Date July 24th 2012

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Objet **Report on IIW Commissions II-A, II-C, IX-H and IX-L meetings at the IIW 2012 Annual Assembly in Denver**

Monday, July 9, 2012 08:30 – 12:30
COMMISSION IX – BEHAVIOUR OF METALS SUBJECTED TO WELDING
SUBCOMMISSION IX-L - LOW ALLOYED STEEL WELDS

II.1 Annual Report of Sub-Commission IX-L by T. Koseki (Japan)

II.2 Technical Contributions

IX-2409-12 Numerical Investigations on Cold Cracking Avoidance in Fillet Welds of High Strength Steels by T. Mente, E. Steppan and Th. Böllinghaus (Germany)

- *The standards and directives recommend preheating, interpass temperatures and post weld heat treatments in order to avoid these imperfections. However, the steels up to a yield strength of 960 MPa are not standardized yet.*
- *The diffusion behavior and the effectiveness of different post weld heat treatments in the welded joint made of the material S1100QL including a filler metal with a yield strength of 960 MPa were simulated.*
- *Compared to the other joints, the T-joint has the highest remaining hydrogen concentration after welding, which has to be reduced. The results of the post weld heat treatments are illustrated in the practical Hydrogen Removal Heat Treatment (HRHT) diagrams.*
- *Base material = 1100 MPa y.s.*
- *Numerical simulation T-joint d = 12mm*
- *Heat input = 1kJ/mm*
- *Simulated distribution of hydrogen*
- *Interesting graph on H diffusivity vs temperature.*
- *It shows that there is no sufficient effusion after 48h!*
- *The simulation shows that HACC in the T-joint can only be avoided by applying a sufficient post weld heat treatments.*

IX-L-1093-12, IX-2410-12 Mechanical properties and microstructure of friction stir welded multilayered steel by J. Taendl, S. Nambu, J. Inoue, N. Enzinger and T. Koseki (Japan/Austria)

- *Laminated compound materials consisting of ductile austenitic steel and brittle martensitic steel are characterized by a combination of high strength and ductility which is unreachable with monolithic materials.*
- *Multilayered steel : layers of brittle and ductile layers*

- *As of now, there is not method to weld these steel.*
- *They tested a FSW procedure that seems to work.*
- *No industrial application yet.*

IX-2411-12/IX-L-1094-12 Influence of heat control on welding residual stresses in multi-layer component joints by A. Kromm and Th. Kannengießer (Germany)

- *Multi-pass submerged arc welding was conducted in a special large-scale testing facility SAW narrow gap.*
- *They change the interpass and measure its influence on residual stress. (test made on the BAM GAPSI 16)*
- *The evaluation shows that the level of reaction stresses measured during welding is strongly influenced by the heat control*
- *It was found that the bending moments formed due to excentric shrinkage of thick walled weld sections may alter the stress formation to a large extend.*
- *The local residual stress levels found in the surface of the samples are influenced by the heat control applied.*
- *Hard to extrapolate to other geometrie or materials.*
- *Shows that it is important to understand the physics and, ideally, modelise your assembly by FEM.*

IX-2412-12 Effect of Oxygen Content on Weld Microstructure and Inclusion Characteristics in Banitic type GMA Weld Metals by J.S. Seo, H.J. Kim and C.H. Lee (Korea)

- *This study was performed to understand the oxygen effect on weld microstructure, especially on the acicular ferrite formation in the bainitic-type weld metals.*
- *They change the protection gas to change % O2*
- *AWS ER100*
- *Effect on microstructure :*
    - *Pure Ar (96 ppm O) = 0% acicular ferrite*
    - *2%CO2 (141 ppm o) = 92% AF*
    - *252 ppm = 56% AF*
- *They find a fine layer of Ti on the inclusions.*
- *It was concluded that the oxygen effect in the welds is due to the phase change occurring at the inclusion surface with oxygen content and not due to the shift of CCT diagram associating with the inclusion density.*

