



IMPROVE

Creating the Factory of the Future
with Innovative 4.0 Solutions

SOLUTIONS FOR IMPROVED AUTOMATED MANUFACTURING

IMPROVE

“Innovative Modeling Approaches for Production Systems to Increase Validatable Efficiency”



01/09/2015–31/08/2018



4.2 Million Euros



13 Partners, 6 Countries

Facing increased global competition, the manufacturing industry depends on high-level solutions to ensure excellent machine functionality. Current industry analyses estimate that system downtimes and component breakdowns lead to an energy waste of 33% in the production and a significant loss of profits. At the same time, the complexity of production plants is steadily rising due to increasing product variances, product complexity, and pressure for production efficiency. Production systems must therefore evolve rapidly and operate optimally, which creates challenges for larger industries and especially for small and medium-sized enterprises (SMEs).

To meet these challenges, the European project IMPROVE has developed novel data-based solutions to enhance machine reliability and efficiency. Innovative tools in the fields of **simulation & optimization, condition monitoring, alarm management, and quality prediction** provide manufacturers with a human machine interface (HMI) and a decision support system (DSS) to ensure best possible user support.

“Our mission within IMPROVE is to provide innovative solutions for small and medium-sized enterprises in Europe to enhance the productivity of automated manufacturing and to facilitate machine operation. With our tools, we help companies be better prepared for international competition in times of Industry 4.0.”



Prof. Dr. Oliver Niggemann

Ostwestfalen-Lippe University of Applied Sciences
IMPROVE Coordinator



MAIN FACTS ABOUT IMPROVE

IMPROVE focuses on the enhancement of automated manufacturing during different phases of production. Our main objective is to develop new ways of user support – notably in the field of optimization, condition monitoring, alarm management, and quality prediction. The data-based tools developed in IMPROVE support operators with regard to self-diagnosis and self-optimization.

By ensuring an efficient and reliable manufacturing process, IMPROVE contributes to reducing energy consumption and making manufacturing more environmentally friendly. The project is funded by the European Union’s Horizon 2020 programme.

Main research fields:

Simulation & Optimization, Condition Monitoring, Alarm Management, Quality Prediction, Decision Support System

Methods:

Model-based and data-driven machine learning approaches applied to Cyber-Physical Production Systems, using normal behaviour models, prediction models and causality models.

Action:

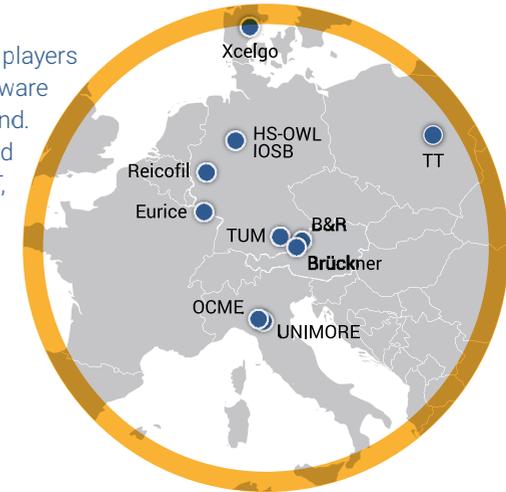
Development and implementation of the algorithms in real production plants to improve manufacturing industry key performance indicators (KPIs).

Outcome:

- IMPROVE the efficiency of production systems using intelligent optimization algorithms
- IMPROVE the cost-effectiveness and uptime of production systems using predictive maintenance and anomaly detection algorithms
- IMPROVE the safety and operator response time to breakdowns in production systems using alarm management approaches
 - IMPROVE product quality using quality prediction models
- IMPROVE interactions of humans and machines by providing a decision support system (DSS)
 - IMPROVE training scenarios by consideration of socio-technical arrangements

PARTNERS

IMPROVE brings together 13 leading players from academia, industry, and software development from Europe and beyond. The project unites experts in the field of industrial automation, industrial IT, engineering, augmented reality, plastics extrusion technology, packaging solutions, and consumer electronics.



<p>Hochschule Ostwestfalen-Lippe Germany Fraunhofer IOSB-INA Germany Technische Universität München Germany University of Modena and Reggio Emilia Italy Marmara Üniversitesi Turkey</p>	Academia
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<p>Transition Technologies S.A. Poland Xcelgo A/S Denmark</p>	IT
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<p>Brückner Maschinenbau GmbH & Co. KG Germany Bernecker + Rainer Industrie-Elektronik Ges.m.b.H Austria Reifenhäuser Reicofil GmbH Germany Arcelik A.S. Turkey OCME S.r.l. Italy European Research and Project Office GmbH Germany</p>	Industry
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FROM RESEARCH TO INDUSTRIAL IMPLEMENTATION

Use Cases

Novel solutions and technologies developed in IMPROVE have been tested and verified in real-life industrial settings. Three central **use cases** have been realised with Reicofil, OCME and Brückner.

