Industry-oriented Research and its Application in the Digital Transformation of the Paper Industry

Availability of digitized research results

The risks of digitalisation for the paper industry, namely, the replacement of paper products, collapse of markets, intensification of competition, etc., are being felt already and are frequently discussed. However, it is very important for the industry to also see the opportunities offered by digitalisation and to work consistently on applying them. PTS, as an industry-oriented research institution, wants to grasp these opportunities in its own work and for the benefit of the industry. Digitalised research results, which are available as data in databases or as process steps converted into algorithms, play an important role here.

Topic Digital Twin

The digital twin is used as a vivid image to understand what digitalisation means. It is the virtual image of real products and processes. It helps to establish a seamless connection of this reality in a virtual world. It is developed during the conception and design stage of products and processes, and accompanies them throughout their entire lifecycle. Today, digital twins are largely understood as images of machines and components or as products of the cargo industry (cars, robots, plant engineering, electrical appliances) and used there as a basis for the Smart Factory. Manufacturers of equipment, machines, aggregates and measurement technology will also be driving the development of digital twins in the paper industry, and based on this, building new and advanced business models such as "Performance Contracting", "Predictive Maintenance", "Product Lifecycle Management", "Total Cost of Ownership" or "Condition Monitoring".

Nevertheless, the potential is still far from exhausted. Each product – in this case, even the raw materials and finished products of the paper industry – produce a digital shadow by way of material characteristics, material condition data, process data, etc. Just as the real material (pulp) and paper machine (system) interact with each other, the digital twin of the material can also communicate with the digital image of a machine *(Fig. 1)*.

If material data is merged with process data (machine data, sensor data and environmental data), then this is an essential prerequisite for influencing the quality of the end product at all times. At all times means both during ongoing production for quality assurance, optimisation or response in the case of deviations of individual process components (process safety), as well as during product development and process planning. With the help of a digital image, the quality can be completely anticipated – "predictive quality" in a broader sense.

However, the digital twin of the materials used in the paper industry is still in its nascent stage. Its growth requires a skeleton of cross-industry standards and regulations that define how fundamentally material characteristics are mapped with properties that can be described in data technology terms. This skeleton is an ISO/IEC compliant system of properties. It is being developed in various projects by international and national institutions. The second contribution to the growth of this digital twin is industry-specific. Information about material characteristics and materials used in the paper industry is the meat on the bone. It is available in a variety of forms as company-specific know-how, and as the results of science and research. These need to be systematised and digitalised. New methods of measure-
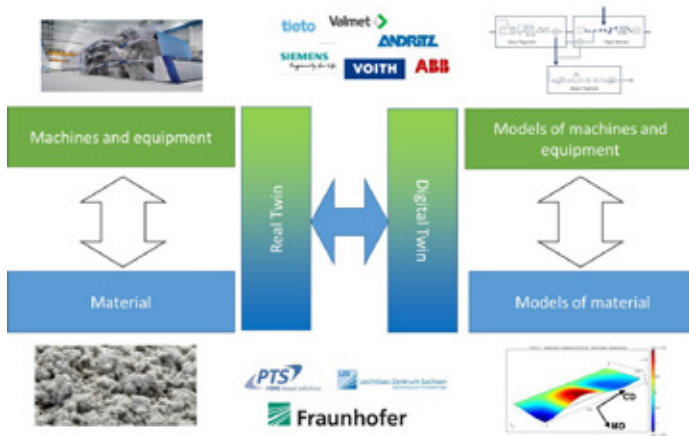
Fig. 1: Real and digital twin of material and machine
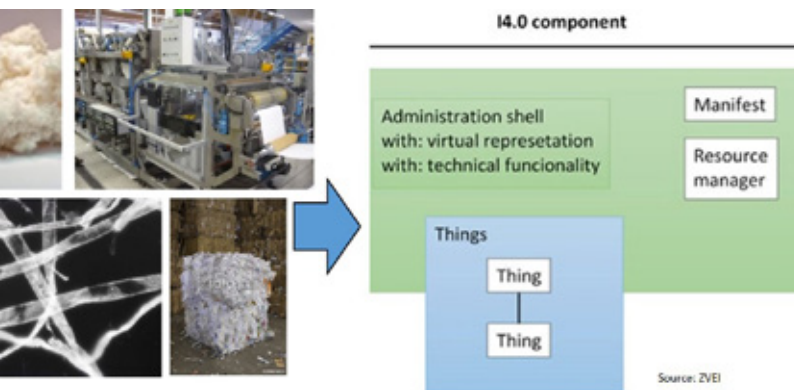

Fig. 2: Material data in PROMETHEUS

Fig. 3: Industry 4.0 components

ment technology and analytics, as well as the evaluation of data and application in models, lead to a continuous expansion and deepening of material knowledge.

