ABSTRACT

Digitalization - the subtle yet powerful force with a significant impact on the power transformer industry. We explore the practical applications of advanced digital technologies, from design and engineering to manufacturing and sustainability practices. In addition, the industry's efforts toward standardization and professional development through digital tools are discussed.

KEYWORDS:

digitalization, sustainability, engineering, manufacturing, advanced technologies, standardization, professional development

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Collaboration towards digitalization of the industry
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Harnessing the power of digitalization in the transformer industry for sustainability

The potential of digitalization extends across various dimensions, encompassing design, engineering, manufacturing, and supply chain operations

Introduction

In recent years, the power transformer industry has witnessed a remarkable transformation with the advent of digitalization. Advanced digital technologies have permeated every aspect of the industry, from design and engineering to manufacturing and supply chain management. In this article, we explore the potential and impact of digitalization in the power transformer industry, highlighting its role in improving efficiency, reducing environmental impact, and enhancing overall performance.

Digital technologies reshaping the industry

The power transformer industry has embraced a suite of digital technologies that are revolutionizing traditional processes and systems. The modern compact substation (CS) is a complex system that relies on the reliable operation of all its power, measurement, and communication subsystems. These technologies include advanced sensing, machine learning, digital twins, big data analysis, and cloud computing. These tools have become indispensable in engineering research and development endeavors, exemplified by the initiatives at the SGB-SMIT Group. The cooperation and collaborations with diverse energy industrial partners and digital technology leaders would allow subsequent growth in the industry towards digitalization.

SGB-SMIT Group's transformers range from 25 kVA to 1200 MVA

The reach of digitalization

The potential of digitalization extends across various dimensions, encompassing design, engineering, manufacturing, and supply chain operations. By deploying harmonized performance-enhancing design tools and platforms, the industry can capitalize on synergies, streamline processes, and minimize human errors. Improved design efficiency, risk reduction, and sustainability successes that match with UN sustainability goals are some of the key advantages.

Coupling of engineering software would offer greater estimation capabilities. At SGB-SMIT Group, a successful implementation of electrical and CAD tools coupled with magnetic, thermal and mechanical finite element method (FEM) software has been proven to yield fruitful

results. The days of solving complex electromagnetic/mechanical challenges are now reduced to only a few hours.

Sustainability at the core

Sustainability is a key driver in the power transformer industry, and digitalization plays a pivotal role in achieving the objectives. Digital tools facilitate material reuse, assess carbon footprints, reduce waste, and enhance control over dangerous substances. This optimization extends to manufacturing processes, reinforcing the industry's commitment to environmental responsibility.

Standardization efforts

Collaborative efforts, such as the DNP project involving SGB-SMIT Group, are pushing for industry standardization. Digitalization not only improves operational efficiency but also aids in harmonizing performance across the organization. Streamlining manufacturing operations with digital tools, including simulations and digital prototyping, accelerates design iterations and ensures product excellence. Also, SGB-SMIT Group is deploying digitalization concepts in building an R&D project consortium to reduce transformer core power losses by 10 % using advanced laser magnetic domain refinement techniques. The role of consortium partners would not only be to develop necessary technological solutions associated with it, but also to implement digital concepts in all project phases while achieving them.

Sustainability is a key driver in the power transformer industry, and digitalization plays a pivotal role in achieving the objectives

Digital twins and real-time monitoring

Digital twins enable the modeling of transformer behavior in real-world conditions, providing accurate predictions and simulations. Automation and real-time monitoring of manufacturing equipment, facilitated by sensors and robotics, boost efficiency while reducing costs. These advancements are essential for meeting the industry's growing demands.

Digitalization was the enabler of SGB-SMIT Group's transformer operating system. The operating system relies on extensive sensing for monitoring Temperature, hotspots, currents & voltages, etc. Calculation methods for losses, DGA, and noise were interfaced with a cloud-based communication system to effectively enhance customer situational awareness of transformer health.