IX-2413-12 Hydrogen diffusion of γ containing weld metals and hydrogen distribution in the welded joint by T. Kasuya, Y. Hashiba, H. Inoue, S. Nakamura and K. Takai (Japan)

- *The hydrogen evolution from weld metals that contain retained austenite was investigated in order to determine the physical properties such as the activation energies for the simulation of the hydrogen distribution in welded joints and to consider the time period to hold a cold cracking specimen before cracking observation.*
- *980 Mpa grade wire containing retained austenite : it is a LTT*
- *14%Cr-4%Ni = 2.5% RA*
- *14%-6%NI = 4.2%RA*
- *14%Cr-8%Ni = 16% RA*
- *They charge the specimen in H2 in H2SO4*
- *Interesting figure on D in martensite vs T*logt*
- *Complex model separating the effect of « trap sites » of those of « normal sites »*
- *One conclusion is that the cold cracking tests should cool during 7 days before concluding on the absence of cracks!*
- *Pertinent remark from the audience. = « Charging H artificially is different than charging H during welding »*

IX-2414-12 Crystalographic Analysis for Acicular Ferrite in Low Carbon Steel Weld by Y. Komizo, A. Takada, H. Terasaki and T. Yamada (Japan)

- *Inclusions contributing to acicular ferrite nucleation were investigated from a crystallographic point of view in low carbon low alloy steel weld metals.*
- *AF nucleates from inclusions*
- *Prove that KS (Kurdjumov-Sachs) and BN (Baker-Nutting) operate*
- *The inclusions related to acicular ferrite formation consisted of several phases, such as amorphous phase, α- MnS and the spinel structure in both ESW and SAW.*
- *Thin TiO layer was formed around inclusions in both ESW and SAW. The TiO have B–N OR with ferrite. Therefore, it can be considered that nucleation of acicular ferrite were encouraged due to low misfit value.*

IX-2415-12 Fatigue improvement of high strength steel welded joints with compressive residual stress by C. Shiga, E. Murakawa, U. Ohsuga, K. Hiraoka, Y. Morikage and K. Yasuda (Japan)

- *In order to improve the fatigue properties of gusset fillet welded joints in high-strength steels, the intensification of compressive residual stress around the weld toe was studied using the computer simulations of welded joints formed varying widths, lengths and depths of low transformation temperature (LTT) weld metal.*
- *They use a new joint geometr to improbve the LTT efficiency.*
- *800 MPa grade steel plates measuring 1000 mm × 150 mm × 20 mm.*
- *The results showed that the elongated bead welding method achieved a significant improvement in fatigue properties; i.e. about 10 times longer than that of conventional welding method at a 150 MPa stress level.*
- *This value is equal to the fatigue lifetime of welded joints treated using high-frequency peening methods such as High Frequency ImpactTreatment (HiFIT)and Ultrasonic Impact Treatment (UIT).*

IX-2416-12 Modeling of deoxidation process on submerged arc weld metal by H. Tanabe, H. Hirata, K. Ogawa and M. Hamada (Japan)

- *Fixed welding tests were performed to investigate deoxidization during submerged arc welding and to develop a model for it.*
- *Nice graph on the relation of CVN vs ppm O2 in steel pipelines.*
- *Based on these results, they found that deoxidization in weld metal during submerged arc welding can be predicted by estimating [O]e and k and briefly determining [O]i.*

X-2417-12 An investigation of simulated CGHAZ in HSLA65 and DH36 naval shipbuilding steels by N. Lane, Z. Sterjovski, M. Callaghan and H. Li (Australia)

- *Application : naval vessels*
- *A Gleeble 3500 thermo-mechanical simulator was used to produce simulated coarse grain heat affected zone (CGHAZ) specimens from two HSLA65 steels and one DH36 steel.*
- *HSLA65(11) has a greater toughness than HSLA65(8) in the simulated CGHAZ due to the following factors:*
    - *Lower carbon equivalent resulting in a smaller volume fraction of MA constituent,*
    - *More favourable small distributed morphology and MA constituent in HSLA65(11), compared to needle like lath MA and grain boundary MA in HSLA65(8),*
    - *Smaller effective grain size with higher resistance to cleavage crack propagation resulting from a smaller prior austenite grain size, possibly due to a more favourable Ti/N ratio.*
- *The two HSLA65 steels have a greater toughness than DH36 in the simulated CGHAZ due to the following factors:*

