Leiv Kolbeinsen Symposium

Professor Leiv Kolbeinsen

Norwegian University of Science and Technology (NTNU)

Born: July 15, 1949,
Nationality: Norwegian.
Present positions: Professor, Materials technology (Process metallurgy), NTNU.
MSc (1974), PhD (1982) from NTNU (formerly NTH).

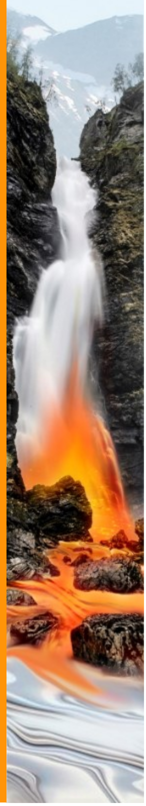
Work experience related to innovation and business sector:

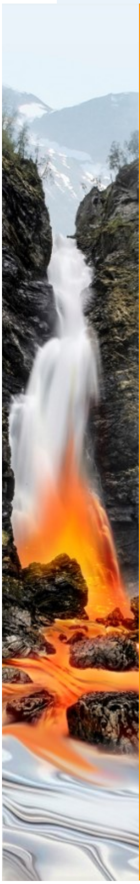
Professor of Materials Technology (Process metallurgy) since 2000 presently as emeritus. As leader of the Research Group "Resources, Energy & Environment" automatically included in the Extended Leader Group at Department of Materials Science and Engineering. Leader of the international study program MSLISIFER (Master of Science Light Metals, Silicon and Ferroalloys 2011-2017) and later (2020-2021) study program leader MTMT and MSMT, 5-year integrated and 2-year international MSc. study programs in Materials Science and Engineering, consequently also a member of the Education Affairs Committee (2011-2021)

Before that employed by NTH (teaching assistant 1975-1979) and at SINTEF Metallurgy/Materials Technology ((senior) research scientist 1980-1999). He has also been part time College lecturer at Trondheim College of Engineering (1984-1992) and a Visiting Scientist at Centre for Iron and Steel making Research (CISR) at Carnegie Mellon University (CMU), Pittsburgh, USA (1996-1997).

Research activities and fields of interests

SFI (Centre for research driven innovation) **Metal Production** (2015 - 2023): Leader of **Research Domain 5: Materials and Society** (-2021) Life Cycle and Material Flow Analysis, industry networking with a special responsibility to identify opportunities and disseminate research aspects that can attribute to the understanding of the social value of metals and support a sustainable development of the society.
FME (Centre for Environment-friendly Energy Research) **HighEFF** (2015 - 2023) Centre for an Energy Efficient and Competitive Industry for the Future; Mainly research on Industrial clusters. **ENSUREAL**: Ensuring zero waste production of Alumina in Europe (H2020) Demonstrate that a modified version of the Pedersen process can produce alumina from a wide range of minerals without any waste materials.
GasMat (2008 – 2010) - & **GasFerroSil**-projects (2010-17): Processing of natural gas – "Where Gas Meets Ore": The establishment of gas based industrial clusters producing materials. Application of Natural Gas in the ferroalloy industry and for pre-reduction of ilmenite as well as DRI is investigated in various scenarios, also often including clusters of several industries.
CORALSEA-project (Chrome Oxide Reduction – an Atomic Level modelling and Spectrographic Experimental Approach) (2014 – 2018): **ULCOS** (Ultra Low CO2 Steel technology); **CarboMat** Project: Carbon Materials Science; **DISvaDRI** Project: Dispersoids In Steel - value added Direct Reduced Iron; **ROMA**- and **FUME**-projects: Optimization of Raw Materials' Properties and Process Operations to Minimize Losses of Materials and Exergy.





International collaboration & Memberships in academic and professional committees:

Luleå Technical Univ. (Sweden), MEFOS (Sweden), KTH (Sweden), Helsinki Univ. of Technology (Finland), RWTH Aachen (Germany), Univ. of New South Wales (Australia), Univ. of British Columbia (Vancouver, Canada), Univ. of Alberta (Edmonton, Canada), and Carnegie Mellon University (CMU) (Pittsburgh USA).