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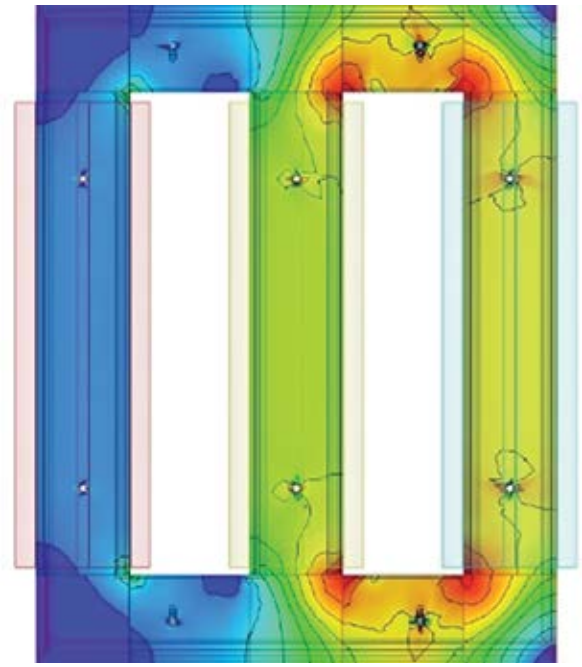
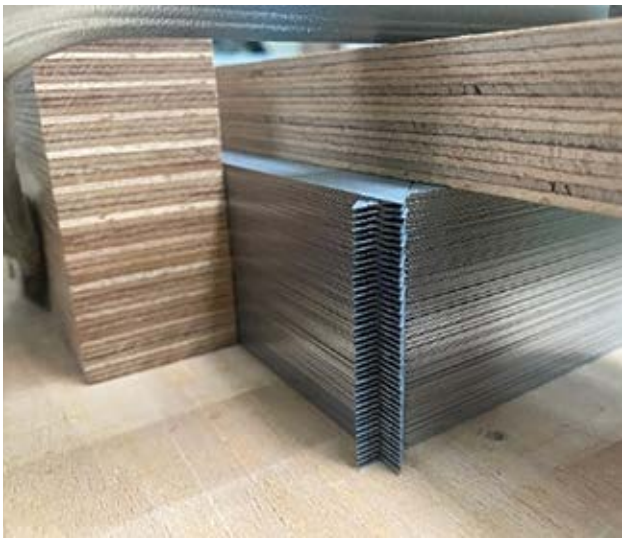


FEM magnetic simulation for core losses by SGB-SMIT Group's R&D

FEM mechanical simulation for core noise by SGB-SMIT Group's R&D



Laboratory scale experimental setups by SGB-SMIT Group to validate core losses improvement

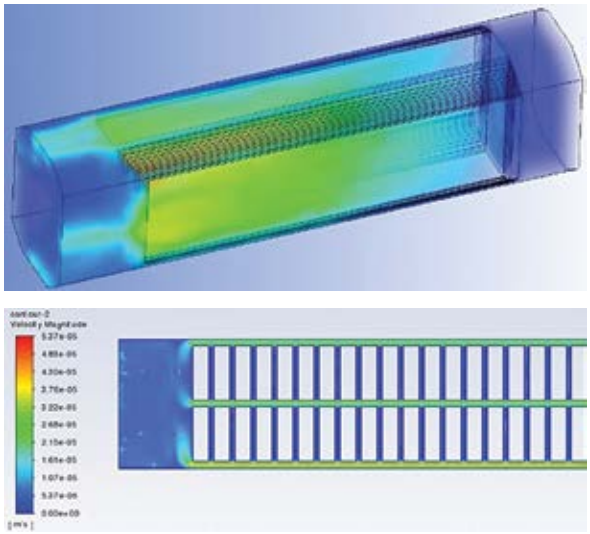
Modern sensors, real-time signal processing algorithms, 3D modeling, and augmented reality systems promise faster, more reliable results, reducing the need for extensive human resources

Enhancing partial discharge measurements

One significant research and development initiative by SGB-SMIT Group focuses on improving the accuracy and reliability of induced voltage localization with partial discharge (IVPD) measurements. Modern sensors, real-time signal processing algorithms, 3D modeling, and augmented reality systems promise faster, more reliable results, reducing the need for extensive human resources. The new framework would allow completing the measurements and obtaining high-fidelity results within 4 hours, which is a significant contribution in terms of speed and accuracy compared to the conventional measurement setup.