- *Lower levels of S and Ca treatment to reduce the detrimental effects of elongated MnS inclusions on the transverse impact toughness,*
- *A Ti/N ratio of 8.57 for the DH36 results in significant grain coarsening in the simulated CGHAZ,*
- *Large TiN particles may act as cleavage initiation sites.*

Monday July 9, 2012, 14:00 to 18:00
COMMISSION II – ARC WELDING AND FILLER METALS
SUBCOMMISSION II-A - METALLURGY

1. Opening remarks

2. Administrative matters of Sub commission II-A

II-1790-11 Annual report from Chennai, Sub commission II (Mr. van der Mee)

- Election of a new chair for Commission II, two candidates: Gerhard Posch (Austria),Thomas Kannengiesser (Germany). Gerhard Posch is elected as new chair of C-II.

II-1793-12 Annual report of Sub commission II-A (Dr. Kannengiesser)
II-1794-12 List of members of Sub commission II-A (Dr. Kannengiesser)
II-1795-12 List of documents of Sub commission II-A (Dr. Kannengiesser)

3. Hydrogen in weld metal

II-1814-12 (II-A-244-12) "Quantification of Hydrogen Diffusion Coefficients and Effusion Bahavior in Duplex Steel Weld Metals" Dr. Th. Kannengiesser.

- *Compare for the first-time the hydrogen diffusion and trapping behavior in electrochemically charged and welded ferritic-austenitic duplex stainless steels (1.4462).*
- *Characteristic extraction temperatures (400, 650 and 900°C) were used to quantify the amounts of diffusible hydrogen and residual (trapped) hydrogen for the basic bulk material as well as for the weld metal*
- *Interesting table on the binding energy of dofferent H traps*
- *At 650°C the diffusible H in austenite and trapped H in ferrite is removed*
- *At 900°C the trapped H in austenite is also removed (after 600 seconds)*
- *Nice explanation of why is H intake during welding is different of that during charging*
- *It was found that the basic material had a higher diffusion coefficient than that of the welded metal. This effect is probably due to the tortuosity of the diffusion path in the weld metal.*

II-1815-12 (II-A-246-12) "Hydrogen Assisted Cracking in the Fusion Boundary Region of Ni-base Alloy Overlays Applied to Carbon Steels". Dr. B.T. Alexandrov.

- *The fracture surface of an Alloy 625 / 8630 steel overlay that failed under cathodic protection was characterized using light optical microscopy (LOM), scanning electron microscopy (SEM) and X-ray dispersive spectroscopy (XEDS).*
- *Brittle structure found at the fusion boundary*
- *De l'austénite à 500HVN (1%C)!*
- *Low-angle sectioning.*
- *Nice and complete study, see also the paper by Lippold for more info.*

II-1823-12 (II-A-249-12, IX-2387-12) “Mesoscale modeling of hydrogen assisted cracking in Duplex Stainless Steel” Mr. T. Mente.

- *This paper contributes to numerical simulation of hydrogen assisted cracking in heterogeneous microstructure, e. g. in a duplex stainless steel microstructure consisting of two phase fractions.*
- *Cracking occurs in ferrite and crack often stops at austenite*
- *By analyzing the stress-strain distribution in the duplex microstructure, crack critical areas in the ferrite can be identified.*
- *Hydrogen assisted cracking was modeled assuming high hydrogen concentrations and regarding the local mechanical load in each phase of the duplex stainless steel.*
- *The mesoscale model qualitatively reflects the crack initiation and propagation process in the ferritic and austenitic phase of the duplex stainless steel.*

II-1824-12 “A new method for reducing diffusible hydrogen in weld metal” Mrs. S. Fiore.