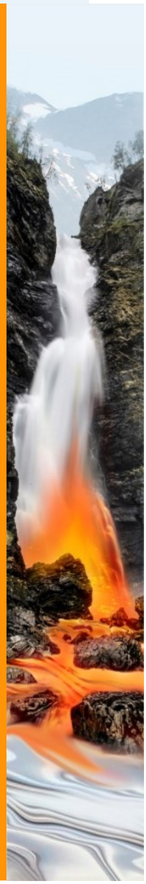
Board member – Norwegian Ferroalloy Producers Research Organization (FFF), Member of Work Group 1 (WG1) “Profit through Innovation” of the European Steel Technology Platform (ESTEP). Program board of NRC “Effective Energy Technology in Industry” (1992-1995). Norwegian Association of Standards Technical Support Group for ISO TC/207 SC4 Environmental Performance Evaluation EPE (1995-1998), and TMS - The Minerals Metals & Materials Society ASM Materials Life-Cycle Analysis Committee (1995-1999). Associated with leadership of conference series Society and Materials (SAM), Co-editor Matériaux & Techniques – Journal.

Prof. Leiv Kolbeinsen – A perfect combination of metallurgy and society

Aud Nina Wærnes
SINTEF Industry

Abstract

Leiv is a major figure in the metallurgical scientific environment at SINTEF and NTNU and has been so since his MSc in 1974. Today, his scientific skills and expertise are well acknowledged nationally, as well as internationally. It started with his PhD thesis in 1982 where a pilot plant for gaseous reduction of iron ores was constructed aimed at modelling, identification and dynamic control of the pilot – a cooperation between process metallurgy and control engineering – in proof of his ability to combine different scientific disciplines. He was the first person who truly saw the potential for utilising natural gas from the North Sea as reductant in metallurgical processes. He has been and still is an inspiration for us all.



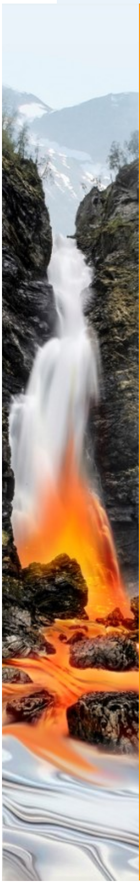
About the author

Senior Business Developer SINTEF Industry, Department of Metal Production and Processing/ Norway.
MSc from the Norwegian University of Science and Technology (NTNU) in Inorganic Chemistry. Research Scientist and Senior Scientist at SINTEF from 1980 to 2000. Research Director at SINTEF Materials and Chemistry, now SINTEF Industry. Since 2013, Senior Business Developer at SINTEF Industry. Centre Manager for SFI Metal Production and coordinator of the FFF (The Norwegian Ferroalloy Producers Research Association).

Renewables in the Global Energy Mix – a Technical and Geopolitical Status autumn 2022

Halvard Tveit

Elkem



Abstract

The author has all his life been interested in energy and energy related politics. He has participated in 2 publications regarding energy. The first paper was "The Norwegian power-intensive metallurgical industry and its role in the global household" that was presented in a NTVA (The Norwegian Academy of Technological Sciences) arranged conference in 2012. The Norwegian King Harald participated at this conference. The main topic was the Norwegian ferro alloy industry and the importance of energy in the future. The paper indicated the possibility that energy and other resources may be used political, and that Norway should prepare!

The other paper was written together with Professor Leiv Kolbeinsen. The paper delt with the importance of energy quality and was presented at at the SAM 13 conference in PISA in 2019. The title was: «The (Love & Hate) Role of Entropy in Process Metallurgy CASE:SILICON"

Unfortunately the importance of energy and energy quality has been sadly enhanced during 2022. Especially the European situation is dire and the winter 2022-23 may give an unpleasant learning regarding energy.

The main learning is that the conversion from fossil energy to renewable is a huge undertaking – and are probably severely underrated!

The presentation will also try to give an update of the consequences of the ongoing war in Ukraine and the sanctions policies for Norway and Europe.

About the author

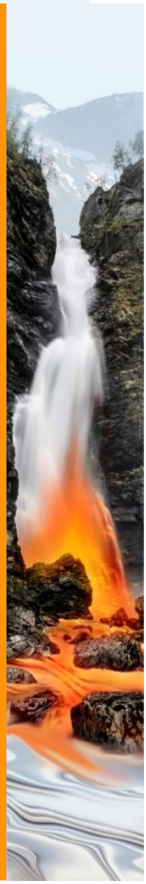
Halvard Tveit works a part time corporate Specialist in Elkem. He served 25 years as an adjunct Professor at NTNU

Meeting the sustainability challenge

Nancy Jorunn Holt
Program Manager Extermal R&D, TOS, Hydro Aluminium

Abstract

The aluminium industry is continuously striving to produce its products as sustainable and with as much profit as possible. We see that stakeholder expectations on climate, environmental responsibility and social value creation will increasingly impact our access to markets, talents, investors, and government around the world. To meet this challenge, Hydro has defined a set of sustainability ambitions with roadmaps for how to achieve these. The new overall ambitions for sustainability and specifically for climate, environment and social, respectively, were launched in 2021. This presentation gives an overview of the sustainability ambitions and the roadmap towards 2050, and with particular emphasis on primary production of aluminium.



