Industrial Hydraulics – Are we really on track concerning Industry 4.0?

Dr. Steffen Haack and Alexander Meißelbach

Bosch Rexroth AG, Zum Eisengießer 1, Lohr am Main, Germany

E-Mail: steffen.haack@boschrexroth.de , alexander.meisselbach@boschrexroth.de

Industry 4.0, a term that we encounter almost every day. What are the effects of networking of machines and entire factories as well as the ongoing digitalization on machine and plant design today and in the future? Based on some theoretical considerations, the entire engineering process is examined from the first product idea to the installed solution.

The requirements of Industry 4.0 are major challenges for manufacturers and users, but they also offer huge potential. What about Hydraulics, are we really on track? The first steps with electro-hydraulic solutions have been taken, but there is still a lot of work and effort needed not least in order to close the gap to electrical solutions.

Keywords: connectivity, digitalization, engineering, industrial hydraulics, machine learning, predictive maintenance, embedded sensors

Target audience: industrial hydraulics, engineering controls, industrial internet

1 Introduction

Digitization is changing technologies at unprecedented rates. In machinery and plant engineering, this development we summarize this with the catchword “Industrie 4.0” here in Germany.

Today, we can increasingly imagine how the networking of individual plants or factories and the networking of the entire value creation process will change our business. Intelligent, self-optimizing software solutions and big data are playing an increasingly role. This is not a dream of the future: Siri and other speech recognition software have long been using machine learning methods. The software already learns something like a human brain.

But what does this development mean for our industry? For one, this is a good chance for us. For another, that's a big challenge! Technically and organizationally. That is probably one of the reasons why particularly medium-sized companies are still cautious about Industry 4.0. The high initial investment and the lack of know-how on how to connect your production in the best possible way initially scares off many. Especially if the immediate benefit is not directly apparent. There are already practicable solutions today. And one thing is clear: there is no time to wait.

Anyone who does not react today will miss the connection and important competitive advantages. So again the question as Fluid Power experts - are we really on track regarding Industry 4.0 in Hydraulics?

2 Digitalization Hydraulics

Basis for Industry 4.0 are digital products delivering data, standardized communication and connectivity as shown in figure 1. This will make “hydraulic data” available for additional services and product optimization. And at the end there are mainly two targets everyone wants to reach: Increase productivity and overall equipment effectiveness (OEE).

In Hydraulics we are facing >80% of standard hydraulics today without any digital connectivity. One area with digital technology on board are the electrohydraulic solutions, but also in the field of standard hydraulics we have a need to catch up.

Figure 1: Digitalization Hydraulics

Standardized communication and providing all relevant data is key for interacting of assets. The basis is set by the RAMI-Modell, the Reference Architecture-Model I4.0 for Europe.

3 Basics Industry 4.0

The first version of a reference architecture for Industrie 4.0 (RAMI 4.0) and their components, which precisely describes Industrie 4.0-compliant production equipment, have been developed.

The RAMI 4.0 model in figure 2 is a three-dimensional map showing how to approach the issue of Industrie 4.0 in a structured manner. RAMI 4.0 ensures that all participants involved in Industrie 4.0 “understand” each other. Starting from the bottom:

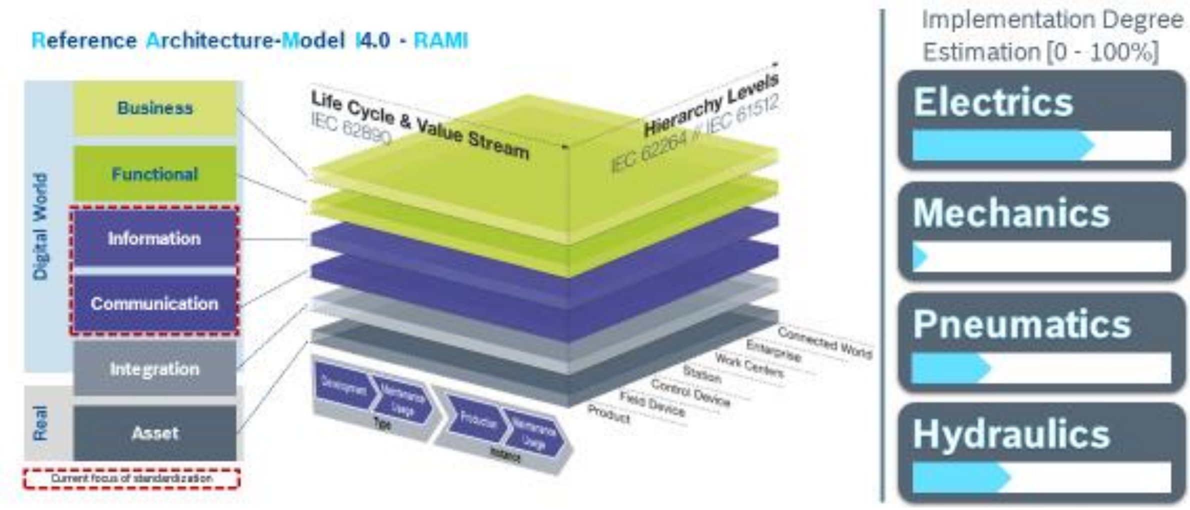

Figure 2: Reference Architecture Model I4.0 (RAMI)

The Assets are the physical things in the real world, the Integration of the Assets is the level with the transition from the real to the digital world. In the digital world the Communication allows access to information. The Information level represent all necessary data for Industry 4.0 which has also to be standardized so that the assets can be understood.

In the Functional level the functions of the assets are defined and on the Business level the functions are integrated in the organizational and business processes. This model allows to generate flexible systems and machines, where functions can be distributed throughout the network and the participants can interact across hierarchy levels. The Reference Architectural Model and the Industrie 4.0 component serve companies as a basis for developing future products and business models.

And where are we today? On the right side the todays implementation is led by the IT and electronic suppliers and the hydraulics is among the other technologies far behind. As Fluid Technology we have to intensify our activities. Therefore Rexroth is driving and supporting different activities.

Major activities are shown in figure 3. One is "VDMA Group Industry 4.0 Fluid Technology" with focus on elaboration of cross-technological and Industry 4.0 relevant standardized data from suppliers, machinery manufacturers/OEM and End-users.

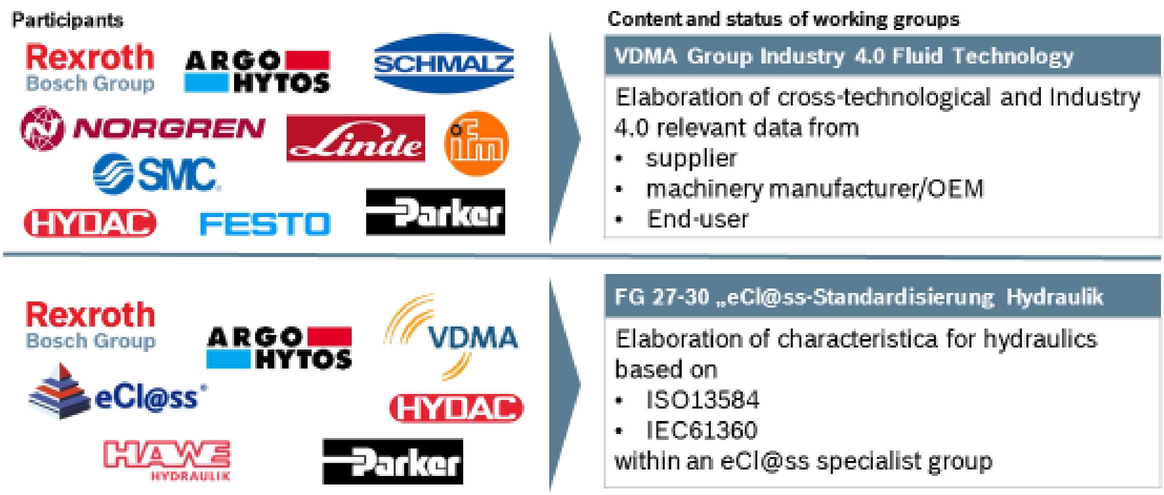

Figure 3: Standardization activities at *VDMA Group Industry 4.0 Fluid Technology and at FG 27-30 „eCl@ss-Standardisierung Hydraulik"*

Another activity is the elaboration of e-class characteristics for hydraulics based on ISO13584 and IEC61360 within an eCl@ss specialist group. The new ecl@ss definitions will be released in 2018.

