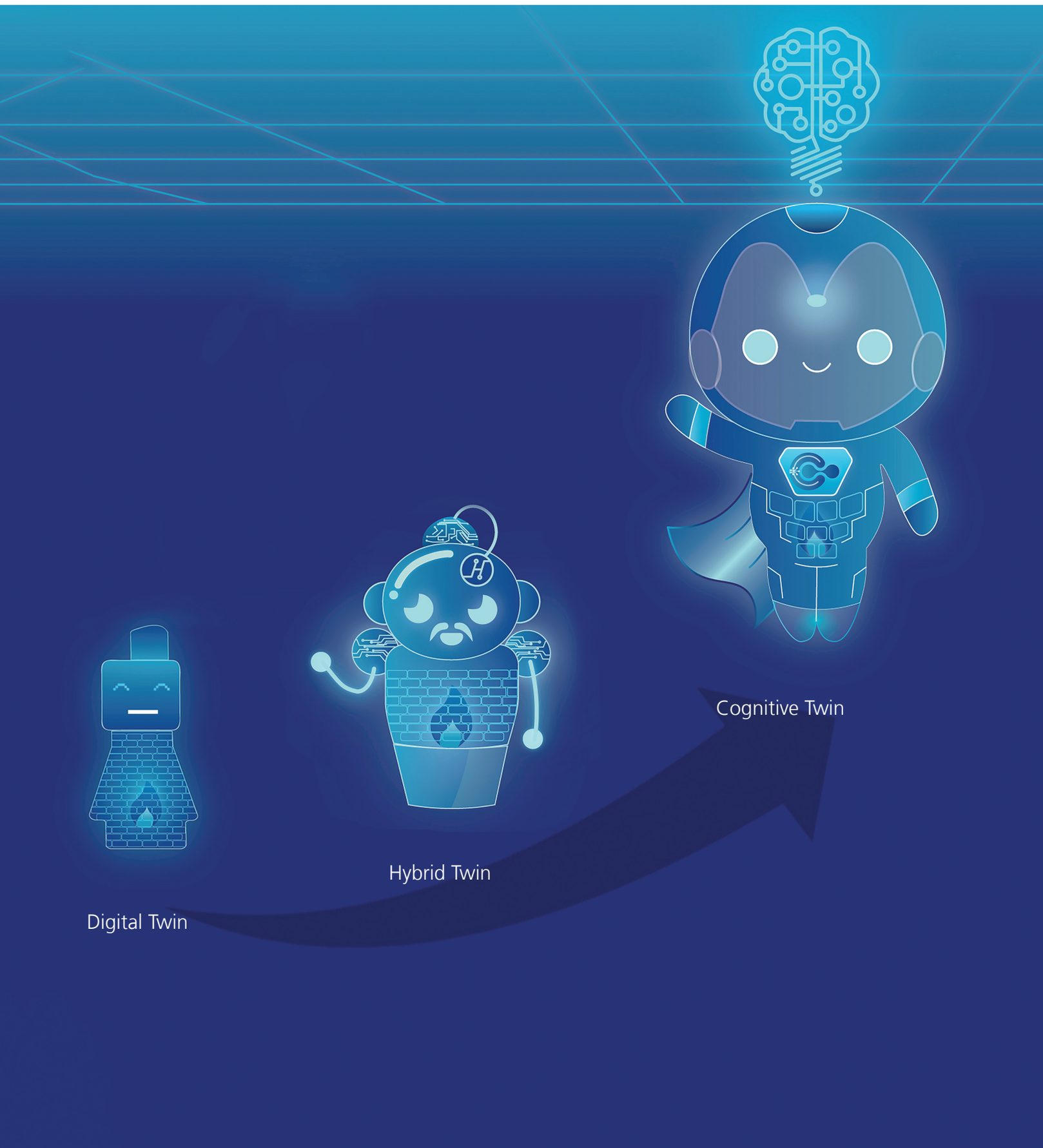
COGNITWIN



CONTENT

COGNITWIN Project Information

The COGNITWIN project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 870130.

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Image taken from:
https://cordis.europa.eu/project/id/870130

Dear readers,

Dear readers,
We are pleased to share with you the final COGNITWIN newsletter.
The COGNITWIN newsletters report on various aspects of the project from different perspectives and are based on the results achieved at the time of writing. While the first newsletter introduced the COGNITWIN project, the second and third newsletters presented the challenges and results from a research/technical perspective and the achievements of the pilot partners, respectively. In the fourth newsletter we focused on the experiences gained during the 30 months of project implementation.
In this newsletter, we summarize the lessons learned from the project and provide recommendations for the period after project completion. The contributions from all partners follow the same structure: for each partner, we have described what they have learned from the project and how the results of COGNITWIN could improve their business. We have also discussed what should be done even better to improve the performance of cognitive production systems and how we can contribute to reducing energy and resource consumption, CO2 emissions, etc. Finally, we made recommendations for future activities in the areas of digitization, standardization, training and education based on the experience gained from the COGNITWIN project. To make the newsletter more attractive and draw the attention of a wider audience, the representative pictures of the key results of each partner are also included.

The results achieved so far are tangible. The public deliverables and publications can be found on the **COGNITWIN web side**, the public videos could be found on the COGNITWIN YouTube channel and the open source results are available at Github (e.g. **https://github.com/FraunhoferIOSB/FAAAST-Service**). For more information about our projects, please join our webinars. Information about the next webinars will be announced on the COGNITWIN LinkedIn.

Enjoy the reading & contact us if you have questions or suggestions!

Best regards
The COGNITWIN project

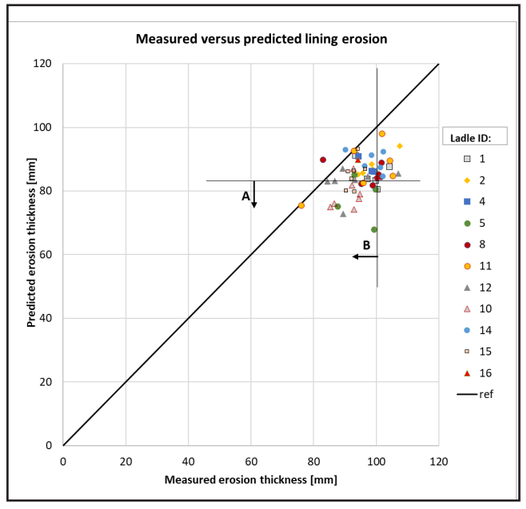
SINTEF - SINTEF AS

LESSONS LEARNT FROM COGNITWIN

Improving industrial processes, cutting costs, reducing energy and resource consumption often involve many complex processes and the decisions are therefore made by humans. In our work with developing a pragmatic physics-based model (PPBM) for steel ladle lifetime prediction, we found that physics-based methods are crucial for assessing the data. Basic conservation principles such as mass, momentum and energy cannot be violated. Industrial data will always have challenges as fast decisions must be made and collected data may suddenly get a different physical origin. In addition, few but reliable sensors are applied. We also note that many things cannot be measured directly but rather indirectly. We see that building hybrid digital twins should be done based on as much physics as possible, and learning from data should be focused on explaining the residuals between the PPBM and the operational data. This applies even if the model is tuned to the data. In the Figure predicted and measured ladle wear lining erosion is compared. As the task is to decide if it is safe to do one more use of a ladle before demolition, we see that from the data that ladles (symbols) to the left of the vertical line (marked B) could have been used one more time. From the model prediction ladles below the horizontal line in the figure (marked A) would be marked for one more use. In metallurgical processes many types of randomness occur, as in in the case of ladle linings, from unknown variations in raw materials such as incoming steel, lining bricks, ladle additions and leftovers from previous heats. Therefore, the interaction between an operator and the model may for a long time be the only viable solution. When the operator has information from his visual inspection of the ladle, together with the PPBM prediction, as well as historical data at hand, he may be able to make better assessment and use the ladle a few times more.

