PROCESSNET
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DECHEMA
Biotechnologie

„Process Industry United in the Digital World“

The current landscape of research for the digitalization of the process industry

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The Tutzing Symposium "100 % digital: survival strategies for the process industry" (see 4.1) in April 2018 was characterized by a great momentum which has been taken up and continued until today. The aim was to implement the ideas from the Tutzing Symposium in a coordinated and targeted manner. For this purpose, development needs as well as the numerous currently planned or already started research and development activities in the context of digitalisation were first compiled and analysed. This resulted in the current research landscape for digitalization in the process industry. It now enables to identify open topics and to translate them into research funding programs as well as to define new projects in the dialogue between users, suppliers and research, which are to be meaningfully interlinked and consolidated with existing projects.

Due to the strong interest in digitalisation, activities are constantly being added, so that this paper can only provide a snapshot of the situation in the period 2019-2020. The motivation of the initiative is

- Increase of the operational safety by supporting the process control with digital techniques. The long-term goal is safe, autonomous operation.
- Establishment of a highly flexible production with adaptation to changing product and delivery requirements with short set-up times and trained employees
- Better use of existing facilities through more extensive use of information from other facilities - method transfer.
- Development and construction of efficient, flexible and modern ("smart") new plants with high energy and material yields.
- Shorter product and process development times through data utilization with the new methods of digitalization to support trained employees.
- Creation of comprehensive standards for information transfer in the digital future.
- Shaping the process of change in the world of work and working processes by providing information and education and training new skills

The aim of the initiative is to increase the competitiveness of the process industry.

1. Introduction

Industry 4.0 is often associated with the manufacturing industry. However, digitalization, networking, big data and artificial intelligence (AI) are also of considerable importance for the process industry, which is the third largest and most research-intensive industrial sector [1] in Germany [2]. Although the process industry - i.e. the producing companies in the chemical, pharmaceutical, life sciences and food sectors - can rely on the results of the manufacturing industry for digitalization, it also has many more specific challenges. These lie in the long and costly product and process developments, the continuous optimization and expansion of existing plants with product changes, and finally the fact that no clearly defined components are produced, but fluids and solids with fluctuating properties and in some cases a high hazard potential.

Digitalisation is opening up new technical opportunities to meet the new challenges as well as new business models. On the one hand, the digitalization of the process industry supports the safe and efficient production of internationally competitive products. On the other hand, new tools, methods and possibilities of networking and intelligent automation enable equipment and software suppliers to export production technology know-how in the form of measurement and control technology worldwide. Both contribute to an enormous regional competitive advantage.

In order to be able to survive successfully in a changed environment, the process industry will have to use the potential of digital technologies in the future. Digitalisation makes it possible to interlink previously separate areas in the development, production and delivery processes. Complex processes can thus be handled, controlled and optimized more safely and efficiently in the future, so that different products can be adapted to customer requirements and brought to market more rapidly.

All this requires building new skills, investing in talent and managing change that engages the entire organization [3] The process industry now faces similar changes to those in the metal and electrical industries, but in a different mode over a long period of time. This requires different design approaches and requires a strong need for research and the validation of results. [4] Digitisation cannot be achieved on its own. It must be created together with all those involved, whereby the value chains of the supply chain and the asset life cycle are to be more closely interconnected (see Figure 1). In order to ensure that German companies in the process industry remain at the forefront of the international market in the future, companies must digitalize their processes and business procedures and develop innovative new methods, equipment, plants, sensors and automation technology as well as data concepts in collaboration with science.
For this purpose, the establishment of a research and development programme of the BMWi would be helpful. The programme should aim at the infrastructural development and empowerment of partners, especially the many SMEs. Research programmes also offer a pre-competitive "protective space" for the legally secure advancement of standards that is not attackable under cartel law. Research and development activities already launched must be accounted for or integrated in the research programme.

2. The concept of digitalisation in the process industry

The process industry is characterized by two value chains. These are the horizontal supply chain and the vertical asset life cycle, both of which converge in production. The efficiency of the overall system is significantly determined by the fast and comprehensive availability of reliable information from all parts of these two value chains. For example, a change in raw material quality may require changes in production that may already have been investigated and are available in process development. Digitalization will bring significant benefits in this respect and increase process reliability, efficiency and finally profitability.

