manufacturing

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NEWSLETTER

Date: 8th of December 2020

The aim of this newsletter is to keep the community up to date with the current research that is being carried out within and related to the centre.

In this issue:

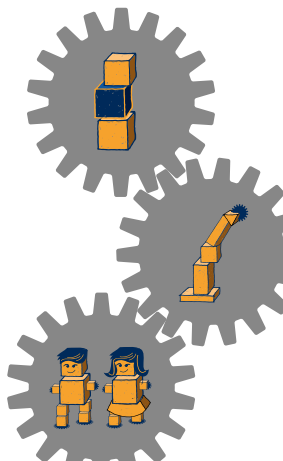
- Update from the centre management
- Sustainable development goals - SFI inputs to UNA Norway
- Update on the research activities
- PhD/post-doc presentations and progress reports
- International relations
- Industrial coordination

sfi Centre for Research-based Innovation

The Research Council of Norway

SFI Manufacturing

A cross-disciplinary centre for research based innovation for competitive high value manufacturing in Norway



Update from the centre management

Still a challenging situation

In the last newsletter in April we reported about a challenging situation for the centre and all our partners due to the Covid-19 situation. We have a continues process for mapping the situation for the centre activities and spin-off projects, and in June we asked all industrial partners for an update on their situation. The overall impression is that the situation is very divers but challenging:

- The SFI Manufacturing activities have some delays according to the work-plan for 2020, but all research areas report that ambition is to deliver according to the overall plan for 2020.
- All workshops for 2020 have been cancelled and we transform to monthly digital workshops
- The limited access to laboratories during the spring has caused difficulties for several of the PhD and post-docs. NTNU have established a compensation support for PhD's and Post-docs that will be delayed due to the Covid-19. 6 of the PhD's have been granted 1-3 months extension of their scholarship period.
- The feedback from our industrial partners reflect a large span in the consequences of the Covid-19 situation: From nearly (still) complete shutdown of the production due to collapse in the market, to doubling of sales compared to 2019 and high demand for increase in manufacturing. Several of the partners fortunately indicates that the there is a more positive development after the summer holidays than expected in June.

The new process for IPN applications in the Research Council with no specific deadline seems be embraced by the SFI Manufacturing consortium, and 4 new spin-off projects were granted in June.

In loving memory of

LIEKE OSTERHOUT

Our dear colleague and communication consultant Lieke Osterhout, tragically ended own life on June 21, in the Netherlands. She was at home, visiting her family at the time. Lieke turned 31 years old in January this year. Her family had a small funeral reception for only her closest friends and family.

We remember Lieke as pleasant, cheerful, dutiful, and clever. She was always positive and did her bit to create a good atmosphere and a good working environment wherever was.

Lieke had a master's degree in communication from the University of Twente and used her knowledge and skills to create web pages, newsletters and reports in SFI Manufacturing.

We will always remember your big smile.

SUSTAINABLE DEVELOPMENT GOALS

In January 2020 SFI Manufacturing discovered a discrepancy in the Norwegian translation in two of UNs 17 Sustainable Development Goals (SDG):

- In goal #9 the word "industri" wasn't incorporated in the title.
- In goal #12 the Norwegian explanatory text had an additional text: "the government may impose rules and fees to force companies investing in environmentally friendly technology". This additional sentence is not presented in the original goal.
- All of the sub goals in #9 and #12 has a satisfying translation from the original.

Conclusion

Together with "Norsk Industri" (organization) we approached UNA Norway with this information, and due to this the following changes are now implemented:

- Change the title of SDG goal #9 to "Industri, innovasjon og infrastruktur"
- Changed the additional text in SDG goal #12 to a text that is more in accordance with the origional UN text.