- *Hobart has recently developed the concept of adding fluorine gas, in the form of carbon tetrafluoride (CF4) to the shielding gas for gas-shielded welding processes (FCAW, GMAW, MCAW)*
- *Goal = lower H.*
- *Exact mechanism not yet fully understood*
- *Because the CF4 is brought into the weld zone through the shielding gas, the technology can be readily applied to GMA welding with solid wire*
- *Reductions of 65% or more in weld metal diffusible hydrogen in FCAW are possible with the addition of CF4 to the shielding gas*
- *Reductions of 75% or more in weld metal diffusible hydrogen in GMAW are possible with the addition of CF4 to the shielding gas*
- *The addition of CF4 may reduce or eliminate the need for preheating in some materials, which may be a particular benefit in the case of temperature-sensitive materials*
- *Lowers B and Ti*
- *Health concern? It should probably be adressed by Commission VIII.*

4. Chemical reactions

No documents

5. The constitution of weld

II-1819-12 (II-A-242-12) “Metallurgical influence of multi-beam technology on duplex stainless steel welds’ Dr. M. Zinke.

- *Results of investigations concerning the development of an electron beam multi-process technology for welding the thick-walled components of DSS without filler material and post-weld heat treatment.*
- *EB welding, Material = 2205 and 2304*
- *Compared to conventional single-beam technology, EB multi beam welding is capable of considerably increasing the $\Delta t_{12/8}$. However, as the number of pools/remelts increases, a clear reduction in the nitrogen content of the weld metal is to be expected.*
- *Best results were provided by multi beam methods which did not use the maximum $\Delta t_{12/8}$, but which guaranteed the greatest possible nitrogen content in the weld metal.*
- *From a metallurgical perspective, using the EB multi beam method together with a preheating temperature of 200 °C generated high-quality beads on the 2205 plate without the need for a filler metal and subsequent heat treatment.*

- *The ferrite content in welds of 2304 could not be reduced by using of multi beam technique with preheating due to the low nitrogen content.*

II-1820-12 (II-A-245-12) "Effect of titanium and nitrogen on the transformation characteristics of acicular ferrite in reheated C-Mn steel weld metals" Dr. G.M. Evans.

- *The nucleation and growth processes of acicular ferrite in C-Mn steel weld metals containing various levels of titanium and nitrogen have been studied using a dilatometric technique in combination with transmission electron microscopy (TEM) associated with energy dispersive X-ray analysis (EDXA)*
- *Authors are not there to present.*
- *Nitrogen can be beneficial if steel contains Ti.*
- *Read paper to know more about acicular ferrite vs Widmanstatten ferrite.*

IX-2419-12 Copper infiltration on copper/stainless steel clad made by cold spray and GTAW, Hee-Joon Sung et al. (Korea)

- *In this study, copper clad stainless steel made by cold spray and GTAW overlay methods were evaluated in terms of copper infiltration during their working procedure and post heat treatment.*
- *Application = ITER project*
- *As a result of test, it was revealed that overlay welding made by copper and CuAlNi wire showed severe infiltration into stainless steel caused by copper. The path of copper infiltration on the overlay welded specimen was grain boundary of stainless steel.*
- *Solution : Ni overlay before welding Cu*

6. Weld metal cracking

II-1791-12, IIW2336 (II-A-239-12) "Cold Cracking Tests – An Overview of Present Technologies and Applications" Dr. Th. Kannengiesser.

- *Post-poned*

II-1816-12 (II-A-240-12) "Welding of hot crack sensitive nickel-base alloys using modified dip arc processes". Ms. C. Fink.

- *This paper contributes to the application of modified dip arc processes for butt welding of alloy 617.*
- *The influence of reduced heat input on microstructural and mechanical properties were investigated.*
- *Ni based alloys used for nuclear pwer generation*
- *Cold metal process (CMT) to lower heat input.*
- *CMT + pulse arc welding = pulse mix welding*
- *The modified dip arc welded joints exhibited high tensile strength and impact toughness.*
- *The mechanical properties are comparable to commonly GMA pulsed arc welding and are not influenced by the microcracks.*

II-1817-12 (II-A-243-12) "Hot cracking analysis using in-situ digital image correlation technique". Mr. C. Gollnow.