4 Engineering

We face now the real engineering and production process. Ever shorter go-to-market cycles confront manufacturing companies with massive challenges. The digitization of production is one of the most important topics. Project planning phases must be completed quickly and efficiently, commissioning times must be kept short.

The engineering process shown in figure 4 starts normally with the selection of products needed for the project. For this process we for example offer easy to use product selectors and configurators.

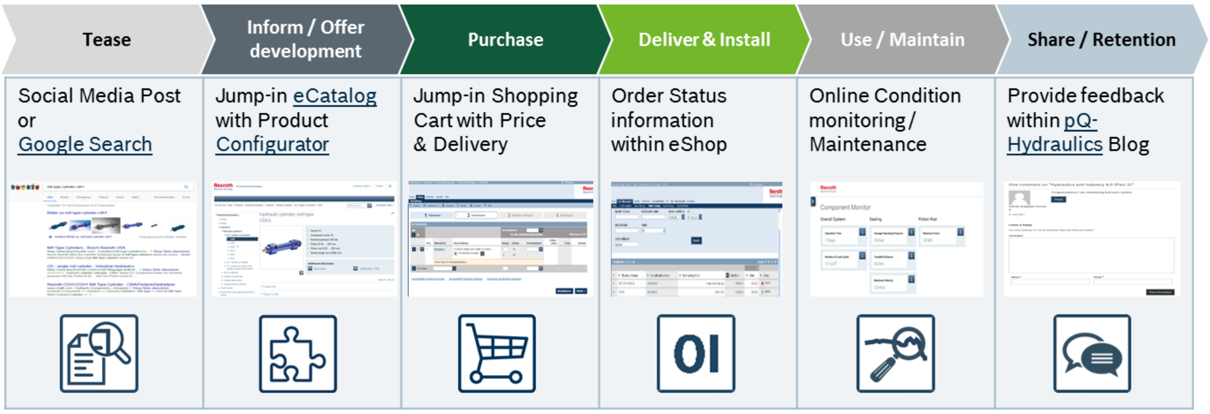

Figure 4: Engineering Process from 1st idea to installed solution

Engineers can design the complete hydraulic project and select and configure the needed products. The Engineers get all the 2/3D Data they need for construction and also simulation data for real physical simulation of the application are provided. After finishing this process a complete digital twin is available and the physical products can be ordered easily and tracked until they are delivered.

A digital twin is a virtual model of e. g. a process, a product or a service that connects the real and virtual world. This digital twin can be useful in the phases of an object's lifecycle. The first phase "Design" deals with the handling of complex product requirements, fast development cycles and strict regulatory requirements. A digital twin helps to explore the impact of different design alternatives and perform simulations and tests to ensure that product designs meet all requirements.

All the necessary engineering – from rapid prototyping to simulation and final programming is done within one open development platform (figure5). Open, because the open core engineering interface allows to integrate 3rd party tools like programming languages e.g. Java and simulation tools e.g. Mathlab Simulink with direct access to the kernel of the control functions. This platform contains also all software tools and function toolkits for all technologies like electric or hydraulic actuators offered by Rexroth.