Update on the research activities

RA1 - Multi-Material Products and Processes

Additive manufacturing

The new SLM 280 HL — a state of the art additive manufacturing, powder bed fusion machine from SLM Solutions Gmbh — has been installed at the Additive Manufacturing Lab at NTNU in Trondheim. This very welcome addition to the research capability for AM technology has been funded by the national ManuLab program, which aims to provide a national research infrastructure for state-of-the-art manufacturing research in Norway. It is ten years since the first laser enabled powder bed fusion machine for metals (or PBF-LB/M, which is the international standard designation for this type of AM machines) was installed at NTNU, so this new machine brings an important update of the capability for research in various aspect of AM technology. The new features, including a heated build chamber, melt pool monitoring and much increased laser power, will be very useful for research in materials that have not been possible to process with the older machine. Among the highlights since the installation are some very promising investigations of aluminium alloys and high-speed tool steels (HSS), that have not been processed successfully by AM technology until now. This machine will be a useful tool for the new PhD and post-doc students (see below).

The SLM 280 HL machine is welcomed by Morten Onsøien (SINTEF Industry) and Vegard Brøtan (SINTEF Manufacturing).

The first build: a plate full of freshly fabricated parts for NTNU's Revolve, Formula Student racing car was completed within half a day.

Multi material metallic products and processes

The state-of-the-art (SOTA) review on joining technology for dissimilar metallic materials has been updated and shared in eRoom.

Linked to the SFI Manufacturing and MANULAB project (https://manulab.org/laboratories/), a 16 KW fiber laser station has been purchased with the support from NFR. Permanova Lasersystem AB is responsible for the delivery and installation of all the systems and components, including the safety system. The laser station that can carry out robot-based laser and hybrid welding. In addition, the system can be applied for surface and heat treatment, additive manufacturing and cutting, which together pave the way for research and innovation that benefit Norwegian industry and public administration. At moment, the final piece of the installation needs to be completed, and the system will soon be ready for operation. We are looking for relevant applications of this laser system and create joint R&D projects with industry partners.

In SFI Manufacturing, small scale characterization of materials has been performed. For example, the nano indentation technology has been applied to study the mechanical property of different inter metallic phases of aluminium-steel joint. This is part of Tina Bergh's PhD work and collaboration with SINTEF. New post-doc work will also be related to interface properties of dissimilar joints (welding, additive manufacturing etc.) using advanced characterization method like TEM.

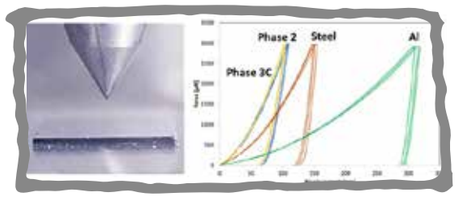


Figure. Nano indentation was applied to study local mechanical properties of aluminium-steel interface.

Update on polymer products and processes

The state of the art analysis (SOTA) has been updated to include new and interesting technologies in the field of joining multi materials which include polymer based components. Examples of research summarized in the updated SOTA include:

- Joining techniques to combine carbon fibre reinforced polymer composites to metals
- Mechanically joining polymers to metals parts by clinching
- Additive manufacturing of multi materials parts (such as fibre reinforced composites)

Additive Manufacturing Polymer Parts

The Polymer and Composite Materials Group at SINTEF Industry in Oslo recently received a new stereo lithography 3D printer for the additive manufacturing of polymer parts from liquid resins, enabling the production of small parts with either hard or flexible resins.

This new printer is in addition to the printers the Polymer and Composite Materials Group already has:

- Powder bed fusion polymer AM-equipment that can produce thermoplastic parts from e.g. stiff polyamides (nylons) to flexible thermoplastic polyurethanes directly from polymer powders (with the option to include glass, carbon or metallic particle fillers to produce stiffer, stronger parts).

- A multi-head printer which enables the deposition of up to 5 different materials simultaneously using techniques such as fused filament deposition, deposition of pastes, slurries and also in situ mixing and printing of two component resins in one continuous print operation.

