Working Group FSW Processing

Sent to: members of WG FSW Processing and B Pekkari

Repport and minutes

No 2

from the meeting **1-2 October 2007** at SKB in Oskarshamn.

Present:

Sylve Antonsson, Esab, Sweden
Lars Cederquist, SKB, Sweden
Sören Claesson, Bodycote, Sweden
Anna de Try, KIMAB, Sweden
Pontus Davidsson, SAPA, Sweden
Behnaz Ahgili, SKI, Sweden
Magnus Andersson, Esab, Sweden
David Hjertsén, Bodycote, Sweden
Mikael Tigerström, SKB
Ulf Ronneteg, Bodycote, Sweden
Gunnar Bolmsjö, Lunds Univ., Sweden
Leif Magne Kaalaas, Marine Alum., Sweden
Mathias Karlsson, SKB, Sweden
Lars Liljeblad, Liljeblad International Consultant, Sweden (repr. MegaStir)
Mathias Lundin, SWC, Sweden
Jukka Mononen, TKK, Finland
Johan Nordström, Esab, Sweden
Tapio Saukkonen, TKK, Finland
Kati Savolainen, Helsinki Univ., Finland
Henrik Schmidt, Tech. Univ. of Denmark
Mikael Soron, Esab, Sweden
Carl Sörensen, BYU, USA

Day 1: Technical visit to Äspö Hard Rock Laboratory (HRL)

Mathias Karlsson, PR Manager at SKB, presented the laboratory which is an underground facility with a 3 600 m tunnel system down to 460 m below ground surface. Research is done to evaluate the safety margins of a deep repository of nuclear waste. Methods for characterisation of a deep repository site are developed and tested here as well as equipment and methodology that will be used in the deep repository. The aim is to manage to store nuclear waste for 100 000 years (4000 generations). The repository must withstand several ice-ages that freeze the rock down to 200 m.

A great many tests are performed that covers all from how a tunnel is built and filled to corrosion testing. See further information at …

High level waste will be brought down from 20 000 W to 1 000 W at Central Interim Storage Facility (CLAB), where after it's stored in deep rock. 1 000 W to 100 W will take 1 000 years. The skin will protect 100 W, however, the waste is still lethal to internal organs.

200 tons/year waste comes from the industry. Copper cylinders containing 2,5-2,8 tons of waste and that are *Friction Stir Welded* shall be embedded in the rock.

Äspö HRL is only going to be used as a research facility and is never going to be a final repository.

Postadress/Postal address
Svetskommissionen
Box 5073
SE-102 42 Stockholm, Sweden

Besöksadress/Office address
Grev Turegatan 12A
Stockholm

Telefon/Telephone
+46-8-791 29 00
Telefax
+46-8-679 94 04

E-mail
info@svets.se
Web location
www.svets.se

Org.nr/Org.no
802017-0307
VAT-no
SE802017030701

Bankgiro
443-4924
PlusGiro
402212-5

Day 2: Meeting and lab tour at SKB Canister Laboratory

Lab tour and weld test at SKB Canister Laboratory

Lars Cederquist presented for the lab tour where a "flat bottom" weld test for the copper canister for nuclear waste storage is shown. The joint configuration was showed. SKB is also developing stable and repeatable weld cycle and intelligent software to eliminate human factor.

During the lab tour live welding tests where shown. The start was placed outside the joint in a pre-drilled hole. The welding speed was 75 mm/min and the tool temperature ca 850 °C (Cu melting point 1 080 °C). Welding of the bottom is not as critical as welding the lid since it's not loaded with nuclear waste.

Minutes from the meeting

1. Opening of the meeting (10.00 h)

   The host Lars Cerderquist, SKB, wished everyone welcome.

   In the absence of the chairman Lars Mohlkert, Pontus Davidsson, SAPA Profiles, was appointed chairman of the meeting.

   The secretary Mathias Lundin noted apologies from Lars Mohlkert, SAPA, Lars Källman, Bodycote, Torben Lorenzen, DanStir, Patrik Hertel, Sandvik and Erik Tolf, KIMAB.

   The agenda was approved with changes of the order of handling of items.

   Short round the table presentation of all participants was performed.

   Associated Professor Carl Sorensen from Brigham Young University participated as a guest just for this meeting.

