibliographical Bulletin* was adopted to publish abstracts of documents presented at the Annual Assembly. In 1963, a quarterly bilingual journal was launched as *Welding in the World*.

That year there were 4 issues published with 17 total papers. The first editor (1963–1966) was Guy Parsloe. In 1968, the number of issues was increased to 6 per year, a publication rate that remained until 2020 when publication increased to 12 issues per year. From 1968 to 1991, Philip Boyd served as Editor and was followed by John Hicks (1991–1995). From1996 through 2009, the CEO of IIW served as the Editor of WitW and included Michel Bramat, Daniel Beaufils, André Charbonnier, and Cécile Mayer. In 2009, a decision was made to appoint editors external to the Secretariat and Bruno de Meester (Belgium), Thomas Böllinghaus (Germany), and John Lippold (USA) were named as co-editors.

The original publication coordinator at the secretariat was André Leroy (1963–1974). He was succeeded in 1975 by Henry Granjon, who held this post until 1986, followed by Michel Bramat (1986–2000), Nöelle Fauriol (2001–2004), Véronique Souville (2004–2012), Pierre Tran (2012–2016), and Nadège Brun (2016–2020). In 2020, the Secretariat headquarters were relocated from the Institut de Soudure to the Istituto Italiano della Saldatura in Genoa, Italy. As part of this move, Erdmuthe Raufelder (2020–present) was appointed as the Managing Editor of the journal.

For its first 20 years (1963–1983), WitW was published by IIW, then by Pergamon Press until 2001. From 2001 through 2012, it was again published by IIW. As described below, WitW has now joined the Springer group of journals and, starting in 2013, was available in both online and print versions. For the first 30 years, the journal was published in both English and French (Le Soudage dans Le Monde) with the transition to English-only occurring in 1994. With all these changes, WitW has taken on many different looks over the years as demonstrated by the journal covers shown in Fig. 1.

Welding in the World was originally established as a vehicle for publishing the work of commissions within IIW (see section below). Selected papers presented at the Annual Assembly were recommended by the commissions for publication. These papers were then edited (and translated) by the Secretariat for inclusion in the journal. Editing and translation limited the number of papers that could be published, as seen in Fig. 2. An average of about 20 papers per

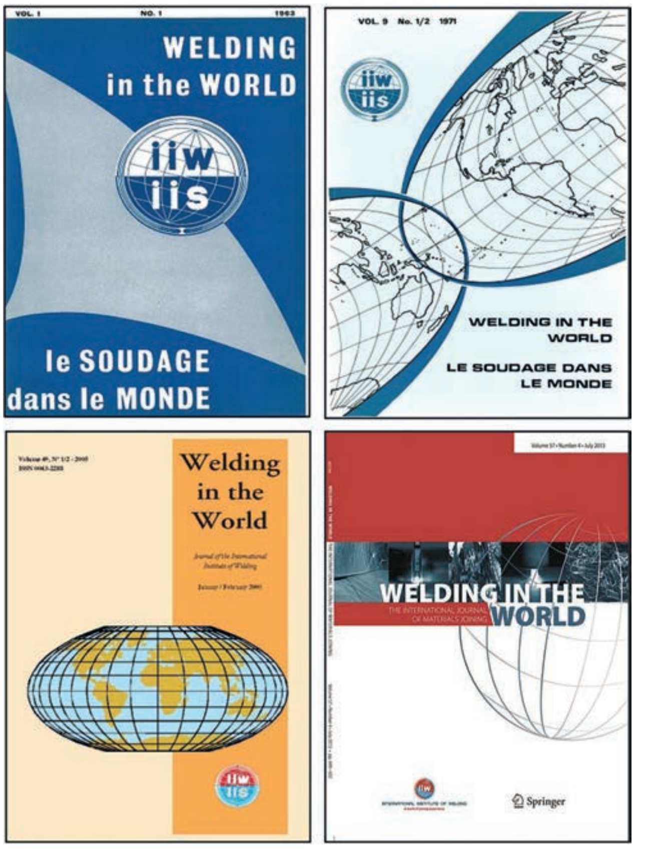

Fig. 1 The changing covers of *Welding in the Worl*

year were published from 1963 to 1993. The transition to English-only in 1993 resulted in a marked increase in papers published, although the number of papers per year was highly variable.

As noted previously, in an effort to promote *Welding in the World* as a leading international journal, editors from outside IIW were appointed in 2009. Bruno de Meester (Belgium) was the first, followed by Thomas Böllinghaus (Germany) and John Lippold (USA). Their first task was to streamline the peer review system, which they had already introduced in 2008, and to improve the quality of papers published. In 2009, an application was filed to join the Science Citation Index (SCI). The SCI, originally monitored by Thompson-Reuters, provides an indicator of the quality and impact of the journal. Entry into the SCI was approved in 2010.

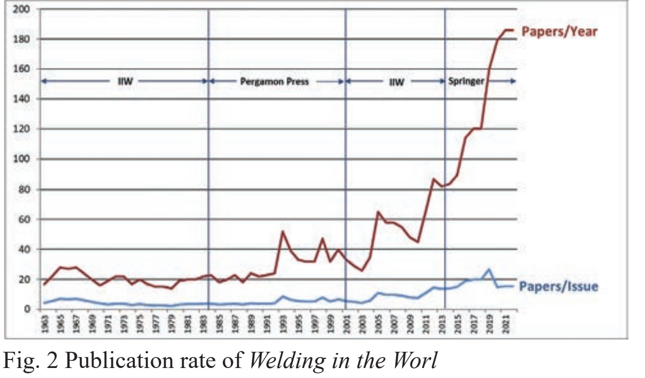

Fig. 2 Publication rate of *Welding in the Worl*

Another significant milestone in the evolution of *Welding in the World* occurred in 2013 with the agreement with Springer to become the journal publisher. An online peer review system (Editorial Manager™) was introduced to streamline the review and approval of papers recommended by the commissions. Papers approved for publication are assigned a DOI and are published immediately through Online First™. This allows papers to be made available online up to 3 months before they appear in print. The relationship with Springer has allowed more papers to be published, since the manuscript throughput is no longer limited by the editorial constraints of the Secretariat.

Over the past 10 years the rate of publication in *Welding in the World* has increased dramatically, as shown in Fig. 2. In 2022, over 180 papers and 2500 pages of fundamental and applied research were published. It is currently projected that over 200 papers and nearly 3000 pages will be published in 2023, the 60th anniversary of the journal.

Metrics that measure the visibility and impact of the journal have also improved dramatically, as shown by the chart in Fig. 3 which tracks the journal impact factor and CiteScore over the last 10 years. Other metrics including number of papers recommended by commissions, total cites of WitW papers, and full text downloads are shown in Table 2.

Prior to 2014, virtually all the papers published in *Welding in the World* were recommended by the commissions, either at the annual assemblies or intermediate meetings. In 2014, the journal made "open submission" possible allowing authors not associated with IIW to submit their work to the journal. As shown in Table 2, this resulted in a dramatic increase in the number of papers decisioned annually and put considerable stress on the peer review system. The Editors quickly developed a "prescreening" procedure for these papers and significantly expanded the Editorial Board and panel of reviewers to accommodate this increased workload. The journal now receives about 500 papers a year with nearly 75% of these papers coming through open submission.

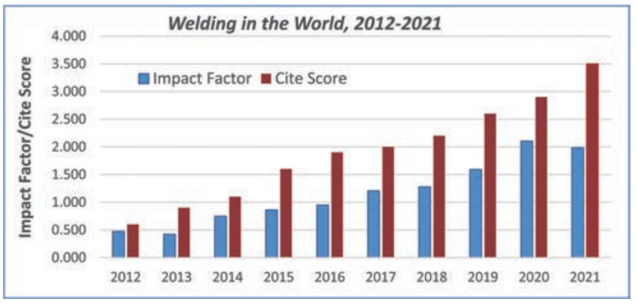

Fig. 3 Impact factor and CiteScore for welding in the world, 2012–2021

The IIW commissions are still the most important contributors to the journal with over 50% of the papers published in a given year coming from those recommended by the commissions. The review and selection processes used by the commissions ensure that only the best papers are recommended for publication in the journal. Rejection rates for these recommended papers are typically less than

20% in contrast to the high rejection rate of open submission papers. Based on the importance of the commissions to the success of *Welding in the World* by recommending highquality papers, containing relevant research and industrial applications, the following section reviews the technical mission of each commission and its "2.2" over the next 10 years.

2.1 The IIW commission structure

As described previously, the technical activities of IIW are coordinated through what is known as a "commission structure." The commissions were established and modified over the years to address important technical issues within the IIW community. The earliest of the commissions, established in the first few years of IIW's existence focused on welding processes, thermal cutting, filler metals, weldability, non-destructive evaluation, fracture behavior, education, and health and safety (see Table 1). As the mission of IIW expanded, commissions were added to address structural integrity, polymer joining, brazing and soldering, and micro-joining processes. Crosscutting commissions were also established to evaluate the application of welding technology to various structural applications. The complete history of the evolution of the IIW commission structure is described in more detail elsewhere [1, 2]. The following

Table 2 Journal metrics, 2015–2022

Metrics	2015	2016	2017	2018	2019	2020	2021	2022
Recommended papers from IIW commissions	115	130	126	135	156	82	93	144
Total decisions	172	358	290	443	477	580	455	510
Papers published	90	114	120	120	160	179	186	186
Pages published	930	1300	1300	1350	1900	2170	2440	2670
Total cites	327	521	807	829	939	1,556	2,319	>2,500
CiteScore	1.6	1.9	2.0	2.2	2.6	2.9	3.5	~3.8
Downloads	43,250	59,093	73,820	83,651	111,022	154,897	216,101	250,541
SCI impact factor	0.861	0.948	1.206	1.278	1.589	2.103	1.984	~2.2

sections provide descriptions of commissions that are currently active within IIW and which contribute to the science and technology published in *Welding in the World*. A summary of papers published in *Welding in the World* from 2017 to 2022, organized by commission, is provided in Fig. 4.