About the author

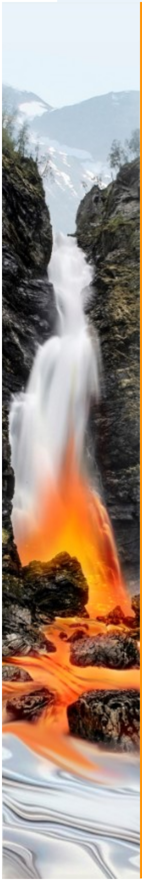
Nancy Jorunn Holt holds a PhD from NTNU in Trondheim and a Master Degree in Technology Management from NHH and MIT. She is currently Program Manager External R&D for Hydro Aluminium's primary Technology development and Operation Support (TOS). She has been with Hydro since 1991.

Wacker Chemicals Norway way to CO_2 neutral Si production in 2030.

Torbjørn Halland
Wacker Chemicals Norway

Abstract

Wacker Chemie AG has put his climate goal forward with 10 years. This presentation shows how WCN will be a central part in this reduction in the company. We work on several solutions to achieve this target, including CCS/U



About the author

Torbjørn Halland is Master of Science in process metallurgy from NTNU.
Several years as process metallurgist at Fesil and Elkem before becoming the CEO of Wacker Chemicals Norway AS from 2010.

LKAB Transformation -deep mining, fossil free iron and extraction of critical products from mining waste

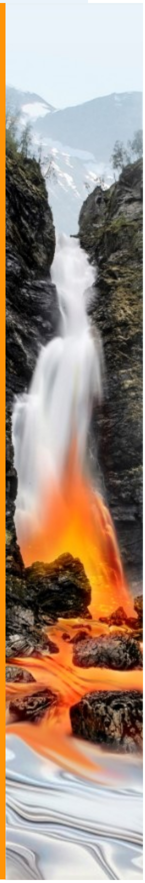
Jacob J. Steinmo
LKAB

Abstract

LKAB is to change from an iron ore producer to become a producer of fossil free direct reduced iron. In addition, develop a new world standard for deep mining at 2000 meters, develop a system for hydrogen production from renewable electricity integrating hydrogen storage to secure stable supply of both hydrogen and electricity.

The transformation has already started, developing technology for hydrogen reduction of iron ore. In this work competence in the field of iron ore reduction has been crucial for a successful project.

Towards 2050 LKAB is planning to invest more than 400 billion SEK in the transformation project securing a sustainable iron ore production and subsequent process to direct reduced iron. LKAB is also planning to start up a process in order to extract phosphorous for mineral fertilizer production and REE from mining waste. This will be a significant contribution to increase EU´s supply of strategic important materials.

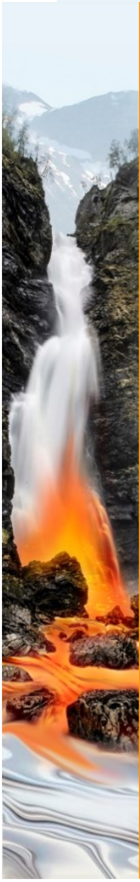


About the author

Jacob J. Steinmo graduated from Norwegian Institute of Technology in 1986. In the next 28 years he had different positions in Norwegian Ferroalloy Industry, both in production at Finnfjord AS and participation in the Norwegian Ferroalloy Producers Research Association. Since 2014 Steinmo has been working in LKAB .

Development of Sustainable Technologies - pilot experiences at MEFOS/Swerim

Guozhu Ye[1] and Eric Burström[2]
[1]Princial Scientist, Swerim, Sweden;
[2]Former Swerim R&D Manager



Abstract

Breakthrough technologies, energy minimization and recycling are the three major pillars for sustainability development works at Swerim for the metal and recycling industries. Energy consumption and its source are always the most important keys for a low CO_2 process. Recycling is a necessity for a circular economic system. New technologies often lead to a lower energy and material consumption thereby improving not just the overall economy but also the sustainability. Swerim, former MEFOS, has in the past decades developed numerous breakthrough technologies in the field, using the pilot and demonstration test facilities at Swerim. Some of the major projects will be highlighted in this paper to illustrate the importance of pilot plant for process development. From continuous steelmaking, strip casting, processing of secondary raw materials, ultralow CO_2 steelmaking, to zero waste and zero CO_2-approaches.