- *Not attended*

Tuesday, July 10, 2012 08:30 – 12:30
COMMISSION IX - BEHAVIOUR OF METALS SUBJECTED TO WELDING
SUBCOMMISSION IX-H - STAINLESS STEELS AND NICKEL ALLOYS

1. Annual Report of Sub-Commission IX-H by E. Westin (Austria)

2. Technical Contributions

IX-2382-12 Predictive and measurement methods for delta-ferrite determination in stainless steels. State-of-the-art review by M. Asunción Valiente (Spain)

- *A good review, nice for education purposes.*
- *Underline the need to do measurements of ferrite delta. Measurements are always more desirable than an approximative calculation.*
- *Those calculations are only as good as the chemical composition analysis. Do not underestimate their imprecision.*

IX-2379-12 Evaluation of the WRC-1992 diagram using computational thermodynamics, by S. Wessman (Sweden)

- *Use Calphad (calculation of phase diagram) and ThermoCalc.*
- *Redid WRC-1992 by calculation.*
- *The results showed that while the coefficients for Mo and N proved accurate, the values for Nb, C and Cu would require an adjustment. Alternative diagrams with adjusted chromium and nickel equivalents and iso-ferrite lines in both ferrite numbers (FN) and volume percent were suggested.*

IX-2386-12 Prediction of Occurrence of Ductility-Dip Cracking in Laser Overlay Welds of Alloy 690 on Type 316L Stainless Steel by K. Saida, H. Okauchi, Y. Nomoto, K. Bunda and K. Nishimoto (Japan)

- *Ductility-dip temperature ranges (DTRs) of alloy 690 weld metals in laser overlay welding were estimated from those obtained in gas tungsten arc welding (GTAW) by using the spot-Varestraint test.*
- *Predicted results of the occurrence of ductility-dip cracking were approximately consistent with experimental ones.*
- *Occurrence of ductility-dip cracking in multipass laser overlay welding of alloy 690 was successfully predicted based on the present numerical method.*

IX-2388-12 Use of the cast pin tear test to study solidification cracking by J. Lippold (USA)

- *Over a past 5 years, researchers at OSU have modified the original test and apparatus design to study solidification cracking in a range of Ni-base alloys and stainless steels.*
- *Very good correlation is found between rankings of the solidification cracking susceptibility in various high-alloy stainless steels and high-Cr Ni-base filler metals generated using the CPTT and other solidification cracking tests.*
- *In addition, the application of the CPTT to study dilution effects in dissimilar material combinations is described.*
- *Those testing solidification cracking susceptibility of welds have to be aware of this study.*

IX-2390-12 Electrochemical noise methods for identifying pitting limits of stainless steel welds
by S. Paul, Q. Lu and P. Woollin (UK)

- *A more rapid test method for qualifying stainless steel for service in hot water with chlorides is proposed, involving brief anodic polarisation to a potential above the pitting potential, eg at the maximum intended service temperature, and then stepping back to the free corrosion potential of the test specimen, to activate pit sites*
- *Electrochemical noise test in low chloride low potential solutions to replace G48.*

IX-2392-12 Microstructural evolution during tool plunging of friction stir welding in single crystal austenitic stainless steel by J. Jeon, S. Mironov, Y.S. Sato, H. Kokawa, S.H.C. Park and S. Hirano (Japan)

- *Not attended*

IX-2393-12 The effect of welding conditions on solidification cracking susceptibility of Type 310S stainless steel during laser welding using in-situ observation technique by Kota Kadoi, Akira Fujinaga, Motomichi Yamamoto, Keiji Shinozaki (Japan)

