Agenda: 75th IIW Annual Assembly C-XI: Pressure vessels, boilers and pipelines

Wednesday, 20th– Thursday, 21st July 2022

Chair: Professor Su Jun Wu (China)

Day 1: Room **Concerto –** 8:30 ~ 12:30, 20th July (Japan time)

Day 2: Room **Étolie A –** 14:00 ~ 18:00, 21st July (Japan time)

Day 1 - Session 1

1. **8:30am**: Opening of the meeting (Su Jun Wu).
2. Identification of C-XI delegates.
3. Request fellow member volunteer to draft the Minutes of the Meeting.
4. News from the IIW Secretariat (Dr Elisabetta Sciaccaluga, IIW Technical Manager).
5. Election of IIW WU C-XI ***Vice Chair*** (Assisted by IIW Technical Manager).

Notice: A candidate nominated by the C-XI Chair is Dr Xing SUN from TWI UK.

Day 1 - Session 2: Technical Papers (30 minutes per paper including 5 minutes of discussion)

9:00 - 9:30 ***Laser beam welding of thick-walled components – Technologies, Challenges, Potentials***
Benjamin Keßler, Dirk Dittrich, Robert Strohbach, Axel Jahn

9:30 -10:00 ***Influence of Sulfur Content on Molten Pool Geometry in TIG Welding of High ManganeseStainless Steels***
Y. Kisaka, S. Miki, F. Kimura, S. Tashiro, M. Tanaka, S. Ozawa,T. Suwa

10:00-10:30 ***Effect of Ti, Zr and Cu content on the microstructure and properties of 2195 Al-Li alloy weldment***
S. H. Wen, H. J. Jiao, L.G. Zhou, H. Cheng, S. J. Wu

10:30 – 11:00 Coffee Break

11:00-11:30 ***Safety of pipeline girth welds based on fatigue and burst tests of full-scale pipeline sections***
A.Y. Dakhel, M. Gáspár, Zs. Koncsik, J. Lukács

11:30-12:00 ***Novel approach for numerical evaluation of limiting state and reliability of corroded pipelines under in-service repair welding***
Alexey Milenin, Elena Velikoivanenko, Galina Rozynka, Nina Pivtorak

Day 2 - Session 3: Technical Papers (30 minutes per paper including 5 minutes of discussion)

14:00-14:30 ***Influence of microstructure on near-threshold fatigue crack growth in the welding joint of 18Ni maraging steel***
Haitao Zhao, Delun Guo, Qi Qin, Sujun Wu

14:30-15:00 ***Diagnostics of equipment of oil refining and petrochemical industries using the metal magnetic memory technique***
A. Dubov, A. Dubov, S. Kolokolnikov, A. Yamchuk, A. Marchenkov

14:30-15:00 ***Probabilistic Fracture Mechanics Approach to Investigate Difference in Charpy Requirements for Pressure Vessels***
Yin Jin Janin, Isabel Hadley

15:30-16:00 ***Video presentation of 'Welding in the World' status – WitW Editor-in-Chief: John Lippold***

16:00 – 16:30 Coffee Break

Day 2 - Session 4: Panel Discussion

16:30-17:30 IIW WU C-XI - Future scope and focus;
Setup of Subcommission XI-H: *Performance of Welds in Hydrogen Environments*

Day 2 - Session 5

17:30-17:40: Recommendation of papers for publication in 'Welding in the World'
17:40-18:00: 75th IIW Annual Assembly C-XI Meeting conclusion and adjournment of meeting

ABSTRACTS OF PRESENTATIONS

1. Laser beam welding of thick-walled components – Technologies, Challenges, Potentials

Benjamin Keßler, Dirk Dittrich, Robert Strohbach, Axel Jahn
Fraunhofer IWS Dresden, Germany

Abstract:

Critical components used in energy and chemical plants are exposed to high mechanical, corrosive and thermal stresses. Consequently, highly developed alloys, such as heat resistant steel or nickel materials are used in components with large wall thickness. Furthermore, typical application in steel construction such as shipbuilding or wind power plants require as well a large wall thickness, the demands are more concentrating on efficient processes than on material requirements.

Laser beam welding offers the possibility of not permanently damaging these properties due to its low energy input during welding [1] and also offers an economical alternative to previously used narrow-gap welding processes [3] or electron beam welding [2]. In the laboratory, wall thicknesses > 100 mm have already been successfully joined by laser [1,4].

The presentation is intended to provide an overview of the state of the art laser welding of thick-walled components compared to the laser multi-pass welding at Fraunhofer IWS. Two process approaches will be described, namely fiber laser welding with an oscillating laser beam and a process variant that uses a diode laser without beam oscillation. The welding results from trials using the two different laser multipass technologies on mild steel (S355), a special nickel alloy (Alloy 617 occ) and an aluminum alloy (EN-AW 5083) and the resulting weld properties (static strength, fatigue strength and creep resistance) are presented.