About the author

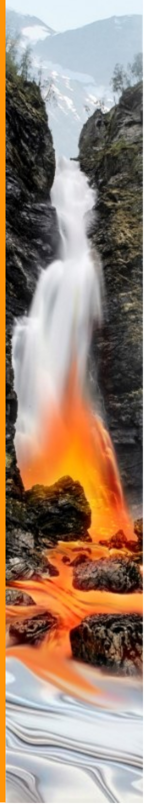
Dr. Guozhu Ye, Principal scientist at Swerim, started at Tsinghua University in Beijing, China (1978), MSc. and PhD at NTNU under Prof. T Rosenqvist (1980-88). Specialized in vanadium and titanium metallurgy, With Swerim/MEFOS since 1989 as senior researcher. Specialist in process modelling and extensive experiences in using pilot test facilities for development of new metallurgical and recycling processes. Expertise areas include slag processing and valorization, low and zero CO_2 metallurgical processes, recycling of V and P from steel slags, cleaning of Cu- and Ni-slag; recycling of spent catalysts and batteries, ilmenite smelting, DC/AC furnace technologies. Zn recovery from ferrous and nonferrous dusts including jarosite etc

Development of the Tyssedal ilmenite smelting process

Stian Seim
Ph.D., Research and Development Manager,
TiZir Titanium & Iron AS

Abstract

TiZir Titanium & Iron AS (TTI) is operating an ilmenite smelting facility in Tyssedal, Norway. The process consists of a prereduction plant and an electric arc furnace to produce a high titania slag and a high purity pig iron.
Over the past two decades TTI been focused on developing and maintaining a connection to the metallurgical research community in Trondheim. Being the sole operator of an ilmenite smelter in Europe this contact has been key to further develop a fundamental understanding of the processes operated. Prof. Leiv Kolbeinsen has been a vital contributor to establish and maintain continuity of research activities in Trondheim related to ilmenite smelting.
Through research programs such as KMB ROMA, KPN GasFerroSil, KPN Reduced CO_2 and SFI Metal Production fundamental topics have been studied. The gained understanding has enabled TTI to develop process operational strategies, make investments to increase productivity and undertake a project to replace the coal-based prereduction unit with a new hydrogen-based process. Obtaining such fundamental understanding of the processes operated has been a corner stone for the evolution of the Tyssedal plant.

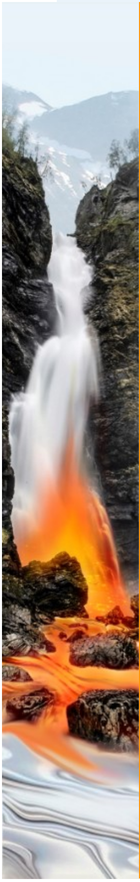


About the author

Stian holds a PhD degree from NTNU within experimental thermodynamics and has been employed at TTI since 2007. The focus at TTI has been within R&D work both as a metallurgist and as manager for R&D. Stian also has experience from production as manager of the prereduction plant.

Materials are social constructs, but they also have agency

Jean-Pierre Birat
IF Steelman, France



Abstract

A puzzling matter about materials, particularly structural materials, is that they exhibit both a rather extraordinary extension in time, bridging over many historical and prehistorical ages, and a dynamic dimension, changing as they are in time to the point that materials may not be easily recognized as similar; today as thousands of years ago. To understand this dichotomy, it is necessary to reach beyond materials science and STEM disciplines and to collect concepts and methods from SSH.

Materials and energy are at the core of the physical world in which society functions: they provide the structure of the artifacts that we need, along with the ability to make and use them. They do not exist in an absolute, Aristotelian world, but are invented along historical time, by people to meet their needs, hic et nunc. Materials are social constructs, as is the "theory" (technology, science in modern language) that gives us the keys for making them. As society changes historically, people's needs evolve and "new" materials are created on the shoulders of older ones, in a kind of evolutionary process. This is the view of social constructivism. This evolutionary metaphor is a first explanation of the continuity between, say, iron from a Roman bloomery and steel, as a contemporary commercial product.