COGNITWIN'S CONTRIBUTION TO BUSINESS IMPROVEMENT

The COGNITWIN project has enabled us to demonstrate how we can build a PPBM from basics, dealing with multiple complex phenomena and data. This will help sell SINTEF expertise to the metallurgical industry, both in direct projects and EU projects. We also see that the PPBM goes far beyond metallurgical industry and would help SINTEF sell new projects in areas dealing with flows of fluids, phase transitions, mass and energy exchange.



Predicted versus measured erosion, at time of decided demolition, for 61 ladle lives at a Sidenor steelwork.

COGNITWIN'S PROPOSAL FOR EVEN BETTER IMPROVEMENT OF THE PERFORMANCE OF COGNITIVE PRODUCTION SYSTEMS

Cognitive production systems should, when possible, be founded on the best possible physics-based hybrid digital twins. In cases like we have worked with, the interaction between model and operator is fundamental. The cognitive production system should therefore focus on how to present data and model output such that the operator can make the best possible assessments and decisions.

WHAT ARE OUR CONTRIBUTIONS TO INCREASING ENERGY AND RESOURCE CONSUMPTION, REDUCING CO2 EMISSIONS

Our development of the PPBM methodology will be very valuable in future green energy projects, reducing resource consumption and CO2 emissions. The PPBM has a strong focus on the physics, applying multiple scales, and simplifying the model to an extent where the model can compute faster than real-time. This type of models would be very useful to support in operator training, planning, but not at least in process control. In the COGNITWIN projects the PPBM can help the operators reduce consumption of refractory material which also cuts energy consumption. At the same time PPBM may help the operator to make the optimum decision with compromising health and safety.

COGNITWIN'S RECOMMENDATIONS FOR ACTIVITIES IN THE AREAS OF DIGITALIZATION, STANDARDIZATION, EDUCATION AND TRAINING

Building next generation PPBM models for digitalization of industry will need strong expertise in physics, thermodynamics, chemistry, numerics and programming. In addition, concepts around how to work with multiple scales in dynamic systems should have more attention. The PPBM methodology should be expanded, introduced into education, and if possible, be introduced as a standard. A focus point in future developments should be how to work with physics-based models and data, to determine improved tuning models or another model layer on top of the PPBM, where these models explore all available data, including data that was not used in tuning the PPBM.

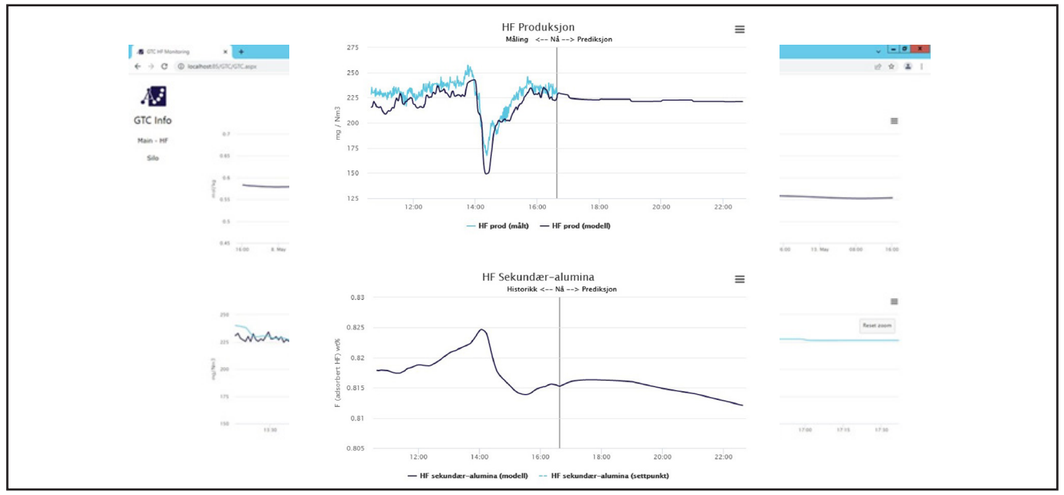
Hydro - HYDRO ALUMINIUM DEUTSCHLAND GMBH

LESSONS LEARNT FROM COGNITWIN

The COGNITWIN project has thought us that digitalization has an un-tapped potential in some parts of our process, which yet has not been controlled. The inhered potential of connect the Gas Treatment Centre closer to the electrolysis, by means of digital hybrid twins and later cognitive twins, evens out raw material variations, resulting in easier control of the main process.
Moreover, the practicalities when collaborating externally on digital platforms, has also revealed need for caution seen from a cyber security side. It has been quite a challenge to maintain cyber security and integrity of the process network, simultaneously with the collaboration with outside resources.

COGNITWIN'S CONTRIBUTION TO BUSINESS IMPROVEMENT

The results of our pilot in COGNITWIN will be based on stabilizing raw material feed to the production. This reduces deviations, and loss of performance hence higher yield through stable conditions. Moreover, the outcome of the COGNITWIN also operates autonomously, i.e. automatically resetting itself. As the use of our twin continues, and the cognitive part is learning to recognize process deviations, and how to resolve them, the process will be able to operate even faster and closer to its limits due to better control.



Digital twin for Hydro Pilot, detecting power outage, and corrects primary alumina feeding to compensate.

COGNITWIN'S PROPOSAL FOR EVEN BETTER IMPROVEMENT OF THE PERFORMANCE OF COGNITIVE PRODUCTION SYSTEMS

To be able to improve on the performance of cognitive production system, the basic facilities must be planned to be digitalised whenever this is possible. In many cases the plants have a certain age, hence the basics in terms of digitalisation level needs to be established. When such digitalisation is done, it should be carried out in a standardised manner with digital twin, hybrid twin and cognition in mind. The major challenge experienced during the Hydro pilot has been to close the digitalisation gaps, and in posterity the data flow and security. It is from this our experience, that plans for digitalisation should be developed for each of our sites.

COGNITWIN'S CONTRIBUTIONS TO THE REDUCTION OF ENERGY/RESOURCE CONSUMPTION AND CO2 EMISSIONS

COGNITWIN reduces process deviations resulting in less emissions, both traditionally associated aluminum emissions such as HF, but also PFC's from unwanted process deviations (Anode Effects (AE)). During an AE the electrolysis is not producing aluminum, but generate PFC's such as CF4 and C2F6, these gases have a GWP (Global Warming Potential) of 6 630 and 11 100, meaning that to maintain both low AE frequency and AE duration is essential in our environmental effort when producing aluminum.
By larger degree of stabilization, energy consumption in electrolysis is reduced, and seen from the direct affected main fans in the GTC, the energy usage is minimized by already 7%.