- *The aim of this work was to investigate the effect of welding speed on solidification cracking susceptibility of Type 310S stainless steel.310 inox.*
- *The critical strain for solidification crack initiation decreased with increasing in welding speed.*
- *The distribution of the residual liquid depended on microstructure and the distribution morphology of the residual liquid changed from and a droplet to a thin film with increasing inwelding speed.*
- *The transition of distribution morphology of the residual liquid induces to be susceptible to solidification cracking.*
- *Impressive experimental study using high speed camera and image analysis to better understand the hot cracking phenomenon.*

IX-2394-12 New generation ferritic and duplex stainless steels: Preliminary study on mechanical and in-service properties of welded joints by P. Nevasmaa, P. Varis, M. Sirén, P. Karjalainen-Roikonen, M. Karhu, V. Kujanpää, J. Hirn, J. Romu, V. Sieppi, H.-P. Heikkinen and J. Säynäjäkangas (Finland)

- *Covers two novel ferritic and one duplex stainless steel: the 17% Cr – double Nb+Ti stabilised EN 1.4509 and EN 1.4521, the latter with additional 2% Mo alloying, and the so-called ”lean duplex” grade EN 1.4162 with 21.5% Cr – 5% Mn – 1.5% Ni – N.*
- *Use ASTM 1921 to determine To =-98°C.*
- *Clear differences were observed in the toughness behaviour between the ferritic grades that should be taken into account in materials selection and structural design.*
- *Possibilities to reliably predict the fracture toughness T0 reference temperature on the basis of the Charpy T27J/28J data were evaluated.*

IX-2395-12 Hot cracking study on some austenitic stainless steels used in fourth generation nuclear reactors
by M. Le, L. Forest, O. Asserin and P. Pilvin (France)

- *316L with nitrogen 19-12-2.*
- *Hot cracking tests (VARESTRAINT, Gleeble, self restrained).*
- *The purpose of this work is to evaluate the susceptibility to hot cracking of the studied materials and to present the methodology applied to define a criterion called "laboratory" for each material and its transfer to a structure test.*
- *First numerical model of hot cracking test.*

- *Test and simulation results as well as hot cracking susceptibility ranking are presented and the transferability to real component welds of hot cracking criteria is discussed.*
- *Foundations of what would be a criterion of transferability.*

IX-2396-12 Mechanical properties of ferritic stainless steel welds in using typical ferritic filler metals
by S. Anttila, P. Karjalainen and S. Lantto (Finland)

- *409LNb, 430LNb, 430T and 308LSi filler metal.*
- *Effect of PWHT(outgassing 200°C and stress relief 750°C).*
- *Availibility of ferritic s.s. filler metal is quite limited.*
- *According to the results, the tensile strength and ductility are acceptable, but the major limiting factor with these as with other ferritic filler metals is the poor impact toughness in the weld region.*
- *Most of papers on high temperature temperature.*
- *Grain refinement does occur when %Ti is sufficiently high.*
- *Laves phase embrittlement in type 441 BM and HAZ.*

Tuesday July 10, 2012, 14:00 to 18:00
COMMISSION II – ARC WELDING AND FILLER METALS
SUB COMMISSION II-C - TESTING AND MEASUREMENT OF WELDS

1. Opening remarks

2. Administrative matters of Sub commission II-C

II-1790-11 Annual report from Chennai, Sub commission II-C (Mr. van der Mee)
II-1797-12 Annual report of Sub commission II-C (Dr. Posch)
II-1798-12 List of members of Sub commission II-C (Dr. Posch)
II-1799-12 List of documents of Sub commission II-C (Dr. Posch)

3. Ferrite in high alloyed weld metal
II-1806-12 (II-C-433-11) “Reagent selection in austenitic stainless steel solidification modes characterization”. Dr. A. Valiente.

- *Although a wide range of reagents is recommended for the microstructural characterization of stainless steels in the literature, the current research compares eight different reagents.*
- *As the conclusion of the current work, only Ferrofluid EMG 911 and Kalling’s nº2 reagents were found suitable based on the chosen criteria.*
- *Comment from the audience: it is important to attack rapidly after polishing to avoid repassaivation of the surface.*

4. Corrosion testing of weld metal
II-1807-12 (II-C-437-11) “Pitting corrosion test methods for welded duplex stainless steel and the effect of nitrogen in the shielding and backing gas when GTAW”. Dr. E. Westin.

