Swedish-German Testbed for Smart Production

POWERTRAIN MANUFACTURING FOR HEAVY VEHICLES APPLICATION LAB
- A COLLABORATION BETWEEN KTH, FRAUNHOFER AND RISE
MADE FOR INDUSTRY 4.0
The internet of things (IoT) connects objects and services, and revolutionizes not only our everyday life but particularly the manufacturing industry. The digital transformation, supported through IT connection of production and logistics, promises a significant increase in productivity and flexibility, saving of resources and the development of better products and processes, consequently leading to increased customer satisfaction and business growth.

Industry 4.0 and smart production, refer particularly to the use of cyber physical systems connecting real and virtual production for both internal and external communication and cooperation. The high-level connectivity is made possible by cloud computing, which today generates substantial amounts of variable data with a direct or indirect connection to production, available for data acquisition and data processing. In turn, this allows for the development of cognitive computing including self-optimizing applications such as artificial intelligence and machine learning.

How the fourth industrial revolution will shape the future of production specifically is yet to be seen. However, it stands clear that the strategic approach of today is of paramount importance for the survival and success of the manufacturing companies of tomorrow.

The Powertrain Manufacturing for Heavy Vehicles Application Lab – a Collaboration between KTH, Fraunhofer and RISE (PMH Application Lab) and its partners work on test cases from the powertrain industry by linking research and development within academia with the industry. Within this R&D Cluster, the mission of the PMH Application Lab is to validate promising technology and to accelerate the transfer of these technologies into industrial applications. Drawing upon its access to leading expertise in the field, and as an acknowledgement and response to the demand of a practical testing ground, the PMH Application Lab – together with its partners – develops a testbed made for Industry 4.0.

“The PMH’s mission is to validate promising technology and to accelerate the transfer of these technologies into industrial applications.”

The predominant focus of existing testbeds and competence centers is currently on solutions for individual locations. However, the Swedish-German testbed for smart production is designed to look beyond this by exploring what values partnership-driven solutions could bring.

This testbed thus offers a unique test and validation platform for cross-location developments in Industry 4.0 and smart production – especially for small and medium sized companies in close cooperation with OEMs as well as other internationally acting companies.
TESTBED CONCEPT
The Swedish-German Testbed for Smart Production is an integrated hardware and software interface, consisting of a set of interconnected machining tools and software systems. It is designed to provide a test and validation platform for cross-location production in powertrain manufacturing. Production systems at different sites are connected to the testbed by a cloud which is used for data acquisition from respective production systems and storage of data of the produced components. Taking the form of a digital twin, the data will follow the component throughout the production process while continuously being updated. In the cloud, software tools are performing model-based data analytics to interpret and enrich the data of the digital twin. Through apps, the data is then accessible and visualized for the process owner independent of location.

The different sites in the concept are the PMH Application Lab at KTH campus, sites of PMH’s partners (e.g. Fraunhofer IPT or Fraunhofer IWU) and industrial partners that would like to test and validate the connection of their sites to a cross-location production environment. The long-term integration of further sites will extend the Swedish-German testbed for smart production in the future.

“Sweden, in particular, has an outstanding innovative culture. Industrial companies and research institutions can not only test their technological expertise on the Swedish market more quickly, but also benefit from the enormous creativity of the Swedish partners and their open-mindedness to new digital solutions for production systems, products and business models.”

Jannik Henser, managing director
GOALS AND OBJECTIVES
The target picture of PMH’s R&D work is cross-location handling of value chains. Regardless if it means cooperation between organizational departments, entire companies or even across national borders, it requires an exchange of planning, process and measurement data for manufacturing processes.

In turn, a technical prerequisite is thus a cross-location digital infrastructure for transfer, analysis and visualization of the data.

Facing these requirements, the Swedish-German testbed for Smart Production shall give the possibility to evaluate on one side the added value of provided data and on the other side the possibilities and risks concerning data security in a complex value chain environment.

Following research questions will be addressed in the testbed:

1. Can a digital cross-location infrastructure in combination with suitable sensors provide the current technical condition of a component in a cross-location value chain independent from the location of the process owner by means of a digital twin?

2. Can model-based data analytic tools, which are provided in a cloud system, enrich the information in the digital twin by means of simulation tools in a way that a close to reality image of the component is generated?

3. Is it possible to properly evaluate the current quality state and to extrapolate the final quality of a component from the data that are stored in a digital twin?
The digital twin is a virtual representation of the elements and dynamics of a real component, containing relevant data such as design, process planning, testing and manufacturing history. Throughout the manufacturing process, the digital twin will follow the component while continuously receiving updates from its surrounding. The information may come from e.g. design and process planning software, simulations, sensors or data-analytics tools. This will allow the process owner to gain quick and easy access to an overview of data and status of the component throughout the process chain and serve as a basis for analysis and decision making. A technical prerequisite is horizontal integration of production processes.

Horizontal integration refers to interconnectivity and data exchange over organizational boundaries such as departments, companies or even countries. This network is a central feature of Industry 4.0 and allows for a cross-location handling of production systems. The figure below illustrates the concept of the digital twin.

In the figure, the bottom half represents the real process chain for the manufacturing of a component, while the arrow on the upper half illustrates the flow of simulations supplied by supporting software, later stored in the digital twin. The red arrows symbolize input and output of data, simulations and models to and from the digital twin via cloud connectivity throughout the process.
MODEL-BASED DATA ANALYTICS
While horizontal integration refers to interconnectivity across production systems, vertical integration focuses on the extraction of data within respective process. Using sensors and connectors, raw data will be acquired from the production equipment and get processed in such a way that it forms a close to live visualization of the production process.