COGNITWIN'S RECOMMENDATIONS FOR ACTIVITIES IN THE AREAS OF DIGITALIZATION, STANDARDIZATION, EDUCATION AND TRAINING

It is recommended that the digital twin implementations are developed in container-based software. This will make the digital model implementation ready once finished. The container-based model will then much easier be maintained and operated by operations, and up-dates will be more efficient. In short make the model-container so standardized, that it can be implemented on any site.
For training purposes, the developed model for our pilot can and will be used to simulate scenarios, giving the opportunity for new operators to learn the responses through gaming. Also, the twin can be used for process and parameter setting testing before implementation in real life.
In terms of education, learning by use of twins are and will be more and more a necessity since our processes becomes more complex. Not only calculate and relate to steady state, but also learn the dynamics in a complex process.

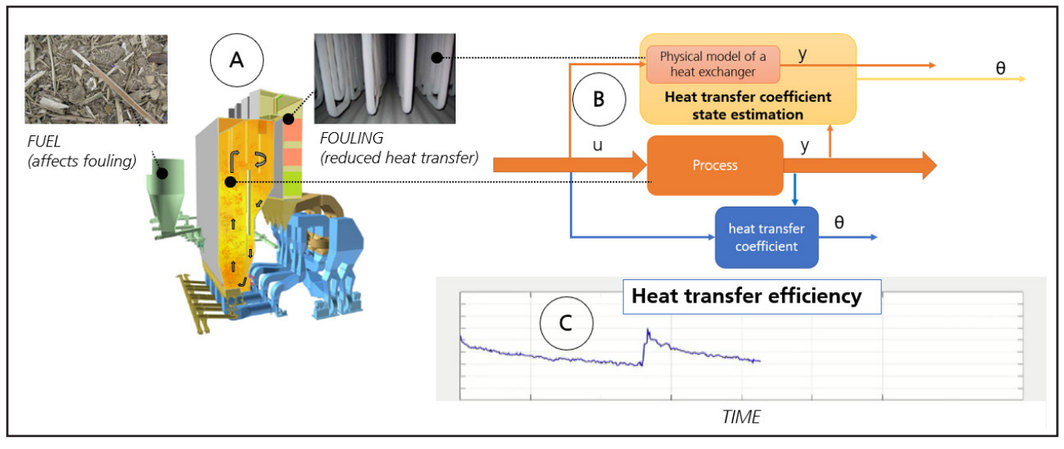
SFW - SUMITOMO SHI FW ENERGIA OY

LESSONS LEARNT FROM COGNITWIN

In COGNITWIN, Sumitomo SHI FW (SFW) and our partners #SINTEF AS and the #University of Oulu have been working on a pilot case with a new process-industry framework that integrates AI, smart sensors, and machine-learning. The pilot boiler unit is a commercial-scale Circulating Fluidized Bed (CFB) boiler designed by Sumitomo SFW for wood-based fuels such as clean wood, recovered wood, and demolition wood collected from both households and industry. From the COGNITWIN piloting activities we have learned new ways to improve the monitoring of fouling on the heat exchange (HX) surfaces of the boiler. In addition, we have managed to improve and optimize the control of HX cleaning operations using Digital Twin technology, including a combination of more efficient direct and indirect monitoring methods, physical models, and the latest approaches in data science.

COGNITWIN'S CONTRIBUTION TO BUSINESS IMPROVEMENT

SFW has its own product family of digital services available for power industry (https://www.shi-fw.com/services/digital-services/), and we are continuously looking for new fruitful approaches that can help our customers in producing steam and power more efficiently and more environmentally friendly. The achievements of COGNITWIN provide new possibilities to offer more advanced, useful digital services aimed at improving the boiler operations in co-operation with the customers.



Twin technology for better fouling management A) The CFB process with HX fouling, B) Model-based estimator for fouling, C) The output of the model-based estimator

COGNITWIN'S PROPOSAL FOR EVEN BETTER IMPROVEMENT OF THE PERFORMANCE OF COGNITIVE PRODUCTION SYSTEMS

In any system relying on sensor information, reliable and adequate measurement instrumentation is a fundamental requirement. In power industry, appropriate monitoring of fuel quality is still an open issue, and we are still lacking cost-efficient and reliable methods for direct and real-time monitoring of certain fuel properties, such as elemental composition of fuel. More exact real-time data on fuel properties would enable better decisions, better cognition, and eventually better control of the process.

COGNITWIN'S CONTRIBUTIONS TO THE REDUCTION OF ENERGY/RESOURCE CONSUMPTION AND CO2 EMISSIONS

SFW customers' business requires high flexibility in the operation. For example, it is important to be able to respond quickly to the market demand, even when using more challenging fuels that may be cheaper to acquire. Power plant operators often struggle with optimal operation when the fuel is continuously changing, especially when firing challenging renewables such as biomass and bio-residues.

The Twin technology developed in COGNITWIN can help the operators of power plants to optimize the boiler controls in such a way that the changes in fuel are better managed, boiler emissions and operational economy are optimal, and the downtime of the boiler is minimized. For example, optimized cleaning of HX surfaces leads to a more efficient process which requires less resources per produced unit of power.

COGNITWIN'S RECOMMENDATIONS FOR ACTIVITIES IN THE AREAS OF DIGITALIZATION, STANDARDIZATION, EDUCATION AND TRAINING

In the area of developing digital products for customers, one should always listen carefully what kind of requirements and needs does the end-user of the product have, because that person will ultimately be the one who will take the developed technology into use and put it into practice. Her/his view will also directly determine the ways we should be presenting the information obtained from the Twin tools. Usually, it is best to keep the presentation of key information on the screen as simple and understandable as possible, although there may be very complex modeling and calculations under the hood.

SIDENOR - SIDENOR ACEROS ESPECIALES SL

LESSONS LEARNT FROM COGNITWIN

COGNITWIN project showed us the importance of different parameters on the refractory wear mechanisms. Sidenor checks historically production parameters, which were considered to have maximum importance, for analyzing the possibility of using the ladle one more heat. Thanks to this project, we verified which parameters are the most critical and we found new parameters to take into account for making the analysis.

COGNITWIN'S CONTRIBUTION TO BUSINESS IMPROVEMENT

The most important result obtained from COGNITWIN project is the possibility of checking all the ladles with the same criterion. This will give the opportunity to improve the refractory working life with standard analysis, and as a result, the amount of wastes generated for producing 1 ton of steel will be reduced.

COGNITWIN'S PROPOSAL FOR EVEN BETTER IMPROVEMENT OF THE PERFORMANCE OF COGNITIVE PRODUCTION SYSTEMS

One of the most important points to achieve a successful cognitive model is to understand the problem to be solved and to know the needs to be covered. Not all the obtained results are correct and this is other important issue to work on. COGNITWIN's partners worked very hard on these points at the beginning and during the project, so the final solution suits quite well to the intended objectives.

The greatest issue is to transfer the knowledge learnt during the development of the model to the workers. The results obtained are promising and the necessity of involve the production people is essential for the success.

Ladle with slag lining demolished

COGNITWIN'S CONTRIBUTIONS TO THE REDUCTION OF ENERGY/RESOURCE CONSUMPTION AND CO2 EMISSIONS

Given that, refractories are indispensable for steel production, and that there is currently no possibility of replacing them, the best way to reduce the wastes (eroded refractory) is to increase the working life of the bricks.

COGNITWIN'S RECOMMENDATIONS FOR ACTIVITIES IN THE AREAS OF DIGITALIZATION, STANDARDIZATION, EDUCATION AND TRAINING

The digitization of the different work areas, especially the most dangerous ones for the operators, is of vital importance. Sidenor's use case is based on increasing the work life of the refractory bricks and in addition, we want to avoid the exposition of the workers to hot areas when checking the ladles.