2.2 Commission I: additive manufacturing, surfacing, and thermal cutting

C-I focusses on thermal processes including additive manufacturing, surfacing, thermal cutting, and allied processes, especially with respect to a better scientific understanding and the practical applications of these processes. Scientific and technical contributions by C-I members give attention to process modelling, mechanical properties of the end-products, production planning, and quality assurance, by both on-line and off-line processing. In addition, improvements in additive manufacturing, surfacing, and thermal cutting equipment are continuously being reviewed and monitored. Recently, a major emphasis has been on additive manufacturing and laser cutting, especially in relation to the newest technology advances. Additive manufacturing covers a very broad set of processes and material types and is rapidly becoming an industrialized process in need of documented research and property development. The work on additive manufacturing will be made in a very close cooperation with other working units interested in the subject (Fig. 5).

2.2.1 Outlook

Additive manufacturing continues to grow in terms of technology and potential applications. This commission will continue to interact closely with process-specific commissions including C-IV, HED Processes, and C-XII, Arc Welding Processes to expand the knowledge-base and application of additive manufacturing processes to industrial applications. The rapid rise in the importance of arcbased AM technology has expanded the range of potential applications to multiple technology sectors. Although the efforts on AM have been led in large part by these commissions, all commissions within the IIW have areas where AM has been growing as a research and manufacturing activity. Worldwide, there have been a significant number of technical conferences devoted to the development and use of AM.

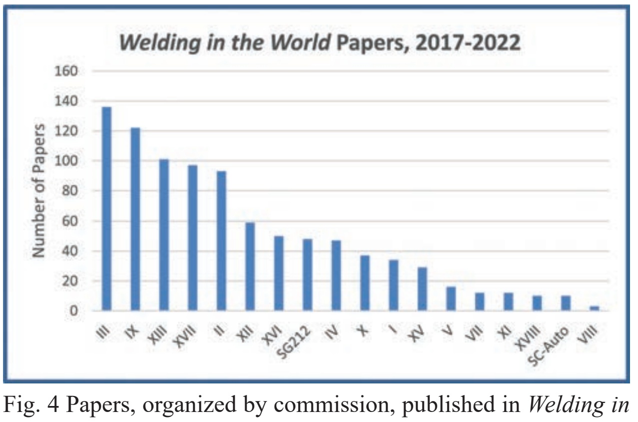

Fig. 4 Papers, organized by commission, published in *Welding in the World* from 2017 to 2022. Note that SG212, Physics of Welding and SC-Auto have now been merged with other commissions

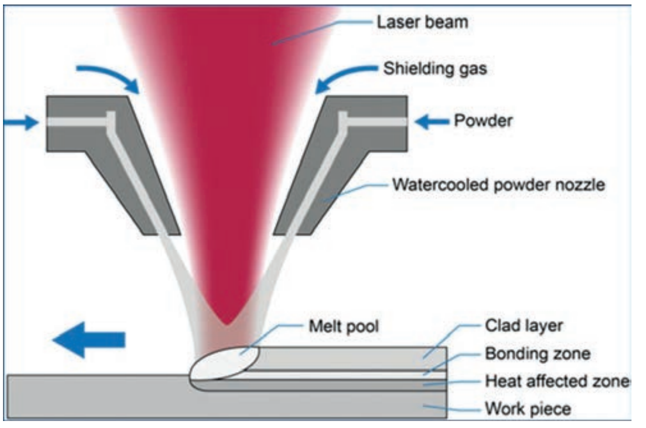

Fig. 5 Additive manufacturing using the laser powder feed process (3)

As an indicator of the important work of this commission relative to additive manufacturing, three Topical Collections have been published in *Welding in the World*, namely, 1) *Welding, Additive Manufacturing and Associated* NDT (2018), 2) *Additive Manufacturing–Processes, Simulation and Inspection* (2020), and 3) *Additive Manufacturing Processes and Performance* (2023).

These collections, each containing 15–25 papers, provide a valuable resource regarding the current state-of-the-art regarding AM processes and applications.

In the other areas covered by C-I, including surfacing technology and thermal cutting, there are very active subcommissions that have reinvigorated the studies and reporting in these areas. Over the last few years, several technical papers and new manufacturing innovations have been reported in these important areas.

2.3 Commission II: arc welding and filler metals

Commission II was established nearly 75 years ago in 1948 under the first Chairmanship of Professor H. E. Jaeger (Netherlands), where the terms of reference were to cover the applications of arc welding in all its forms. Today, Commission II is mainly concerned with arc welding and the filler metals that are used with those processes.

The commission identifies, develops, and transfers scientific and technical information, in some cases leading to International Standards or best practices, with respect to Arc Welding and Filler Metals. Its principal areas of focus include the metallurgy of weld metal (e.g., hydrogen in weld metal, chemical reactions, constitution of weld metal, and weld metal cracking), and the testing and measurement of welds (e.g., ferrite in high-alloyed weld metal, corrosion testing and testing of weld metal for hot cracking and micro-fissuring). The commission is also involved in standardization of welding consumables, including the coordination of the evaluation of ISO standards which are under systematic review, assuming responsibility for appropriate testing standards and conducting round-robin tests as may be required in support of the general work program. These activities have greatly contributed to the understanding, acceptance, classification, and adequate use of arc welding processes and filler metals.

In the early days of the commission much of its activity was focused on hydrogen-assisted cracking and the development of materials and procedures to avoid this form of cracking. Many of the now widely used procedures for avoiding HAC were developed through the efforts of C-II. Many of the commission activities involve the metallurgy of weld metals, the influence of the chemical composition including major alloying elements and minor trace elements on the mechanical, corrosion, and weldability properties, and ultimately on the reliability of welds in practical services.

Over the years, the commission work has involved various issues of filler metal optimization and development with respect to metallurgy, new material grades, new arc welding processes, and practical applications. There is a thematic overlap with other IIW commissions in some general technical topics of interests, particularly with Commission IX regarding metallurgical issues and weldability. Because of the strong emphasis on filler metals, there is also an emphasis on health and safety particularly with respect to welding fume, where it cooperates with Commission VIII.

Due to the common interest and goals for welding filler metals, a unique and close partnership has grown among IIW C-II, ISO/TC 44/SC 3 and CEN/TC 121/WG 3, where C-II has been involved in development of Testing Standards as well as Filler Metal Standards. IIW pioneered the measurement of diffusible hydrogen in welds. ISO 3690, for instance, is a direct product of the collaboration of experts within C-II and ISO/TC 44/SC 3. Another example is ISO 8249 standard for the determination of Ferrite Number (FN) and the latest ISO Technical Report, ISO 22824 (DTR stage), for the best practices for specification and measurement of ferrite in stainless steel weld metal which were prepared in collaboration with ISO.

Since the founding of the journal 60 years ago, Commission II has been one of the leading contributors to *Welding in the World* and has recommended a large number of high quality research and engineering papers published in the journal. Many of its members serve on the WitW Editorial Board and serve on its peer review panel.

2.3.1 Outlook

As new, advanced structural materials are developed to meet existing or future applications, joining technology and filler metal development continue to be a critical part of this development. It is well documented that many highperformance materials are often developed without the consideration of techniques used to join them. The development of new filler metals that are compatible with these advanced materials and allow application in a wide range of engineering designs will be a continuing challenge (Fig. 6).

2.4 Commission III: resistance welding, solid-state welding, and allied joining processes

Commission III provides a unique platform for more than 300 international experts to exchange scientific and technical knowledge on resistance welding, solid state welding and allied joining processes. In the 1990s, a large amount of work in C-III was invested on the development of standards for resistance spot welding. As a result, a substantial number of ISO standards were issued, providing the industry, especially the automotive sector, with much needed guidance on process control and monitoring, testing and analysis, and quality aspects. By the end of the 1990s, the introduction and application of Friction Stir Welding (FSW) technology revolutionized the world of solid-state joining processes. The unique thermomechanical conditions imposed by this process on the base materials fascinated and intrigued researchers around the world. Furthermore, the possibilities offered by FSW were also noted by a range

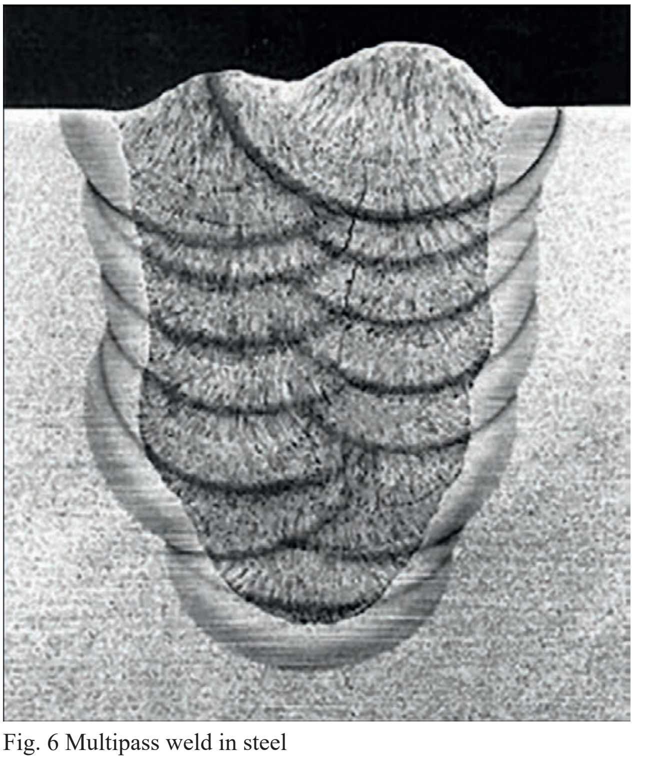

Fig. 6 Multipass weld in steel

of industries, which actively supported research to study the mechanisms of joint formation and the understanding of microstructural evolution and the resulting properties. As a result, FSW became a main topic for scientific and technical contributions to Commission III and for manuscripts published in *Welding in the World*.

The available body of work on FSW encouraged the formation of a standardization group which produced in 2011 the first dedicated ISO standard (ISO 25239:2011-Friction stir welding—Aluminium, Part 1–Part 5). This standard, which was reviewed in 2020, provides much needed support for FSW-based industrial fabrication and is extensively used by small and medium enterprises worldwide. Since the introduction of the FSW technology, a number of process variants were developed and introduced in the market expanding the interest of the industrial and scientific communities on solidstate processing of materials.

Resistance welding in general, and resistance spot welding in particular, faced an increasing demand for solutions addressing the use of Al and Al-based dissimilar joints in body-in-white production. This demand was met by a number of creative solutions both in process control and hardware side of the process. With the introduction of advanced high strength steels (AHSS), the focus of the resistance spot welding community started to turn to issues of liquid metal embrittlement (LME). As a result, in the last years, C-III has developed an impressive portfolio of documents on the understanding and mitigation of LME (Fig. 7).