The data provided by the sensors and connectors will be stored in the digital twin. Depending on the specific use case, it might be necessary to include a first data processing step to aggregate the raw data. The data will be analyzed by respective model-based data analytic software. For this, digital models of the production equipment will support the analysis of the process, enabling higher accuracy of the results. These results are again stored as enriched information in the digital twin and can together with the raw data be visualized to the process owner.

In the Swedish-German Testbed for Smart Production, model-based analytics will be accessible through apps provided from the cloud, and serve as a support for the process owner when making adjustment of the production process. The testbed will thus examine how model-based analytics could enrich raw data for simulation and visualization of the current status, while also explore how the data could be extrapolated to forecast future and final qualities of the components in the manufacturing process.

Moreover, a challenge that is specifically addressed in this project is the integration of production equipment that is not initially equipped with state of the art sensors and connectors into the smart manufacturing network.
To realize the connection of the Swedish-German testbed for Smart Production to the cross-location infrastructure and for the realization of data acquisition, storage, processing and provision, a digital infrastructure is required. The infrastructure is designed in a generic way to enable the involvement of new solutions. The generic infrastructure consists of a local digital infrastructure that is implemented at respective sites and a cloud-based smart manufacturing network that communicates with the local sites.

At the local sites the production equipment like machines, tools, workpieces, measurement devices or transport systems are monitored by sensors and communicate via protocols (e.g. OPC-UA, TCP, MTConnect) over broadband networks (e.g. 5G). Also, an information system architecture using an information broker will be implemented. The information broker organizes the communication between the respective equipment, on site analytic tools or via gateways with the smart manufacturing network in the cloud. These services accessible from the cloud are e.g. model-based data analytics, data storage or simulation apps as well as services for the manufacturing execution system (MES). The figure below illustrates the generic digital infrastructure.

The top section of the figure summarizes the cloud services while the bottom section represents possible clients by means of e.g. connected machines, devices and tools. The middle section maps out the key gateways and how the broker acts as a central commutation node. Together, it forms the digital infrastructure of a particular local site within the testbed.
Industrial motivation

The demand for freight transport has grown constantly over the last years. Customer demands on the powertrain of heavy vehicles include: High reliability, low costs, environmental sustainability and the availability of spare parts. Moreover, legislation and global competition lead to further ecological and economical demands for heavy vehicle powertrains.

The properties of a heavy vehicle powertrain are strongly affected by the technologies used for manufacturing the powertrain components. This means that the ability to fulfil the above mentioned requirements is dependent on the chosen manufacturing chain.

Objective

Therefore, KTH Royal Institute of Technology in Stockholm, the German research organization Fraunhofer-Gesellschaft zur Förderung der an-gewandten Forschung e.V., and RISE – Research Institutes of Sweden with its associate Swerea AB have established the "Powertrain Manufacturing for Heavy Vehicles Application Lab – a collaboration between KTH, Fraunhofer and RISE" (PMH Application Lab) which will coordinate and perform research and development projects for the heavy vehicle industry and also provide education, training and dissemination.

A major task of the PMH Application Lab will be the coordination of the Powertrain Manufacturing for Heavy Vehicles R&D Cluster which shall bring together the industrial and research partners of KTH, Fraunhofer and RISE for the purpose of joint research projects. The PMH Application Lab and the R&D Cluster have the objective to enhance the Swedish industry in the field of powertrain manufacturing for heavy vehicles.
Access and benefits

There are several ways for industrial companies to get access to the offers of the PMH Application Lab, incl. the Swedish-German Testbed for Smart Production. The most common way is a membership in the R&D Cluster.

A Follower membership is the smallest membership category in the R&D Cluster and gives access to the community. A follower participates in the preparation process for collaborative R&D projects and may suggest new project ideas. Furthermore a Follower receives mailings about all matters in the R&D Cluster and gets reduced seminar fees. The participation in collaborative R&D projects is optional but has to be chosen at least every third year.

In addition to the above mentioned Follower benefits, a Partner has a seat in the Steering Group in which the representative may distribute 8 points for the first selection of collaborative R&D projects. In other decisions all Partners have a collective vote in the Steering Group.

The third category is the Key-Account category. In addition to the Follower & Partner benefits, a Key-Account may distribute 20 points for the first selection of collaborative R&D projects and has an own vote in all other decisions. Furthermore, Key-Accounts receive a key-account manager as contact person for all R&D Cluster matters and receives an annual finance report.

The members in the highest membership category are Premium Partners. In addition to the Key Account benefits, a Premium Partner may distribute 35 points in the first selection of collaborative R&D projects and gets two votes in the Steering Group.

The PMH Application Lab collaborates also with non-members of the R&D Cluster. This happens usually within public funded research projects or in contract research projects. Furthermore, non-members are invited to public events of the PMH Application Lab as e.g. seminars.

<table>
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<th>Expenses &amp; Membership fees</th>
<th>Non-members</th>
<th>Follower</th>
<th>Partner</th>
<th>Key-Account</th>
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### Collaborative R&D

- Planning workshop (project suggestions)
- First project selection by the steering group
- Decision workshop (final project selection)
- Value cheques for projects (à 2500 €)
- Receive results of collaborative R&D

### Individual R&D

- Individual research roadmap
- Key account manager in Sweden
- Annual finance report

### Others

- Receive mailings
- Invitation to seminars
- Reduced seminar fees
- Participate in the annual colloquium
- Steering group
- Invited to cooperate with PMH in public funded projects

* This option has to be selected at least every third year
** Sessions about results of collaborative R&D require a financial contribution to the collaborative R&D projects
*** One shared vote for all partners in strategic decisions
Contact

Powertrain Manufacturing for Heavy Vehicles Application Lab
- a Collaboration between KTH, Fraunhofer and RISE

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