On the other hand, the workers must be well trained on the understanding and use of the developed models, so they can use the new tool as part of their working practice and integrate it into their tasks.

ELKEM - ELKEM AS

LESSONS LEARNT FROM COGNITWIN

During the project period, Elkem has explored infrared camera technology for probing the metallurgical production process of ferrosilicon alloys. There are several types of cameras available, operating in different wavelengths of the infrared spectrum. Process parameters such as slag content in metal and temperature will in general require different wavelengths for optimal performance. In addition, smoke and dust obscures the visibility so there is need to select very particular wavelengths to be able to see through smoke and dust. A benchmark study has established which type of camera is most suitable in different areas of the ferrosilicon production process.

The cameras generate a large amount of information which can strain the local data network. It is critical that the data infrastructure is able to handle the data flow. In the Elkem case, data from the camera is processed on a local computer and compressed before further transfer through the network. The overall data infrastructure is shown in the picture.

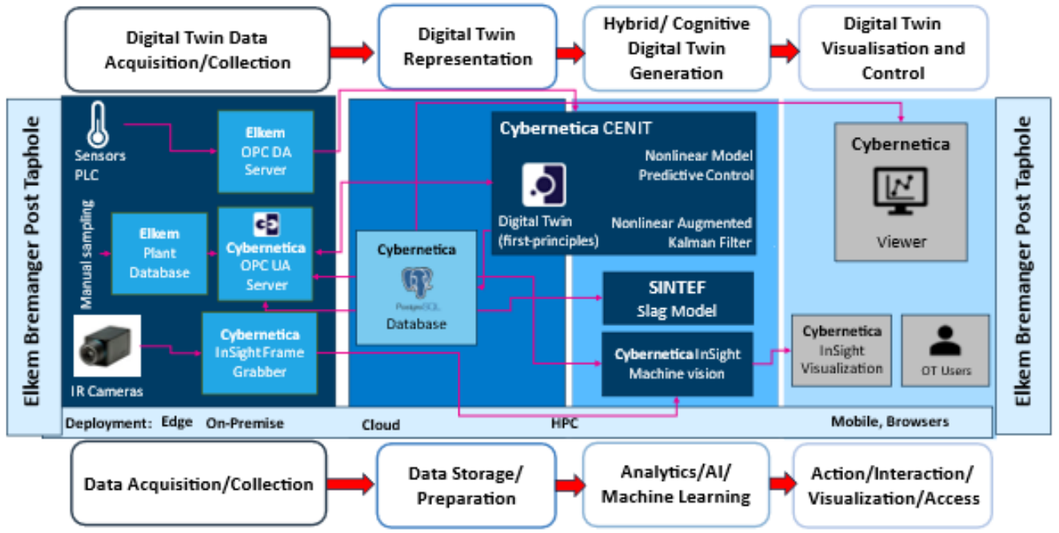
The work has also highlighted the importance of proper and automatic logging of other process parameters, with a precise time stamp. The models used for the cognitive twin have a resolution of seconds, thus time-stamps with an accuracy less than this will introduce errors and uncertainty in the model predictions.

COGNITWIN'S CONTRIBUTION TO BUSINESS IMPROVEMENT

The information from infrared camera technology allows for a continuous prediction of the state of the process (temperature, chemistry) based on a model for mass/energy balance as well as other measured process parameters. Being able to understand the actual state of the process for any given time allows for making the proper adjustments to meet the desired end state. Overall, this will give higher accuracy and maximum process yield.

COGNITWIN'S PROPOSAL FOR EVEN BETTER IMPROVEMENT OF THE PERFORMANCE OF COGNITIVE PRODUCTION SYSTEMS

The sensors and the equipment supporting it are prone to mechanical and thermal wear. During typical harsh industrial operational conditions great effort must be done to ensure stability and lifetime of the IR-sensors. Otherwise they will quickly fail rendering the cognitive production process useless.



Architecture for integration of IR-cameras and online process models.

COGNITWIN'S CONTRIBUTIONS TO THE REDUCTION OF ENERGY/RESOURCE CONSUMPTION AND CO2 EMISSIONS

The cognitive approach to the ferrosilicon production process will, if fully and successfully implemented, increase the output of the post taphole production process while keeping the input constant. Thus, the specific CO2-emission will be reduced (kg CO2 per kg metal) as well as the specific energy consumption (MWh per ton metal). In the Elkem case the potential CO2-reduction will be of the order 2% which equates about 2000 tons of CO2 per year from one ferrosilicon furnace.

COGNITWIN'S RECOMMENDATIONS FOR ACTIVITIES IN THE AREAS OF DIGITALIZATION, STANDARDIZATION, EDUCATION AND TRAINING

The implementation of a digital production system, working together with heavy-duty machinery and people requires that the organization have access to digital infrastructure and personnel that can maintain, troubleshoot and repair when issues arise. Availability of digital competence is crucial for the industry as a whole, and educational strategies must ensure that the next generation of engineers, data specialists and instrumentalists etc. are prepared for the challenges

Saarstahl - SAARSTAHL AG

LESSONS LEARNT FROM COGNITWIN

The potentials of machine learning and cognitive digital twins in the process industry are manifold. The combination of 1st principles and data driven models together with the harnessed human experience makes solutions more robust and even feasible. The exchange of ideas in an interdisciplinary consortium was inspiring and provided new viewpoints and perspectives.

COGNITWIN'S CONTRIBUTION TO BUSINESS IMPROVEMENT

We will work further with the tracking system results to improve the blooming train operation and billet tracking.
We will use the results and know-how gained from the punch stamp reader development to improve the stamp reading process throughout the production sites and for developing and improving other computer vision solutions.
We will apply the developed anonymizer system wherever applicable to protect employees' rights and avoid unnecessary surveillance.
Moreover, the general concept of cognitive digital twins and cognitive production systems can be applied to other plant operations as well.

M6 Project Meeting at Saarstahl AG in Völklingen in 2020

COGNITWIN'S PROPOSAL FOR EVEN BETTER IMPROVEMENT OF THE PERFORMANCE OF COGNITIVE PRODUCTION SYSTEMS

More ambient processes could be included into existing cognitive digital twins or be added as cognitive digital twins in their own right to cognify entire production routines and plants. The vision for Saarstahl AG is an AI-powered steel production.

COGNITWIN'S CONTRIBUTIONS TO THE REDUCTION OF ENERGY/RESOURCE CONSUMPTION AND CO2 EMISSIONS

The systems and models SAG developed in the COGNTIWIN project can help reducing error rates and optimize production routines. As the steel industry is an energy-intensive branch, optimization of production routines and reducing error rates can always be related to a reduction of energy and resource consumption per ton of finished steel grades. And as, at least for now, energy consumption is not carbon-free, and the blast furnace route for steel production is CO2-emission-intensive, this is directly linked to a reduction in carbon emissions as well.

COGNITWIN'S RECOMMENDATIONS FOR ACTIVITIES IN THE AREAS OF DIGITALIZATION, STANDARDIZATION, EDUCATION AND TRAINING

For many industries, one of the main obstacles to a successful implementation of advanced cognitive digital twin solutions is the lack of a basis such as sufficient data in a machine-readable format and an understanding for the value in data in the staff ranks. Activities should target this and animate companies to build up these foundations. If they want to implement solutions as presented in the various COGNITWIN Use Cases at some point even in the far future, they should start today with those basics.

