Digital avatars for powertrains expand digital twin concept

A digital twin is an almost identical copy of a physical device. However, to really benefit from digital opportunities, a digital representation with more capabilities than the physical object is desirable. This “digital avatar” interacts with the digital world in ways its physical counterpart cannot.

Digital powertrain

A digital powertrain is a suite of solutions for the digitalization of, for example, the compressors that are so critical to the oil, gas and chemical industries. The digital powertrain concept encompasses devices, software and services. Digital powertrain solutions exploit the advantages of connectivity and data analytics melded with domain expertise. Each physical powertrain, including all its components such as drives, motors, bearings and target applications like pumps and compressors, can send data to the cloud that is then visible to the operator on a simple dashboard. In a further stage, condition monitoring and predictive maintenance services can be employed to make support or repair recommendations based on actual, ongoing levels of stress and wear.

To fully benefit from digital opportunities, a digital representation that has capabilities additional to those of the physical object is required – this is the digital avatar.

Modern industry strives to meet many challenges, such as operational excellence, better efficiency and improved profitability. In short, what is called for is to produce more with less, with a larger profit and to do it in an environmentally friendly way.

One way to meet these goals is to exploit the power of digitalization. From a practical point of view, this could mean creating appropriate “digital twins.” A digital twin can be characterized as the mixture of data and intelligence that represents the arrangement, context and nature of a physical system of any kind, including an interface that gives one understanding of the past and present operation, and allows for predictions. However, the digital twin concept is limited. The challenge lies in representing the physical version of an entity much more authentically in the digital world. There is much more information available than just that relating directly to the device, system, plant or model. For example, user interaction produces and uses many kinds of digital information. Real-time measurements, models, 3D graphics, user manuals, operator notes and service instructions are all aspects of the object that may also be important. To fully benefit from digital opportunities, a digital representation that has capabilities additional to those of the physical object is required – this is the digital avatar. The digital avatar is a digital object, native to the digital world, that represents the physical object but that can interact in the digital world in ways its physical counterpart cannot.

The data comprising a digital avatar can be grouped and classed as a particular system – e.g., a digital powertrain.

ORKAN

To remain at the forefront of digital and technological innovation, ABB develops intelligent concepts that are verified by means of design review, advanced model simulations and rigorous experiments conducted under strictly controlled conditions, especially in relatively small-scale setups. The ORKAN compressor control and diagnostic test stand is one such setup.
The ORKAN compressor test rig allows evaluation of all different kinds of concepts connected with digital powertrains [3].

The ORKAN stand is used, for instance, to gauge the influence of electrical faults on process-side stability and develop solutions to protect against these disturbances. In recent years, the test rig has been successfully employed to develop and test solutions that cope with grid disturbances, and electrical and mechanical issues. Process control modes – such as basic process control, suction pressure control, discharge pressure control and anti-surge control – can also be explored on the test rig and robust solutions for operational eventualities developed.

The test stand is equipped with ABB devices such as ACS880 and ACS850 low-voltage drives, two induction motors, an ACB800 PEC controller, AC500 high-performance and ACS500 CMS (condition monitoring system) PLCs (programmable logic controllers), an Emux Sace breaker (with additional Raspberry Pi logger), and a variety of flow, pressure and temperature sensors. The inclusion of an ABB ServicePort application allows all users to view, scan and track all key performance indicators (KPIs) to enable maximum performance of the compressors and the processes involved [4-5].

**Case study**
The ORKAN test stand has the basic elements of the digital twin – and additional facets that comprise the digital avatar: document management, modeling, simulation, 3D representation, data model, visualization, model synchronization and analytics.

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**Document management**
Software is tracked by Git (an open-source version control system). A full set of stand operating instructions is maintained and service records are available in the form of data logs, event logs and reports.

**Modeling**
Modeling is based on analytical process models, and electrical and mechanical dynamic models, of the compression system. Simulation and measurement campaigns were used to verify the accuracy of the modeling. Optimization is focused on process control and uses MPC (model predictive control) – anti-surge control for compression systems – including T2S (time to surge) functionality. The diagnostics part is based on algorithms and analytics that handle both the rotating machinery and the process. Diagnostics are implemented on different levels (from the sensor and monitoring device up to the gateway and cloud). Modeling focuses on condition monitoring as well as on energy and process management.

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**Simulations**
The simulation part consists of two major elements: design simulation and compressor system throughput simulation. The former uses detailed simulation models that cater for set-point change, disturbances, fault modes and noise. The latter makes it possible to simulate and evaluate throughout optimization for compression systems (load sharing, series operation, anti-surge operation, etc.) during normal operation or during various faults. Simulations are then verified by experiment.

**3D representation**
The 3D representation is based on design drawings of ABB and third-party components.

**Data model**
The data model uses engineering data relating to sensors, measurement and control equipment, and other devices all the way up to the gateway and the cloud. The data model is designed to fulfill different tasks: control, processing, diagnostics and condition monitoring, and analytics. The production data used consists of details on produced gas characteristics (flow, pressure, etc.) Operational data input covers availability, performance, quality, overall equipment efficiency (OEE), etc. The service data used is obtained from various sources – ServicePort, Java Apps, Emux, the AC500 CMS, the ABB low-voltage distributor, etc. – [5-6].
Visualization
The digital visualization is presented as plots, characteristics and time-series data generated by the simulations.

Model synchronization
The synchronization of digital simulation data with the real measurements is based on real-time evaluation in terms of control, process, diagnostics and monitoring.

Analytics
Analytics focus on algorithm verification based on models, simulations and measurements. The analytics generate a suite of KPIs: operational KPIs are based on the process, electrical, mechanical and control data; asset health KPIs use detailed service/diagnostic KPIs – process, electrical, mechanical and control – implemented in the new ServicePort Rotating Equipment Analyzer channel.

All the points above can be included in a cloud platform connected to ORKAN – e.g., Electrical Distribution Control System, which is a cloud computing platform designed to monitor, optimize and control electrical systems. Part of the ABB Ability™ offering, Electrical Distribution Control System is built on a state-of-the-art cloud architecture for data collection, processing and storage. This cloud architecture has been developed together with Microsoft in order to enhance performance and guarantee the highest reliability and security.

The digital avatar opens up new fields
Digital twins are limited in that they are “merely” a digital representation of an object and its real-time performance. In contrast, the digital avatar, as described using the ORKAN stand example, is a bigger concept. Digital avatars should be able to interact as digital twins do, but also in enhanced ways and with a much wider set of digital partners and circumstances. In principle, the idea is to make as much information and as many entities as possible available to the digital avatar’s analytic algorithms.

The ORKAN stand has been used to illustrate the digital powertrain of an oil and gas compressor. However, this unique testing environment utilizes so many ABB products and technologies that it can be treated as a general ABB digitalization testing facility.

The digital avatar concept opens up many fields for additional actionable insights, analyses and informed decision making.