This has been formulated as the Social Cycle of Materials (CCM) by sociologists of Knowledge and Innovation, as a process of continuous innovation in which materials are socially constructed over and over again, a process often called "progress".

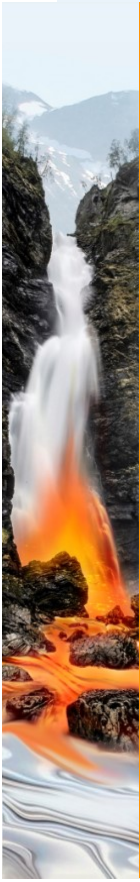
The continuity from old to new materials needs to be explained by some other model, however, to be fully understood: indeed, why is iron enduring so much, when it might have been displaced by another material at each evolutionary step and it didn't. The explanation we propose is to accept that "materials have agency", i.e. that they themselves are the actors of their perenniality. This refers to another model, the Actor Network Theory (ANT) of Latour et al., which analyzes how change is pulled by a combined network of actors, that include people, organizations, non-human living entities and inanimate things as well.

About the author

Jean-Pierre Birat was born in France after the War. He studied in Paris, last at Ecole des Mines, and then in Berkeley, California at UCB. He worked for most of his carrier at IRSID research center in Maizières, France, and evolved from a steel person to a material researcher, focusing on environmental and social issues related to materials and energy. He now runs IF Steelman, a consultancy that delivers services related to these topics, as well as pro bono activities. He met Leiv some 20 years ago, Anne-Kath, more recently.

Carbon Saturated SiMn and FeMn Alloys in Carbothermic Smelting Reactions

Young E. Lee
Technical Consultant



Abstract

Smelting processes of SiMn and FeMn alloys are designed and practiced with temperature as the independent variable at the gas phase pressure of P_{CO}=1atm. The system of carbon saturated SiMn and FeMn alloys is univariant, and temperatures at carbon saturation describe reduction and distribution reaction equilibria in smelting process.

For smelting of standard grade SiMn alloy, the alloy melt is saturated with carbon, and the liquidus of carbon is established well to describe the relationship with temperature. The distribution reaction between alloy and slag phases from simultaneous reduction of MnO and SiO_2 is shown to attain equilibrium chemically at about 1600°C and electrochemically at temperatures lower than that. An independent measurement shows melt temperatures of SiMn alloy from a furnace with 20MVA capacity to be in the range of 1300 to 1450°C. It indicates that the electrochemical reaction equilibrium describes the metallurgical performance of SiMn smelting operation practiced at present.

For FeMn alloys, the state of carbon saturation cannot be assessed properly because of insufficient information. The chemical distribution reaction equilibrium is shown to be attained at about 1412°C. On the other hand, an independent measurement of FeMn alloy melt temperature at tap is observed to be at about 1315°C. By virtue of this temperature difference, the electrochemical reaction equilibrium is taken to be responsible for the observed metallurgical performance at temperatures less than about 1412°C.

About the author

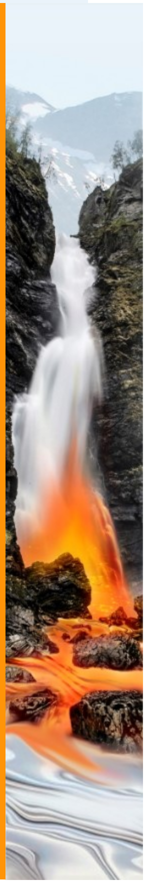
1964 BS Inha Institute of Technology
1970 MS University of Pennsylvania
1972 PhD Univ. of Pennsylvania
1975 Research Metallurgist, Union Carbide Corporation
1981 Scientist, Elkem Metal Co.
1999 Senior Scientist, Eramet
2005 Research Scientist, SINTEF
2008 Technical Advisor, DB Metal
2015 Technical Consultant

Thermodynamics at small scales

Signe Kjelstrup
Prof.em. Department of Chemistry, PoreLab, NTNU

Abstract

Classical thermodynamics, heavily used in metallurgy is due to Gibbs. This theory fails as the surface-volume ratio of the system increases as for example in nucleation. Gibbs energy is then no longer extensive in the nucleus particle number. Already in 1963, Hill proposed a way to restore extensivity. He defined thermodynamic properties of ensembles of clusters, grains, small systems in general. In this talk I summarize the principles of Hill's theory and show how it can be applied on the nano- or micrometer scale. The first example concerns a two-phase fluid in a pore. The second concerns the determination of activity coefficients, say of surface-adsorbed CO_2. In addition to produce practical information, we obtain a scaling law, which can be used to predict result for another geometry. In contrast to classical thermodynamics, an equation of state will, however, depend on the environment. This may nevertheless help define representative elementary volumes in porous media, and therefore help provide a thermodynamic basis for transport in porous media. We conclude that Hill's theory deserves a wider use.