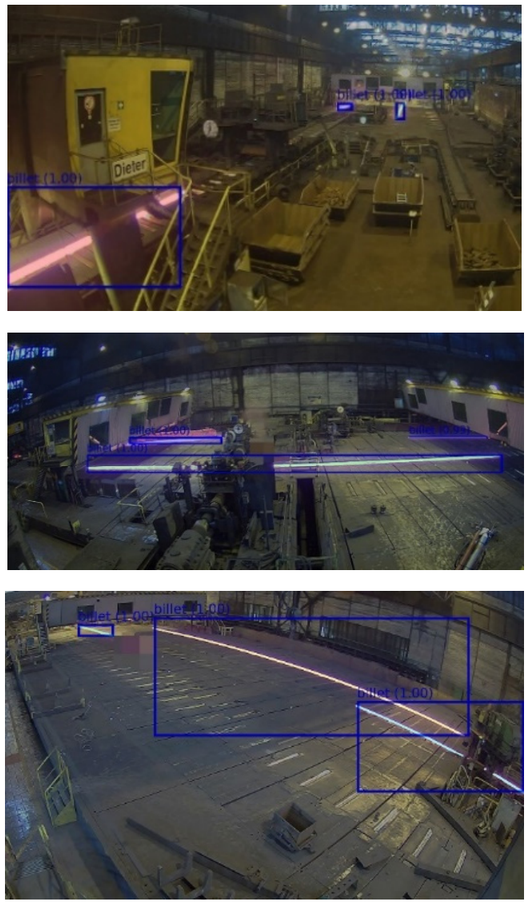
DFKI - DEUTSCHES FORSCHUNGSZENTRUM FUR KUNSTLICHE INTELLIGENZ GMBH

LESSONS LEARNT FROM COGNITWIN

In the COGNITWIN project, DFKI was involved in the implementation of a camera-based billet tracking system in the SAARSTAHL pilot. During the course of the project, we have learned that it is not the best way trying to find a single AI solution that satisfies all needs and requirements of the system without exception. It is wiser to break the complex task down into smaller parts and to find a robust AI or non-AI solution for each of them. We also have learned challenges of data-driven projects: limited or impossible access to raw data, lack of processing resources, data quality issues. Therefore, synergy, trust, and open communication between IT experts, data scientists, and business departments are immensely important for successful digital transformation.

COGNITWIN'S CONTRIBUTION TO BUSINESS IMPROVEMENT

The focus of DFKI was testing usability and applicability of models completely trained on synthetic data in real manufacturing processes. We have seen great potential of synthetic data for AI-supported evaluation of image and video material. The results and insights gained during the project can be generalized to other applications in production, robotics, healthcare etc., where large amounts of real-world data must be analyzed at great effort and expense.



Snapshots from three blooming train cameras in Saarstahl's Nauweiler rolling mill. Billet tracking networks trained solely with simulated data track billet instances in real videos

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COGNITWIN'S PROPOSAL FOR EVEN BETTER IMPROVEMENT OF THE PERFORMANCE OF COGNITIVE PRODUCTION SYSTEMS

Especially for computer vision systems, cameras, optics, and camera position in a scene should be selected very carefully. It could simplify the use of the original recordings for standard AI and non-AI solutions without complicated reduction of systematic and non-systematic disruptive influences like chromatic aberrations, radial lens distortion.

COGNITWIN'S CONTRIBUTIONS TO THE REDUCTION OF ENERGY/RESOURCE CONSUMPTION AND CO2 EMISSIONS

AI is a tool to generate knowledge, increase efficiency and automate processes. DFKI's application-oriented research can be used in many ways to protect the environment and increase resources efficiency by developing sustainable, future-oriented methods.

COGNITWIN'S RECOMMENDATIONS FOR ACTIVITIES IN THE AREAS OF DIGITALIZATION, STANDARDIZATION, EDUCATION AND TRAINING

There is still a large gap between academic research and industry. For bridging the gap, a special emphasis should be put in training professionals who transfer the newest developments from research to practical applications. For digital transformation, the culture of learning and rapid response must also be cultivated. Because the speed at which new technologies take hold is tremendously high, it is very important to have people with diverse backgrounds who want constantly to reinvent themselves and take on different perspectives.

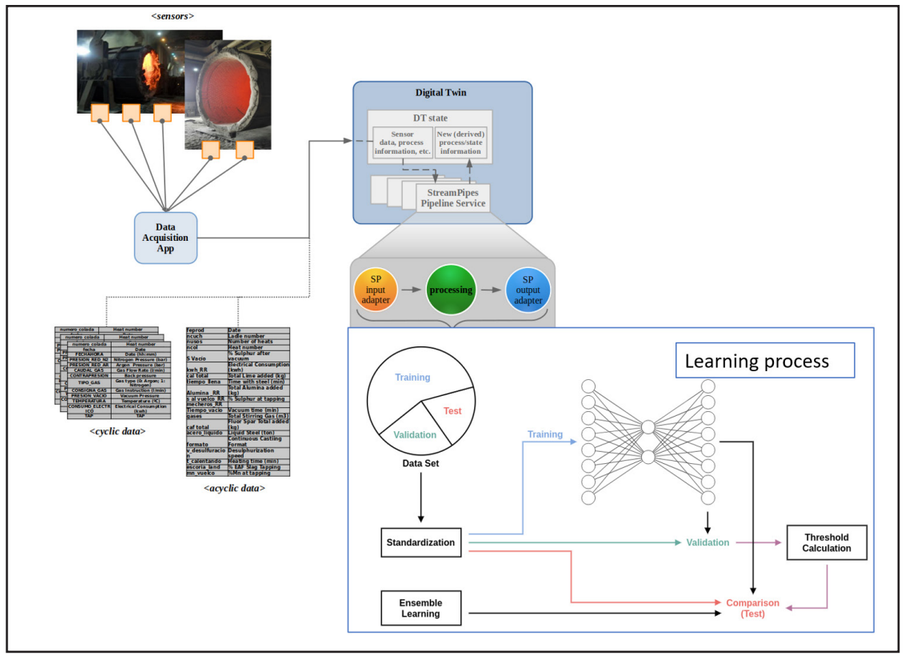
COGNITWIN FINAL NEWSLETTER

Nissatech - Company for Provision of Services, Research and Development NISSA Innovation Centre DOO

LESSONS LEARNT FROM COGNITWIN

Our main contribution is related to the use of human-like cognition for the maintenance of industrial systems, leading to what we call cognition-driven maintenance. We define cognition as the ability to deal with unknown situations. Basically, cognition-driven maintenance is an extension of predictive maintenance (based on predictive analytics) to include the concept of cognition.

Analytical models and algorithms for predictive maintenance, enabled by instrumentation and connectivity of critical assets, allow asset-intensive companies to detect impending asset degradation or failure long before the actual event and proactively address the problem, often without impacting production schedules. On the other hand, many routine repairs and maintenance procedures are known to experienced maintenance personnel. Work orders, repair logs, etc. in enterprise asset management systems are also important sources of maintenance information. The combination of predictive and cognitive analytics can optimize many facets of maintenance activities.



