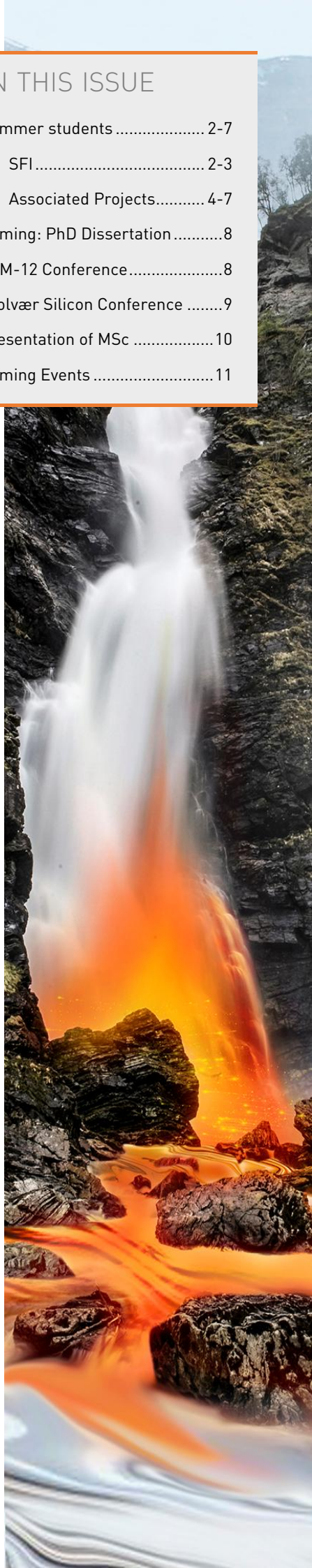
metal production

SFI **METAL** PRODUCTION

Newsletter Q2/18

In this issue



The first part of 2018 is over, busy months with many activities for the members of the SFI Metal Production: Workshops, Conferences and Project Meetings with participants from research and industry - covering the wide span of the SFI. Some examples are seminars on Dross formation, Dust emissions from the industry, Alumina dissolution in the bath and the SFI Spring Meeting. The SFI members have also been presenting their work at Conferences like TMS in Phoenix, Infacon XV in Cape Town and Silicon for the Solar and Chemical Industry in Svolvær.

Now, there are several summer students at the Centre from both the SFI Metal Production and associated projects. You will find introductions of some of them later in this Newsletter. On behalf of the SFI, I would like to thank the summer students for their contribution to the SFI Metal Production.

The focus for the Centre this autumn will be the preparation and implementation of the Midway Evaluation. The Research Council has formulated a number of success criteria for the SFI Centres. A key question for the evaluation will be whether a specific centre is well underway to satisfy these success criteria. Particular emphasis will be on whether a centre is enhancing the industry's capability to innovate.

The Midway Evaluation process will involve the whole Centre: students, the research partners NTNU, SINTEF and Norse, all the industrial partners, the Executive Committee and the Scientific Committee.

The SFI team will like to thank all partners in the SFI for an interesting and productive winter and spring. We are looking forward to meet you all after the summer holiday.

Have a nice summer holiday!

Aud N. Wærnes

Center Director

SUMMER STUDENTS

SFI and Associated Projects

From the left: Selma Lund, Erlend Flø Gustad, Magnus Skramstad, Sigmund Langedal Breivik

SFI

Report — Metal Production in Norway

Selma Lund, Erlend Flø Gustad, Magnus Skramstad and Sigmund Langedal
Breivik (2nd grade)

This year, four summer students from the MSc program in Material Sciences will be working on a comprehensive report about metal production in Norway. The basis for the report is a 2015 report by MSc student Eirik Nøst Nedkvitne, "En oversikt over norsk metallindustri". The four students will look at many different aspects of Norway's metal industry, such as total production, emissions, resource and energy efficiency, and the end use of the materials.