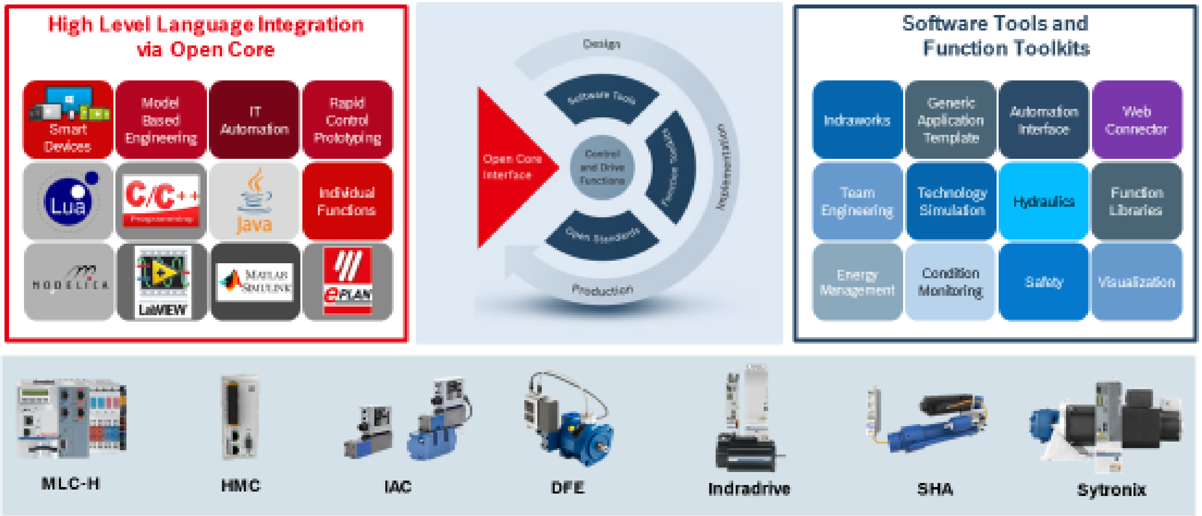

Figure 5: Engineering Support – Intuitive, easy to use engineering tools

In the second phase "production (manufacturing)" the twin can help to achieve better efficiency, quality and higher yield in production. In the third phase "Use (operate)" a digital twin can be used to improve the availability of objects (e. g. machines). In the fourth phase "recycling", a digital twin can be used, for example, to plan replacements or to determine upcycling potentials. /1/

What does this mean for device manufacturers? In addition to the physical product, they must also be able to provide the associated digital data, e. g. 3D models, Eplan macros and simulation models or simulation tools.

Hydraulic components today contain complex control algorithms, see also /4/. For OEMs, this means a change from their own algorithms to those of the device manufacturers. In order to be able to integrate them into their machine simulation, appropriate simulation models are needed.

5 Products

Industry 4.0 is the main enabler for transformation of industrial controls towards a digitalized portfolio. In future nearly all electronics will based on digital platforms as shown in figure 6. Digital interfaces will become the standard communication interface. Standardized communication protocols will play an important role in communication between components and control units.

Embedded sensors, especially pressure sensors, open up new possibilities for functional improvements and extensions.

Figure 6: Industrial Hydraulics going digital – in platforms, in interfaces and with embedded sensors

Industry 4.0 requires the right exchange points at crucial places: platform-independent, fast and easy-to-program communication interfaces for the perfect dialog between all levels of the automation pyramid. To the component level ethernet-based bus systems shown in figure 7 are available in different variants (e.g. Sercos, PROFINET, EtherCAT, POWERLINK, EtherNet/IP), which offer comprehensive networking possibilities. Products with such digital interfaces are nowadays standard and available from several suppliers on the market.

Figure 7: Industrial Hydraulics going digital – in platforms, in interfaces and with integrated sensors

But even simple digital point-to-point connections such as IO-Link feature the option of digital data exchange for both commanding and parameterization. Devices have to be easy to integrate in applications. To this end, open interfaces are required, which allow simple access to device functions and parameterization.

OPC-UA is a standardized, open protocol for consistent and secure data exchange in heterogeneous production systems - across all automation levels and up to cloud applications. It offers comprehensive networking between all systems, platforms and manufacturers.

The new TSN standard (Time Sensitive Networking) will replace the existing mainly proprietary quasi standards, at least in part. Together with OPC-UA, this has the potential to become the communication standard for future Industry 4.0 and Industrial IoT applications. OPC-UA will probably extend down to the component level for communication with PLC's or at least with cloud-based systems.

Apart from cable-bound communication, wireless interfaces are conquering industrial automation. They will also play a role for hydraulic devices in the future - at least as service interfaces and information provider.

Nowadays many hydraulic components are equipped with position sensors. The progressive digitalization and miniaturization paves the way for the integration of further sensors into hydraulic components (figure 8).

The integration of pressure sensors in particular opens up new possibilities at lower costs. Examples are usage of captured data in cloud based applications, improvement of control algorithms or processing of this data in component-based condition monitoring functions.