COGNITWIN'S CONTRIBUTION TO BUSINESS IMPROVEMENT

We plan to offer the cognition-driven maintenance as a service to the industry. Cognition-driven maintenance combines: predictions (based on data-driven models) and knowledge (based on human-like cognition) with the goal of better understanding the behavior of the underlying process and consequently better identifying and resolving critical situations.

COGNITWIN'S CONTRIBUTIONS TO THE REDUCTION OF ENERGY/RESOURCE CONSUMPTION AND CO2 EMISSIONS

Cognition-driven maintenance solves the problem of the high rate of false positive alarms generated in predictive maintenance systems. In this way, resource utilization is optimized, leading to a reduction in energy consumption or CO2 emissions.

COGNITWIN'S PROPOSAL FOR EVEN BETTER IMPROVEMENT OF THE PERFORMANCE OF COGNITIVE PRODUCTION SYSTEMS

Cognition-driven maintenance solves an important industrial challenge: how to efficiently monitor an extreme variety of situations that can occur in dynamic and complex power systems, with the main goal of reacting when an anomaly is approaching (leading to predictive maintenance). The challenge is that it is not possible (with numerical and data-driven models) to model all situations that might be of interest, so hybrid methods are required. However, creating hybrid models is very time consuming and labor intensive. There is a need for new approaches to self-manage/improve hybrid models.

COGNITWIN'S RECOMMENDATIONS FOR ACTIVITIES IN THE AREAS OF DIGITALIZATION, STANDARDIZATION, EDUCATION AND TRAINING

There is a huge demand for better modelling of the human decision-making process to be used in the digitization and automation of industrial processes. We can define a set of constraints to which the human decision-making process is subject:

1. human decision making is based on his expe rience and implicit rules that he cannot formalize. The decision-making process is not well defined.
2. the human decision-making process is based on univariate analysis. The expert checks the parame ter values for the last N instances individually, which means that he does not consider possible relation ships between different parameters - it is possible that the parameters, when checked individually, have appropriate values, but when analysed together, they may indicate that there is a problem and that repair/ replacement is needed.
3. the human expert uses a subset of all parameters during his decision-making process. It is possible that analysing more parameters would lead to better decisions.

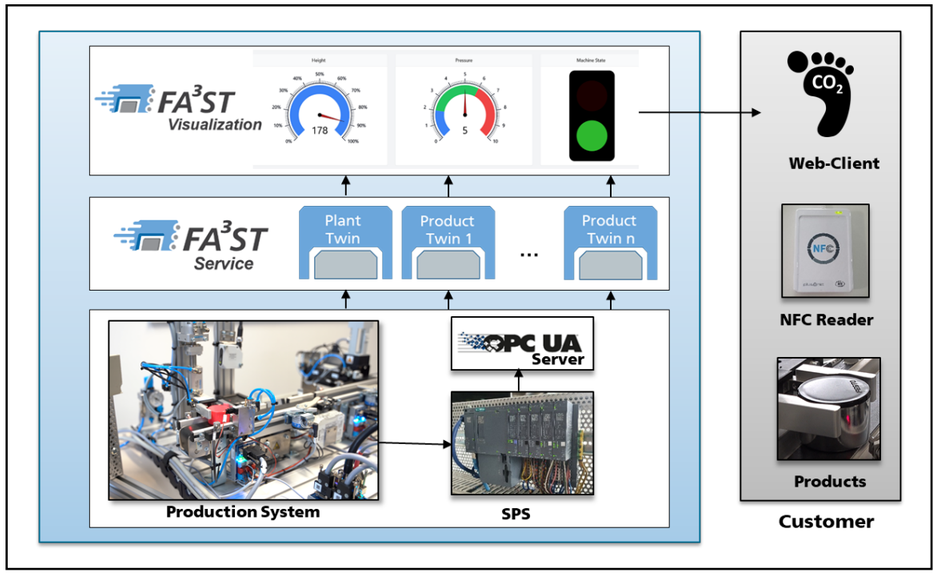
Fraunhofer IOSB – FRAUNHOFER GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V.

LESSONS LEARNT FROM COGNITWIN

In the COGNITWIN project, Fraunhofer was in charge of the realization of the digital twins as well as the standardization. In the course of the project, we learned that in practice there are many proprietary software systems called digital twins that only partially fulfill the technical requirements for digital twins and, above all, do not support interoperability. On the other hand, it is difficult to convince end users to use standards-compliant solutions because they do not see any immediate benefits in such a solution and want to solve a concrete problem quickly without looking at the big picture.

COGNITWIN'S CONTRIBUTION TO BUSINESS IMPROVEMENT

The most important result of the COGNITWIN project for Fraunhofer is the FA³ST service. Since it has been developed considering the best practices of software engineering, is standards compliant and designed to be extensible, we have achieved a great visibility. FA³ST service has not only helped us to write scientific publications and obtain new research projects to advance the research on digital twins and their realization, but more importantly, thanks to FA³ST we have established many contacts with industrial partners who want to use FA³ST for the realization of digital twins.



FA³ST Eco-Twin

COGNITWIN'S PROPOSAL FOR EVEN BETTER IMPROVEMENT OF THE PERFORMANCE OF COGNITIVE PRODUCTION SYSTEMS

It is necessary to consider and digitalize all relevant pre-existing knowledge, including human knowledge and experience. Additionally, all types of data, developed models, and accumulated knowledge generated throughout the whole life cycle of a plant should be combined in order to achieve better quality of results. Applying lessons learned and reusing models from similar cases (e.g., through data spaces) could further strengthen outcomes and foster collaboration.

COGNITWIN'S CONTRIBUTIONS TO THE REDUCTION OF ENERGY/RESOURCE CONSUMPTION AND CO2 EMISSIONS

We developed an FA³ST-based demonstrator for SPS 2022 to show how standards-compliant digital twins can be used for sustainability use cases. The focus was on collecting and tracking the CO2 emissions generated during the production step of a product. The digital twin provided by the FA³ST service makes it possible to trace the CO2 footprint of a product over its entire life cycle. Two sensors were physically added to the demonstrator to measure the circular parameter. The Asset Administration Shell Product Carbon Footprint (PCF) submodel template was used to represent the sustainability related data. The AASs for the products are dynamically filled by the data coming from the inspection system, for example with the CO2 footprint of the product.

COGNITWIN'S RECOMMENDATIONS FOR ACTIVITIES IN THE AREAS OF DIGITALIZATION, STANDARDIZATION, EDUCATION AND TRAINING

Close cooperation between industry and research partners is required to ensure that, on the one hand, the most appropriate state-of-the-art results are applied and, on the other hand, the actual needs of industry are taken into account in the research. For example, we are now entering a phase of digitization where the use of digital twins is rapidly increasing and they are more complex than before. An important part of this process is the emphasis on interoperability, which requires a paradigm shift from proprietary digital twins to standardized digital twins. In order to reap the benefits of digitization and digital twins in the long term, the key players must be well trained.

Training should be a continuous process, as new technologies and tools emerge very quickly. The wheel should not be reinvented, but the new possibilities should be fully exploited and used to create new wonders of economic and social development.