The digital twin will play a central role in this process, mapping the processes in the supply chain and the asset life cycle (see Figure 1). The digital twin is a virtual representation of the physical objects, brings together data and knowledge from the asset life cycle and the supply chain and continuously updates these. The Digital Twin also includes models that simulate processes and conditions in the real world. The models are able to access all data from the supply chain and the asset life cycle and realize relationships that are currently not visible. Physically based and modern data-driven and hybrid models are employed.

In this form, the digital twin enables fast and comprehensive access to information from all areas. In addition, a wide range of opportunities arise from the model-based evaluation of the data, which results then flow back into the real world and have an influence on it. For example, the wear condition of a component can be predicted on the basis of design and operating data, or data-driven dynamic process models can support the dynamic optimization of process control.

Of course, a digital twin will not completely map the supply chain and the asset life cycle, but can be limited to partial areas. However, the decisive factor is automated continuous data synchronization with the real world, which requires standardized data models that are still under development. Such data models are already available in some areas. The development of suitable models that incorporate a wide variety of data has also only just begun and still requires more development efforts.

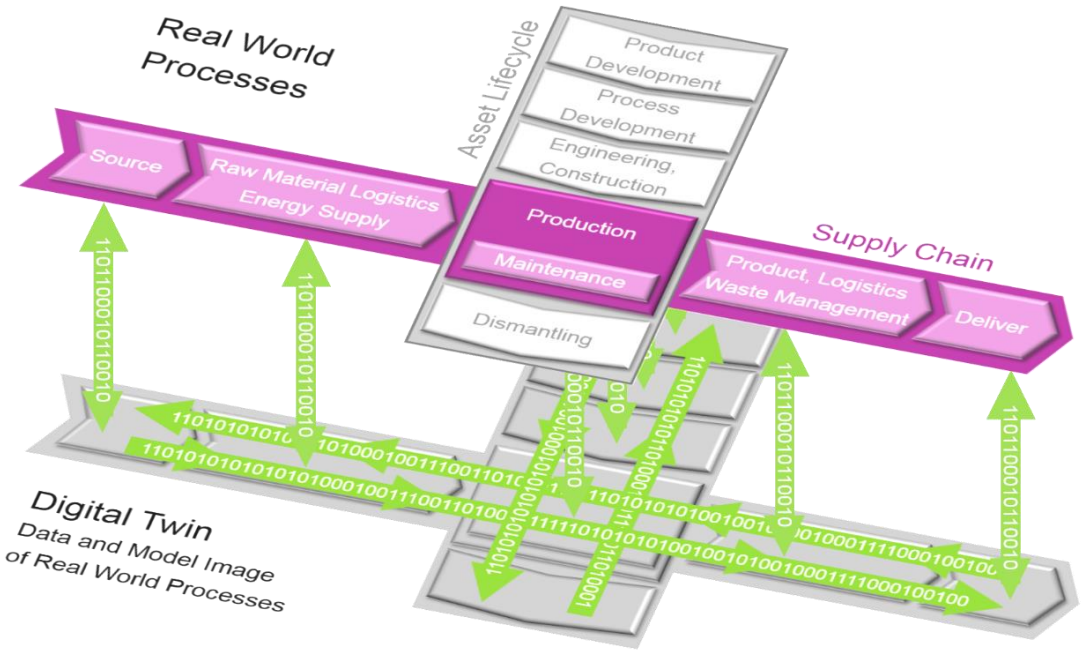

Abbildung 1: Schematic illustration of the digital twin as an image of the value chains of the real process world, i.e. the horizontal supply chain and the vertical asset life cycle (Source: Bröcker, Evonik)

3. Accompanying the digitalisation of the process industry and designing potential infrastructural R&D focal points

In order to take up the dynamics from the 57th Tutzing Symposium "100 % digital: survival strategies for the process industry" [5] and to transfer them into activities, the following measures were taken.