The first stage of the project is to obtain sets of raw data from the producers, which in itself can be quite challenging. Next, the students will have to interpret the data. Identifying trends and patterns in the data is key to making the report a useful tool.

A report like this is valuable for both educational and research purposes. It is important that there exists a comprehensive and impartial account of the developments in Norway's biggest land-based industry.

The Report: «Metal Production in Norway»

- First written in 2008 as part of the ROMA project, updated in 2010, 2012 and 2015.
- The report was in 2016 translated to English, under the title "An overview of Norwegian metals production".
- Previous iterations of the report have been referenced in several papers and presentations.
- The report is estimated to be finished this year.

Ivar Furu and Sigvart Eggen

Book — Principles of Metal Refining

This summer, two students will assist Senior Research Scientist Anne Kvithyld with revising the book "Principles of Metal Refining (Engh, 92)". Their contributions are valuable in making sure that the book stays relevant and up to date.

SIGVART:

So far I have been working on a chapter from the '92-version of the book. As a part of the revision we will be moving some chapters around to improve the feeling of continuity and natural progression. We are also working on a new chapter about recycling. There has been a lot of development in that area the last 25 years, and it is a very relevant subject for future students. In this project there is a lot to do, and little time to do it, so we are working hard in hopes of delivering a good product.

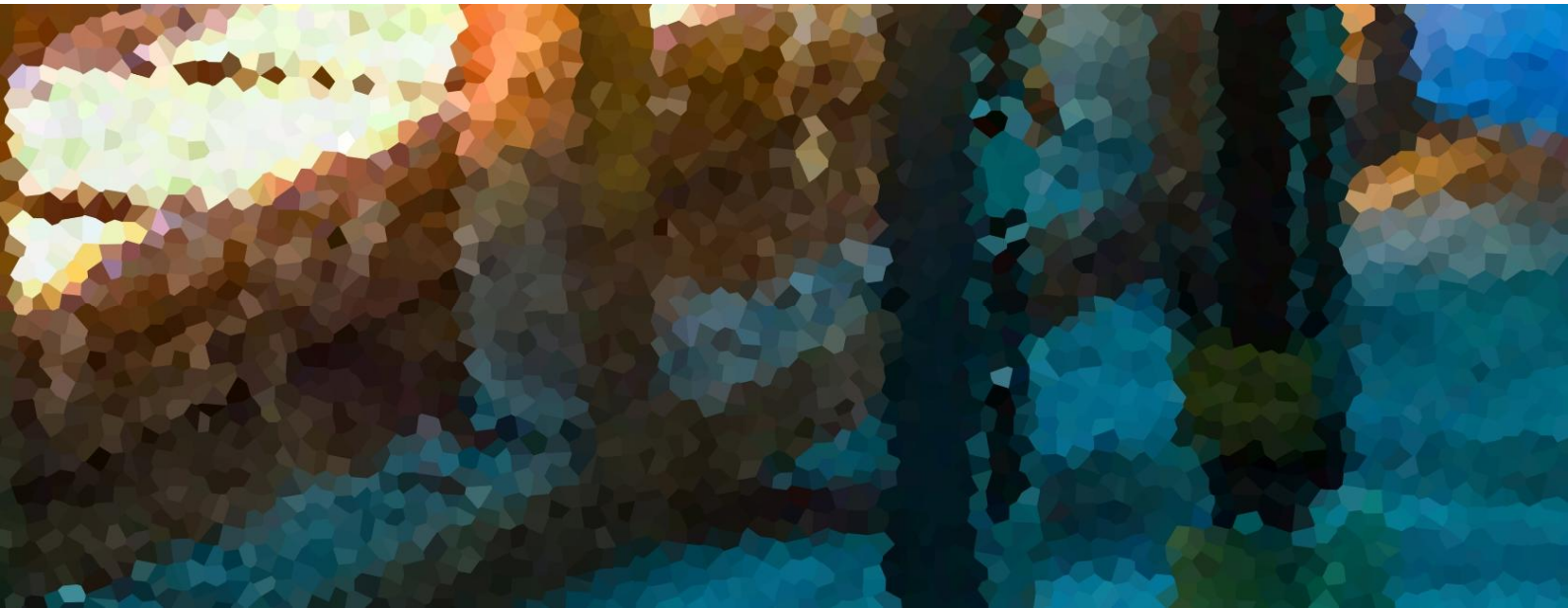
IVAR:

In this project I am working a lot on ensuring a good readability throughout the book. I will be looking at the content through the eyes of a student, and focus on making the text, figures, and formulas easier to understand. I am also looking through new papers on the subjects covered by the book, to make sure the content is scientifically well grounded. The reworking of some specific chapters is also upcoming.

Sofie Nilssen Neverdal

B.Sc.

I am a summer student at SFI Metal Production, and my work is a continuation of a Bachelors degree that was written this spring, in cooperation with Andrea Nautnes and Ingrid Hansen. Our thesis examined the electrolysis of aluminium, more specifically the formation of porous oxide rafts during the addition of alumina to the cryolite bath. Studying the circumstances around this phenomenon is essential to optimising the energy efficiency and usage of raw materials. I am working with SEM and XRD to characterize different phases in oxide rafts from Alcoa Mosjøen to better our understanding of this process.



Associated Projects

- In which the summer students are working

RemovAl (H2020)

The goal of the RemovAl project is to deliver and validate a complete feasibility study for four alumina producers and one legacy site owner detailing the optimum processing flow sheet for valorising the produced Bauxite Residue, (BR) along with other industrial by-products, taking into consideration waste characteristics, logistics and potential for symbiosis with other plants in the geographical vicinity.

AMADEUS (H2020, FET-OPEN)

A research project funded by the European Commission for the development of a new generation of ultra-compact energy storage devices based on molten metals and solid state heat-to-power converters. NTNU is one of seven partners in this H2020 project coordinated by Universidad Politécnica de Madrid. The project investigates the next generation of materials and devices for latent heat thermal energy storage (LHTES) at ultra-high temperature and the final goal of this project is to demonstrate the proof-of-concept of this idea and kick-starting an emerging research community around this new technological option.

DeMaskUs (KPN)

The DeMaskUs project is a collaborative project that aims to improve the working environment in the Norwegian ferroalloy, silicon and silicon carbide plants. The project will study how airborne dust is formed, how it affects human cells and how people can protect themselves from the airborne dust in the working environment. An interdisciplinary team of experts consisting of occupational physicians, hygienists, toxicologists, metallurgical scientists and industrial engineers will work together to examine the smallest particles in airborne dust.

Controlled Tapping (KPN)

The Controlled Tapping project will focus on stabilizing tappings of slag and metal in the metallurgical industry. The goal is to determine the fundamental tapping mechanism through studying materials and zones in the furnaces, through industrial campaigns and CFD modelling work.

Waste to Value (IPN)

The Waste to Value project aims to create value from the secondary material streams from the metallurgical industries to new products. Spent pot lining from the aluminium producers, and sludge and fines from industry are all big challenges that this project aims to tackle.

Partners in this project are Glencore Nickel, Alcoa, Hydro, Eramet, Elkem, Resitec, Eyde, SINTEF and NTNU.

BEST (IPN)

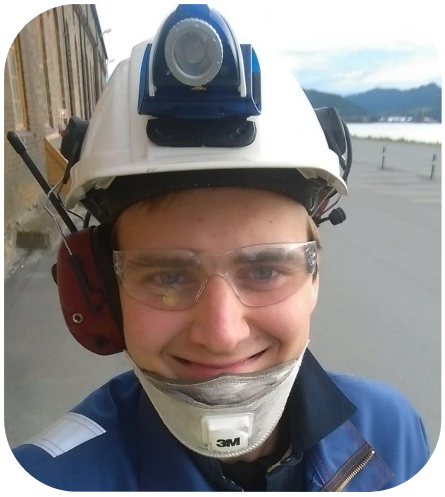
The BEST project aims to eliminate all particles with a size greater than 30 micrometres from aluminium. Especially removing hard carbide inclusions is an important step to improve aluminium quality.