PTS considers the innovative creation of this information for existing and new materials as one of its essential tasks. In research projects, the local knowledge and product design platform PROMETHEUS is used as a platform for PTS-internal research data management *(Fig. 2)*. The resulting research data is recorded, archived, systematically organised in material flows, indexed using meta data and thereby made available for model-based product design.

In the future, research partners will also be able to work on this platform. Linking it to international research and material databases will be an important task in the future.

Exchange of information is becoming increasingly important in the course of the increasing cooperation between all the participants of dynamic value creation networks. On the one hand, flexibility and effectiveness in modern product design and cooperation with suppliers and customers require open communication. On the other hand, data becomes more valuable because its ownership is a key element of future business models. It is important to establish a balance between trust and security. This is a cross-industry topic. Providers are developing fundamental technical solutions for data security as an integral part of IT concepts and IT structures. International agreements and legal regulations are another component which needs to be used by politics to create framework conditions. At the same time, companies must create the necessary prerequisites. Isolation will not be an option.

Research for the implementation of Industry 4.0 in the industry

Together with its project partner Institut für Automatisierung und Kommunikation (Institute for Automation and Communication – ifak) in Magdeburg, PTS is researching the foundations and manifestations of digitalisation in the paper industry. Both partners are working on a project within the scope of the INNO-KOM Forschung für den Mittelstand (Research for SMEs) programme. The project is a sort of preliminary program and is funded by the Federal Ministry for Economic Affairs and Energy (BMWi). The joint project INVITE4.0 aims to develop a method for the engineering of technology-based services using Industry 4.0 technologies. The project is therefore dedicated to the topic of building innovative and digital development and service systems in the context of Industry 4.0, with a focus on applications in plant and process engineering and the value-creation chain of paper and fibre-based materials.

A fundamental task of INVITE4.0 is to prototypically develop the real things of the paper industry, also called objects or assets in this context, into Industry 4.0 components. For this purpose, the objects are digitally described and provided with administration shells *(Fig. 3)*. The idea of the digital twin is implemented using the digital description based on machine-readable properties in defined semantics. The administration shell, with its integrated interfaces to the asset, enables the virtual representation of a technical functionality. As described above, the material, as an object, plays an important role in the work of PTS.

An Industry 4.0 component is a globally uniquely identifiable, communication-capable participant consisting of an administration shell and an asset with a digital connection, offering services with defined

quality-of-service characteristics. The "objects" of the paper industry can thereby be addressed in the digital world or can themselves actively communicate. Digital work – execution of Smart Services – and therefore also communication are carried out on so-called digital platforms *(Fig. 4)*. Creating the necessary interoperability requires well-defined structures and interfaces. The fundamental, internationally standardised reference architectural model RAMI 4.0 originates from the field of information and communication technologies. Project INVITE4.0 demonstrates the work on RAMI 4.0-compatible platforms for paper industry applications.

Demonstration with the help of Use Cases

In project INVITE4.0, various use cases are designed and partly implemented for demonstration purposes. A particularly exciting use case is the optimisation of raw material input into the de-inking plant of a paper mill by means of targeted control of the recovered paper sort-
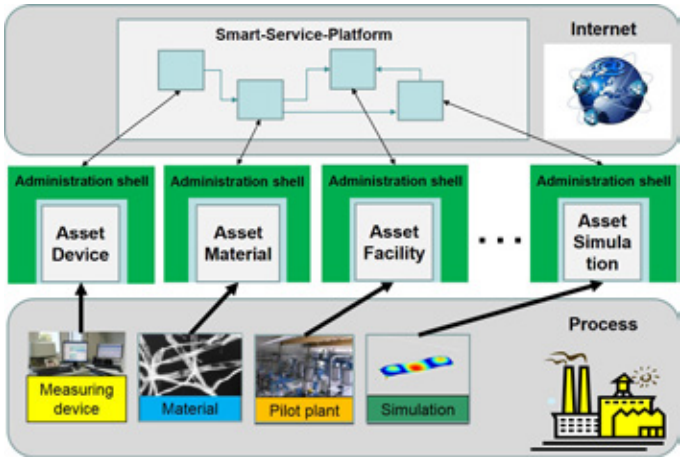