- The results were published in a monthly series of articles in CITplus [6] to share the results widely.
- On the part of the ProcessNet association, the "Temporary Working Group 100 % Digital" (short: "TAK Dig") was established. As described in the following, this working group had a coordinating effect and developed concepts which contributed to securing the future of the German process industry in the long run. It also aims to provide input for other bodies and steering committees. Within TAK Dig, four working groups have been established with the following focal points:

  1. Smart equipment / digital workflow (Urbas, TU Dresden)
  2. Data exchange formats - DEXPI (Soemers, AixCAPE)
  3. Digital twin, make existing brownfield facility digital (Bamberg, Merck KGaA)
  4. influence of digitalisation on education and the world of work (Klaer, Bayer AG)

- In September 2018 the Federal Institute for Materials Research and Testing (BAM) and DECHEMA approached the BMWi with a joint letter to promote the digitalisation of the process industry. The letter proposed the establishment of a research programme "Process Industry Together Digital". At the same time, discussions took place with representatives of large industry and SMEs, who, for their part, gave a strong commitment and confirmed the need for research and development associated with the digital transformation.

  In February 2019, the TAK Dig formed the KEEN consortium (AI incubators in the process industry), which aims to introduce artificial intelligence methods in the various areas of the process industry. To this end, incubation laboratories are being set up and tested on many case studies. In August 2019 a concept paper was submitted by the 24 participants under the consortium leader Prof. Leon Urbas, TU Dresden, and was nominated for the second round of the competition. The team submitted a full proposal by 15 October 2019, which was evaluated positively. The project start was the 1 April 2020.

All activities concerning the digitalisation of the process industry - including those which go beyond a research programme - were accompanied in a sustainable manner by experts from the process industry who were involved as actors of the Tutzing Symposium and/or TAK Dig.

In addition to representatives of the process industry from large industry and SMEs, many representatives from the thematically related ENPRO initiative in the research field of "chemical process engineering" [7], from industrial associations (NAMUR, ZVEI, ...), scientific working groups (GDCh, DECHEMA, VDI, ...) were active in TAK Dig (see 2.3). These experts have carried out valuable lobbying work, resulting in the overall coordination of all digitalisation topics as well as the sustainable handling of priority research topics.

3.1. Urgent research topics for the digitalisation of the process industry

Digitalisation requires the specific, close cooperation of users from the process industry, their suppliers (i.e., equipment and software manufacturers in automation and plant and apparatus engineering) and research institutes at eye-level. If these developments are to progress rapidly, this is only achievable in specific projects. Ideally, this is done in joint R&D programs in which demonstrators and prototypes are developed. In addition, jointly validated devices and software with a lasting effect on the digitization infrastructure can also be created here, i.e. a difficult part of product development, the certification, is accomplished jointly and can be implemented particularly quickly.

The digital networking of the horizontal supply chain and the vertical asset life cycle as shown in Figure 1 is the ultimate goal of digitalization in the process industry and holds the greatest potential. The following research and development topics are emerging on the way to this goal:

- Supply chain, production architecture and platform solutions (horizontal)
- Process development, asset life cycle (vertical)
- Digital twin
- Standardized data structures

In addition to these specific topics, the following cross-cutting issues that influence the success of digitalisation need to be addressed:

- Learning Processes
- Artificial intelligence (AI) and IT infrastructure
- Structural and cultural change in the world of work and work processes

3.1.1. Supply chain, production architecture and platform solutions

The creation of digital platform solutions in the supply chain between manufacturer, supplier and customer is essential for networking with efficient workflows. The challenges for networking lie in mutual trust and cooperation in the exchange of data. Here, concepts for the secure exchange of data between the process industry and its suppliers through open, standardized, manufacturer-independent interfaces are developed.

3.1.2. Process development, asset life cycle and digital twin

Work is already underway on the development of "smart and intelligent equipment" and concepts of "modular production" or "continuous engineering". These approaches increase the efficiency and flexibility of the process industry and reduce time-to-market. The digital twin is a central element of digitalization, will gain in importance in the future and is currently under development in many places. Working groups 1 and 3 of TAK Dig have developed and published a position paper on the digital twin [8].

The two working groups have also formed the consortium that developed the project proposal for KEEN within the framework of a call for AI against the background of the requirements of the process industry.