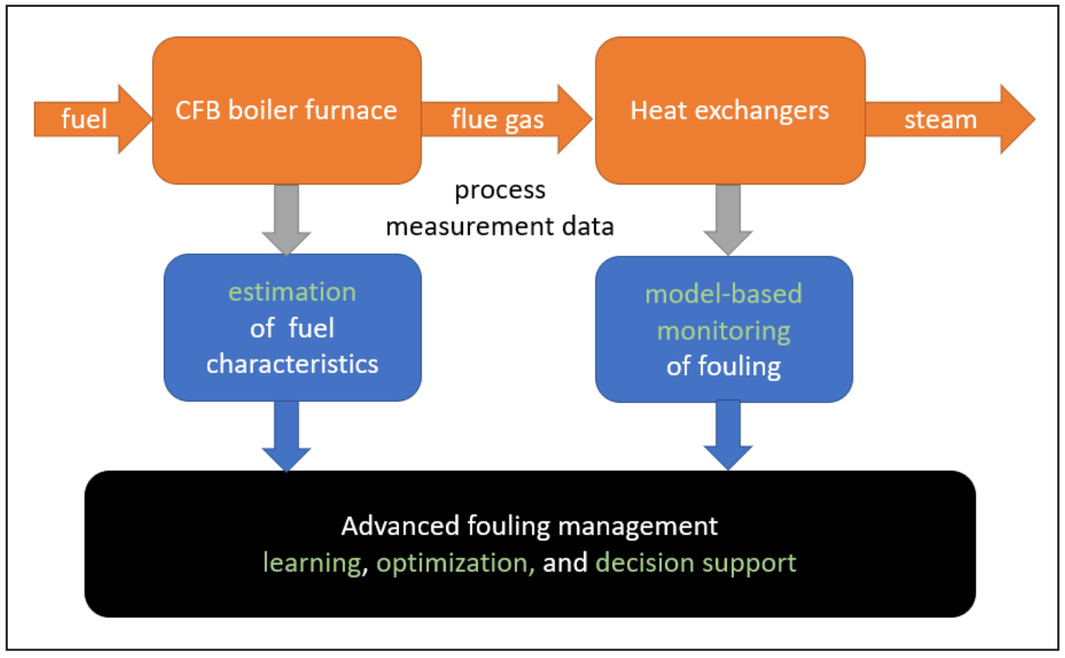
UOULU - University of Oulu, Intelligent Machines and Systems research unit

LESSONS LEARNT FROM COGNITWIN

In the COGNITWIN consortium, we've learned on the developments towards cognitive digital twins in the process industry in the wide scope of methodology, applications, and pilots present in COGNITWIN. Participating the project has extended our skills from theory and algorithm development for process monitoring and control, towards mastering the entire data pipeline and the technology development chain.

COGNITWIN'S CONTRIBUTION TO BUSINESS IMPROVEMENT

COGNITWIN has linked us with new technological partners, including research organizations and process industry, and we look forward to continuing the cooperation in the future. The gained advanced knowledge, skills, and developed tools on digital twins will improve not only our opportunities in research but also in bringing the outcomes to university education.



Tools for advanced fouling management

COGNITWIN'S PROPOSAL FOR EVEN BETTER IMPROVEMENT OF THE PERFORMANCE OF COGNITIVE PRODUCTION SYSTEMS

The developments towards uncomplicated fusion of physical knowledge with experimental data and human interaction will need to continue, so that the various sources of knowledge may further support and complement each other. Plant design, operation, maintenance, and integration will require focusing on field-specific approaches, in order to develop tools for efficient, agile, and sustainable production in the heavy industry.

COGNITWIN'S CONTRIBUTIONS TO THE REDUCTION OF ENERGY/RESOURCE CONSUMPTION AND CO2 EMISSIONS

Much of the work of the University of Oulu focused on the COGNITWIN pilot on biomass-based power production, an important component in the operation of integrated smart energy systems. The application of advanced monitoring and improved soot blowing optimization aim at direct impact on the efficiency of power plant operation, as a flexible component of the energy network.

COGNITWIN'S RECOMMENDATIONS FOR ACTIVITIES IN THE AREAS OF DIGITALIZATION, STANDARDIZATION, EDUCATION AND TRAINING

Agile development support tools should be further developed for the fusion of physics-driven and data-driven knowledge in optimization, including the role of humans in decision-making. The possibilities and significance of knowledge integration should be introduced already at the basic levels of education at higher education institutes.

TEKNOPAR - TEKNOPAR ENDUSTRIYEL OTOMASYON SANAYI VE TICARET ANONIM SIRKETI

LESSONS LEARNT FROM COGNITWIN

What TEKNOPAR has learned from the COGNITWIN project can be grouped into two categories: 1) in technical domains and 2) in management domains.
As part of technical learning, TEKNOPAR's team has closely followed the state-of-the-art technologies related to digital, hybrid, and cognitive digital twins, and developed a cognitive digital twin that learns by itself and enables proactive actions to be taken. TEKNOPAR's management team involved in the project has learned and experienced collaborative project management procedures that are required by European Union for HORIZON 2020 projects.

COGNITWIN'S CONTRIBUTION TO BUSINESS IMPROVEMENT

With COGNITWIN, TEKNOPAR has enhanced its' IIoT Platform and improved TEKNOPAR's Industrial Automation Platform, namely TIA Platform.
Our observable and evidence-based contributions to the pilots provided opportunities for TEKNOPAR to increase the TRL of its existing technologies, add new models to its existing model library, develop new services and tools as part of TIA Platform, and validate them in real manufacturing environment settings.
TEKNOPAR's R&D team has also been motivated to share its work with other industry partners and researchers by means of dissemination activities, as a result of which several academic articles and conference papers have been written and presented. These activities contributed to TEKNOPAR's good word of mouth to be known both nationally and internationally.

TIA platform

COGNITWIN'S PROPOSAL FOR EVEN BETTER IMPROVEMENT OF THE PERFORMANCE OF COGNITIVE PRODUCTION SYSTEMS

One of the challenges that appeared to be solved in the project is related to COVID-19. Due to COVID-19 restrictions, some of the site visits, and face-to-face meetings were conducted online. Despite the known limitations of not being able to visit the pilot sites in person, carefully planned and implemented online meetings contributed to the success of the project. It could have been better to visit the pilot sites, and experience solutions at the sites, yet the handicaps due to COVID-19 were successfully overcome. To support the interoperability of digital twins, the use of Asset Administration Shell (AAS) and International Data Spaces (IDS), more datasets, shared data, and accessible AI platforms/toolsets could have been better.

COGNITWIN'S CONTRIBUTIONS TO THE REDUCTION OF ENERGY/RESOURCE CONSUMPTION AND CO2 EMISSIONS

Through the cognitive digital twin developed for and deployed on the SWP machine of NOKSEL, energy consumption and the number of machine downtimes have been reduced by 10%. Being able to identify one of the most common reasons for the welding process failures of the machine, TEKNOPAR also designed and developed a control system to prevent the failure case to happen. TEKNOPAR is glad to be able to reduce the carbon footprint of NOKSEL, and improve sustainability.

COGNITWIN'S RECOMMENDATIONS FOR ACTIVITIES IN THE AREAS OF DIGITALIZATION, STANDARDIZATION, EDUCATION AND TRAINING

As a technology provider, TEKNOPAR recommends problem owners and technology providers invest in digitalization, and develop digitalization strategies in line with their visions and missions. Digitalization enables the use of past and current data, and use of this data can be used to estimate the future. With the help of digitalization, required actions can then be taken to prevent future unwanted situations, such as machine breakdowns, reduced OEE, and increased cost.
Involving the players leading international standardization of digital twins-related topics, the COGNITWIN project helped TEKNOPAR to be closely informed of these standardization studies, which will be requirements in the future. Being informed about the standardization work, TEKNOPAR became more prepared for future studies.
TEKNOPAR gained a lot from the webinars prepared by the project partners and other events organized by other related EU projects. Hence, as TEKNOPAR, we strongly recommend active attendance of the events, which may act as training activities.