2.4.1 Outlook

The work in Commission III will focus on addressing societal needs related to de-carbonization and the optimized use of resources, especially materials. Additionally, the supply chain problems experienced in the last years will also receive attention from C-III members. These changes are reflected by the creation of a new sub-commission dedicated to solidstate additive manufacturing and a recurring symposium on the application of resistance and solid-state welding in the fabrication of electric vehicles. Furthermore, the use of data management, machine learning, and artificial intelligence in resistance and solid-state welding is becoming frequent topics in the current work plan and will continue into the future, forming the basis of a new sub-commission. The extensive amount of available data on resistance spot welding will lead to pioneering work in these fields.

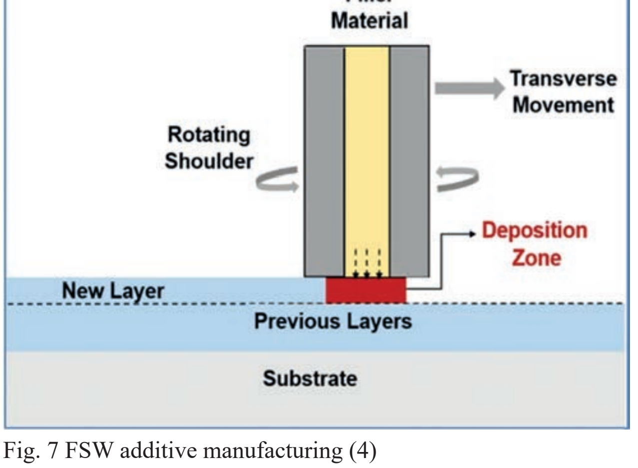

Fig. 7 FSW additive manufacturing (4)

2.5 Commission IV: power beam processes

Commission IV operates for scientists, engineers, and technical personnel who are involved in the research, development, and application of power beam processing technologies including laser, laser–arc hybrid, and electron beam welding processes. These processes are in a continuous state of development and advancement as new technologies and innovations offer a nearly unlimited array of welding, joining, and processing opportunities. Technical and scientific presentations by Commission members focus on new processes, process modeling, mechanical properties of end products, and environmental health and safety. C-IV is especially active in the study of the application of power beam processes to novel and otherwise difficult to weld materials including high-strength steels, stainless steels, light alloys, dissimilar materials, and coated products. In conjunction with C-I and C-XII, the Commission works to establish more reliable welding and joining technologies with higher productivity through an improved understanding of the physical phenomena governing beam processes. In particular, this joint group of commissions has been active in the laserbased additive manufacturing processes (Fig. 8).

The key objectives and working program of C-IV include the following topics:

• Fundamental technological knowledge of power beam processes with respect to the weldability of structural metals.

• Relevant EN ISO standards, which are applicable for power beam processes.

• Definition of process parameters according to industrial demands using laser, electron, and laser-arc hybrid welding.

2.5.1 Outlook

C-V will continue to be the focal point of basic research and applications of power beam processes within IIW. It will also continue to collaborate through joint meeting and workshops with Commissions I and XII. Specific goals of C-IV include a) providing the right knowledge and skills to existing and future welding professionals and b) eliminating international barriers to establish uniform regulations for products, services, and individuals.

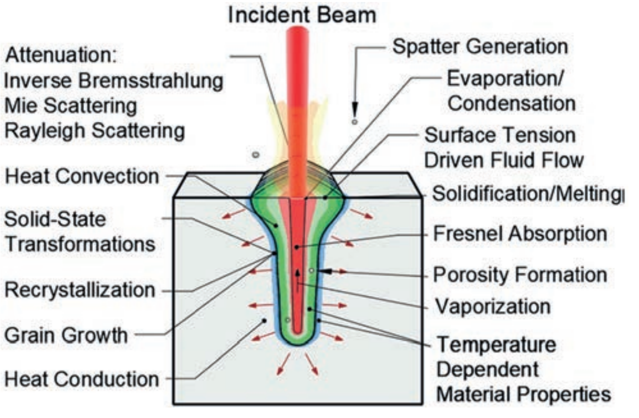

Fig. 8 Schematic showing beam-material interactions during keyhole LBW (5)

2.6 Commission V: NDT and quality of welded products

Commission V has the challenging task of monitoring, reviewing and contributing to all international standardization activities related to non-destructive testing (NDT) and evaluation of welded structures. The Commission has specialist groups concentrated on the following fields:

- CV-A, radiographic-based weld inspection
- CV-C, ultrasonic-based weld inspection
- CV-D, structural health monitoring
- CV-E, weld inspection based on electric, magnetic, and optical techniques
- CV-F, NDT reliability including simulation of NDT techniques

Non-destructive testing is a cross-sectional discipline that has its interfaces with component design, construction and fracture mechanics. A component's design must ensure both that it functions properly and that it can allow subsequent nondestructive testing. Once material damage is detected, and its size, location, and orientation determined, fracture mechanics will determine whether the component can still remain in operation. Particularly when it comes to joined components, attention must be paid to any alterations in mechanical material parameters in the weld and the adjacent heat-affected zone. Imaging techniques also have the ability to detect defect dynamics of damage that grows during operation. The objective of nondestructive testing is therefore to convert the test data as realistically as possible into a statement about the existing material defects and the resulting mechanical condition of a component. This is especially difficult in cases involving complex materials with high anisotropy or heterogeneous morphology like in composites or austenitic steels. Taking the tremendous progress in NDT-techniques into account, the working group on ultrasonic-based weld inspection *(*CV-C) is currently preparing a new edition of the austenitic *Ultrasonic Handbook*.

Generally, the interpretation of a test result related to a component's true condition is based on solving the inverse problem. In three dimensions, the greatest strides have been made by computer tomography which offers a comprehensive 3D solution using digital detectors. Sub-commission CV-A has helped to shape the change from film-based radiography to digital flat-panel detectors by making important contributions to standardization.

Many alternative scanning inspection methods come up short on data because only one viewing direction is scanned two-dimensionally. That makes 3D reconstruction extremely difficult. In the last decade, however, non-destructive testing has seen a clear trend towards 3D imaging inspection. In the field of ultrasonics, methods such as TFM (total focusing method) have been developed as a 3D-reconstruction tool, and strategies on how to apply them have also been improved. This knowledge has been transferred into an ISO standard (ISO 23864) by the experts of Commission V. C-V also deals with the adjacent field of SHM (structural health monitoring), where permanently mounted test equipment monitors the condition of a component. CV-D and recently initiated the revision of ISO 18211, Guided Wave Testing.

To improve the solution of inverse problems, all aspects of NDT must be taken into consideration, including wave generation, wave defect interaction, wave detection, signal processing, and imaging algorithm. Predicting this complex interaction has been made possible through advanced modeling and simulation tools that have paved the way for access to materially complex testing situations. Sub-commission CV-F has initiated new simulation approaches to support practical applications and to prove the feasibility of new testing methods. In addition to ultrasound, for example, active thermography is rapidly on its way to becoming a viable near-surface 3D method thanks to creative, new reconstruction approaches such as virtual wave concepts, AI-reconstruction or new flexible excitation strategies to compensate lateral heat flow. Eddy current inspection is another surface method that is following the trend towards the use of higher data density. Here, the use of eddy current arrays lead to shorter inspection times. Commission CV-E has taken up this development and is currently pushing ahead with a new standard on Eddy current arrays. In the field of magnetic methods, a revision of the standard of the Metal Magnetic Memory Method (ISO 24497) has been finalized (Fig. 9).

2.6.1 Outlook

As in many other fields of technology, non-destructive testing is currently undergoing a transformation towards a higher degree of automation. This includes both the field of robotics and automated approaches to analyze raw data and evaluate test results. Both the omnipresent cost pressure in quality assurance and the shortage of qualified inspectors in many

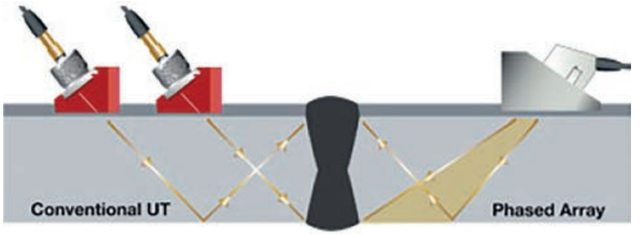

Fig. 9 Conventional versus phased array ultrasonic testing (courtesy Olympus)

sectors are driving the trend towards machine-based inspections. It is obvious that the current rapid progress in the field of artificial intelligence (AI) will massively accelerate this change. Already, numerous examples demonstrate the enormous power of AI-based algorithms in the field of 3D reconstruction. There is no question that AI will find its place as a mathematical tool here. However, numerous standards will have to emerge to address how to deal with AI as a "decision maker" and how much responsibility can be handed over to synthetic examiners. Finally, there will also be a legal and social issues associated with AI. To address this important question, the IIW tradition of multi-disciplinary joint sessions with other IIW Commissions will be key to finding optimized solutions.

2.7 Commission VI: terminology

Commission VI is responsible for the development, collection, and maintenance of welding terminology using appropriate tools and software capable of handling multiple languages. This terminology is obtained from the comparison and evaluation of existing international, regional, and national standards in order to avoid duplication and ensure global relevance. The terminology is made available in print and electronic media, especially through a close collaboration with ISO, the International Organization for Standardization. Thus, the technical output of Commission VI is represented by the publication of the ISO 25901 series of standards, rather than through the publication of articles in journals such as *Welding in the World*. In this regard, Commission VI quite atypical as compared with the other IIW commissions.

Its areas of interest cover a wide range of disciplines and technologies, including, but not limited to, welding and joining processes, joint design, performance and testing, metallic and non-metallic materials, and many additional aspects of materials joining such as personnel and quality management, welding equipment, and consumables. In order to ensure technical reliability and accuracy on specific topics, Commission VI is committed to enlist, whenever possible, competent experts from other IIW commissions or organizations.