   Further, new members of the group, see item 4, were welcomed.

2. Practical issues

   The language is English. In connection with lunch a tour of the Canister Laboratory will be performed, see above.

3. Minutes (nr 1) of the last meeting in Stockholm

   The chairman briefly went trough the minutes. The minutes were approved.

4. Presentation of each organisation and their activities

   A short summary of the presentations below, see also attached documents for some presentations.

   Michael Soron, Esab

   Michael is involved with robotic FSW at Esab. He is also a PhD student. See further **appendix 1**.

   He explained about the main issues with robotic FSW, being e.g. flexing of the robot arms, control system etc. Monitoring and control of down force, side force and seam tracking.

   The reason to automate is to have a more flexible system with multidimensional capability. Will be shown at a fair in Gothenburg the week after this meeting.

   Michael was also at the IIW work shop during the Annual Assembly in Dubrovnik in July. It was a very broad symposium. Few papers on NDT and also FSW titanium. No papers on industrial projects, manly or only research papers.

   Tapio Saukkonen, TKK

   Tapio gave a presentation on "EBSD studies of FSWed and FSPed copper". See further **appendix 2**.

   He showed the analysis of the microstructure in FSW copper alloys by electron beam microscope. In some welds the area right below the pin has a very fine grain structure. Some disorientation, annealing in the grain boundaries,

Tapio mentioned the 15th International Conference on Textures of Materials (ICOTOM 15) at Carnegie Mellon University Center, Pittsburgh, 1-6 June 2008, see http://www.acers.org/ICOTOM15.

Henrik Schmidt, Technical University of Denmark

Henric is an Associate Professor at the Dept. of Manufacturing Engineering & Management. He has three (3) employees involved in modelling of FSW. Henrik presented the modelling activities at the university. See further **appendix 3 & 4**.

Why modelling FSW? To evaluate temperature history. Predict much that is not possible with only measurement. To predict the microstructure, residual stress, distortion. Investigate different welding parameters, backing, plate properties, cooling, clamping, tool design. Finally to optimise the process. Also to try to answer questions: How is heat generated? Where, How much? How does heat flow? What happens if the RPM is doubled?

Have made trials with 2024 and 7075 aluminium.

The main problem is to find materials properties in hi strain rates and temperatures.

The stiffness of the equipment is in the model.

Henrik also address the cooperation between DanStir and Bayards. The DanStir facilities in Copenhagen is moved to Bayards Aluminium Constructies B.V. headquarter in Netherlands. See further **appendix 5**.

Behnaz Ahgili, SKI

Behnaz represents the Swedish government regulatory body that supervises all nuclear activities in Sweden. She explained her interests in the FSW process and activities, and involvement in the project at SKB.

5. Theme – NDT and imperfections

Ulf Ronneteg, SKB

Ulf gave a presentation about “NDT reliability study at SKB including UT and RT equipment”. See further **appendix 6**.

The reason for NDT is to verify the canister as corrosion barrier, safe handling from sealing to deposit, and the mechanical strength in the deep deposit, and to make sure that the radiation don't affect the bentonite buffer.

In the lab they can handle NDT for 5 m canister. They are using Phased Array ultrasonic testing and High-energy radiographic testing.

Phased Array UT: The beam can be steered to make sure that the signal is perpendicular to the defect. Scanning from the lid with UT angle 0, ±10° and ±20°.

Looking for root defects (joint line hooking, JLH) and worm holes.

Making reliability studies in a project at the German BAM. POD-value (probability of detection) showed joint line hooking 4 mm and wormholes 5 mm. UT is suitable for FSW which is a very stable process. The reliability of the NDT-methods is sufficient.

Discussion on the defects and how they appear and are avoided. Wormholes appear at the shoulder on the advancing side.

Carl Sorensen, BYU

Carl, that was invited by Lars Cederquist for this meeting, is an Associate Professor at BYU. He gave a presentation about “FSW of steel”. See further **appendix 7**.

Carl works at the Center for Friction Stir Processing at BYU, where they cooperate with five (5) other universities and 27 companies, e.g. FSRL and Mega Stir.

Approx 80 % of welding is in steel or stainless steel. "There must be a way".

Tool material is the main issue. Refractory Metal Alloys and super alloys are investigated.