Partners in this project are Hydro Aluminium, Hycast Gränges, Alcoa, SINTEF and NTNU.

High-Temp Quartz (IPN)

High-Temp Quartz is a joint project with Sintef and Norwegian University of Science and Technology (NTNU). The project is led by Aasgeir Valderhaug, Director of Process Development at Elkem Technology. Researchers from Elkem Technology participates in the project, together with colleagues in the Quartz team at Elkem Silicon Materials. The full-scale testing is undertaken at Elkem Silicon Materials plants; testing of one type of quartz that will be investigated in this project has already started.

IPN	- Innovation Project for the Industrial Sector. Read more here
KPN	- Knowledge-Building Project for Industry. Read more here
EU	- Project as part of EU's Horizon 2020. Read more here



Tobias Mohn Werner

4th grade
Project: Controlled Tapping

I am doing a project under the Controlled Tapping project, in co-operation with Elkem. In a metallurgical grade silicon furnace at Elkem Thamshavn, I am doing temperature measurements of molten silicon in the runner beneath the taphole of the furnace. These measurements will then be coupled to other parameters of the production to calculate an energy balance analysis for the process. Later on the obtained data will hopefully also contribute to my master's dissertation, with some slightly different approaches to the process.

Magnus Kyrre Windfeldt

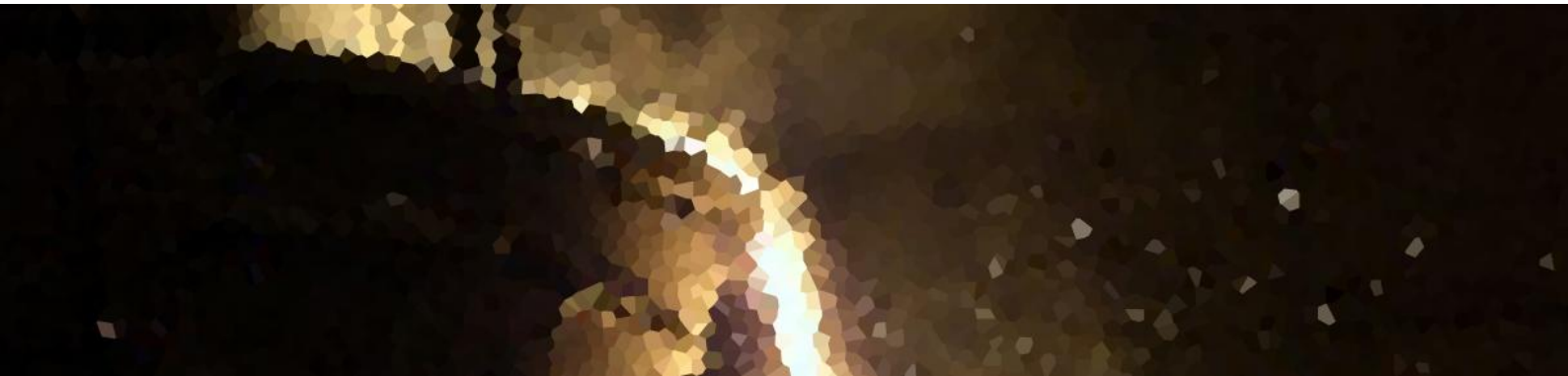
3rd grade
Project: Controlled Tapping

During the excavation of a silicon furnace at Elkem Salten in March, a great deal of samples from different locations were recovered. My job this summer is to analyse these samples, using SEM for imaging and analysis. By looking at the different phases that appear in different locations, we can learn more about where and how reactions happen in the furnace. We have a lot of good theories about the process inside the furnace, but excavations like this shows us that we still have much to learn. I am looking forward to using SEM in my work, and it would be exiting to find results that challenge established knowledge.