Further, Commission VI closely focuses on the multiple interdependencies between all the terms and definitions it manages, to ensure a comprehensive, coherent, and organized vocabularies relevant for the whole materials joining community (including individuals involved at the academic, research, and/or industrial levels). To do so, it notably relies on its sub-commission VI-A, which maintains and develops the IIW Thesaurus. The Thesaurus is used by information specialists who are constructing bibliographic databases in order to index scientific and technical literature in the field of welding and allied processes.

2.7.1 Outlook

The current focus of the commission is on laser welding, with an existing work item in ISO's work program (ISO/ AWI 25901-5 "*Welding and allied processes–Vocabulary–Part 5: Laser welding*"). Other subjects under development include plastics thermal joining (draft developed under collaboration with ISO/TC 61 (:*Plastics*"), and thermal cutting. Other projects are being developed in conjunction with ISO/TC 44/SC 7 ("*Welding and Allied Processes–Representation and Terms*") for the revision of ISO/TR 25901-1 ("*General Terms*") and of ISO/TR

25901-4 ("*Arc Welding*"). According to the evolution of ISO's policies, these two Technical Reports are to be converted to official International Standards in the framework of the technical revision of their contents.

2.8 Commission VII: micro-joining and nano-joining

Commission VII focuses on micro-joining, nano-joining, and related materials processing technologies that occur at the micro-/nano-scale. The goal of the commission is to

1) promote knowledge exchange on the latest progress in microand nano-joining research, particularly with respect to materials and process issues; 2) review general trends in micro-joining and especially nano-joining research for integration and assembly of microand nano-scale devices and systems; and 3) promote awareness about recent developments in microand nano-joining research and applications. Special attention is given to new industrial sectors such as micro-electro-mechanical systems (MEMS), medical implants, nano-scale devices and systems, etc. which are not significantly addressed in other IIW commissions.

2.8.1 Outlook

Over the last 10 years, novel methods and principles of micro-joining and, more significantly, nano-joining have evolved rapidly. Monitoring and promoting the applications of the micro/nano-joining is a primary goal of thecommission. For example, advanced nano-joining materials, including metal nano-particle paste and nano-film, are applied to the packaging of power devices, and new nanojoining technology is applied to the research and development of high-performance micro/nano-devices. The future goal of C-VII is to attract more industry participants to the IIW Annual Assembly and to solicit industry-relevant papers for publication in *Welding in the World*. There are still many technical challenges to be overcome in nanojoining, including acquisition of heat sources at nanoscale, precise location and efficiency of nano-joining, performance testing of joint quality, and reliability evaluation.

2.9 Commission VIII: health, safety, and environment

Health, safety, and the environment are all critical considerations for any application or process involving welding. Many potential hazards can be present in the welding workplace, some of which include electric shock, fumes and gases, explosions, fires, burns, eye hazards, and noise. Although welding is intrinsically safe when proper safety precautions are followed, the welder and other personnel within the weld zone must have the information, training, and knowledge to assess these hazards and counteract them appropriately. As a result, the welding industry has a long track record of health and safety based on the development of guidelines for safe welding practices and welder safety programs.

IIW C-VIII is an interdisciplinary network that regularly reviews, exchanges and shares knowledge and general trends in international and national regulations, laws, and rules, and develops best practices/ guidelines and statements that can affect health, safety, and the environment regarding exposure to physical and chemical agents in welding.

Historically, health and safety hazards were recognized in the early days of the 20th century and one of the first commissions set up by IIW in 1948 was C-VIII, originally named "Hygiene and Safety." The 1980's was a particularly active time in C-VIII and IIW held a very successful *Colloquium on Health and Safety* that addressed many of the problems facing the welding industry.

Throughout the 1990's and into the 2000's and beyond, IIW C-VIII member experts continue to discuss and debate the health, safety and environment welding related concerns to develop best practices/guidelines and statements. As an example, important documents including 1) *IIW Statement on Manganese, Chromium and Manganese in Welding, 2) Health and Safety in Fabrication Repair of Welded Components, Aspects, Impacts and Compliance to Regulations,* 3) *Lung Cancer and Arc Welding of Steels,* and 4) *Arc Welding of Steels and Pulmonary Fibrosis* have been published through the work of the commission. A complete list of documents can be found at http://iiwelding.org/iiw-resou rce-materials.

Welding fume and the exposure limits continue to be the topics of most interest within the commission. Some specific recent presentations included compar ing the effects of acute MMA fume inhalation, quantifying the efficiency of technical measures for welding fume protection, fume emission during laser welding, modeling the fume emission rate of GMA welding, and reducing fume exposure of welders.

Welding industries in need of information/guidance/ best practices and specific welding industry segments of focus are shipbuilding, any confined spaces, production welding—in facilities or confined spaces, facilities incor porating multiple welders, fume extraction/mitigation, general PPE regarding electrical shock mitigation, and general welding/cutting information regarding fire prevention. New products of interest are as follows: Collaborative Robots/ COBOTS—need new and different safety information/guidance and standard references than automated robotic welding or manual welding and handheld laser welding (Fig. 10).

2.9.1 Outlook

In the near future, focus will be on updating the IIW Best Practices documents, reviewing health and safety training materials, and continuing attention to welding fume-related discovery. C-VIII will continue to interact with other commissions, particularly those that are process orientated, and to encourage attendance at commission meetings to all who have an interest in health, safety, and the environment as it applies to welding.

2.10 Commission IX: behavior of metals subjected to welding

Commission IX deals with a diverse range of materials, primarily focused on metals used in structural applications. Gaining new insights into the relationships among chemical composition, microstructure, and weldability is one of the challenging tasks of welding metallurgy as those three factors are often vary widely from those of the base metals. C-IX has

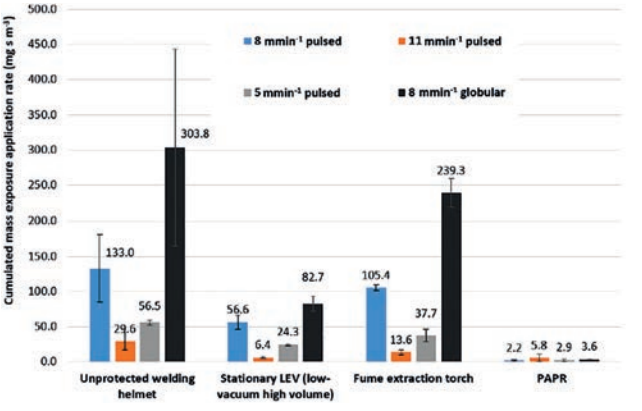

Fig. 10 Example of C-VIII work on weld fume exposure rates for different fume extraction conditions as a function of wire feed rates and transfer conditions (courtesy D. Werba)

made important contributions toward this goal in a variety of metallic materials, including high-strength lowalloy (HSLA) steels, heat-resistant Cr-Mo steels, stainless steels, Ni-base alloys, and non-ferrous alloys such as copper and aluminum. Special emphasis is given to the understanding and avoidance of welding defects during associated with welded structures and the associated service failures of welded joints and components. This is the essential behavior of metallic materials subject to welding, often referred to as "weldability." In fact, the creation of C-IX in 1954 under the title of "Behavior of Metals Subjected to Welding" was the result of the amalgamation of earlier commissions on weldability and brittle fracture (see Table 1).

Over the years, C-IX has issued many recommendations concerning weldable structural C-Mn steels which have had a profound inf luence on inter national codes and specifications far beyond the purview of IIW. An example of this is the IIW carbon equivalent, CE(IIW), which is imbedded into many inter national standards. C-IX activities have also expanded to other metallic materials to cope with the change of industrial interests resulting in the current scope of materials listed above. Better understanding the factors controlling the weldability and ser vice per for mance, such as for examplethe fer rite/austenite balance in duplex stainless steels, can enable the optimization of welding processes and the design of new materials to withstand severe service conditions. Based on the wide variety of materials considered and their implications with respect to design and process technology, the commission interacts with many of the other commissions, including C-I, C-II, C-IV, C-X, and C-XII.

2.10.1 Outlook

Met allurgical or weldability problems are nor mally encountered when the new processes or mater ials are developed and/or introduced into industrial use. Recently, for example, a major emphasis has been on laser-based and arc-based additive manufacturing (AM) processes. Because AM covers such a broad spectrum of processes and material types, C-IX will continue to include AM in its working program. There are also many new materials being introduced into a variety of industries that will pose weldability challenges. For example, improved battery efficiency will require new materials that must be joined in order to be of practical importance. Many other examples exist in the automotive, power generation, electronic, and defense industries. C-IX (in conjunction with C-II) will continue to be the focal point of metals technology and weldability within IIW (Fig. 11).

2.11 Commission X: structural performance of welded—fracture avoidance

The mission of Commission X is to establish practical procedures for assessing the strength and integrity

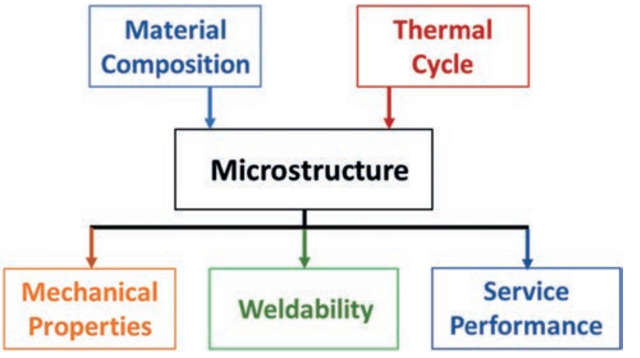

Fig. 11 Block diagram summarizing the evolution of weld microstructure and influence on properties and performance (courtesy J.C. Lippold)

of welded structures in design as well as in service, with attention to specific properties of welds such as welding residual stresses, strength mismatch, and toughness inhomogeneity in welds. Key activities of the commission have focused on the development of a practical guideline for fitness-for-service (FFS) assessment for welded components containing a flaw and damage, which includes stress/strain-based assessment, constraint analysis, and toughness testing procedures for welds. The FFS objective consists of specific subjects not covered by existing standards/guidelines, which operates as a "supplement," which gives the state-of-the art knowledge, advice, and/or recommendations on the structural performance assessment of welds with respect to avoidance of brittle, ductile, and environment induced fracture. With further development of FFS for welds, Commission X faces the challenge of advanced design of transport vehicles and infrastructures such as energy plants, pipelines, bridges, and buildings constructed with high performance steels and advanced welding technologies in a carbon neutral society.