The 58th Tutzing Symposium "Separation Units 4.0 - Separation Technology in the Chemical Industry on the Way to the Digital Future" took place on the topic of Digital Chemical Plant. In October 2019, representatives from academia and industry met at the invitation of the ProcessNet Association "Fluid Dynamics and Separation Technology" to determine the status and further development of the field. In contrast to previous events, the focus was on the individual separation equipment and fluid process engineering itself in a complementary manner. In five topic clusters,

each with several workshops, future developments and emerging separation tasks, opportunities, challenges and potentials of fluid separation technology were identified and intensively discussed. In addition, potential and necessary networking and cooperation with other industries and knowledge disciplines were discussed, which forms the basis for further concept developments and for the derivation of necessary activities.

3.1.3. Standardized data structures

Digitization requires comprehensive and efficient access to data from different sources in vertical and horizontal value chains. To enable this access, so-called data models are appropriate, which enable the unambiguous addressability of the data. The DEXPI initiative described below has made a start for the asset life cycle, but data models should now be developed for other areas.

3.1.4. Cross-cutting issue: artificial intelligence (AI) and IT infrastructure

Trust centers and the use of secure IT infrastructure (possibly also involving federal institutes) play a fundamental role in the design of an IT infrastructure and the use of artificial intelligence.

Research into artificial intelligence concepts for use in the lifecycles of products, processes and systems is pending. Artificial intelligence should contribute to an increase in efficiency and, in particular, also to an increase in plant safety (assistance systems), since it can be used to quickly analyse complex interrelationships and to provide appropriate support to plant operating personnel.

In the field of AI in the process industry, the BMWi, project sponsor DLR in Cologne, granted start-up financing from 15 April 2019 for the TU Dresden, TU Dortmund and FhG-ITMW Kaiserslautern for a full proposal to set up incubator laboratories. Making artificial intelligence understandable in the process industry is the goal of the KEEN start-up project. The project was funded in the competition phase until October 2019. At the end of August 2019, the project has been positively evaluated and will enter the implementation phase as a comprehensive joint project in April 2020.

In a competition for the best ideas, the project developed a concept for the establishment of a platform to promote the application of artificial intelligence methods in the process industry by the end of July. Three full-day creative workshops in Frankfurt at the DECHEMA building served to determine the need for action and generate solution approaches in five pillars:

- AI-based modelling
- AI-based engineering & optimization
- AI life cycle models
- AI fully automated
- AI Training

From this, three areas have been formed for modelling, engineering and fully automated plant, which are being tackled in different work packages.

3.1.5. Horizontal issues: Learning processes; structural and cultural change in the world of work and working processes

Digitalisation will bring about profound changes in the world of work and in work processes. This will initially involve new technologies, but also, to a large extent, methodological and structural changes. New learning concepts as well as further training opportunities for industry, science and public authorities must be created. Furthermore, the implementation of change management concepts is necessary. Working on these topics requires the integration of non-technical disciplines (e.g. industrial psychology). TAK Dig has established a working group for this topic area, sees itself as a mediator and would like to bring together the various specialist areas.

3.2. Existing R&D programmes for the digitalisation of the process industry

There are mainly programs for the automation of the manufacturing industry as well as for increasing efficiency and modularization in chemical process technology. No current program addresses the comprehensive digitalization of the process industry, as suggested in 3.

3.2.1. Increasing efficiency and modularisation in chemical process technology (ENPRO, http://enpro-initiative.de/ – [9])

Project duration: 03/2015-08/2018

Funding: BMWi

In the medium term, the Chemical Process Engineering research field is to link the areas of sensors and artificial intelligence even more closely with efficiency and modularisation concepts. In this respect, new funding directions can also be linked there.

1st funding phase: ENPRO 1.0: From 2014 to 2017, four collaborative projects and one accompanying project were carried out in the ENPRO initiative:

- Continuous processes for polymer specialities with the aid of novel apparatus concepts (KoPPonA)
- Smart-Mini Plant for the development of efficient continuous separation processes (SMekT)
- Modular equipment for energy-efficient production (modularization)
- Improved energy efficiency and process acceleration through data integration from process development to production (data integration)

2nd funding phase: ENPRO 2.0: The first projects from the 2nd funding phase of the ENPRO initiative have been running since November 2017.