Carl showed successful tests with HSLA-65, 304 Stainless. Had to use reduced section test specimen for the tensile test since the weld and HAZ was stronger than the parent material.

Why no commercial application? Machine and licens cost. Tool cost. Tool life. What is the compelling reason to use FSW in steel?

Resent advances in tool material and design. Tools are getting more and more complicated geometry. CS 4 Tool Design has a concave shoulder and Step spiral Probe tool a convex shoulder. Tool runs with zero tilt which produces a more symmetric loading.

PCBN grade has increased wear resistance and toughness. Have observed tool life for 80 m weld in mild steel.

Carl showed an application where knife blades where "FSW treated" to increase hardness and corrosion resistance. This is now the fist commercial product in steel made with FSW.

He also showed FSW pipe welding of X65. Also looking for applications of FSW panel line welding for ship yards, 18 m long in 10 mm thick plate. Reason is to avoid distortion.

More commercial application is underway.

Residual stress? The peak is probably the same, however, the area is smaller hence less distortion.

Liquid cooled tool: Cooling is very important for the weld quality and repeatability.

Pontus Davidsson, SAPA Profiles

Pontus presentation about “Quality assessment at SAPA” was postponed to the next meeting.

6. Report on FSW standardisation activities in IIW (ISO/DIS 25239-1 to -5)

   The secretary reported that the draft standard ISO/DIS 25239-1 to -5 is out for voting until January 2008. The drafts where circulated before the meeting as well as an inquiry for comments.

   Each part was discussed and some comments were agreed and prepared in separate template forms, see further **appendix 8-12**.

   Part 1 is carefully

   It was decided that further comments be sent by the working group members to the secretary, Mr Lundin (mathias.lundin@svets.se) before the end of January 2008.

   Further, it was decided that the working group supports the drafts in general, hence voting to accept with comments.

7. Working program and administration

   The secretary showed the draft working program circulated with the minutes from the last meeting for acceptance by the working group. The working program was accepted with no further comments.

   Further, the secretary noted that no opposition to the proposal from the last meeting that SWC will administrate the working group. Hence it was agreed that the group is now sorted in SWC organisation scheme as AG 52 FSW Processing.

   In the future to finance administration non-SWC-members will be approached for member fee (one share only, 9.700 SEK, for non-Swedish members, otherwise depending on size).

   At SWC web site the group has a space accessed by the members via www.svets.se/ag52, where minutes, reports, members and other information can be downloaded. And further, inputs to the "forum" can be uploaded.

8. Member issues

   A list members so far is attached **(appendix 13)** to the minutes. Suggestions for other members of the working group (anyone missing?) can be forwarded to Mathias Lundin.

9. Arrangement for subsequent meeting

Next meeting was decided for the **16-17 April 2008 at MarineAluminium in Haugesund, Norway**, after an invitation by Leif Magne Kaalaas.

Suggested program will include:

Day 1 (16 April)

- Tour of production at Hydro
- Dinner

Day 2 (17 April)

- Tour of production at MarineAluminium

Preliminary agenda items:

- Quality assessment at SAPA, Pontus Davidsson or Lars Mohlkert
- Quality of FSW in steel at Sandvik Process Systems, Patrik Hertell

Please contact the chair, Lars Mohlkert, or secretary, Mathias Lundin, on additional agenda items.

Venue, see www.m-a.no

Flights suggested (see further www.sas.se)

16 April		
SK 1456	CPH-OSL	12:15-13:25
SK 8381	HEL-OSL	12:00-13:00
SK 861	ARN-OSL	11.55-12.50
SK 312	OSL-HAU	14:35-15:30

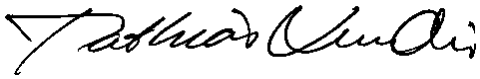
17 April		
SK 315	HAU-OSL	15:55-16:45
SK 1471	OSL-CPH	17:20-18:30
SK 6616	OSL-HEL	19:15-21:40
SK 1484	OSL-ARN	18:10-19:05

"Please do not hesitate to announce your possible presentations or hosting of coming meetings."

10. Closure of the meeting

The acting chairman thanked everyone for their attendance and contribution, and for the excellent arrangements (including dinner) by SKB, Lars Cederquist and Mathias Karlsson, and subsequently closed the meeting.

Meeting secretary



Mathias Lundin