2.11.1 Outlook

The commission FFS target and new, challenging, innovative research topics are summarized by the following:

1) Advancement of the current C-X FFS standard including additional new supplemental items:

• K-solutions for welded joints

• Limit load of weld joints (3D solution including mismatch effect)

• Residual stress profiles for thick weld components

• Constraint correction for welded joints (strength mismatch and residual stress effects)

• Pre-strain/dynamic loading effects on weld components

• Fracture toughness testing of welds (including small specimen test technique)

1) Pre-crack straightening treatment for CTOD test

2) Toughness requirement of butt welded joint of very thick plate

• Strain-based assessment (strain-based FAD) for weld components

• Environment (hydrogen) induced fracture assessment for weld components

2) Development of new assessment tools together with an expansion of FFS target and new, challenging, innovative research items;

• Artificial intelligence (AI)/machine learning (ML)assisted assessment tools (data-driven assessment) including 1) welding residual stress distributions and 2) mechanical/fracture toughness properties related to welding process parameters

• Simulation-based design and structural integrity assessment tools (FEA-based digital twin) including 1) welding mechanics simulation method and 2) physical-based fracture modelling (e.g., local approach)

3) Establishment of WG in C-X as well as in structural integrity group (C-V, IX, X, XI, XIII, and XV) for works of specific and timely topics leading to more effective, relevant and practical C-X FFS:

• A new initiative in AM (additive manufacturing) research by making a working group (or sub-commission) in C-X.

• Setting a new working group on "fracture toughness testing at cryogenic temperature."

2.12 Commission XI: pressure vessels, boilers, and pipelines

The engineering technology for pressure vessels, boilers, and pipelines is of great importance in many industries. There are high potential risks of catastrophic failures due to the harsh service environments involving high pressure and/ or high temperature and also with complex loading. Commission XI and its sub-commissions deal with any aspects of pressure vessels and pipelines that can be impacted by welding throughout their life cycle. To improve the weldingrelated technology associated with pressure vessels, boilers and pipelines, C-XI provides a platform for disseminating experience and expertise from relevant academic, industrial, and professional organisations, regulatory agencies, and individuals. C-XI acts as an interface between the academic research and industry applications, to focus on the latest research and development results and related information on all its associated aspects, with particular emphasis on 1) advanced welding and inspection facilities, 2) technology and the underlying science, 3) integrity and safety assessment, and 4) maintenance and life extension of the welded pressurized engineering plants (Fig. 12).

2.12.1 Outlook

Besides placing emphasis on common industrial practices and scientific research, C-XI will continue to concentrate on the welding technology and performance of welds in the following areas (Fig 13).

• Performance of welds for hydrogen service: current and future activity will focus on the development of a practical guideline for structural integrity assess-

Fig. 12 Keystone pipeline in USA (courtesy TC Energy Corp.)

ment for welded structures and components in pressurized hydrogen gas environments and include the following topics:

• Effect of pressure variations on fracture and fatigue performance of high-pressure hydrogen pipelines.

• The inhibiting the effect of oxygen on hydrogen effects on pipeline steel.

• Effect of load frequency on fatigue performance of pipeline material in hydrogen environment.

• Fracture mechanics properties and fatigue properties of welded pipeline materials in hydrogen.

• Degradation of material properties of the welded natural gas pipeline in hydrogen.

• Feasibility of repurposing or potential uprating the local transmission system assets to convey hydrogen.

• Hydrogen embrittlement—fundamentals, modeling, and experiments.

• Permeation, diffusion, and solubility measurements.

• Composite technology for hydrogen pipelines.

• Recommendations/guidelines/standards for welding for hydrogen service.

• Welding facilities and technologies in harsh environments: special facilities and technologies are required for the welding and inspection of the pressurized structures and equipment operating in harsh environments, such as the underwater or offshore pipelines, in-service high-temperature boilers and pipes/tubes, nuclear pressure vessels, and coolant systems with dissimilar metal welds. Topics also include microstructure evolution and degradation and mechanical property deterioration of welds in harsh environments.

• Fracture mechanics-based structural integrity digital twin platform: C-XI has also identified a new challenging and innovative research topic for developing a new assessment tool—"fracture mechanics based structural integrity digital twin platform," which will combine the artificial intelligence (AI)/machine learning (ML)-assisted data driven assessment and the NDT sensor and simulation -based structure integrity digital twin platform for pressure vessels, boilers, and pipelines. The concept is shown in the schematic below.

2.13 Commission XII: arc welding processes and production systems

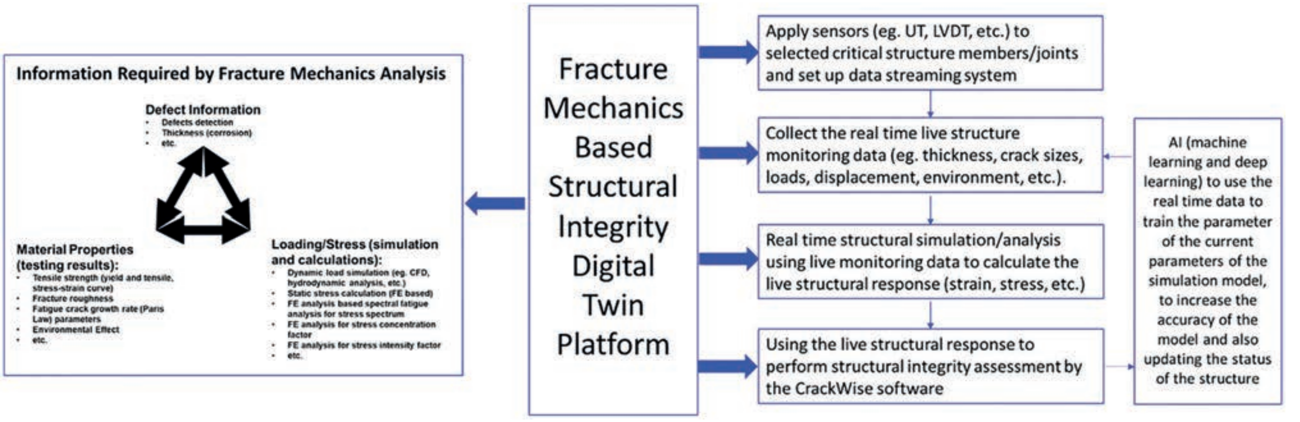

Fig. 13 Fracture mechanics-based structural integrity digital twin platform

Commission XII covers the application of arc welding process to various fabrication fields and the production systems for various industry sectors to realize low cost production with high quality. In 2021, SG-212 "Physics of Welding" was disbanded and established as a new sub-commission in C-XII. Therefore, fundamental issues of arc physics were are now covered in C-XII. Good practices presented at Commission XII can be spread worldwide and published as state of the art papers in Welding in the World.

Commission XII currently consists of six sub-commissions, namely XII-A Sensors and Control, XII-B Arc Welding Processes, XII-C Production Systems and Application, XII-D Underwater Engineering, XII-E Quality and Safety in Welding, and XII-F: Physics of Welding (formerly SG212). Current topics under consideration by the commission are the following:

• High efficiency and high quality arc welding process.

• Robotic and automatic welding system with sensors and process control.

• Measurement and monitoring for quality control.

• Modeling and numerical simulation for arc physical phenomena

• Intelligent manufacturing, cyber-physical systems, and artificial intelligence

• Wire–arc additive manufacturing for innovative production

Also, Commission XII holds joint meetings with C-I and C-IV for obtaining and consolidating the latest information on additive manufacturing and welding processes.

2.13.1 Outlook

For the realization of innovative production, Commission XII will focus specifically on the areas of intelligent manufacturing with artificial intelligence and additive manufacturing based on fundamental issues of arc physics.

2.14 Commission XIII: fatigue of welded components and structures

Since its establishment in 1951, Commission XIII has been dealing with the challenges regarding the structural integrity of welded components and structures under cyclic loading. C-XIII focuses on the newest scientific achievements on assessment methods and innovative technologies to avoid fatigue failures in welds.

The commission consists of the following working groups:

• WG1, fatigue testing and evaluation of data for design

• WG2, fatigue improvement and retrofit engineering techniques

• WG3, stress analysis

• WG4, effects of weld imperfections on fatigue strength

• WG5, life extension of welded structures by repair, retrofitting and structural monitoring (disbanded)

• WG6, residual stress effects in fatigue

The experts in different working groups of Commission XIII have developed a strong industrial research network to increase the awareness about the fatigue phenomenon and the methods to assess and avoid it. This network is being further developed by combining the interests of leading global companies and major international universities and research institutes. Industries which benefit from Commission XIII include aerospace, shipbuilding, rail transportation, bridges, and infrastructure, offshore, automotive, mechanical engineering, and process equipment. The commission also holds joint meetings with C-XV concerning fatigue effects on welded structures.

Commission XIII has developed and published a number of guidelines with high industrial relevance and impact for the welding community. These include 1) IIW Recommendations for Fatigue Design of Welded Joints and Components, 2) IIW Recommendations for the Fatigue Assessment of Welded Structures by Notch Stress Analysis, 3) IIW Recommendations on Methods for Improving the Fatigue Strength of Welded Joints, 4) IIW Recommendations for the HFMI Treatment, 5) IIW Guidelines on Weld Quality in Relationship to Fatigue Strength, and 6) IIW Best

Practice Guideline for Statistical Analyses of Fatigue Results.

C-XIII is currently developing several new science-based guidelines that can be applied to challenging design and life extension cases. One of these documents which is under peer review is a best practice on "Retrofitting Engineering for Fatigue Damaged Steel Bridge Structures."

Due to the high number of documents presented during the annual assemblies, C-XIII meetings often occupy 4 days. The papers and documents in C-XIII are of high standard and always well presented. Since the founding of the IIW journal 60 years ago, Commission XIII has been one of the leading contributors to *Welding in the World* and has recommended many high-quality research and engineering papers published in the journal. As shown in Fig. 4, C-XIII is among the leading commissions for publication of papers in WitW.

2.14.1 Outlook

The fundamental knowledge of weld fatigue as the original focus of C-XIII forms a solid basis supporting the development of guidelines and best practices to avoid fatigue failures in welds. C-XIII will transfer the available solid foundation of weld fatigue knowledge to the emerging additively manufactured parts as well for more structural safety. It will continue to serve as an important IIW platform for scientific discussions and exchange in a network of industrial partners and research institutes. It will continue to contribute high quality papers to the journal and publish Recommendations and Guideline documents regarding fatigue performance of welded structures relevant to industry.