- Efficient orchestration of modular systems (ORCA, start: 01.11.2017)
  In the EPRO 2.0 ORCA project, plant operators, module manufacturers, automation engineers, system integrators, authorities and universities are working together to derive process engineering, safety engineering and automation technology integrating concepts for modular, intelligent and flexible production plants.
- Cross-scale methodology for planning and developing resource-efficient processes (SkaMPi, start: 01.11.2017)
  The aim of the SkaMPi project (cross-scale methodology for planning and developing resource-efficient processes) is to break through inherent barriers and to supplement the existing methodology in such a way that the selection of the optimal

apparatus technologies can be carried out at an early stage for a new product or an envisaged product portfolio. In doing so, an optimal resource-efficient process connection is taken into account.

- Separation processes with efficient and intelligent equipment (TeiA, start: 01.01.2018)
  Currently, pharmaceutical, fine and specialty chemicals are still produced and purified in batch processes, whereas a changeover to continuously operated and modularly designed plants can be a promising approach for energy and time savings. For this purpose, various crystallization and extraction apparatuses are being investigated within the TeiA project. Their operating windows are characterized and tested for different material systems. In addition, novel sensors will be developed, integrated into the apparatuses and used for an improved process understanding.
- Modules in the life cycle of a process plant - applications for integrated models (ModuLA, start: 01.09.2018)
  In the ModuLA project, the specification of a continuous and consistent information model, i.e. a digital twin, for modules and systems is being developed. The information model covers the entire life cycle from laboratory, planning and construction to operation, maintenance and deconstruction. The results of the project provide a basis for linking modules with each other in terms of information technology and making relevant life cycle information of modules and plants available more easily than at present.

3.2.2. Scalable integration concept for data aggregation, analysis and processing of large data volumes in the process industry (SIDAP, http://www.sidap.de)

Project duration: 03/2015 - 08/2018

Funding: BMWi „Smart Data“

Partners: Bayer AG, IBM Deutschland GmbH, Chair of Automation and Information Technology TU Munich, Evonik Industries AG, Gefasoft AG;

Associated partners: Covestro AG, Krohne Messtechnik, NAMUR, Samson AG, Sick AG, ZVEI; cooperation partners: Interessengemeinschaft Regelwerke Technik (IGR) e.V.

SIDAP developed a data-driven as well as service-oriented integration architecture, which makes already existing structural information and data streams in engineering and process control systems accessible for interactive analyses by authorized users in an abstracted, integrated and access-protected form, taking into account their different semantics. This enables device manufacturers to analyze device malfunctions on the basis of usage data of their devices in production plants and maintenance, to identify faults preventively and to intervene in time to provide plant operators with optimal support in the future. For the plant operator, optimum use of the devices and thus the most trouble-free operation possible is ensured. The final report is available here [10].

3.2.3. Data Exchange in the Process Industry (DEXPI)

Project information: Working group of the ProcessNet (http://dexpi.org/)

Owner/Operators: Air Liquide, BASF, Bayer, Covestro, Equinor, Evonik, Merck

Technical consulting: AixCAPE, pnb plants & bytes

Software manufacturers: Aucotec, Autodesk, AVEVA, Bilfinger, eVision, Hexagon, PTC, Semantum, Siemens, X-Visual

Research facilities: Kyungpook National University, RWTH Aachen University AVT.SVT, Tecgraf/PUC-Rio, TU Berlin, VTT Finland

Insufficient interoperability between CAE tools makes it difficult to plan, build and operate process plants across organizational boundaries, e.g. between different companies or even business units within the same company. Therefore, the DEXPI working group aims to develop a manufacturer-neutral exchange format for engineering data and documents and to implement it in interfaces of existing CAE tools. Currently, the focus is on the exchange of P&I diagrams including graphical layout and engineering data.