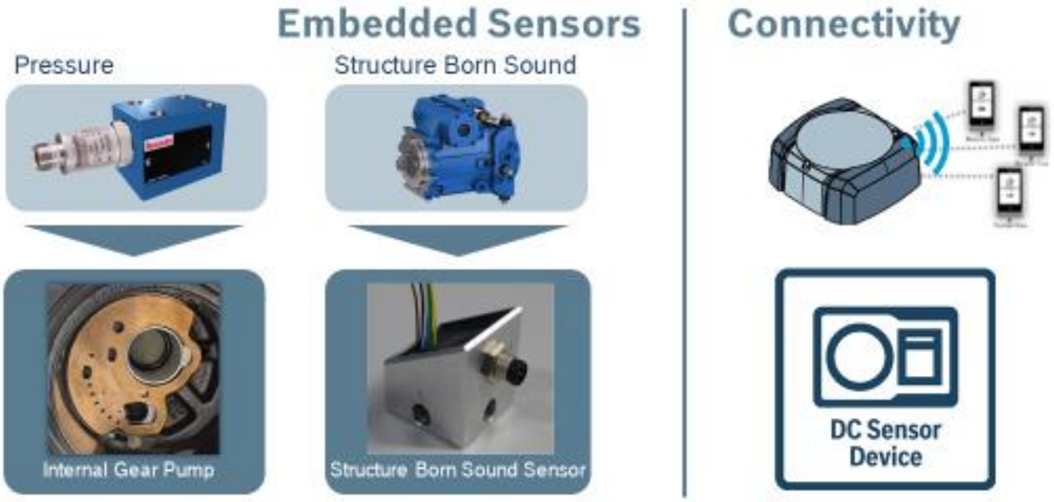

Figure 8: Industrial Hydraulics with integrated sensors

6 Commissioning

Getting to the function with only a few clicks. This is the requirement of users and hence the challenge for device manufacturers.

Today, digital devices feature a multitude of functions and setting options. This extended scope of functions inevitably increases their complexity. The challenge is to make this complexity manageable and to give the users an easy start and quick success. This requires engineering tools that can be operated intuitively and make all necessary functions available to the user simply and clearly.

Knowledge of hydraulics as well as control engineering is required for commissioning electrohydraulic drives. The aim must be to enable as many target groups as possible to commission hydraulic drives without the need for expert knowledge.

This task is performed by commissioning assistants (figure 9) who query familiar data such as cylinder type, installation situation, pressures etc. and make all necessary settings at the push of a button so that the drive can be moved.

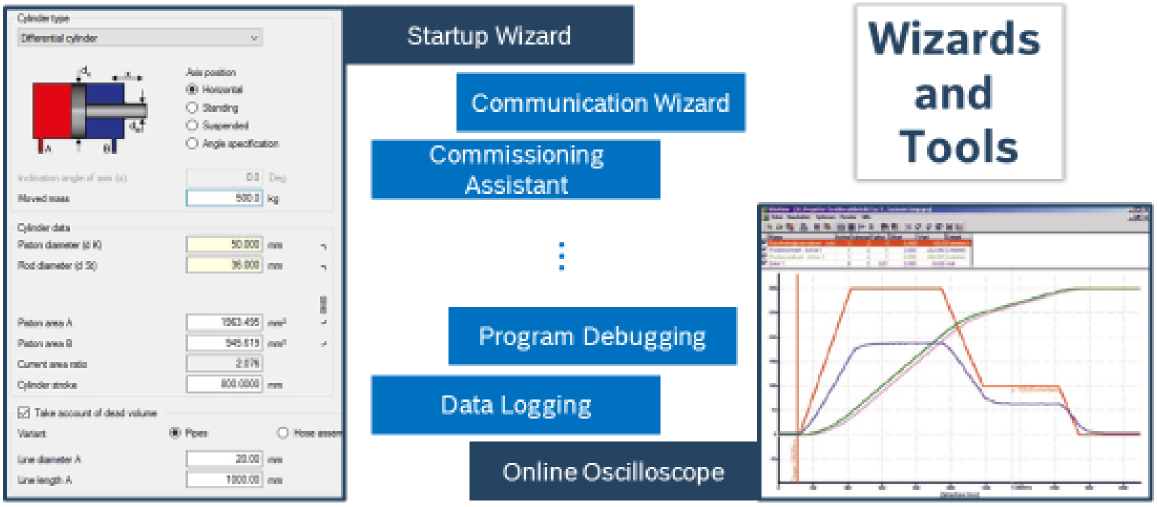

Figure 9: Commissioning assistants for Hydraulics

For fine-tuning after that, integrated oscilloscope functions and suggestions generated from the tool for improving the drive behavior are useful and necessary.