Sigurd Johannes Slåtsve Øvrelid

4th grade
Project: Controlled Tapping

In April i attended an excavation of a silicomanganese furnace at Eramet Kvinesdal. Like Magnus, I will try to learn about the environment inside the furnace by looking at the specific chemistry of the samples. The work starts with a sample, which needs to be cut to size. This sample is cast into an epoxy casing, which is then sanded down and polished to a very fine grit. Lastly the samples are degassed, and carbon coated. Only after this very thorough process, the samples may be analysed with SEM and EDS. Participating in the excavation was fun, and though some of my tasks can be a bit tedious, it is very exciting to see the results of my work during the analysis.



Caroline Sindland

3rd grade
Project: AMADEUS

This summer I will be producing two silicon based alloys and look at their characteristics around their melting temperature. The phases that form and the reactivity of the alloys is particularly interesting, since the project I am involved in aims to find suitable alloys for liquid-metal battery technology. I am looking forward using an experimental approach in my job, and I am excited about working with practical science, as we usually use a theoretical methodology during the rest of the year.

Erling Aares Vårli

2nd grade
Project: DeMaskUs

I will be working with PhD-candidate Håkon Olsen on dust formation during the production of different ferrous alloys. The work consists of heating, melting, and oxidising different alloys. Dust produced in this process will be captured in filters, and I will look at size distribution and amounts under different conditions.

Hanne Edfelt and Elisabeth Nordnes

High-Temp Quartz

The purpose of our experiment has been to investigate how different material properties of charge and fines influence gas permeability in the furnace during silicon production. The impact of fines on permeability of the charge was tested for 6 different fractions ranging from 0-8 mm. A small scale test cell was used in the experiments. The cell consisted of a cylinder, gas was injected, and the flow rate was successively increased while logging the corresponding pressure. Using our theoretical knowledge in a practical experiment have been rewarding.

Daniel Stormer Vadseth

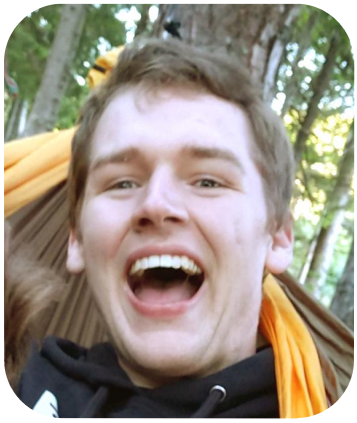
2nd grade
Project: RemovAl

My project aims to utilize biproducts from the metallurgical industry. This summer I will attempt to create ferrosilicon and iron from red mud, which is a hazardous waste product from the aluminium process. Afterwards I will analyse the metal produced through SEM/EDS and XRD. I am looking forward to producing an actual metal, as the 50 shades of red dust I'm working on now aren't particularly interesting. I am also looking forward to analysing the samples, I hope we manage to create a good product.

Andreas Voll Bugten

2nd grade
Project: Waste to Value

My project is centred around the utilization of sludge and slag from the production of silicomanganese. I will attempt to extract the manganese from the sludge by adding iron and lime from different sources, including scrap. The goal is to produce ferromanganese with a low level of phosphorous, that can be used as an alloying element. I am very excited to try out the equipment here. It will be interesting to see how the results vary when you alter different parameters, like amounts of raw materials and the rate of stirring.



Henning Dahl

2nd Grade
Project: BEST

This summer I will be working on refinement and recycling of aluminium, more specifically the problems related to traces of aluminium carbide. Al_4C_3 is a result of the aluminium bath reacting with the carbon anode in the electrolysis cell, where it is solved in the molten metal. When the temperature is lowered, however, the carbide precipitates into small particles. These small particles may cause problems later, especially if the aluminium is worked into very thin foils and similar products.