3.2.4. smartLAB (Biotechnologie)

Project duration: 2014–2019

Funding: State of Lower Saxony (MW and MWK)

Partners: Sartorius, Mettler-Toledo, Eppendorf, Schmidt & Haensch, Noack Laboratories, labfolder, IGo3D, Presens, Köttermann, Realworld One, Fraunhofer IPA, Institute for Journalism and Communication HMTMH, Institute for Technical Chemistry LUH, Deutsche Messe

The smartLAB initiative has been in existence since 2014 and has set itself the goal of evaluating technologies for digitisation in the laboratory sector in a holistic approach, developing corresponding functional and digitalized laboratory environments and ultimately presenting its results in a showroom, so that this important topic for the development of laboratory infrastructure is clearly presented, opportunities for the various players are identified and further developed and an intensive discussion on this topic is initiated.

Every two years, the smartLAB therefore presents its current results at a highlight stand at the LABVOLUTION trade fair, the last time in May 2019. smartLAB not only shows the latest technologies in the laboratory sector, but also demonstrates exemplary, fully digitally supported workflows live, in order to make digitalization a tangible experience for visitors.

Important aspects of the smartLAB are the basic networking of laboratory equipment with a LIMS, flexible and modular laboratory infrastructure, integration of innovative technologies also from the consumer sector (e.g. smartphones, 3D printing, augmented and virtual reality, etc.), interaction media for human-machine interaction (e.g. LabGlasses, touch beamers, speech assistance systems, etc.) and the standardization of interfaces, device drivers and communication protocols.

3.2.5. Digitisation in industrial biotechnology (DigInBio)

Project duration: 2018–2020

Funding: BMBF

Partners: Chair of Biochemical Engineering TU Munich, Institute of Technical Chemistry LU Hannover, IBG-1: Biotechnology Research Centre Jülich, labfolder GmbH;

Supporters: Sartorius, TECAN, Eppendorf, 2mag, m2p-labs, Eppendorf Bioprocess Center, Presens, iTiZZiMO, Clariant, Qiagen, Evonik, Mettler Toledo, BRAIN, VCI, IG BCE, Deutsche Messe.

The joint project "DigInBio" will demonstrate to industry and young academics the future possibilities of digitalization, automation and miniaturization for biotechnology. By setting up demonstration laboratories, the potential of digitalization in this field will become visible and how it can be shaped in concrete terms.

The main focus is the development of digital workflows starting with the selection of suitable production organisms up to the processing of the product. Important aspects here are the acceleration of experimental work through automation and digitalization as well as the modularization of the processes combined with intelligent data management via a LIMS. Communication between system components and laboratory equipment plays a major role in the digital accessibility of experimental data and is a central challenge.

4. Current associations and working groups shaping the digitization of the process industry

4.1. Industrial Associations

4.1.1. NAMUR User Association of Automation Technology in Process Industries

Link: https://www.namur.net/de/

NAMUR is an international association of users of automation technology in the process industry with member companies in the process industry with a focus on Germany/Europe. The work of NAMUR is mainly based on fields of work that have been established for specific groups of topics: AF 1 Planning and Construction (project management, quality management, project planning and construction), AF 2 Process and Operation Control Systems (process control and operation control level), AF 3 Field Equipment (measurement technology ("sensor technology") and actuator technology), AF 4 Operation and Maintenance (maintenance, electrical engineering, training and safety of process control equipment).

The recommendations and worksheets prepared by NAMUR explain procedures, offer working tools such as checklists and define requirements for devices and systems. These documents describe the state of the art and often serve as a basis for discussions with manufacturers and influence standardization projects.

The advancement of digitalization is carried out by many working groups (see website). Current comprehensive projects (partly in cooperation with the ZVEI) are:

- Automation of modular systems

  The use of so-called Module Type Packages (MTP) is a solution approach to modularize today's automation systems and thus increase the flexibility of production plants. It contains a manufacturer-neutral, functional description of the automation of process modules for integration into orchestration systems, for example conventional process control systems. The MTP is created in the engineering tool of the module supplier and can be imported into that of the plant manufacturer

- NAMUR Open Architecture

  The NAMUR Open Architecture (NOA) concept offers opportunities for both existing and new plants to efficiently upgrade plants for future innovations. The core idea is to export the data of the previous core automation world through open interfaces such as OPC UA into the system world for monitoring and optimization tasks, while leaving the core automation largely unchanged.