- *This paper shows the additional positive effect of nitrogen in the shielding and backing gas on the austenite formation and pitting corrosion resistance of welds in the lean duplex stainless steel LDX 2101® (EN 1.4162, UNS S32101).*

- *On the rootside, welding with argon had a seriously detrimental effect, while nitrogen-based backing gas significantly increased the critical pitting resistance (CPT).*
- *The highest values were obtained using 90% N2 + 10% H2 as backing gas.*

5. Testing of weld metal for hot cracking and micro fissuring

II-1808-12 (II-C-434-11) "Improved Varestraint Testing by Modification of Sample Geometry". J. Andersson.

- *Varestraint testing, they tested the fixturing effect (suuport plate, thickness of plates)*
- *The cracking response of two precipitation hardening Ni-based superalloys - Allvac 718Plus and Haynes 282 - was analysed in the context of the actual tensile/compression ratio imposed and measured by strain gauges attached to the upper and lower surface of the test plates.*
- *They found no influence of compressive stress on the Varestraint cracking response*

II-1809-12 (II-C-440-11) "Weldability studies on borated stainless steel using Varestraint and Gleeble Tests". Dr. A. Bhaduri.

- *Not assisted*

6. Procedures for weld metal chemical analysis and weld metal sample preparation – Comparison of analysis methods.

No documents

7. Testing of high-strength weld metals

II-1810-12 (II-C-436-11) "Welding technology for high strength welds and their microstructural evolution during cooling". R. Schnitzer.

- *HIgh strength steel 690 MPa y.s.*
- *The influence of different shielding gases and welding parameters were tested and evaluated using new-developed high strength metal-cored wires.*
- *The influence of different cooling times on hardness and microstructure was investigated to develop a continuous cooling transformation (CCT) diagram for the investigated welds.*
- *Test also in the CGHAZ, 600 samples for full characterization*
- *Confirm that CGHAZ have more than 100J at 0°C (CVN)*
- *Fatigue results in IIW-II-1724-10*
- *Very nice experimentation with a confocal microscope they visualize the transformation from the liquidus to room temperature (University of Leoben)*
- *It was concluded that the material solidifies via δ-ferrite, transforms to austenite of smaller grain size followed by a final transformation to a mainly bainitic microstructure at the applied cooling rate (t8/5=40 s).*
- *The grain size of austenite is much smaller than the one of δ-ferrite.*
- *Formation of precipitates occurs at a temperature of around 1000°C, which was confirmed by thermodynamic simulations suggesting that these could be of (Nb,Ti)C type.*

II-1812-12 (II-C-435-11) "Effect of Titanium on Solidification and Post-solidification Microstructure of High-strength Steel Welds" W. Vanovsek.

- *The dipping test simulator reproduces casting parameters of the strip casting process as well as welding parameters of gas metal arc welding.*
- *The objective of this work was to research the comparability of the microstructure and the mechanical properties of dipping test samples and weld samples with the same alloying composition.*

- *Measure the austenite grain size in function of the cooling rate and heat input.*
- *Even if %oxygen is different the fraction of ferrite is similar but not its morphology.*

8. Testing of Creep- and heat resistant weld metal

II-1813-12 (II-C-439-11) "Comparison of weld HAZ simulated microstructures of P22 grade steel". Dr. S. Mandziej.

- *Recent creep rupture tests and accelerated creep tests on P22 grade steel welded joints revealed creep cracks nucleating in fine-grained regions of heat-affected zones (HAZ) of the joints, in which regions larger than average carbide precipitates appeared.*
- *The weld thermal cycle simulations were carried out on Thermorestor-W and Gleeble 3800 simulators.*
- *They found differences the two methods; could be explained by thermal gradients that cause strain gradients.*

9. Testing of non-ferrous weld metal

No documents