



Report and minutes

No 3

from the meeting **16-17 April 2008** at Marine Aluminium in Haugesund, Norway.

Present:

Lars Mohlkert, SAPA, Sweden (Chair)
Mathias Lundin, SWC, Sweden (Secr)
Magnus Andersson, ESAB, Sweden
Sylve Antonsson, ESAB, Sweden
Harald Bergesen, Marine Aluminium, Norway
Sören Claesson, Bodycote, Sweden
Jostein Fabrin, Hydro Aluminium Profiler, Norway
Jari Inermo, Marine Aluminium, Norway
Jan Johannesen, Marine Aluminium, Norway
Torvald Larsen, Marine Aluminium, Norway
Torben Lorentzen, DanStir, Denmark
Ole Terje Midling, Hydro Aluminium Profiler, Norway
Johan Nordström, ESAB, Sweden
Mikael Soron, Esab, Sweden
Mikael Tigerström, SKB, Sweden
Helge Vaage, Marine Aluminium, Norway
Nils Arne Vik, Marine Aluminium, Norway

Day 1: Technical visit to Hydro

Jostein Fabrin guided through the production of aluminium from AIO to press bolts, wire, cold rolled or die-cast products.

Hydro Aluminium in Haugesund is Europe's biggest integrated aluminium smelting plant. At the site there are 1400 employees plus 300 external. Main products are 6000-alloys (6082). Research facility for e.g. joining of aluminium with other materials, corrosion (salt water facilities) etc.

The plant uses 4,5 TWh which is 4 % of the power production in Norway.

Production numbers:

Electrolyses	290 000 tons/year	in total whereof
	Söderberg	170 000 tons/year
	Pre-baked	120 000 tons/year
Press bolts	270 000 tons/year	
Cold-rolled	60 000 tons/year	
Die-cast	15 000 tons/year	

The Söderberg process must be terminated after 2010 for environmental reasons. Power consumption is 17 kW/kg with the Söderberg and 12 kW/kg with the Pre-baked process. 4 kg bauxite => 2 kg AIO => 1 kg Al. The one (1) km long shop is the longest in Norway. The EMF levels are very high for the process.

Söderberg is an old technique with one anode. Pre-baked process is more modern. Söderberg is managed with a 240 people crew whilst the pre-baked process only requires 16 per shift. Hydro produces its own carbon blocks for anodes in the electrolyte process.

The casting shop for press bolts has four (4) ovens of 90 tons each. Up to 40 % is re-melted aluminium (not primary). Produces bolts up to D 280 mm (equal the diameter of the power transfer). With its 7,5 m the bolt weigh a full 1 ton. After casting the bolts are post heat treated up to 500 °C.

The tour of the pressing plant was presented by Ole Terje Midling. Ole was active in the beginning of the development of FSW in the early nineties, however, is now the manager of the pressing plant.

The die casting is performed with 485 °C front temperature and 545-550 °C press temperature. After extrusion the profile is stretched 2-3% for properties reason, where after it bares of to the hardening, and

Day 2: Meeting and Technical visit to Marine Aluminium

Minutes from the meeting

1. Opening of the meeting (08.30 h)

The chairman, Lars Mohlkert, opened the meeting at

Apologies was noted from Lars Cederqvist, Patrik Hertel, David Hjertsén,

Special welcome to the quests/hosts Harald Bergesen, Jari Inermo, Nils Arne Vik, Jan Johannesen, Arild Frøkedal and Helge Vaage from Marine Aluminium, and Ole Terje Midling and Jostein Fabrin from Hydro.

The agenda was approved with item 6 changed to "Licens and patent issues".

2. Minutes (nr 2) of the last meeting in Oskarshamn

The chairman briefly went trough the minutes.

Carl Sorensen presentation is still missing.

Item 6: Delete "*Part 1 is carefully*"

With this amended the minutes were approved.

3. Practical issues

It was decided to keep the meeting in native language (Norwegian/Swedish/Danish) since no Finnish colleague was present. However, the minutes will be in English.