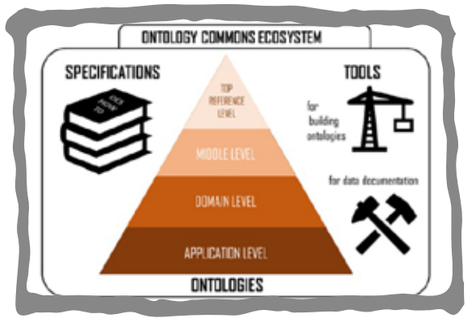
Picture: www.prusa3d.com

Standards for documentation of data in materials and manufacturing

SINTEF is involved in several new EU projects related to digitization in material modelling and manufacturing. One of these is the coordination and support action Ontology-driven data documentation for Industry Commons (OntoCommons), which will start up before Christmas. This project will lay the foundation for establishing common standards for the description of data for all domains within materials and manufacturing. OntoCommons' ambition is to simplify and support data sharing and be a driving force for data-driven innovation and the development of new business models that will make European industry better equipped to meet opportunities in digitalisation and sustainable solutions.

This is achieved by gathering and coordinating a wide range of stakeholders (both within and outside the consortium) to develop an Ontology Commons Ecosystem consisting of a set of ontologies and tools that follow specific standardized rules. This system will make it possible to harmonize existing standards (expressed by ontologies), make it easier to find, interpret and reuse data and enable the implementation of practical, robust and user-friendly mechanisms for communicating data across domain boundaries in materials and manufacturing.

ONTO COMMONS



OntoCommons shall provide the ecosystem of specifications, ontologies and data documentation tools..

RA2 - Robust and Flexible Automation

Publicity and publications

The research area 2 have had a very productive year so far in 2020. 10 conference publications and 2 journal articles were published between 1st January and 1st September 2020.

Our PhD and Post-doc students have participated on IFAC World Congress 2020, Germany (organized as a virtual event) and on the symposium arranged partly by the research area (SIMS 2020, Gjøvik).

Also results from on-going research projects connected to the SFI Manufacturing (e.g. KOPROD) and first tests in the MANULAB (https://www.ntnu.edu/ivb/manulab) has been presented on SIMS 2020.

Work-in-progress: Loading and unloading of hanging trolleys

In this work we want to demonstrate automatic loading of objects onto a swinging conveyor trolley using a robot manipulator arm. The hardware in the experimental set-up consists of a UR10E robot, two Azure Kinect 3D cameras, and trolleys made from welded steel bars. The work so far is focused on camera integration and calibration, tracking of trolley using Aruco markers, and planning of manipulator arm motion. Future work will focus on model based detection and tracking of the trolleys and objects (without the use of markers), and planning and control for the interaction operation between moving object and robot arm.

The figure shows the experimental set-up where the robot arm is synchronizing its end-effector position and orientation with respect to the Aruco marker attached to the swinging trolley.

RA3 - Innovative and Sustainable Organisations

As a joint effort between the research area's two work pages and one of the main deliverables in 2020 is a Whitepaper "The trends that will shape Norwegian manufacturing in the next decade". The paper cover major trends both within technologies and non-technological areas, that will potentially have huge consequences in the industry and their competitive leverage in the future. Together with the whitepaper there will also be developed scenarios that can guide the industry in their choices for the future and potential consequences of their choices of technological and non-technological developments. The whitepaper will soon be finalized, and the scenarios will be accomplished within this year. The whitepaper including the scenarios can also be seen as a useful platform to support cross disciplinary activities within the three research areas in the SFI.

PhD and Post-doc progress reports

Håkon Linga

My name is Håkon Linga and I started my PhD on 10th of August 2020. I took a master's degree in materials science and engineering at NTNU during the spring of 2020, where I studied the eutectic morphology of an aluminium cast alloy. During my PhD I will be working on additive manufacturing of metals, and although the exact direction of the work has not yet been decided I believe many exciting paths can be taken within this field. Either way I am looking forward to contributing to such a promising and rapidly developing technology.

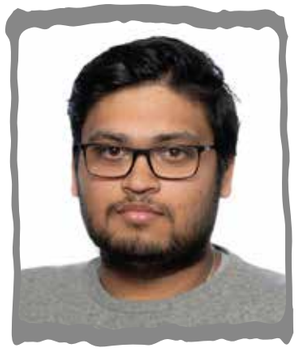
The supervisor team: Prof. Bjørn Holmedal (NTNU), Vegard Brøtan (SINTEF) and Xiaobo Ren (SINTEF).