- Asset Life Cycle Data Model

  In future, this is intended to improve the development, planning, operation and maintenance of process industry plants on the basis of international standards.

- 5G in the process industry

  NAMUR is currently engaged in an intensive exchange with associations, industrial users, politics and the Federal Network Agency, thus ensuring that the requirements of the process industry are taken into account in the development and implementation of 5G. NAMUR thus supports the future

adequate and economic use of 5G technology in the industrial environment and actively shapes the path of digitization in the process industry.

Recently, the American Chemistry Council ("ACC"), representing its Process Automation Users Group ("PAUG"), and NAMUR, the association of users of automation technology in the process industry, signed an agreement to cooperate in the fields of automation and instrumentation technology.

The agreement focuses on the exchange, improvement and further development of processes, strategies, guidelines and standards on the instruments and system technologies used in the process industry. Both organizations - on behalf of their members - pursue coordinated solutions in order to advance technological developments globally.

4.1.2. ZVEI – German Electrical and Electronic Manufacturers' Association

Link: https://www.zvei.org

The member companies in the ZVEI employ around 90 percent of the electrical industry's employees in Germany. The ZVEI and its member companies are pacemakers of technical progress. Everywhere in focus: digitization. The electrical and electronic industry is pushing ahead with networking, in its own companies, with suppliers, customers and also in the private sphere. As the industry's innovation driver, it is actively shaping digital change in the five lead markets Industry 4.0, Energy, Mobility, Health and Buildings, as well as in the areas of cyber security, Society & Environment and Education & Research.

With more than 330 member companies and a turnover of around 54.7 billion euros (2018) in Germany, the Automation section of the ZVEI is the platform for all companies in automation technology, industrial information and communication technology and related industry-related services.

The topic of digitalization is dealt with in various working groups within the Association for Automation, in some cases on an interdisciplinary basis with NAMUR: (selection)

Modular Automation Working Group, Energy Efficiency through Process Automation Working Group, CE Marking Working Group, Technical Documentation Working Group, Automation Technical Committee, Automation Research Association, Industrial Communication Steering Committee, Automation Security Steering Committee, System Aspects Working Group, Manufacturing Execution Systems Working Group, Security Systems in Automation Technical Committee, or the 5G-ACIA Working Group.

4.1.3. VDMA - Mechanical Engineering Industry Association

Link: https://industrie40.vdma.org/

The VDMA has published several brochures and information leaflets on the subject of digitization, which are also of interest to companies in the process industry. Examples are:

New VDMA guideline Self-learning production processes: Machine Learning step by step, September 2019 The new VDMA guideline provides support on the subject of machine learning and shows step by step how the introduction can be carried out in your own company.

New VDMA guideline "Interoperability through standardised features", August 2019 The guideline "Interoperability through standardised features" describes how signals and values are exchanged between production units and thus follows the Industry 4.0 idea. The key word is "standardization". Products, individual parts Assemblies or plant elements are described by characteristics that are transmitted in a format.

VDMA guideline "Industry 4.0 meets Lean" in German and English. The merging of Industry 4.0 with Lean Management offers great potential for the successful development of companies. The VDMA guideline is intended to support companies in this.

Industry 4.0 concrete - new edition 2019, Industry 4.0 has reached the breadth of companies. The publication shows current solutions from industrial practice and provides an overview of VDMA activities related to the topic.

It is a good information platform and offers numerous suggestions and opportunities for cooperation also for companies in the process industry.

4.2. Scientific working groups

4.2.1. ProcessNet Section (DECHEMA and VDI)

Link: https://processnet.org/Fachgemeinschaften.html

The nine sections form the superordinate structure of ProcessNet.

- Chemical Reaction Engineering
- Fluid dynamics and separation technology
- Particle technology and product design
- Process, apparatus and plant engineering
- Plant and process safety
- Sustainable Production, Energy and Resources
- Materials, construction, service life
- Education and innovation
- GeCatS - German Catalysis Society

The relevant specialist groups, working committees and temporary working groups are assigned to the professional associations. The aim of the sections is the comprehensive exchange in the respective assigned committees as well as the development and representation of research policy statements for the superordinate subject areas.