[1] Kessler, B., Dittrich, D., Brenner, B. Standfuß, J.; Leyens, C. (2019): Extension of the process limits in laser beam welding of thick-walled components using the Laser Multi-Pass Narrow-Gap welding (Laser-MPNG) on the example of the nickel-based material Alloy 617 occ. Weld World 65, 1359–1371.

[2] Dittrich, D.; Strohbach, R.; Zimmermann, F.; Jahn, A. (2020): Laserstrahlschweißen großformatiger Stahlbaustrukturen mit modernen Dioden-Lasern am Beispiel eines Hallenkransegments; In: DVS-Berichte Band 365, DVS Media GmbH, Düsseldorf.

[3] Rathod, D.W.; Francisa, J.A.; Vasileioua, A.N.; Roya, M.J.; Englisha, P.D.; Balakrishnanb, J.; Smitha, M.C.; Irvinec, N.M. (2019): Residual stresses in arc and electron-beam welds in 130 mm thick SA508 steel: Part 1 – Manufacture; In: International Journal of Pressure Vessels and Piping Volume 172: 313-328.

[4] Yang, W.; Xin, J.; Fang, C.; Dau, W.; Wie, J.; Wu, J.; Song, Y. (2019): Microstructure and mechanical properties of ultra-narrow gap laser weld joint of 100 mm-thick SUS304 steel plates, In: Journal of Materials Processing Technology 265: 130-137

2. Influence of Sulfur Content on Molten Pool Geometry in TIG Welding of High Manganese Stainless Steels

Y. Kisaka, S. Miki, F. Kimura, S. Tashiro, M. Tanaka, S. Ozawa,T. Suwa
Nippon Steel Engineering Co., Ltd.

Abstract:

High manganese stainless steels have been utilized in various application due to excellent characteristics such as high strength and non-magnetic properties, etc. When TIG welding was performed with high manganese stainless steels, penetration depth was clearlydifferenteven though just sulfur content in the steels are slightly different with 5ppm and 20ppm.On the other hand, it is well known that Marangoni convection of molten pool will be inward in the case of large amount of sulfur content involving materials, then penetration depth shall be deeper. However, sulfur content changing penetration depth we faced was maximum 20ppm, it is fewer than the value of conventional knowledgebased on typical stainless steels.In this research, temperature dependent of surface tension coefficient of both high manganesestainless steels was measured by an electromagnetic levitation technique.Then the numerical simulationsapplying the obtained relation of temperature dependent of surface tension coefficient were conducted. Additionally, in-situ observation onthe flow of molten pool surface was also carried out. As the results from

theirapproaches, it was revealed that the Marangoni convection changedwith between 5ppm and 20 ppm of sulfur content.

3. **Effect of Ti, Zr and Cu content on the microstructure and properties of 2195 Al-Li alloy weldment**

S. H. Wen, H. J. Jiao, L.G. Zhou, H. Cheng, S. J. Wu
Aerospace Research Institute of Materials & Processing Technology, China
School of Materials Science and Engineering, Beihang University, Beijing, China

Abstract:

2195 Al-Li alloy was welded using six kinds of weld filler wires with different contents of zirconium, titanium and copper. The S2503 weld demonstrated fine α-Al/Al_2Cu/Al_3(Ti, Zr) microstructure and superior mechanical properties. The addition of Zr and Ti refined the grain and modified the solidification mode of the weld metal. With the increase of Ti/Zr addition in the fusion, the tensile strength and corresponding elongation of the Al-Li weld increased significantly. The excessive Al_2Cu at the grain boundary helped to alleviate the cracking sensitivity by a “self healing” mechanism, but greatly deteriorated the impact toughness of the weld joint.

4. **Safety of pipeline girth welds based on fatigue and burst tests of full-scale pipeline sections**

A.Y. Dakhel, M. Gáspár, Zs. Koncsik, J. Lukács
Institute of Materials Science and Technology, Faculty of Mechanical Engineering and Informatics, University of Miskolc, Hungary

Abstract:

The main objective of our ongoing research is data collection for integrity management tasks, in other words for Pipeline Integrity Management System (PIMS), helping the transporting pipeline operators in different decision situations. Either the reserves of the girth welds after a long-term operation can be identified or the girth welds with different defects should be repaired and/or replaced. From the operators point of view the long term operation is the cost effective way, however, from the safety point of view the managing of the lifecycle of the pipeline is the more reliable way. Unfortunately, inadequate girth welds cause catastrophic damages in transporting pipelines, all over the world. Consequently, the optimal operation of the pipelines is a complex task. The paper introduces our investigation program executed on full-scale pipeline sections. Fatigue (100.000 cycles) and burst tests were executed on different pipeline sections containing girth welds. Both long-term operated and replaced gas transporting pipeline sections and artificial pipeline sections, furthermore, both appropriate and inadequate girt welds were investigated. The testing results and the damage histories were compared with each other; safety factor was defined and calculated for the assessment of the reliability of the girth welds. The investigation program will be continued, the effect of mixing of hydrogen to natural gas in the gas network will be investigated.