Exploring alternative materials

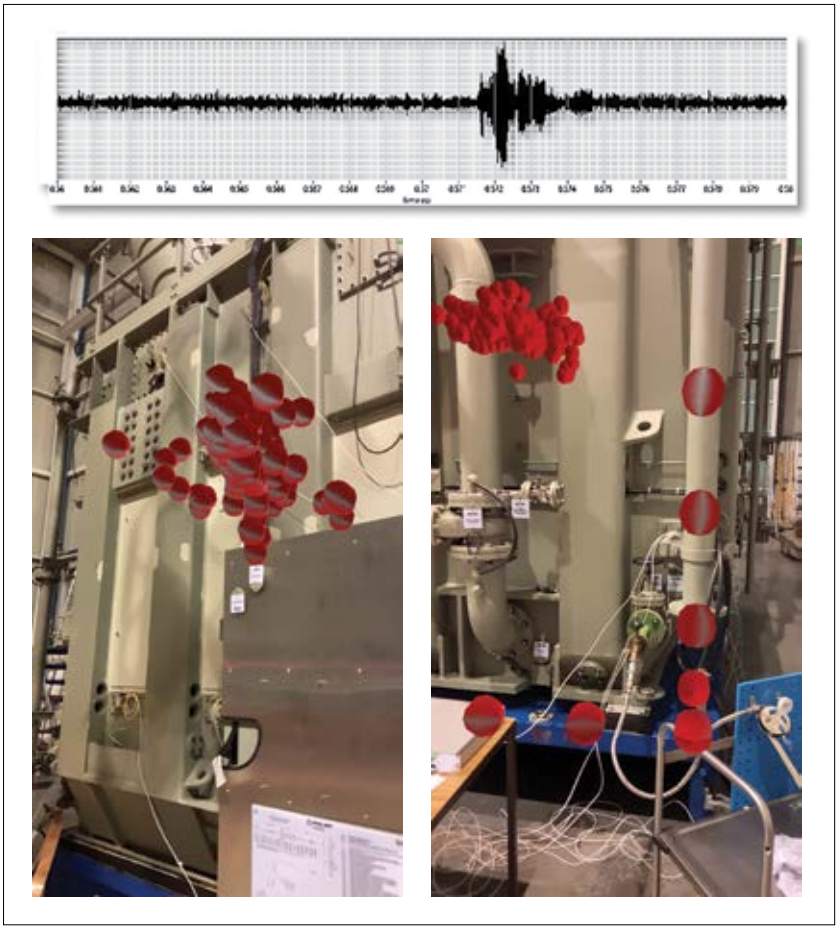
Digitalization is instrumental in exploring alternative materials for transformer insu-



Visualization of Computational Fluid Dynamics (CFD) simulation capabilities adapted in the SGB-SMIT Group's operational R&D activites

SGB-SMIT Group's transformer operating system visualizes the real-time measured data of power quality, losses, and temperatures

SGB-SMIT Group, a global player in the transformer market with 14 manufacturing plants, is leveraging digitalization in electrical design



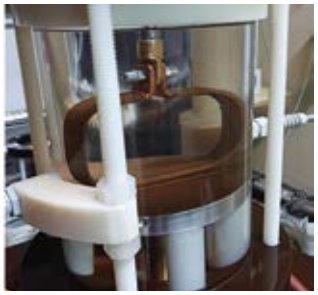
IVPD Measurement developed by the SGB-SMIT Group equipped with fiber optic sensors on the external surface of the transformer tank and real-time signal processing of PD.

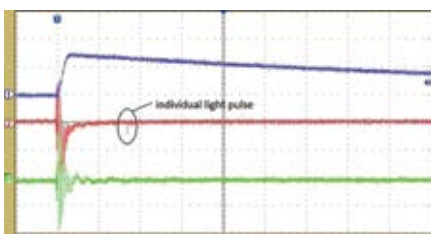
lation. The adoption of new bio-based, biodegradable, and low viscosity liquids in power transformers by the SGB-SMIT Group boosting towards sustainability targets. Collaborations with universities allowed digital tools to facilitate experiments, data collection, and the development of heuristic formulas for assessing the Lightning Impulse breakdown curves for oil gaps. This collaborative approach aims to create more efficient and sustainable transformers.

Digitalization in electrical design

SGB-SMIT Group, a global player in the transformer market with 14 manufacturing plants, is leveraging digitalization in electrical design. The creation of a common design platform standardizes rules, practices, documentation, and materials across all factories. This unified approach increases efficiency, reduces waste, and enhances customer value.