Ding Peng (post-doc)

Ding Peng, who has taken his master's degree and PhD at Monash University in Melbourne Australia, arrived in Norway this September. During a 2-year postdoc, Peng will use advanced electron microscopy techniques to characterize multi-material interfaces in order to understand the physics and chemistry of these interfaces. 3D printed materials will be his main focus. Generic material properties and challenges, such as flaking during the initial stages of printing, will be characterized and linked to the experimental printing parameters. The aim is to achieve a better fundamental understanding about how the various experimental parameters during 3D printing affects the material properties. Such fundamental understanding will help to design better recipes for improved properties of the of 3D printed object.

In SFI Manufacturing, we always aim to link PhD and Postdoc work with industry case studies. Therefore, discussion and input are welcome and appreciated.

Chaman Srivastava



Glass or carbon fibre reinforced polymer composites are examples of complex multimaterial structures in which the performance of the two phases (the fibre reinforcement phase and the polymer matrix phase) and the interface between them determines the performance of the overall structure. PhD candidate Chaman Srivastava (NTNU Gjøvik, 2019 – 2023) is investigating the long term properties of different composite materials in his PhD project under the supervision of Prof. Sotirios Grammatikos and Prof. Are Strandlie (NTNU) and Ben Alcock (SINTEF).

Test coupons of composite materials are currently being exposed in the lab at NTNU Gjøvik to a range of different conditions to simulate some of the environmental challenges that real parts experience in their applications, such as constant high temperatures in wet or dry environments, cycles of high and low temperatures, exposure to strong sunlight etc.

All of these environments present different challenges to the materials, changing their performance and thus determining the lifetime of parts made from them. One of these long-term tests is a hygrothermal (combined water and heat) exposure. Several specimens are being exposed in parallel at different temperatures in controlled chambers (as shown in figure) and their decay in performance is being measured over several months, as a function of temperature. When complete, these data describing the performance in different environments will provide valuable understanding of how these different conditions effect the failure mechanisms of composite materials. This will also help us to develop numerical models to predict how the lifetimes of these materials change when used in parts in the similar environments in the real world.

Linn Danielsen Evjemo

The plan for my final year as a PhD-student in the SFI was to do a lot of practical work in the lab at SINTEF Industry, but this was naturally put on hold for a while when everything closed down in March. Due to this hold-up, I have been given a 6-week extension to my PhD, which means that I plan to submit my thesis in the beginning of February 2021.
Two different experiments have been done over the summer using wire-arc additive manufacturing (WAAM). This resulted in the structures shown here, built using two different nickel alloys (UTP 759 and Inconel 625) and cold metal transfer (CMT) welding. These structures both have overhangs, i.e. parts of the structure that stick out over a lower part of the structure without being supported in a directly vertical direction. For most traditional methods for additive manufacturing, overhangs would require building additional support structures which must then be removed in post-processing, but this was not necessary here.

The structure to the right is the first practical attempt on a vase structure with both an outwards- and an inwards-facing overhang. The orientation of the welding gun followed the direction of the wall it was building, demonstrating that it is possible to build such overhangs by depositing material in a non-vertical direction when welding. The structure to the left, a twisting hexagonal, was built without changing the orientation of the welding gun. This shows that with WAAM, slight overhangs can be constructed even with a strictly vertical orientation of the tool.

Ingrid Fjordheim Onstein

In June, I presented a literature review on state-of-the-art and future challenges in robotic deburring at the 3rd International Symposium on Small-scale Intelligent Manufacturing Systems. This is the first article that I have published and a big milestone for me. In July, I presented an article based on the work from my master's thesis about additive manufacturing path planning for robot manipulators at the IFAC World Congress. At this conference, all participants had to pre-record their presentation and all presentations was available on demand.

My focus this Autumn has changed a bit since I am taking a course and also helping with teaching at my department at NTNU. The course that I am taking, Deep Learning for Visual Computing, is project based and the vision group at SINTEF Digital is collaborating with me on it. This makes it possible for me to link the course project to my research which is very beneficial.