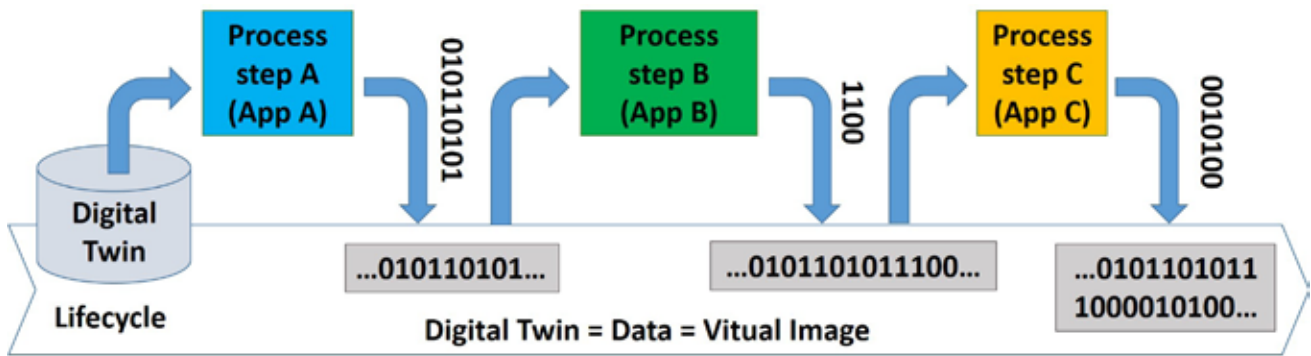**Fig. 4: Paper "objects" on Smart Service platforms**

Fig. 5: Changing of the digital twin parallel to the real process

ing plant, taking into account the raw material qualities from the warehouse of loose and baled items. Stora Enso is supporting this use case with great commitment. Consideration of the material side of the raw material recovered paper – a very heterogeneous material – as a digital twin creates very high demands. The problem lies in the description of recovered paper in the industrial process, particularly when generating data for a description of the quality. This information forms the basis for the effective use of raw materials in paper and paper board production. The level of development in the industry is varied. All in all, however, it is technically underdeveloped. At the same time, digitalisation is regarded as having the greatest potential for cost reduction when increasing the fibre yield. The digital twin is the promising, future-oriented approach to comprehensively and systematically mapping the lifecycle of the raw material recovered paper in paper manufacture, starting from acquisition in collection and sorting systems, to goods receipt and the papermaking process *(Fig. 5)*. The approach taken and the selected data structures make it possible to link the data, which is obtained from collection systems and paper mills, and which accumulates at different points in time with varying frequency and quality and at different locations, to goods receipt, to dry sorting, to the supply for recovered paper dissolution and to the quality of the produced pulp in such a way that it can be used for optimal paper manufacture.

In this context, a process refers to all operational processes starting from recovered paper supply, storage, formula composition, recovered paper treatment to paper manufacture. The models of individu-

Fig. 6: Digital service platform

al process steps access original data from the digital twin, modify and make additions to this data and return it to the digital twin. Transferring this digital methodology to all material flows in the paper industry circuit can create a system of services for global usage optimisation of the valuable resource of recovered papers.

Measurement Technology for Digitalisation

For several years, PTS has been providing measurement technology solutions to the industry for generating quality data. In the context described above, the PaperBaleSensor, as well as the Haarla and Valmet tester solutions that are based on it, are essential building blocks for the digitalisation of recovered paper management. In user companies, information about the raw material recovered paper which flows into MES and ERP systems is obtained from using the measurement data from PBS and bale testers. Another example is the merQbiz platform from VOITH, which was established in 2017. It is a quality-oriented online trading platform for recovered paper, which is based on the OnCumulus digital platform from VOITH. Among other things, PTS PaperBaleSensors are used for generating data that describes recovered paper. The platform was launched in the US market. Expansion into other regions and markets after the start-up phase has been announced.

Analytical Services for Digitalisation

Based on a great deal of know-how from research projects, PTS offers a broad portfolio of measuring and testing services. In the course of digitalisation, it is logical to provide the diverse services on digital service platforms. PTS's own platform *(Fig. 6)* is the first step. The benefits of this include a good, technically sound overview and efficient access to information that potential customers need for measurement and analysis tasks during quality assurance and research and development. PTS sees it as a building block for the provision of Smart Services. The English page will be launched.

Outlook – Development of the Competence Centre for Fibre Technology 2030

PTS sees the use of cutting-edge IT technology in the development of new fibre-based materials and products made from these materials as a key catalyst for its future success. In Heidenau, PTS plans to concretise its research results by building an international Competence Centre for Fibre Technology 2030, which will fundamentally develop and demonstrate high-end fibre technologies in the context of Industry 4.0 technologies for intelligent production and processing, and launch them on the market.

Verdict

The driving forces of digitalisation in German industry, which are the forerunners and which provide path-breaking input, are the providers in the field of information and communication technologies. The German paper industry is a user industry. Digitalisation poses a threat to established industries. At the same time, it creates opportunities to achieve greater effectiveness and innovation in industry. These opportunities must be exploited by means of diverse and concrete implementation projects by individual companies. PTS aims to promote successful, industry-specific application and implementation with its industry-oriented research and the resulting range of services offered.