5. **Novel approach for numerical evaluation of limiting state and reliability of corroded pipelines under in-service repair welding**

Alexey Milenin, Elena Velikoivanenko, Galina Rozynka, Nina Pivtorak
E.O. Paton Electric Welding Institute of NAS of Ukraine, Kyiv, Ukraine

Abstract:

For assessment of limiting state and reliability of corroded pipelines under design loading and in-service repair welding, complex numerical methods for predicting the kinetics of thermodeformation processes taking into account the ductile damage of material have been proposed. They allowed evaluating the features of interaction of stresses of different types (caused with operation loading along with the local stress concentrator near geometry anomaly and assembly or repair welding) and their influence on subcritical damage and limiting state of specific structure. By the example of interaction of assembly/repair weld and semielliptical anomaly it was shown that the main characteristic of corroded pipeline reliability is the stress triaxiality that predetermines the intensity of ductile damage accumulation and nucleation of macroscopic tearing. The implementation of novel criterion of plastic instability gave an opportunity to trace the state of corroded pipeline under multipass in-service weld deposition repair and determine the allowable heat input parameters from the point of view of possible burnthrough and excessive residual deformation of the pipe. The generalization of calculation results as two-parameter diagrams showed the wider application of in-service repair welding of corroded pipelines in comparison with actual recommendations.

6. Influence of microstructure on near-threshold fatigue crack growth in the welding joint of 18Ni maraging steel

Haitao Zhao, Delun Guo, Qi Qin, Sujun Wu
School of Mateials Science and Engineering Beihang University. Beijing China

Abstract:

The influence of microstructure of both base metal and welding seam of 18Ni maraging steel on the fatigue crack growth behavior near-threshold region was studied. The microstructure and phase distribution of welding joint were analyzed by optical microscope and scanning electron microscope, and near-threshold fatigue crack growth rates were tested. Results show that The segregation of elements such as Mo, Ti and Ni results in the formation of a massive reversed austenite phase between welding dendrites, and correspondingly reduces the content of these elements in the welding matrix, thereby reducing the amount of Ni_3(Mo, Ti) in the welding matrix, and making the microhardness and tensile strength of the weld lower than that of the base metal. When stress ratio R is 0.1 and fatigue crack growth rate is less than 10^{-5} mm/cycle, roughness-induced crack closure induced has a greater influence on crack growth behavior of base metal microstructure than that of the weld. The lath martensite block is the microstructural unit that controls crack growth behavior near-threshold region in 18Ni maraging steel. The sliding reversibility of lath martensite block in the welding seam is greater than that of the base metal, which makes the crack growth rate near- threshold region lower than that of base metal under the worst-case condition with R of 0.9.

7. Diagnostics of equipment of oil refining and petrochemical industries using the metal magnetic memory technique

A. Dubov, A. Dubov, S. Kolokolnikov, A. Yamchuk, A. Marchenkov

Abstract:

In modern conditions of increasing production and processing of hydrocarbons, reliable and trouble-free operation of an oil and gas complex is essentially important for energy security and sustainable

socio-economic development of any industrially developed country. However, the level of accidents and injuries in the industry remains high. One of the ways to prevent impending failures of critical equipment is application of technical diagnostics in terms of the stressed-strained state analysis. The articles consider the case studies of the metal magnetic memory (MMM) technique application during inspection of equipment of oil refining and petrochemical industries.

8. Probabilistic Fracture Mechanics Approach to Investigate Difference in Charpy Requirements for Pressure Vessels

Yin Jin Janin[a], Isabel Hadley
Fatigue and Fracture Integrity Management, TWI Ltd. Cambridge, Cambridgeshire, UK

Abstract:

The probability of failure (POF) of a structure is dependent on design, manufacture, inspection, operation and human factors. The POF may be determined on the basis of direct observation or theoretical methods, or some mixture of both. In this study, two methods are used to estimate probability of failure of pressure vessels: (1) a 'top-down' method based on a mixture of failure statistics and engineering judgement, and (2) a 'bottom-up' method based on fracture mechanics/engineering critical assessment (ECA). Using pressure vessel design codes as an example, this work also demonstrates whether and how the two methods can be integrated.