Andreas Hanssen Moltumyr

This spring, I conducted a survey on the use of cameras and laser scanners for in-process monitoring and closed-loop control in additive manufacturing. The survey revealed significant effort directed towards controlling the layer height, or the height of deposited material, by adjusting process parameters during additive manufacturing. Layer height being one of the most important quantities to ensure consistent printing. The survey was presented at the 3rd International Symposium on Small-scale Intelligent Manufacturing Systems in June and has been my first contribution to the scientific community and therefore a significant milestone in my PhD.

A month later, I attended the IFAC World Congress 2020, presenting an article based on my master's thesis about Fractional-order calculus for control.

In August, development on a prototype system for in-process geometry comparison between a "so-far printed object" and the CAD model used in the slicing and tool-path generation step was started. Further down the line, this might not only enable the measurement of deviation during additive manufacturing, but also set the stage for closed-loop control in 3D printing.

Mathias Hauan Arbo (post-doc)

Although often presented as instantaneous, industrial robot controllers contain motor drivers, motion buffers, trajectory handlers and many other aspects that may contribute to communication latency and motion delay that may adversely affect control algorithms. This was initially investigated for our KUKA robots by Ivar Eriksen in 2017 under the supervision of Mathias Arbo and Tommy Gravdahl. The results were improved upon and presented at IFAC world congress 2020. The article presents both the commercially available KUKA RSI interface, and the open-source KVP interface, and compares their results.

In collaboration with the Shafi Kurieshi and Lars Tingelstad of the department of Mechanical Engineering, the features of the new STEP AP242 exchange format was investigated for use with robot programming with CAD information. STEP AP242 is a neutral file format standard that can include geometric dimensioning and tolerance information, as well as basic geometric constraints for representing the positioning of parts relative to each other. These basic geometric constraints were used to try to infer the robotic motion required to assemble the parts. The article is to be presented by Shafi Kurieshi at CIRP CATS 2020.

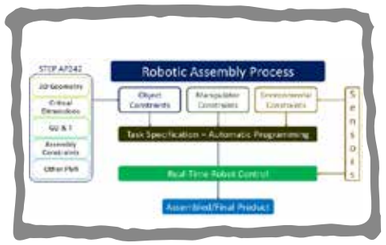


Figure 1 Illustration of the robotic assembly process when working with STEP AP242 as the neutral file exchange format. Note the some of the relevant information that can be extracted to inform the object constraints informing the automatic programming system.

Assiya Kenzhegaliyeva

My name is Assiya Kenzhegaliyeva, and I started my PhD in January 2020 at the Department of Geography, NTNU, under the supervision of Asbjørn Karlsen. My educational background includes an LL.M (Master of Laws) in European and International Law (Europa-Institute, Saarland University, Germany) and MSc in Globalization, Politics and Culture (Department of Geography, NTNU, Norway). Prior to my PhD I was working at the Department of Technology Management, SINTEF Digital, where I continue to work part-time now.
During the first semester of my PhD I spent time doing a literature review and familiarizing myself with possible empirical cases. A transition to circular economy requires many changes, including the changes in the institutional infrastructure. In my PhD I want to look closer at the role of standards for transition to circular economy of the global production networks and value chains. Standards can represent a severe barrier for the companies that wish to increase the circularity of their products. However, standards could also become an important driver of circular transition if developed properly and in line with the principles of circular economy. The complexity of the problem increases, as many different standards coexist at multiple scales and in multiple sectors.

During the next phase of my project I plan to attend relevant courses and start my fieldwork to learn more about the perceptions of this problem by the relevant stakeholders.