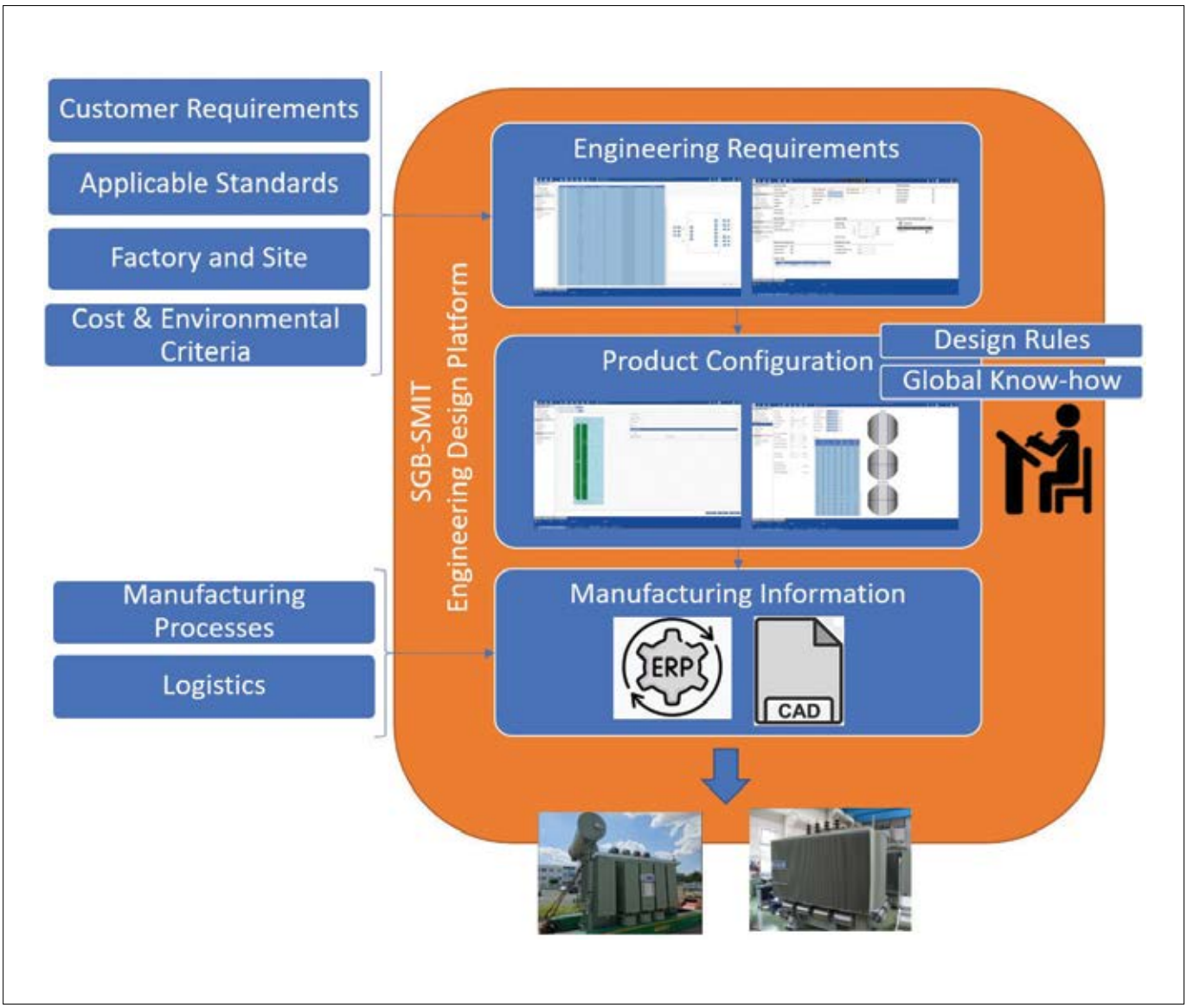
The state-of-the-art Engineering Design Platform comprehends the entire process of transformer manufacturing in an optimized way. By creating a unified approach, SGB-SMIT Group aims to