The coordination of the activities of the sections is carried out by a steering committee, which involves the chairmen of the assigned committees.

4.2.2. DFG and the National Research Data Infrastructure NFDI

Since spring 2019, the German Research Foundation has been funding the establishment of subject-oriented data infrastructures. For this purpose, about 30 consortia submitted a concept on 4 July 2019.

www.dfg.de/foerderung/programme/nfdi

No consortium has yet been established in the process technology sector. DECHEMA is the coordinator of the NFDI4cat consortium, which deals with catalysis, reaction engineering and also related process technology. Other consortia with close links to process technology and technical chemistry are NFDI4 are NFDI4chem (chemistry), FAIRmat (materials science), NFDI4ing (engineering with a focus on production technology) and NFDI4mse (mse stands for Material Science & Engineering). In October 2019, a full proposal is to be submitted for funding of further activities.

5. Important events to shape the digitalization of the process industry

5.1. "Sensors for the Digitalization of Chemical Production Plants – Requirements, Technologies and New Approaches to Solutions", DECHEMA workshop on 18 June 2019

On June 18, 2019, a workshop for the development of requirements, technologies and new approaches for sensors in the field of digital chemical production took place in the DECHEMA building in Frankfurt am Main with about 100 participants. The meeting was organized by the trade associations AMA Association for Sensors and Measurement and ProcessNet "Wanted Technologies" (which has been supporting various technical groups of the ProcessNet Association for Fluid Dynamics and Separation Technology since 2010). Digitalization in chemical plants is currently focused on operational planning based on complex data and through the intelligent analysis of large amounts of data based on increasing computer performance and machine learning. Flexibilization of plants, changes in the raw material base, energetic load management or shorter "time-to-market" are some future challenges for process design and plant operation. This results in application areas of new and improved sensor technology for plant monitoring, spatially and temporally closer monitoring of critical process variables or closer monitoring of product and raw material flows.

Aims of the workshop were the identification of R&D needs for the following topics

- Sensor technology for condition monitoring and predictive maintenance of operating systems
- Sensor technology for the acquisition of substance-related variables
- Sensor integration in plants
- Communication, data management, data analysis and process automation

and the promotion of cooperation and networking on the subject. The results of the workshop resulted in a position paper in January 2020 [11]. By May 2020, the initiating group had collected ideas for concrete research projects and consortia in order to bring them to the attention of research funding.

5.2. „Field instruments supporting digital transformation", 81st NAMUR General Meeting, Bad Neuenahr, 8-9 November 2018

At the NAMUR General Meeting on November 8 and 9, 2018, the subject of field devices was the focus of the event in Bad Neuenahr, which was attended by 650 participants. "Field instruments supporting digital transformation" was the motto that users of automation technology in the process industry, invited experts and managers from manufacturers and associations discussed extensively. [7] Thus, requirements for the change in process analysis technology of today and in the future were presented. Even with the current care-intensive PAT installations, information can be provided where it is needed through digitalization. And the specialist does not necessarily have to be on site. In order to be able to successfully introduce more digitalization in the future, the complexity must be capsuled so that the user can easily and directly feel the benefits.

5.3. „100 % digital: Survival strategies for the process industry", 57th Tutzing Symposium of the ProcessNet section PAAT, Tutzing, 15-18.04.2018 [5]

In April 2018, around one hundred experts and decision-makers from the chemical and process industry spent three days with lectures and creative workshops exploring what special requirements the process industry has for digital innovations, which of these have already been implemented and where there is still need for action. For this purpose, the entire vertical asset life cycle from process development to production and decommissioning as well as the horizontal supply chain life cycle from supplier to customer in chemical production was examined in terms of the opportunities and risks of digitalization. Requirements for intelligent apparatus and plants,

sensors and automation as well as the topics of data concepts, data analysis, big data and artificial intelligence were also discussed. The perspectives were initially summarized in 12 theses and summarized in a series of reports in CITplus [6].

Referenzen

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