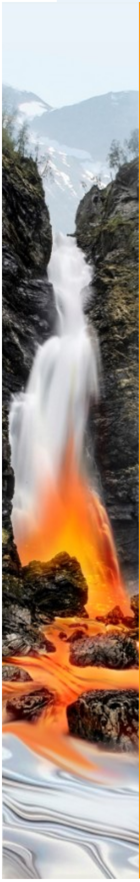


About the author

Prof.em. Signe Kjelstrup is principal investigator emerita in PoreLab Center of Excellence, NTNU. She has published 395 journal articles and 4 books. As a professor at NTNU she supervised 31 Phd and 62 MSc. She spent 2 months in HA Årdal and was a member of Bedriftsforsamlingen, Hydro Aluminium. From 1993-2000 she served in the executive board of the Norwegian Research Council.

From Calphad Thermodynamic Database to Virtual Process Simulation

In-Ho Jung
Professor, Seoul National University



Abstract

The CALPHAD type computational thermodynamic databases have been developed since 1970. The key concept of CALPHAD database is the description of thermodynamic properties of all phases within a given target system using the thermodynamic models with optimized model parameters as a function of composition and temperature. The most powerful and comprehensive thermodynamic database for pyrometallurgical industry is the FactSage thermochemical computing system. The FactSage database allows to calculate the complex chemical reactions and phase diagrams. As a key developer of the FactSage database, our group has expanded the database for pyrometallurgical applications. We also introduced the so-called Effective Equilibrium Reaction Zone (EERZ) model which links the CALPHAD thermodynamic database with reaction kinetics for process simulations. Using the EERZ concept, we have successfully developed a series of process simulation models for steelmaking and other pyrometallurgical processes. These process models are recently used as key components for Twin Factory project in several steel companies. In this study, the recent development of FactSage database and process simulation models will be highlighted.

About the author

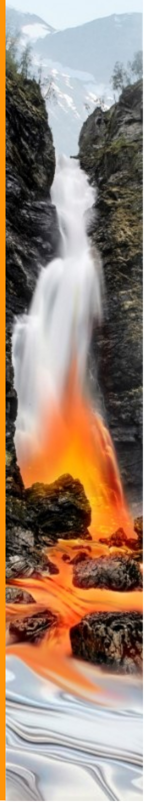
Professor In-Ho Jung is an expert in chemical metallurgy and thermodynamic database development. He has led the "FactSage Steelmaking Consortium Project" (sponsored by 13 companies) since 2009. He is also a recipient of 2022 AIST John F Elliott Lectureship award.

Reflections

Alan W. Cramb
Professor, Illinois Institute of Technology,
Chicago, Illinois

Abstract

During Prof. Kolbensen's career, there have been many changes to both technology and education. In this presentation, the impact of change will be briefly discussed with reference to metal production and the future of metals education



About the author

Alan Cramb is a distinguished professor in the Materials Department at Illinois Institute of Technology. He is a member of the National Academy of Engineering and formerly was a Professor at both RPI and Carnegie Mellon University. While at Carnegie he had the pleasure of working with Leiv during his sabbatical in Chicago.

Organizing committee

Jafar Safarian
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Norwegian University of Science and Technology

Stephen Lobo
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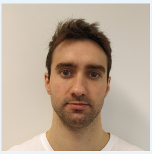
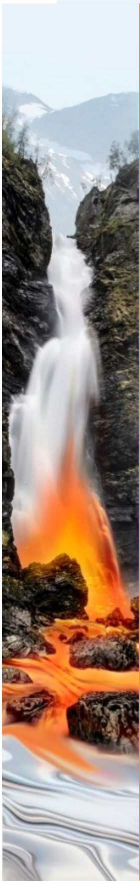
TiZir Titanium & Iron AS



Vincent Canaguier
Researcher
SINTEF



Acknowledgements

This symposium has been funded by SFI Metal Production (Centre for Research-based Innovation, 237738). The financial support from the Research Council of Norway and the partners of the SFI Metal Production is greatly acknowledged.

metal production

sfi Senter for forskningsdrevet innovasjon