2.15 Commission XIV: education and training

Commission XIV actively facilitates the sharing of best practices among Member Countries to promote welding standards, effective education and training methods, improved teaching techniques, educational research, and welding technology as a desirable career pathway. This commission focuses on global regulations, new education and training methods, digital and distance learning, training for intelligent manufacturing, education research, improving educator understanding of learning theory, safe welding practices, and the image of welding as a profession. It works in cooperation with the other Commissions to identify and present education and training solutions that help member countries prepare their work forces for skilled welding employment and welding professionals acting as engineers, technicians, and researchers, in a fast-changing world. There is an additional emphasis on the development of young professionals. Besides supporting existing methods, C-XIV also prepares its community for emerging challenges, regardless of a member country's level of advancement.

2.15.1 Outlook

Commission XIV will continue to be the focus of Education and Training within IIW. Among the agenda items for the commission over the coming years will be a) keeping pace with new technologies, b) identifying the right knowledge and skills needed to train current and future welding professionals, c) bringing awareness and useable solutions to address sustainable developments, and d) breaking down global barriers to facilitate consistent regulations for products, services, and people.

2.16 Commission XV: design, analysis, and fabrication of welded structures

Commission XV addresses the design, analysis and fabrication of welded structures, including buildings, bridges, offshore structures, and equipment, built primarily of structural steel, stainless steel, and aluminum. The commission is organized into six sub-commissions: analysis, design, fabrication, planar structures (buildings and bridges), tubular structures (both onshore and offshore), and economy, forming a matrix to facilitate exchange between specific technical topics and their applications in welded structures. In addition, there is a strategic effort to facilitate the exchange of information and possible harmonization regarding the national standards used for welded structures. Recent activities have focused on 1) design guidelines for welded structures subjected to seismic, impact or blast loads, 2) weld design and the welding of high strength structural steels, 3) advanced welding processes in the fabrication of structural steel, 4) fabrication quality requirements including the influence of flaws, welding residual stresses and distortion measurement, and 5) weld joint preparation standards, structural repair guidelines, and optimization and economy factors in design and fabrication.

C-XV has cooperated closely with industry groups in preparing design guidelines for welded joints in tubular structures subjected to both static loading and fatigue, with responsibility for two ISO standards on these topics. It also works closely with Commission XIII regarding fatigue effects upon welded structures, with a Joint Working Group and frequent joint meetings to facilitate the exchange of such information. It also cooperates with the other IIW working groups when their areas of activity have direct influence upon fabrication or performance of welded structures.

2.16.1 Outlook

For the future, Commission XV will expand their existing work to include components and structures produced using additive manufacturing, and the use of additional materials such as ultra-high strength steels (UHSS), stainless steels, and castings. The manufacturing and welding of machinery and equipment will also be added. Applications using new and improved welding processes such as hybrid laser and electroslag welding will be addressed, as well as processes to apply protective coating systems. The study of seismic performance of welded connections in structures will continue.

2.17 Commission XVI: polymer joining and adhesive technology

Commission XVI focuses on the areas of polymer joining and adhesive technology. Both of these joining techniques are used in series production, which necessitates high automation levels. Polymers (and reinforced polymer materials referred to as composites) cover a broad range of materials, including plastics and natural polymers such as starches and woody materials, which primarily consist of cellulose. These materials are found in everyday life and impact the quality of life on many levels, including medical applications, food security, and cover many industries. One goal of the commission is to improve and expand the joining techniques for these materials, including the use of adhesives to join a wide range of materials.

The commission provides a forum for high-level discussions among the world's leading scientists, who represent the very small scientific communities involved in material joining. These meetings highlight the development of novel materials and methods to join them, as well as novel techniques that expand the applications of polymeric materials. The commission also highlights fundamental principles for joining polymers, including complex flow models, temperature field prediction, and molecular diffusion models. These fundamental principles allow the community to further develop new joining methods and improve on existing ones. As additive manufacturing is fundamentally a joining technology, the scientists and engineers on the commission also focus on developing novel additive techniques, including hybrid systems. Developments over the past years have increased the importance of polymer joining and adhesive technology for application to modern hybrid materials and fiber-reinforced plastics (Fig. 14).

2.17.1 Outlook

The commission will continue to focus on the development of new technologies and material developments in several areas. This includes the following general areas:

1) Sustainable materials. Materials that are fully or partially derived from renewable feedstocks, such as starch, cellulose, or oil-rich biomass. It is important to note that this includes the development of sustainable composites as well as sustainable adhesives. These materials can be durable or easily digested by a natural pathway, such as compositing or hydration.

2) Additive manufacturing. Technologies are growing on many levels, including the development of hybrid processes, new materials, and understanding.

3) Hybrid joining. Techniques that are based on the simultaneous or sequential use of traditional plastic joining technologies to allow the development of novel assembly and joining technologies.

The commission will also continue to address new developments of traditional polymer joining techniques, while continuing to assess the application of these emerging technologies to meet the needs of the future.

2.18 Commission XVII: brazing, soldering, and diffusion bonding

Commission XVII started its activities during the 2009 IIW Annual Assembly in Singapore. It comprises experts and delegates from several disciplines related to the metallurgical and mechanical property characterization of brazed, soldered or diffusion-bonded materials, components. In addition, new filler materials are identified and evaluated. The commission currently solicits a variety of contributions to achieve its work program including a) ceramic-to-ceramic and ceramic-to-metal brazing, b) wide gap brazing, c) brazing and diffusion bonding in microsystems, d) brazing of intermetallics, e) repair brazing, f) brazing of Al-and Tibased alloys, and g) surface brazing. The commission also addresses testing, inspection and applications including, a) NDT of brazed and diffusion-bonded joints, b) applications of vacuum-brazed and diffusion-bonded joints as well

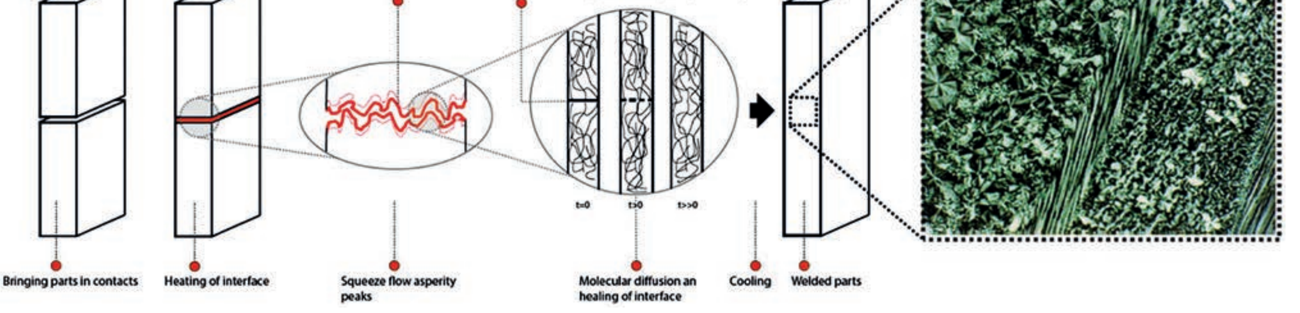

Fig. 14 Schematic of a polymer joining process (courtesy D. Grewell)

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as dissimilar joints, c) development of new brazing filler metals, d) testing methods of brazed and diffusion-bonded joints (i.e., tensile, shear, stress rupture, bending, corrosion and erosion, and thermal shock, etc.), e) low-temperature brazing, f) weld/brazing (for e.g., MIG brazing, electron beam brazing, and laser brazing), and g) diamond and super-abrasive joining. In addition to the topics listed above, the process equipment used and its further development are considered, especially for diffusion bonding.

The depth and breadth of the work of the commission is reflected in the many papers recommended and published in *Welding in the World.* From 2020 through 2022, nearly 15% of the papers published in the journal were on topics associated with C-XVII. It is anticipated that this trend will continue in the future.

2.18.1 Outlook

The overarching goals of C-XVII are to advance the technologies of Brazing, Soldering and Diffusion Bonding and to expand research activities and improve productivity for a friendly and sustainable world. This is accomplished by the sharing of knowledge within worldwide community of IIW, support pioneering and basic research endeavors, and provide a platform for sharing successful experiences, new research achievements, new concepts and ideas, as well as technical difficulties and problems to be solved. As demands for energy supplies and storage increase, brazing, soldering and diffusion bonding will be applied more in the manufacture of new products. In particular, diffusion bonding is gaining importance for gas storage and transportation. Even the concepts of 3D-printing will lead to increased usage of the processes covered by Commission XVII. In addition, an updated work program for soldering is being developed.

2.19 Commission XVIII: quality management for welding and allied processes

Commission XVIII maintains the goal to identify, create, develop, and transfer global best practices in the field of quality management for welding and allied processes. This includes quality management systems, the qualifications for personnel and companies involved in welding and allied processes, and standards that are needed in these fields. In its work, the Commission acts as an interdisciplinary body within the IIW, working with other Commissions to develop industry quality management documents and standards for use by technical experts, quality managers, and production personnel.

C-XVIII was formed in 2016 from a Select Committee on the subject that was initiated in 2001. This permitted the work of its members to expand to include the development and maintenance of welding and joining related ISO standards that were not addressed in ISO/TC 44 or other Technical Committees. The Commission is currently organized with three sub-commissions: XVIII-A Quality Personnel, XVIII-B Quality Management Systems, and XVIII-C Quality Management Standards.

The Commission has produced numerous documents to guide and assist industry in welding management, including “Improving the Quality and Effectiveness of Welding by Utilizing the Standard ISO 3834–Guideline for Company Implementation,” “Index of Welding Quality Management System Requirements used Globally in Arc Welding Applications,” “IIW Recommendations and Best Practices for Welding Inspection–Tasks and Responsibilities,” and “Recommendations and Best Practices for Welding Coordination to ISO 14731-Tasks and Responsibilities.” In addition, the Commission worked cooperatively with Commission XVII Brazing, Soldering, and Diffusion Bonding to create new standard ISO 22688 “Brazing-Quality requirements for brazing of metallic materials” and now manages the standard.