Ulrik Aalborg Eriksen

2nd Grade
Project: BEST

This summer I will be working on the BEST-project for SINTEF by analysing filters from the aluminium industry. When the molten aluminium passes through the filters, inclusions get stuck in the filter. I will be looking at their sizing, distribution, and other relevant factors. My results will later be compared with results from inline-measurements. I am excited to figure out how to analyze this new filter. Finding effective solutions in collaboration with experienced people is a rewarding process.

Coming:

PhD Dissertation

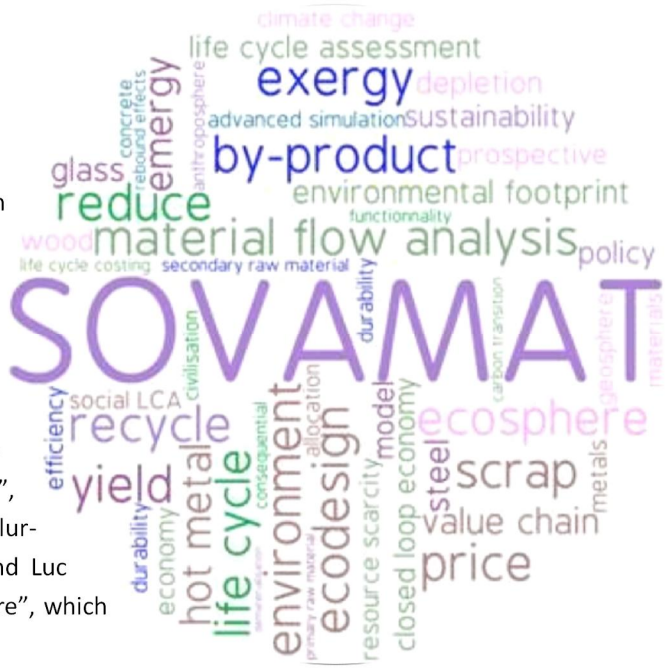
12. September - Trondheim

This fall, PhD candidate Pyunghwa Peace Kim will defend his Doctoral Thesis "The Reduction Rates of SiMn Slags from Various Raw Materials". Peace has been in Norway for five years now, completing his MSc and soon, his PhD. The dissertation will be held September 12. Look forward to a comprehensive interview with Peace in the next issue of the SFI Metal Production Newsletter!

SAM-12 Conference

22-23. May - Metz, France

The annual SAM Conference was arranged for the twelfth time this year. The SOVAMAT Initiative, an EU funded networking platform for uniting material "hard" sciences and social "soft" sciences, is responsible for the yearly realization of the conference.



This year featured an abundance of high quality presentations. Worth highlighting were Ignacio Calleja's Keynote lecture on "EIT Raw Materials and Circular Economy", Markus Reuter's keynote on "Circular economy and Metallurgy", Håkon Fyhn's presentation on "Human Factors" and Luc Chefneux's keynote on "Innovation for a sustainable future", which was described as "an eyeopener".

Jean-Pierre Birat, chairman of the SOVAMAT Scientific Committee and CEO of IF Steelman, held a keynote about the environment from the standpoints of philosophy, social sciences, and political activism. The presentation went through the viewpoints of many known philosophers, ecologists, and scientists, and how their work has contributed to creating a framework for dealing with the environmental issues of today. The late Norwegian Eco-philosopher Arne Næss was brought up as an influential figure.

To see the presentations and get more information about the SAM Conferences, visit their website at SOVAMAT.org

Silicon for the Chemical and Solar Industry XIV

11.-14. June - Svolvær

The 14th bi-annual silicon conference was held 11.-14. June in Svolvær. The conference attracted a lot of international attention, with over 110 attendees from many different countries and corporations. The guests were greeted and got the chance to mingle the evening of the first day.