Henrik Brynthe Lund

Doctor Henrik Brynthe Lund defended his thesis for the phd. grade at Norwegian University of Science and Technology, Department of Geography. The title of the PhD-thesis is:'Navigating emerging technologies and knowledge demands: system perspectives in knowledge development in Norwegian manufacturing industry'

The PhD-committee included professor Heidi Wiig, BI, professor Martin Henning, University of Gothenburg and Associate professor Gjermund Wollan, NTNU. The trial lecture took place 12. June 2020 on the given topic of current interest: «Are production networks too global? How Covid-19 has challenged the theory and practice of Global Production Networks»
The public defense took place later the same day. After a well performed presentation of the thesis, there was a stimulating discussion between the candidate and the opponents on highly relevant topics for SFI-manufacturing. Due to the current corona situation both trial lecture and public defense were digital. It still turned out as a nice and educational experience. Congratulations to Henrik.

Sourav Sengupta (post-doc)

Sourav Sengupta is requited as post doctor in RA3, and started in the position 6th August 2020, but will not be physically located in Trondheim before the end of September. Sourav is from India holding a PhD within operations management which is a dual degree, joint award from Indian Institute of Technology, Bombay and Monash University, Australia. He has stated to work by exploring literature about integrated business planning (sales and operations planning) and the impact of digitalization, aiming to identify opportunities and barriers for integrated tactical planning in manufacturing in Industry 4.0.

Update on international relations

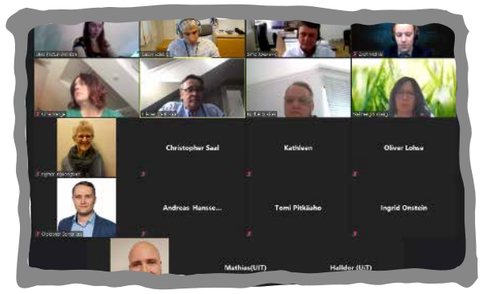
International Scientific Advisory Board

Originally, we planned to invite the IASAB for a face-to-face meeting in our last 2020 workshop. Since these workshops will digitally, we still plan for this but then only as a digital meeting. The main topic for discussion would be the choices we have made for the 2nd part of the SFI, especially on the topics for our PhD candidates and Post-docs.

IEEE SIMS 2020

3rd International Symposium on Small-scale Intelligent Manufacturing Systems
The SFI Manufacturing has been a major partner in the 3rd IEEE international symposium on Small scale Manufacturing Systems in June 2020. The symposium was initially planned to be hosted at NTNU Gjøvik from June 10th to 11th and an industrial visit to Raufoss Industry Park on June 12th, but the plans was altered to an online symposium on the 10th and 11th due to the Covid 19 pandemic. See the web page at the following URL: https://www.ntnu.edu/ieee-sims-2020/ieee-sims-2020 The papers from the symposium are available through the IEEE Xplore: https://ieeexplore.ieee.org

Between 10-12 June 2020 the SIMS 2020 conference was successfully arranged as a virtual event. Participants from over 6 countries, academics, research institutes and industry have shared their knowledge with each other.



INMAN International partnership project

Tee INMAN project is an international partnership project with partners from Norway, Japan and India. Due to the COVID 19 pandemic, all activities in the INMAN has been digital only, and the summer school and the final meeting at IIT Hyderabad is postponed to 2021.

MAVIS International partnership project

SFI Manufacturing is a partner in a new project for international partnership; MAVIS: Management of Variations In a Sustainable manufactured product life circle

The main goal is to consolidate international collaboration and partnership in between the Norwegian University of Science and Technology (NTNU) and SFI Manufacturing with partners in Germany and France; University of Stuttgart, Fraunhofer IPA and IAO, Grenoble INP, University of Technology of Compiègne as well as IRT Jules Verne. The research collaboration between the institutions and universities are already established, and with this project we can Broaden and deepen this strategic collaboration as well as expand the collaboration on education. The main topic for the collaboration is research and education within Industry 4.0 and how IoT and cyber-physical systems can be useful to manage the inevitable variations in manufacturing of products, the product life cycle and at the end-of life/ reuse /re manufacturing. We will ask ourselves: How can digitalisation be useful, create better products and contribute to UN SDGs?