2.19.1 Outlook

C-XVIII will continue its work to guide, assist, and improve welding and joining quality management as it applies to industry practices and industry personnel. It will also continue working to develop and improve existing qualification standards and guidelines for welding personnel and for companies, with a careful eye for the needs of new joining processes and new developments in existing processes. This work also supports the work being done within the IIW International Authorization Board (IAB) and other organizations.

Commission XVIII will also be performing comparative studies of industry practices, with a goal for developing new and improving existing best practices. This includes the harmonization of audit criteria and practices for welding company audits. Because the Commission is interdisciplinary and includes representation from industry, standards bodies, and certification bodies, from a diverse array of nations and regions, it will be working to address the needs of all constituents in welding and allied processes for quality management and improvement.

3 Summary and outlook

As IIW celebrates its 75th anniversary, it stands as the leading international organization promoting welding, joining, and allied technologies. Initially established as a primarily European technical society, its membership now includes over 50 countries and 65 member societies from around the world. The organization has undoubtedly far exceeded the expectations of its founders.

To sustain this success, IIW must continue to evolve and react to the changing world environment. This includes global challenges to the environment that will require more efficient, agile and “green” manufacturing processes. In 2023, IIW launches a new strategic plan that will focus specifically on these and other issues associated with advanced manufacturing. Included in this plan are aspects of artificial

Table 3 List of IIW commissions and Chairs

Commission	Chair	Conta ct
C-I, additive manufacturing, surfacing and thermal cutting	Doug Kautz	doug.kautz@iiwelding.net
C-II, arc welding and filler metals	Zhuyao Zhang	zhuyao.zhang@iiwelding.net
C-III, resistance welding, solid-state welding and allied joining processes	Jorge dos Santos	Jorge.SANTOS@iiwelding.net
C-IV, power beam processes	Herbert Staufer	Herbert.STAUFER@iiwelding.net
C-V, NDT and quality of welded products	Marc Kreutzbruck	marc.kreutzbruck@iiwelding.net
C-VI, terminology	Jérôme Dietsch	j.dietsch@iiwelding.net
C-VII, micro-joining and nano-joining	Guisheng Zou	guisheng.zou@iiwelding.net C-VIII, health, safety, and environment
C-X, structural performance of welded jointsfracture avoidance	Mitsuru Ohata	mitsuru.ohata@iiwelding.net
C-XI, pressure vessels, boilers and pipelines	SuJun Wu	sujun.wu@iiwelding.net
C-XII, arc welding processes and production systems	Satoru Asai	satoru.asai@iiwelding.net
C-XIII, fatigue of welded structures and components	Kenneth MacDonald	Kenneth.MACDONALD@iiwelding.net
C-XIV, education and training	Carl Peters	carl.peters@iiwelding.net
C-XV, design, analysis, and fabrication of welded structures	Stefano Botta	stefano.botta@iiwelding.net
C-XVI, polymer joining and adhesive technology	David Grewell	david.grewell@iiwelding.net
C-XVII, brazing, soldering and diffusion bond	Huaping Xiong	huaping.xiong@iiwelding.net ing
C-XVIII, quality management in welding and allied processes	Robert Shaw	robert.shaw@iiwelding.net

intelligence and intelligent materials joining which will be transformative in the very near future.

The new IIW strategy 2023–2028 describes an operational plan that is heavily reliant on IIW's Technical Commissions. A substantial component of this strategy involves stronger participation by industry and will require implementing appropriate mechanisms for engineers and scientists from industry to take advantage of the expertise already established within the commissions. Under this plan, the needs of industry will be more directly reflected in the work plan of the commissions. It is envisioned that *Welding in the World* will be a key element in the new strategy, on the one hand competently continuing to focus on fundamental research, but progressively to encourage representatives from industry to share their work and advanced technology application results in a form that meets the standards of the journal.

Welding in the World will continue to play a major role in the evolution of IIW, serving as the outlet for much of the technical work conducted through the IIW commissions. As shown in Fig. 2, there has been a nearly 5-fold increase in the number of papers published annually over the last 20 years. In 2023, it is projected that the journal will publish over 200 papers and 3000 pages highlighting the many technical areas covered by the IIW commissions. In the future, more special issues and topical collections are anticipated to specifically target new developments, particularly those of important industrial relevance.

Such growth also brings challenges, and the Technical Management Board, Editors, and Editorial Board must be prepared to manage this growth while maintaining the high standards of the journal. The commission structure and its leadership will be the key to the continued success of *Welding in the World* since it is the work plan of the individual commissions and the technical papers that emanate from these commissions that will drive the journal. *Welding in the World*, subtitled "The International Journal of Materials Joining," will continue as the technical "voice" of IIW and strive to maintain itself as the leading scientific journal for materials joining and allied technologies.

Appendix

Acknowledgments The authors wish to thank all the commission chairs who provided input for this article. A list of current chairs is provided in Table 3. Readers who wish to participate in the technical activities of IIW are encouraged to contact the chair of the relevant commission.

Declarations

Conflict of interest J.C. Lippold is the Lead Editor of *Welding in the World*. S. Egerland is the Chair of the Technical Management Board of IIW. R. Shaw is Chair of the TMB Subcommittee WG-TCOM and C-XVIII, Quality Management in Welding and Allied Processes. E. Raufelder is the Managing Editor of *Welding in the World*.

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Permission of Luca Costa, Chief Executive Officer International Institute of Welding, 28 August 2023.

Fronius WeldCube Navigator. Повний контроль над кожним швом

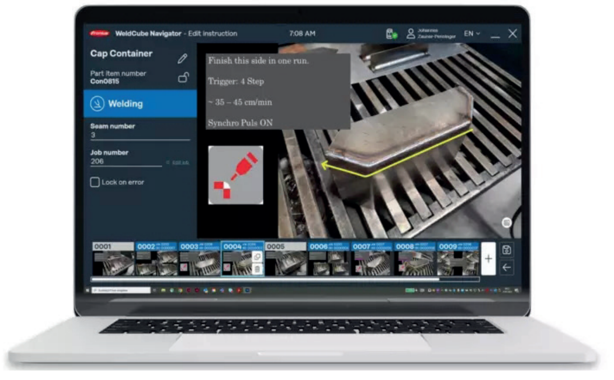
Зварювати без помилок і з високою ефективністю дуже просто: з новим програмним забезпеченням Fronius WeldCube Navigator тепер доступний цифровий план послідовності виконання зварювальних операцій для TPS/i. З ним зварювальник зможе виконувати всі завдання з обробки певної деталі максимально точно та безпечно. WeldCube Navigator поєднує в одному ПЗ дві основні функції: відповідно до робочих інструкцій контролер послідовності дає зварнику ілюстровані покрокові вказівки стосовно того, що і як потрібно зробити, та автоматично вибирає в системі попередньо налаштовані параметри зварювання. Потрібні робочі інструкції можна легко перевести в цифровий формат у редакторі ПЗ.

За допомогою добре продуманого плану послідовності виконання зварювальних операцій компанії можуть оптимізувати процеси ручного зварювання під час серійного виробництва. Для кожного завдання найкраща послідовність задається як стандарт, а уніфікований і структурований підхід забезпечує правильне виконання всіх кроків із визначеними допусками. Це не тільки гарантує високу якість швів, але й заощаджує час і кошти під час виробництва. WeldCube Navigator дає новачкам змогу швидко освоїти необхідні навички та працювати на рівні з професіоналами, а досвідченим зварникам – можливість з легкістю використовувати різні робочі станції, не витрачаючи час на вивчення інструкцій, навіть якщо якісь деталі потрапляють у роботу досить рідко.

Зменшення кількості помилок. Висока якість зварювання є критично важливою для багатьох деталей. Недостатньо якісні зварні з'єднання або їх відсутність там, де вони конструктивно передбачені, призводить до значного зростання вартості виробництва. Що раніше буде виявлено помилки в процесі виробництва, то швидше буде вжито заходів. І тут стане в пригоді WeldCube Navigator, а саме його функція надання інструкцій і попереднього визначення параметрів завдання: якщо зварник відхиляється від плану послідовності виконання зварювальних операцій, відразу подається аварійний сигнал. Якщо ж на шві виявляється відхилення (недотримання лімітів), яке порушує параметри безпеки, WeldCube Navigator автоматично блокує процес зварювання, після чого розблокувати його зможе тільки відповідальна особа, наприклад, керівник. Це означає, що помилки не повторюються і не дублюються, а відразу виправляються. Так забезпечується висока якість попри великі обсяги виробленої продукції, а кількість браку або виправлень значно зменшується.

Простота й зручність у експлуатації. Зварювальна система з програмним забезпеченням WeldCube Navigator становить собою самодостатнє комплексне рішення. Спеціалісти Fronius приділили особливу увагу зручності використання. Просто завантажте зображення в редактор і введіть потрібну інформацію. Так можна заздалегідь налаштувати всі важливі параметри зварювання й реакції системи на подію відхилення від плану. Звісно, можна також ін-

Цифровий план послідовності виконання зварювальних операцій допомагає заощадити час і кошти, забезпечуючи однаково високу якість шва під час виготовлення кожної деталі. Ви нічого не забудете й не робитимете помилок, що значно зменшить кількість браку та виправлень під час виробництва



Унаочнення – запорука швидкого розуміння: на екрані відображається кожен шов, усі налаштування та важливі примітки до кожного етапу, а функція зворотного зв'язку попереджатиме користувача про помилку, щойно ту буде допущено

Навігація через зварювальний пальник: для пересування пунктами цифрового плану послідовності виконання зварювальних операцій можна скористатися кнопкою пальника, яка дає змогу вибирати, підтверджувати й виконувати операції

тегрувати загальні робочі кроки, зокрема, підготовку чи проміжні етапи, які не передбачають зварювання.

Контролер послідовності допомагає зварнику в безпечний спосіб досягнути бажаного результату за цифровим планом послідовності виконання зварювальних операцій у редакторі. Зварювальник може з легкістю керувати послідовністю операцій просто на пальнику: вибирати, підтверджувати й виконувати певні дії. Екран робочої станції чітко показує кожен етап і не дає переходити до наступного, поки не буде повністю та з належною якістю виконано попереднє завдання. У результаті письмові інструкції, зазвичай написані різними мовами, відходять у минуле. Крім того, повідомлення про системні помилки надсилаються відразу оператору, що зменшує кількість помилок і знижує необхідність переробляти завдання, а отже, заощаджує час і матеріали. Це покращує процес з економічної та екологічної точки зору й буде корисним, якщо фахівці зі зварювання відсутні або часто змінюються.