Tuesday the 12th was devoted to primary production of Si and carbon electrodes. Several SFI employees held presentations about the primary production. After the presentations and the following discussions, the attendees were served dinner, followed by a boat ride to beautiful Henningsvær.

The following Wednesday was dedicated to solar grade silicon, production of trichlorosilane, and other applications of silicon. Many SFI employees presented their work. The day ended with a banquet accompanied by some entertainment.

The last day of the conference tackled the subjects of new markets and environment, health and safety. Better utilization of dust and fumes was a hot topic, and the continued development in China also gathered attention.

The 14th Silicon Conference was a great success, and the SFI extends thanks to all contributing parties.

Welcome back again in two years, for the 15th iteration of the conference!

Photo: Caroline Sindland

Presentation of MSc Students

From the left: Hanne Mette Hustad, Bettina Grorud, Cathrine Kyung Won Solem, Gina Opstad Andersen, Kevin Lim, Trygve Storm Aarnæs, Fredrik Rudjord, Matthew Wermers

4. June - Trondheim

On June 4th this year's master students of the REM-group (Resources, Energy & Environment) had the end-of-term celebration day. The day started with an introductory speech by the head of department, Jostein Mårdalen.

Throughout the day, all the students showcased their theses, as well as some of their most important results. The students who presented their work were Bettina Grorud, Fredrik Rudjord, Matthew Wermers, Cathrine Kyung Won Solem, Hanne Mette Hustad, Ingrid Meling, Kevin Lim, Sindre Engzelius Gylver, Gina Opstad Andersen, Trygve Storm Aarnæs and Mathias Grønberg Gustum.

The master students supervisors closed the program and the day came to an end with mingling at the SFI Metal Production's area.

The SFI Metal Production would like to wish the students the best of luck in their future work.

Portraits from the left: Sindre Engzelius Gylver, Ingrid Meling
Below: Mingling in the SFI office space

Photo: Petter Sjursen

Coming events

August 8-10, 2018 Kick-off and Summer School, INTPART- Norwegian-Canadian Partnership in Research and Education on Primary Production of Aluminium (CaNAl)
Trondheim, Norway

August 14, 2018 PROSIN-konferansen
Arendal, Norway

September 11-13, 2018 Nature Conference: Minerals and Materials for a Sustainable Future
Contact person: Jostein Mårdalen (jostein.mardalen@ntnu.no) - NTNU
Trondheim, Norway

September 12, 2018 Pyunghwa Peace Kim will defend his Doctoral Thesis *«The Reduction Rates of SiMn Slags from Various Raw Materials»*
Trondheim, Norway

September 17-18, 2018 Conference: Mathematical Modelling in Metallurgical Industry
A meeting place for intertaction between industry and academia
Kristiansand, Norway
More info and registration

September 26-27, 2018 Industri 2018
Bodø

October 14-17, 2018 Furnace Tapping 2018 Conference
Kruger National Park, South Africa

November 6-7, 2018 SFI Metal Production Autumn Meeting
Trondheim, Norway

metal production

sfi Senter for forskningsdrevet innovasjon
Norges forskningsråd

Center Director

Aud Nina Wærnes

Senior business developer, SINTEF

Cell: *+47 930 59 428*

Mail: *Aud.N.Warnes@sintef.no*

Executive Committee

Tor Grande, NTNU (Leader)
Nancy Holt, Hydro
Ketil Rye, Alcoa
Leif Hunsbedt, Eramet
Marit Dolmen, Elkem
Eli Aamot, SINTEF Industri
Svenn Anton Halvorsen, Teknova
Tor Einar Johnsen, NFR

SFI Metal Production

NTNU Gløshaugen
Alfred Getz' vei 2
NO-7491 Trondheim
Norway
www.ntnu.edu/metpro
Twitter: @sfimetprod