4. Presentation of each organisation and their activities

A round the table presentation of the participants.

The Marine Aluminium representatives present where
Nils Arne Vik, business development manager and also marketing manager,
Helge Vaage, operator and foreman
Jari Inermo, quality manager

Torben Lorentzen, see presentation appendix 1.

Torben gave a presentation on DanStir activities. Have been in the projects from the beginning with access to core research at TWI, projects such as GSP-12030 (co-sponsor), EUROSTIR, AL-JOIN, SOLVSTIR and INNOJOIN.

Have for example worked with "ferry tanks" to Boeings unmanned aircrafts, floor panels for a LOKHEAD Martin aircraft, door panels for Renault, wheel parts (rims) for VOLVO XC90, etc

The summer of 2007 DanStir change strategy and made a business agreement with Bayards. Dan Stir in Copenhagen remains, project screening, weld fixture, training, marketing.

The production (machine 15,5 x 3,5 m) is moved to Bayards in Holland. Is now located in a work shop site where it has a more suitable environment.

Representative production is vehicles for the defence, ship building, off shore, structural components etc.

5. Presentations on "Quality for FSW"

Patrik Hertel could not attend but we look forward to hear about "*Quality of FSW in steel at Sandvik Process Systems*" at a later meeting.

Quality assessment at SAPA (Lars Mohlkert, SAPA)

Lars Mohlkert presented how quality issues are handled at SAPA, see also **appendix 2**.

Lars described how qualification of procedures and operators, tolerances, fit-up, inspection and testing is managed at SAPA.

In principal the quality issues are the same as for fusion welding. SAPA has up to now used existing standards.

Focus is held on tolerances and fit-up, gap max 0,1t or 0,5 mm and misalignment max 0,5 mm. The height of the profiles may very well differ 1 mm.

Further, possible imperfections appearing by FSW and testing thereof was described. Undercut/underfill, overlap/flash are analogous to fusion welding in regard to the quality requirements.

Specific imperfections: Faying surface flaws appearing on the weld surface. Voids (not pores) usually due to large gap or curved surface. Joint line remnant (JLR), an oxide inclusion, do not affect the mechanical properties, but must be agreed. Lack of penetration (LOF) is a serious defect avoided by accurate choice of tool in relation to plate thickness.

These discontinuities are detected by VT, RT, UT or destructive testing (PT not recommended).

Robotic FSW for aerospace application (Mikael Soron, ESAB)

Mikael gave a presentation hinting what a robot can accomplish with FSW. ESABs trials shows grate possibilities. The robot project started 2003 and aimed for flexible 3D joining with FSW for e.g. the automotive industry. A prototype was finished in 2007. Hope to have a verified system in 2009.

Aero Space application was not on the original agenda, however, welding of curved panels for aeroplane structures is achievable.

Equipment is a modified ABB IRB-7600 with at IRC5 control system. Rotation of the tool is managed with the 6th robot axis. The process is forced controlled.

Alloys 7075 (18 cm/min), 7020-T6 (18 cm/min), 2050-T3 (60 cm/min) and 2024-T6 was tested regarding thickness, joint geometry, tool, welding speed etc.

60 cm/min was feasible for this type of application. 10 kN is the limit for the robot. Have tested 13 kN with some instability.

Test showed good or excellent results. Limitations: tests only on planar objects, unstable results on 45 degrees bevel. Unpredictable plunging, max 3 mm butt and 5 mm overlap joint.

Positioner and fixture of the workpiece must be optimised. Grate possibilities if one realize the limitations of the robot.

Esab is aiming for more trials to verify mechanical properties.

6. Licence and patent issues

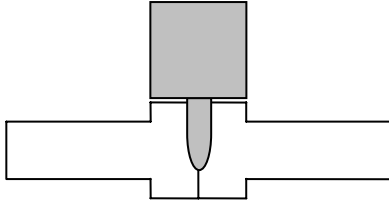
TWIs patent is valid until 2011. After that the process is open for free application for all uses. However, there is some 2500 patent and patent applications mainly concerning tool geometries and joints.