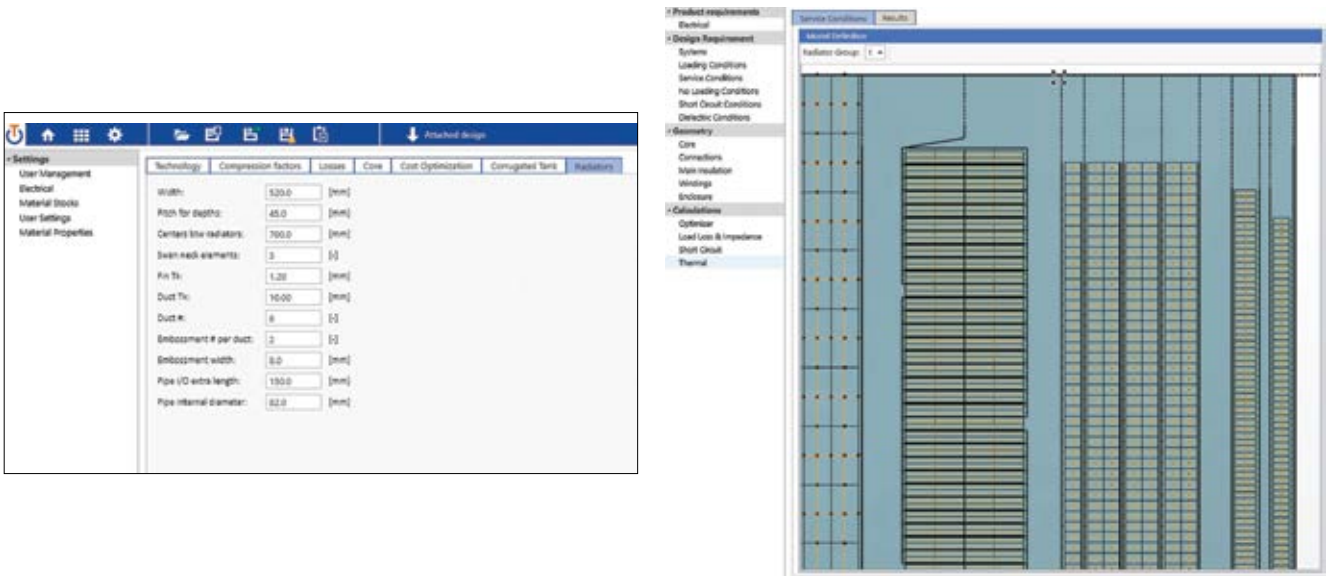


SGB-SMIT Group's laboratory testing of oil properties and assessment of Lightning Impulse Breakdown curves

SGB-SMIT Group's 80 MVA 115/21 kV power transformer with Gas-to-Liquids (GTL) insulating fluid



SGB-SMIT Group's Engineering Design Platform showcasing the synergy of transformer design



Creation of automatic/Semi-automatic optimized designs based on advanced computational techniques in the SGB-SMIT Group's digital design platform

Digitalization can also have a noteworthy application in the aspect of professional development, and SGB-SMIT Group deploys digital tools for training and nurturing new talents

increase efficiency, reduce waste, minimize processing time, and provide better value for the customers.

Towards sustainability goals

The digital design platform aligns with sustainability goals by reducing CO_2 emissions and optimizing material use. It includes advanced computation techniques for loss and short-circuit current calculations, ultimately leading to increased energy efficiency.

Professional development through digitalization

Digitalization extends beyond operations and product development; it can also have a noteworthy application in the aspect of professional development. SGB-SMIT Group deploys digital tools for training and nurturing new talents. These tools include physical and online project leadership training, on-the-job training, and collaboration with experts from esteemed universities on various research topics.

Conclusion

In conclusion, the power transformer industry is on a path towards sustainability, driven by digitalization, careful material selection, and advanced design optimization. As the industry moves towards its sustainability targets, digitalization remains a powerful ally, helping to reduce CO_2 emissions, enhance efficiency, and meet the evolving demands of the power transformer sector. The roadmap laid out by the SGB-SMIT Group serves as a testament to the industry's commitment to a more sustainable future.

Road map of the SGB-SMIT Group's Professional development through digital training

Authors

Marco Milone received the M. Sc. degree in Electrical Engineering from Politecnico di Milano, Italy and the MBA degree from SDA Bocconi School of Management, Milano, Italy in 1999 and 2004, respectively. Mr. Milone has been actively engaged in the transformer design and engineering since 2000. Since 2005 he has held several global management positions in transformer technology. He worked at the ABB Power transformer factories in Italy, Poland, and Germany. Since 2020, Mr. Milone has been with the SGB-SMIT Group, where he is currently the Group Technology Manager (CTO). His main areas of research interest are management of R&D teams, innovation management, simulation of high voltage and high current fields, electrical machine design, power transformer design and failure analysis, short circuit duties in power transformer, alternative fluids for HV applications. He is an active member of IEC TC 14 with contributions as MT member for IEC 60076-1, 60076-5, 61378-3.

Sudheer Mokkapaty received Bachelor of Technology degree in Electrical & Electronics Engineering from Jawaharlal Nehru Technological University, Hyderabad, India and Master of Science degree in Electrical Power Engineering from Brandenburg University of Technology, Cottbus, Germany in 2011 and 2015 respectively. Since 2014, Mr. Mokkapaty has been associated with the product development of electrical transformers initially as a student and later as a R&D Engineer in the business unit Distribution Transformers, SBG GmbH, Neumark. Since the beginning of 2023, he has been working with the SGB-SMIT Group as R&D Project Manager and currently as Group Innovation Manager. His main areas of interest are innovation, research and development management, FEM simulation of HV and LV applications, electrical steel technologies and product development in transformers. He has authored & co-authored multiple technical papers on transformers for different international technical conferences and fairs.