Стандартизація: ефективне рішення для забезпечення належної якості. Новачки та недосвідчені зварники можуть швидше та ефективніше вчитися за допомогою цифрового плану послідовності виконання зварювальних операцій, просто дотримуючись наочних покрокових інструкцій на екрані. Це дає змогу переконатися, що всі операції виконуються відповідно до вимог і стандартів. Жодна дрібниця не залишиться поза увагою, а параметри зварювання буде визначено заздалегідь. Завдяки цифровому плану послідовності виконання зварювальних операцій компанії можуть сконцентрувати знання та професійні навички зі зварювання в одному центрі й передати їх усім співробітникам. Це забезпечує безперервне виробництво та знижує залежність від досвідчених майстрів.

Максимально гнучке керування даними та користувачами. WeldCube Navigator – ще одне важливе рішення в асортименті програмного забезпечення Fronius. Використовуючи наше ПЗ в поєднанні з функціями централізованого реєстрування й аналізу даних та централізованого керування користувачами WeldCube Premium, компанії можуть ще більше розширити кількість функцій і переваг для свого бізнесу, щоб максимально розкрити свій зварювальний потенціал.

Ми є *Fronius*. У нас працює більш ніж 7000 працівників по всьому світі, частка експорту в нашому виробництві складає 87 %, а портфоліо наших винаходів і розробок нараховує 1446 активних патентів. Наша компанія була започаткована у 1945 р. як маленький приватний бізнес, а нині ми є потужним гравцем на світовому ринку, що підтверджує розвинена структура з 37 міжнародних дочірніх компаній та потужна мережа торгових партнерів у більш ніж 60 країнах світу. Та все ж по суті своїй залишаємося австрійським сімейним підприємством, яке працює в галузях виробництва та обслуговування фотовольтаїчних систем, зварювальних апаратів, а також технологій заряджання акумуляторних батарей. Наші товари та рішення завжди були спрямовані на формування гідного майбутнього, а замовники отримують комплексні пакети обслуговування: від професійного планування та надання консультацій до постійного моніторингу ефективності та ремонту обладнання відповідно до їхніх потреб. Ми створюємо інновації. Ми відкриті для всього нового. Ми є Fronius.

Для отримання додаткової інформації звертайтеся до
Fronius Ukraine GmbH, Lilya Korzin
вул. Слави, 24, с. Княжичі, Київська обл.
Тел.: +380 (44) 2772141
korzin.lilya@fronius.com

ЛЮДИНА, ЯКА ПРИЙШЛА З МАЙБУТНЬОГО

Пам'яті В.М. Глушкова

24 серпня 1923 р., 100 років тому, народився Віктор Михайлович Глушков – видатний вчений та громадський діяч, широко відомий у нас та за кордоном, засновник Інституту кібернетики Національної академії наук України, активний учасник світового процесу становлення та розвитку нових напрямків науки XX та XXI ст. – обчислювальної техніки, кібернетики, інформатики.

Його внесок у ці напрями науки коротко охарактеризував колишній Президент НАН України академік Б.Є. Патон:

«В.М. Глушков як мислитель вирізнявся широтою та глибиною наукового бачення, своїми роботами випередив час, ставши основоположником інформаційних технологій в Україні та колишньому Радянському Союзі, та й у світі загалом.

Віктор Михайлович мав величезні різнобічні знання, а його ерудиція просто вражала всіх, хто з ним спілкувався. Вічний пошук нового, прагнення прогресу в науці, техніці, суспільстві були відмінними його рисами.

В.М. Глушков був справжнім подвижником у науці, що мав гігантську працездатність і працьовитість. Він щедро ділився своїми знаннями, ідеями, досвідом з оточуючими його людьми.

В.М. Глушков зробив великий внесок у розвиток АН УРСР, будучи з 1962 р. її віце-президентом. Він суттєво впливав на розвиток наукових напрямів, пов'язаних із природничими та технічними науками. Великий його внесок у комп'ютеризацію та інформатизацію науки, техніки, суспільства.

Віктора Михайловича сміливо можна віднести до державних діячів, які віддавали себе служінню вітчизні, своєму народу. Його знали та поважали люди у всіх куточках колишнього Радянського Союзу. Він не шкодував сил для пропаганди досягнень науки, науково-технічного прогресу, спілкувався з вченими багатьох зарубіжних країн. Його роботи та досягнення керованого ним Інституту кібернетики АН УРСР були добре відомі за кордоном, де він мав заслужений авторитет.

Добре розуміючи значення обороноздатності своєї країни, В.М. Глушков, разом із керованим ним інститутом, виконав великий комплекс робіт оборонного значення. І тут він завжди вносив своє, нове, долаючи численні труднощі, іноді просте нерозуміння. Він справді вболівав за країну, їй і науці віддав усе своє чудове життя».

В.М. Глушков був нагороджений багатьма орденами і почесними званнями, відзначений Ленінською премією, Державними преміями СРСР і УРСР.

Він був одним з ініціаторів створення факультету кібернетики Київського національного університету імені Тараса Шевченка. З 1965 р. до дня своєї смерті очолював кафедру теоретичної кібернетики за сумісництвом.

В.М. Глушков опублікував понад 800 робіт, у т.ч. 30 монографій.

В.М. Глушков фундатор наукової школи кібернетики. Створив теорію цифрових автоматів і теорію автоматичного проектування комп'ютерів (1964). Започаткував українську школу з проблем штучного інтелекту й розпізнавання образів. Під його керівництвом розроблено принципи оцінки ефективності систем математичного забезпечення обчислювальної техніки, створено і впроваджено у практику математичного забезпечення ЕОМ «Київ» (1961). Створив проект ЕОМ «Україна» (1966); серію ЕОМ «Мир» (1968); системи автоматизації проектування «Проект» та машини «Київ-67» і «Київ-70» для керування іонним променем (1977). Автор проекту загальнодержавної автоматизованої системи збору й оброблення інформації.

Здавалося б, науковий і життєвий шлях академіка В.М. Глушкова був щасливим і безхмарним. Насправді ж, як людина відповідальна і небайдужа, він хотів не лише внести значний вклад в кабінетну науку, а й бачити практичне застосування своїх розробок. Але часто наражався на нерозуміння чи просто небажання розуміння з боку чиновників тоталітарної командно-адміністративної системи.

Ось деякі факти з життя вченого:

Віктор Глушков вів родовід від кубанських козаків. Бабуся вченого жила на Донбасі та розмовляла українською мовою. Від неї він дізнався безліч українських пісень, вважав їх найкрасивішою музикою та любив співати на сімейних урочистостях та у колі колег.

В.М. Глушков володів німецькою та англійською мовами. Знав напам'ять багато поетичних текстів. Одного разу на суперечку кілька годин поспіль читав по пам'яті німецькою Фауста та інші вірші Йоганна Вольфганга Гете.

У 1960-х роках під керівництвом вченого створили прототипи персональних комп'ютерів, а також розробили ідею безготівкового розрахунку населення – прообраз електронних грошей.

В останні дев'ять днів життя В.М. Глушков, будучи вже не в змозі працювати, диктував дочкам спогади про своє життя та наукові проекти, дотримуючись власного головного принципу – не гаяти часу.

ПЕРЕДПЛАТА 2024

Журнали	Вартість передплати на друковані версії журналів*, грн.			
	місяць	квартал	півроку	рік
«Автоматичне зварювання», видається з 1948 р., 6 випусків на рік. ISSN 0005-111X. Передплатний індекс 70031.	–	–	900	1800
«Сучасна електрометалургія», видається з 1985 р., 4 випуски на рік. ISSN 2415-8445. Передплатний індекс 70693.	–	300	600	1200
«Технічна діагностика та неруйнівний контроль», видається з 1989 р., 4 випуски на рік. ISSN 0235-3474. Передплатний індекс 74475.	–	300	600	1200
«The Paton Welding Journal»**, видається з 2000 р., 12 випусків на рік. ISSN 0957-798X. Передплатний індекс 21971.	600	1800	3600	7200

*Вартість з урахуванням доставки рекомендованою бандероллю.
** Журнал «The Paton Welding Journal» містить статті, отримані від авторів з усього світу і вибірково переклади на англійську мову статей з журналів «Автоматичне зварювання», «Сучасна електрометалургія», «Технічна діагностика та неруйнівний контроль».

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Передплата на електронну версію журналів.
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Журнал **«Автоматичне зварювання»** є міжнародним науково-технічним та виробничим журналом у галузі технічних наук. В журналі публікуються результати досліджень за напрямками: матеріалознавство та металургія зварювання, наплавлення та інших споріднених технологій; технології та матеріали для зварювання конструкційних матеріалів; виробництво зварних металоконструкцій для різних галузей промисловості; відновлювальний ремонт для подовження ресурсу зварних конструкцій і вузлів; проблеми міцності, конструювання та оптимізації зварних конструкцій; технології 3D друку, які базуються на зварювальних процесах; гібридні технології зварювання. В журналі публікується також інформація про нові зварювальні матеріали, джерела живлення та технології; звіти про виставки, конференції та семінари, анонси нових книг та винаходів, новини від відомих компаній та інше.

Журнал **«Сучасна електрометалургія»** є міжнародним науково-теоретичним та виробничим журналом у галузі технічних наук. В журналі публікуються результати досліджень у сферах: металургія чорних і кольорових металів та сплавів; спеціальна електрометалургія (електрошлакова, електронно-променева, плазмово- та вакуумно-дугова технології); нові матеріали; енерго- і ресурсозбереження; матеріалознавство, 3D технології у спеціальній електрометалургії. Публікується також допоміжна інформація з тематики журналу.

Журнал **«Технічна діагностика та неруйнівний контроль»** є міжнародним науково-технічним та виробничим журналом у галузі технічних наук. В журналі публікуються результати досліджень з діагностики матеріалів і конструкцій та методи неруйнівного контролю для оцінки стану матеріалів і конструкцій; теорія, методи і засоби технічної діагностики. Розміщуються матеріали з моніторингу конструкцій та подовження ресурсу та працездатності засобами НК. Публікується супутня інформація з тематики журналу, а також інформація про події та новини в Українському товаристві НК та ТД.

ВИДАВНИЦТВО

Міжнародна Асоціація «Зварювання»
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