In the beginning Hitachi applied for 150 patents at once.

SKB have some patent applications together with TWI.

There are some patents on joint geometries which seems completely inconceivable that they were approved. The level of innovation is zero. The strategy seemed to be to have some thing to bargain with in litigations.

Example, a patented joint geometry where excess material reduce sensitivity of gap variation:



ESAB has a new employed patent engineer also to review patent applications.

AG 52 will return to the matter in coming meetings.

7. Short report on FSW standardisation activities in IIW (ISO/DIS 25239-1 to -5)

The secretary reported that the result of voting on ISO/DIS 25239-1 to -5 that ended in January. The draft was approved by all countries except Australia, China and Finland which all abstained.

The drafts and comments from the DIS-vote are posted at www.svets.se/ag52 under “Info & documents”.

IIW Com III-B1 meeting Columbus Ohio Monday 26 April to Friday 2 May. If not finished another meeting in Graz in connection to the Annual Assembly.

A published standard is expected in the spring of 2009.

8. Reports and news coverage (fairs, articles, conferences etc)

Mathias Lundin reported from a contact with Pekka Levijoki, Kitkahitsaus Jori in Kurika, Finland: Pekka is a teacher at Kurika school for vocational education. They examine 50 welders a year of which *15 also as FSW operators*.

TWIs 7th International Symposium on Friction Stir Welding will be held 20-22 May 2008 at Awaji Yumebutai Conference Centre, Awaji Island, Japan.

The 8th International Symposium on Friction Stir Welding will be held 20-22 May 2010 in Germany. See also www.twi.co.uk.

The 3rd FSW Modelling and Flow Visualisation Seminar will be held at GKSS, Geesthacht on the 28-29 April 2008. The seminar is jointly organised by GKSS and CENAERO and is centred on the presentation of results of the European project DEEPWELD.

The 19th AEROMAT in 23-26 June 2008 in Austin Texas. Have each year standing session FSW.

IIW Annual Assembly is 6-11 July in Graz, Austria.

The worlds largest welding fair “Schweissen und Schneiden” in Essen will take place 14-19 September 2009

ESAB Process Technical Days will be held 29-30 May in Gothenburg.

9. Working program and member issues (prospective participants etc)

Mathias posted the working program and made a short summary. Is also available at www.svets.se/ag52.

It was decided to amend AUTOMATION.

A list members so far is attached (**appendix 4**) to the minutes. Suggestions for other members of the working group (anyone missing?) can be forwarded to Mathias Lundin.

10. Arrangement for subsequent meeting

The working group has an invitation from Henrik Schmit at DTU, Denmark. The possibility to have a meeting at TWI in Cambridge was also discussed. TWI would probably be positive (contact: Philip Threadgil).

Next meeting was decided for Danish Technical University, Lyngby, Denmark, the 25-26 February 2009. (Secr. note: Later changed to 24-25 February)

Possible items for presentations:

- NDT on FSW or other issues at FORCE
- Simulation of FSW Process at Technical University of Denmark, Henrik Schmit
- Quality of FSW in steel at Sandvik Process Systems, Patrik Hertell
- New software for process control (temp) at SKB, Lars Cederqvist
- Possible application, Sylve Antonsson
- Tool design (pin and shoulder) at SKB, with following discussion. Two aspects: wear and och pinn fracture

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

More details to come in the meeting invitation.

11. Closure of the meeting

The chairman thanked everyone for their attendance and contribution, and for the excellent arrangements including a superb dinner hosted by Marine Aluminium.

Technical visit to Marine Aluminium

The second day of the meeting was rounded of with an interesting visit to the MarineAluminium plant. The group witnessed the production of various off-shore products, panels, ladders, helidecks etc.

The FSW machine is capable of welding maximum length of 16 m, and up to 20 metres in width. Only aluminium alloys in the 6xxx-series are certified for production. The profile thickness varies from 2 mm to 12 mm, at welding speeds up to 3.6 m/min.

From January 1997 to September 2004 approx. 465.000 m of FSW welds have been produced.

Meeting secretary



Mathias Lundin