NOKSEL - NOKSEL CELIK BORU SANAYI AS

LESSONS LEARNT FROM COGNITWIN

COGNITWIN enabled NOKSEL employees, especially the management and maintenance teams to learn more about digital twins, including hybrid and cognitive digital twins. The team has gained experience in utilizing a smart condition monitoring system for the SWP machine. Plus, we also learned that past and current data can be used to predict the future at very high accuracy levels.

Being part of the COGNITWIN project, we know now more about the importance and use of IoT platforms to monitor real-time data. By means of the project, we have learned to get notifications about the current and future status of the machine.

The COGNITWIN project has been the first H2020 project in which NOKSEL has participated. Through the project, we learned to actively be a contributing partner of an international R&D project. Our experiences in the project provide more motivation for us to be part of similar projects in the future.

COGNITWIN'S CONTRIBUTION TO BUSINESS IMPROVEMENT

The results of the COGNITWIN project have improved NOKSEL's business by directly decreasing the energy consumption rate. The unexpected machine breakdowns have been prevented in advance by means of pretrained and tested models providing information about the remaining useful life of the machine. The decreased cost of production could impact our price and hence we could gain a competitive advantage.

COGNITWIN'S PROPOSAL FOR EVEN BETTER IMPROVEMENT OF THE PERFORMANCE OF COGNITIVE PRODUCTION SYSTEMS

TIn the COGNITWIN project, NOKSEL and its technology provider TEKNOPAR worked closely and in harmony to fulfill the requirements of the project. One of the challenges met in the project was the lack of data related to machine breakdowns. In order to cope with this problem, TEKNOPAR has built a data generator producing high-fidelity synthetic data. One thing that could have been better would be to be able to collect the machine's real failure data for us to be able to train the models.

COGNITWIN'S CONTRIBUTIONS TO THE REDUCTION OF ENERGY/RESOURCE CONSUMPTION AND CO2 EMISSIONS

Energy consumption is an important ingredient of steep pipe production. By means of the COGNITWIN project, the cognitive digital twin developed by TEKNOPAR has resulted in gaining 10% decrease in energy consumption of the SWP machine that has been used within the pilot's scope. As a result, the carbon footprint of NOKSEL has decreased.

COGNITWIN'S RECOMMENDATIONS FOR ACTIVITIES IN THE AREAS OF DIGITALIZATION, STANDARDIZATION, EDUCATION AND TRAINING

Having seen the positive contributions of digitalization, NOKSEL strongly recommends the use of digital twins for the SWP machines. Digitalization provides data about the past, current, and future of tangible machines and enables processes to be estimated. Standards are needed for the interoperability of digital twins provided for different systems. Thanks to TEKNOPAR, minimum training is needed for our staff who are involved directly with the development studies. Without being technically trained about the artificial intelligence and the related machine learning and deep learning algorithms, NOKSEL staff have been able to use applications, and take required actions accordingly.

Cybernetica - CYBERNETICA AS

LESSONS LEARNT FROM COGNITWIN

COGNITWIN has provided us with insight into the strength and capabilities of Cybernetica's digital twin toolbox components and has bettered our understanding of outstanding digitalization challenges in process industry.

As has been highlighted numerous times by COGNITWIN, collecting and integrating data from different sources for meaningful use by digital twins remains a challenge.

These challenges include:

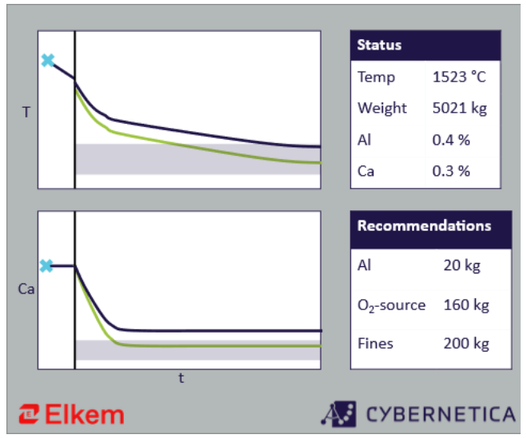
1. needed data/signals are in some cases missing or non-existent;
2. certain data (e.g., lab measurements) are often not available online;
3. the need for data that originates outside of the plant network to be integrated securely. Cybernetica OPC UA Server has been a suitable tool for overcoming many data-related challenges that arose during COGNITWIN.

Regarding numerical modelling, Cybernetica CENIT combined with first-principles models has delivered good results during COGNITWIN for controlling and optimizing different processes (e.g., Gas Treatment Centre - GTC - and ferrosilicon refining). We learned that combining first-principles models and data-driven techniques is not always straightforward, especially in cases where the data-driven model performs poorly due to problems with the raw data.

On the plant side, we learned that obtaining reliable measurements from new sensors (IR camera, HF sensor) is very challenging in an industrial environment (smoke, flames, moving equipment etc.) Stabilizing new sensor data can take longer than expected.

COGNITWIN'S CONTRIBUTION TO BUSINESS IMPROVEMENT

COGNITWIN has allowed us to develop new expertise and create new/improve upon our products for industrial customers. Our Cybernetica CENIT application for the GTC process represents a new innovation. Through the GTC case, we have gained experience working with weather data and integrating weather forecasts into our optimization solution. The solution developed for the ferrosilicon refining case in COGNITWIN is also beneficial to new and existing customers.



Mockup of the Operator Support System developed for the Elkem pilot.

COGNITWIN'S PROPOSAL FOR EVEN BETTER IMPROVEMENT OF THE PERFORMANCE OF COGNITIVE PRODUCTION SYSTEMS

Integration of more continuous data (less manual input) is an important barrier to overcome in order for cognitive digital twins to reach their full industrial potential. Industrial partners should also consider and clearly define the corrective actions that cognitive digital twins should be allowed to take, as in practice it is not acceptable for automatic systems to take actions that have not been cleared with operational personnel. The digitalization community should work to bridge the gap between hybrid digital twin solutions and cognition even further and develop better tools to enable cognition.

COGNITWIN'S CONTRIBUTIONS TO THE REDUCTION OF ENERGY/RESOURCE CONSUMPTION AND CO2 EMISSIONS

Our work in the Elkem pilot leads to reduced off-spec production and increased material recycling at Elkem Bremanger, thereby increasing material yield and reducing energy consumption. In addition, we anticipate future energy consumption reductions when installing the system developed during COGNITWIN at other metal refining processes.

Our work in the Hydro pilot improves the stability of the raw material to energy-intensive electrolysis process, thereby reducing energy consumption and reducing greenhouse gas emissions.

COGNITWIN'S RECOMMENDATIONS FOR ACTIVITIES IN THE AREAS OF DIGITALIZATION, STANDARDIZATION, EDUCATION AND TRAINING

Standards for data transfer and collection exist, but are not always used in the industry. Concise and useful training on the advantages and disadvantages of different machine-learning techniques would be very useful for new users. In addition, data-driven methods require clean datasets, and automatic dataset cleaning would be a very useful tool.

CONSORTIUM

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