Open standards based Digital Twin for manufacturing - Opening the door to new technologies

A wire harness, often referred to as a cable harness or wiring assembly, is a systematic and integrated arrangement of cables within an insulated material. The purpose of the assembly is to transmit optical signals or electrical power, for example in aircraft, vehicles or ships.

Can wire harness design and manufacturing be automated in order to reduce costs and time, and to make the exchange and archiving of information involved in these processes easier?

In order to explore this, the FORTIFIER project is developing a next generation solution for designing and manufacturing wire harnesses. This solution combines advanced simulation techniques, the use of digital twins, and artificial intelligence. Open international standards are paramount in the project, and blockchain technology is also addressed by the solution.

FORTIFIER aims to reduce design time of wire harnesses by up to 30 percent, manufacturing planning cost by up to 25 percent, and administrative and information search cost by up to 50 percent.

The project is a cooperation between Ingenieurgesellschaft für Intelligente Lösungen und Systeme (IILS) and the University of Stuttgart (UoS) in Germany, and T&G Elektro and Jotne in Norway.

FORTIFIER is a 24-months EU/Manunet Project funded by the Norwegian Research Council and the German Federal Ministry of Education and Research.

Technology demonstration in manufacturing operations

The Norwegian company T&G Elektro manufactures wire harnesses for the aerospace and defence industries, used in planes, missiles, satellites, submarines, combat vehicles and more.

-We both design the wire harnesses and manufacture them. They can be made of copper or fiber optics, for transporting respectively power or optical signals, says Martin Grimsgaard, CEO of T&G Elektro.

The company uses military standards defined by their customers. Standards are needed because the vehicles or craft have several instruments, such as computers, monitors, sensors and radios. All this is powered and controlled via the wire harness and its couplings.

T&G´s role in the FORTIFIER project is to provide the specifications needed to design wire harnesses and optical circuit boards for robotic manufacturing. Towards the end of the project the company will perform a technology demonstration of these processes for customers.

-We joined the FORTIFIER project because we are familiar with Jotne and their software for standardization and life cycle management. These issues are very important for our customers because the products of the defence industry often have life-times of 25 years or more, says Grimsgaard.

Thus, it is important to have all the documentation, 3D models, and spare parts easily accessible and available throughout the entire life cycle of the product. Block chain technology is implemented to support the supply management concerns.

-Block chain is used to verify and ensure that the documentation, serial numbers, tracking and other information for all the components in the entire value chain of contractors and subcontractors are correct, Grimsgaard says.

T&G started their work in the FORTIFIER project in the beginning of 2021 and will continue until the end of 2022.

-We anticipate fruitful results from the project because it is very innovative and on the cutting edge of what is technologically possible, with partners that are highly competent and at the forefront of their fields, Grimsgaard finishes.

The first digital factory for wire harnesses

The theoretical side of the software work in the FORTIFIER project is done at the University of Stuttgart (UoS), using modern approaches to create specialized algorithms and artificial intelligence methods to achieve learning in manufacturing operations and quality control.

-We will be the first in the world to create a digital factory to demonstrate virtual wire harness manufacturing, says professor Stephan Rudolph, leader of a group of researchers working in the field of automation of engineering design at the UoS.

They are working together with IILS in the FORTIFIER project to develop the software to automate wire harness design. This collaboration will also create the software to simulate the manufacturing of wire harnesses in a digital factory.

In conventional manufacturing simulation, such as for vehicle chassis, the product is usually rigid, whereas wire harnesses are flexible.

-Thus, their flexible behavior is much more complex to simulate and also much more challenging for manufacturing robots to manipulate, than rigid parts, says Rudolph.

The main challenge is to translate the programming language used for the definition of the wire harness itself automatically into commands for the generation of the digital factory used for their manufacturing, and then to translate the wire harness design into executable commands for the manufacturing robots.

-Despite this apparent complexity, I am confident that this can be done, Rudolph says.

The virtual manufacturing process will use artificial intelligence algorithms to inspect the product visually for quality control. Virtual manufacturing will also reduce the amount of scrap and waste produced by the process, and will thus support a sustainable environment. The digital space makes it easier to find the optimal solutions for the manufacturing in the physical world.