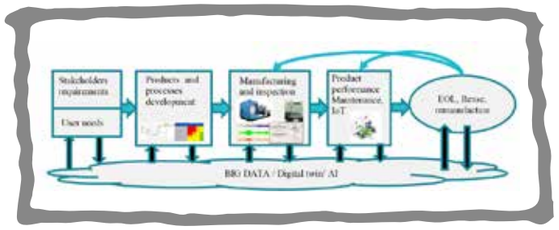


Figure 1 MAVIS flow of material and data/information.

Industrial coordination

Håkon Raabe

Industrial workshops

Due to the Covid-19 situation we have not been able to carry out the physical workshops. As follows, the planned March workshop at Raufoss with Kongsberg Automotive as host company was postponed, first to June, then to September, and then cancelled.

As a remedy while we await acceptance for larger physical assemblies, we initiated a series of shorter, digital workshops – or rather webinars. The firstwas held on September 23 and highlighted news from the center as well as an update of the MTNC Catapult center. We will strive to achieve an engaging format using not only presentations, but also pre-recorded videos and break-out sessions during the 2-hour meeting. The aim is to have these digital workshops at a monthly basis until we again can meet physically.

Two additional digital workshops has been executed:
Okc 28.th - Covered the three research areas with plans for 2021.
Nov 25.th - Focus on topics and challenges in Kongsberg Automotive.

Digital industrial workshop with Kongsberg Automotive ASA 25.Th of November 2020

1-1 meetings

This spring's 1-1 meetings started out in a situation much different from today. The first few meetings, we met physically, knowing little about what was to come during the Covid19 outbreak. After March 12, the meetings were rescheduled to Teams-meetings and discussions were marked by the Covid19 effects hitting the partner companies in quite different ways. Despite this, we received a lot of well-founded views and ideas for further research. We highly appreciate our partner companies' willingness and ability to communicate challenges to their manufacturing operations!

If one term should be chosen to mark this year's discussions, it must be 'sustainable manufacturing'. To expand this, the following trends and topics were highlighted in the meetings:

RA1-related:

- Additive manufacturing (AM) applications, and multi-material AM (different metals as well as polymers).
- AM for spare-parts and repairs, robotic AM for reach.
- Joining technologies and different welding methods for aluminum, steel and other metals.
- Large aluminum structures.
- Sensor-driven material- and product-control, especially in composites.
- Models and processes for CF winding of reinforced composite products.
- True multi-material metal products (different metals, polymers, composites, ...)
- Sustainable material choices in new product development. Upcoming regulations will demand changes in current products.
- Advanced real-time control of injection moulding processes.
- Injection moulding combined with extrusion, high viscosity injection moulding.

RA2-related:

- Human-machine cooperation, robots/cobots, especially assembly operations
- Small volume, flexible processes, one-piece flow, large and complex products; low-volume flexible manufacturing.
- Digital manufacturing / digital twins must support manufacturing operations. Same applies to AR/VR.
- New and more sustainable (as in less material waste) production technologies.
- Machine vision for handling complex shapes and surfaces, both process control and quality inspection. Sensor fusion (machine vision, ultrasound, x-ray, CT, ...)
- Automated / robotic support operations such as tool changes, fixtures placement, warehousing and internal logistics (AGVs/IGVs/cranes etc.)
- 'Control room manufacturing' using robots in harsh, dangerous, difficult operations.
- Getting more out of manufacturing control systems and machine-provided data in terms of data collection, 'big data' analysis, and manufacturing/business intelligence.
- AI and machine learning for improving complex manufacturing operations.

RA3-related:

- 'The green shift' including circular manufacturing and circular business models.
- Design for dis-assembly/dismantling for easier recycling and material re-use.
- LCA and reducing carbon footprint in new and existing products.
- Integrated product and process development.
- Industrializing digital, 'sensorized' products, both new-builds and retrofits.
- Building global competitiveness combined with strengthening local communities.
- Home-shoring to avoid excessive transport and improve material cycles.
- The possible paradox of lean and digitalization.

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Stay updated! Visit the website, or follow SFI Manufacturing on Twitter, for updates and information about the program and research areas

http://www.sfimanufacturing.no/

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