7 Predictive Maintenance

The machine is now operating in the production process and should be 100% available. To increase the availability of our customers' systems near to this target, data are captured via sensors integrated in the automation components and additional sensors in the machine if needed (figure 10). To come to a reliable prediction the data are evaluated with intelligent software, analyzing tools and drawing the right conclusions.

Figure 10: Predictive maintenance with ODiN

Such systems, which learn by machine learning methods themselves, still needs to be improved. Because there is a lot of potential in the process data available to us in networked production.

The evaluation alone is not enough. We still need the technology experts and the mechanical engineers. Because their domain knowledge is necessary to interpret the results correctly, which we received from the analysis of the mass data. In our view, it is necessary to bring together mechanical engineering, IT, users, automation and science. Together they can make a prediction of the health index of the machine (figure 11) and initiate the necessary actions to achieve highest availability with lowest operating cost. With this technology we are able to know today what will happen to the machine tomorrow.

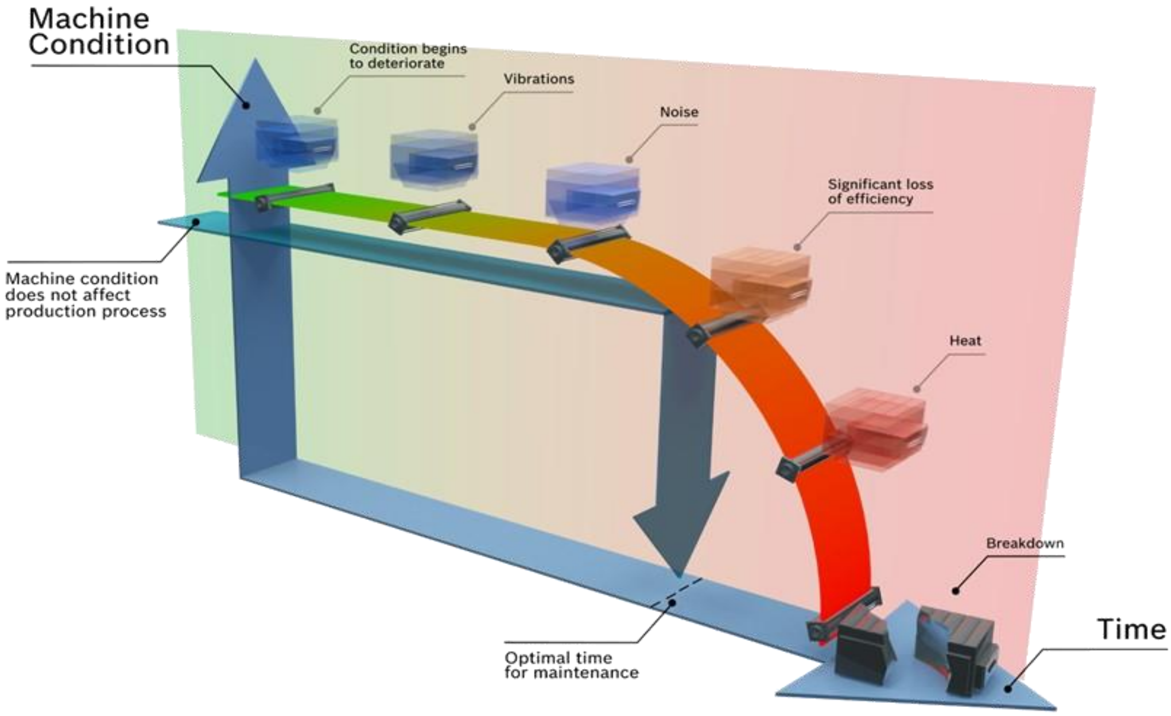

Figure 11: Prediction of machine condition and health index

Our algorithms are able to generate a valid health index of the machine automatically and upfront an upcoming machine break down the necessary activities can be planned in regular downtimes and the needed spare parts can be procured in time. This is a clear advantage for the operator of the machine and basis for that are embedded Sensors and digitalization.

8 Summary

Back to the beginning question: Are we really on track concerning Industry 4.0?

The answer is: Currently not yet – Activities have been started in the hydraulics but we have to speed up to close the gap to the electric solutions.

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