-In the FORTIFIER project we will show proof of concept that this can be done. However, we are not only doing proof of virtual manufacturing, but also proof of physical manufacturing with a hardware robot at T&G in Norway. Thus, we have the full story from end-to-end, Rudolph says.

Standardized data easier to use in coding

-In the FORTIFIER project it should be possible to use advanced programming methods to apply artificial intelligence for wire harness design and manufacture, and gain a lot of new experience, says Nico Hahn, one of the researchers in the FORTIFIER project at UoS.

For this work he is using the Vehicle Electrical Container (VEC) standard, required by his software.

-Jotne is using the ISO 10303 (STEP) data models to support data exchange and sharing processes including long time archiving of data. The more standardized the data format is, the easier it is to get the information required for the coding, says Hahn.

He hopes to find the programming solutions for challenges that will appear during the FORTIFIER project, thus learning new things that can be used to solve other problems in the same field or in completely different domains.

-We have already learned a lot in the project, and in the next few months we will be able to present the first solutions. We have also gained a lot of new knowledge from our partners in the project, says Hahn.

Creating a holistic model with graph-based design languages/artificial intelligence

IILS is a spin-off company from the UoS. IILS has fourteen employees and creates a software tool-suite for the automation of multi-disciplinary engineering design of complex systems in general.

IILS has previously made software solutions for designing wire harnesses for aerospace engineering, the automotive industry, as well as for designing pipe systems for ships.

-We also wish to look into automating the design of connectivity solutions for optical fibers in two-

dimensional planes, called optical circuit boards, Marc Eheim at IILS says.

For this project IILS uses the VEC format. They will also use this standard for the manufacturing side of the process.

-For designing wire harnesses, the task is to combine the geometry of the installation space and the electrical schematics. We integrate this in a holistic model which includes all the information needed to describe the harness including other information such as design rules and constraints like minimal bending radius and sequence of the wires, says Eheim.

-Using the unified model together with tailored algorithms for collision detection and path finding, an optimal wire harness can be automatically generated using our software, continues Eheim.

Bringing it all together by open, publicly available, and international standards.

Norway-based Jotne EPM Technology data management products have successfully reduced product development and product life cycle costs through applying ISO 10303 standards to data management in the areas of aeronautics, space and defence and other high technology industries.

Availability of accurate information is crucial for efficient long-term product use and maintenance, but data management systems become obsolete long before the machinery itself. The result is often expensive re-engineering or clumsy workarounds.

Using common standards for this type of data is one key to cost-efficient monitoring and use of information. Common standards eliminate the need for re-entering information into different computer systems throughout the life cycle of a product. This might otherwise occur when a product changes ownership or when a new organisation becomes involved in monitoring, maintenance or repair. It becomes even more critical when users are implementing the digital twin in the supply chain and over the life cycle.

All Jotne products implement ISO standards to increase interoperability; today more than 80 percent of all world-wide file exchanges uses the STEP standards.

To support the manufacturing challenges, such as rapidly reconfigurable production processes, Jotne applies their expertise, methods and developments in Open Standard Based Digital Twin repositories and in converter toolkits that allow external tools to communicate with such digital twins using ISO standards.

Jotne´s ISO 10303 database management system is designed to meet the needs of engineering, manufacturing, and operational support enterprises to exchange and share technical data with colleagues, customers, subcontractors, suppliers, authorities, and other business partners throughout the life of their product accurately and reliably.

Jotne cooperates with the international standardization community, such as the EWIS (Electrical Wiring Interconnection System) working group in the LOTAR (Long Term Archival and Retrieval) membership organization, where large manufacturers like Airbus and Boeing and different vendors come together to agree on readable standards and best practices.

-When realizing digital twin software solutions, use of standards as part of their DNA ensures that you can share digital twin models between suppliers and partners with diverse systems. Furthermore, the opportunity to work with these talented teams enabled by the Norwegian Research Council and its German counterpart, is creating new knowledge that will benefit all partners and foster new products and services for a better future, says Dr. Remi Lanza, product owner at Jotne.