Use Case 1 :

Predicting maintenance requirements at Reicofil

Reifenhäuser Reicofil is the globally leading provider of complete nonwoven, meltblown and composite lines. The monitoring maintenance is an important task to ensure an efficient and high-quality production. Without a technical solution, the wear of machine parts could just be estimated by experienced staff. Within IMPROVE, the project partners have established methods that allow predicting erosions.

By applying IMPROVE's new condition monitoring tools, an objective maintenance prediction becomes possible. Respective machine parts can be replaced in time before their wear impacts product quality. The IMPROVE tool thus ensures high product quality and enables better planning of maintenance actions during scheduled machine stops.

Use Case 2:

Increasing line efficiency at OCME

OCME is a leading packaging machinery company headquartered in Italy, which provides premium, innovation-based packaging solutions. At OCME, novel solutions for condition monitoring and simulation & optimization have been applied to predict maintenance requirements, decrease



Use Case 1, Reicofil



Use Case 2, OCME



Use Case 3, Brückner

downtimes, and enhance line efficiency. Traditional packing machines are typically efficient and reliable, but changing the product range is difficult and requires high engineering efforts. Due to a shorter product lifecycle, performance became an important issue along with flexibility.

By applying IMPROVE's new tools, OCME has reached a great improvement of their mean time between failures (MTBF). Additionally, the combination of optimizing a single module and the whole line has increased the line efficiency by 20%.

Use Case 3:

Guaranteeing best quality production at Brückner

Brückner Maschinenbau is the world's leading supplier of production lines for high-value mono- and biaxially stretched film. As most quality parameters of the film are measured in the laboratory after production, a tool for predictive automatic diagnosis is required to reduce waste.

Brückner applied simulation & optimization tools developed within IMPROVE to enhance the startup operations of machines and plants. Furthermore, acquisition techniques for expert knowledge were designed to create a cause and effect related representation.

Adding prediction models for product quality, IMPROVE partners develop a prototype for a decision support system. The socio-technical arrangement is analysed to ensure an efficient use of the support system.

IN-DEPTH: IMPROVE'S MAJOR FINDINGS

The multidisciplinary experts involved in IMPROVE have developed innovative solutions to enhance manufacturing production and find answers to some of the most pressing industrial challenges of our time. In this regard, key achievements have been made in the fields of **simulation & optimization, condition monitoring, alarm management, and quality prediction.**

Combining solutions in these fields into one holistic approach, a **decision support system (DSS)** assists the operator in taking the right choices in the manufacturing process.



Simulation & Optimization

Intelligent optimization algorithms help determine optimal plant parameters by simulating and evaluating different parameter configurations before the configuration is tried in the real plant. At present, despite big potential and disruptive possible impact on machine manufacturer business, simulation is little used in real industrial application.

The main reasons for this are:

- Little knowledge in industry about the modelling and simulation theory and best practices
- Question of accuracy of the simulation results (availability of validated models)
- Resources to be committed to the modelling and simulation process

Based on a real industrial case, IMPROVE demonstrates that modelling and simulation, combined with optimization, is a resource-effective way to improve the overall machine design. Optimized production creates less waste, leads to a higher productivity and, consequently, greater profits.

Our solution

We provide the first combined simulation-optimization round trip solution ready for industrial application. The tool can be implemented as an upgrade to already existing production plants and allows educating operators with augmented reality.

Central characteristics of the simulation-optimization solution:

- Quality forecast, energy optimization, roll change simulation, and education of operators
- Education of operators:
 - Tool uses repeatable augmented reality (AR) experience to teach the operator in the fields of process/machine KPI, machine documentation, and instructional content with video/audio
 - AR applications support the operators by providing information related to predictive maintenance and step-by-step service/replacement procedures
- Reducing resources by automatising tasks in modelling development
- Based on a model library the tool automatically configures the simulation model



Condition Monitoring

Condition monitoring of the manufacturing system uses simulations of learned normal behaviour models to forecast maintenance requirements. Live data from the system is compared to the predictions of the model, allowing anomaly detection, condition monitoring and, predictive maintenance.

Actions can be classified in two main groups:

1. "preventive change", meaning that some components are substituted on the basis of a predefined timetable;
2. "change when the machine has failed", meaning that components are replaced only after a damage or a malfunction has appeared.

In the first case, machine users spend potentially more money than needed to replace parts still in good working condition, while in the second scenario, they lose money since the replacement of damaged parts stops the normal production. Human operators often struggle to diagnose faults or anomalous behaviour in the system, leading to system breakdown, unexpected downtime or degradation in product quality. A dynamic detection of a system's real condition or degradation can support experts in better planning maintenance times and avoid the aforementioned negative effects caused by system degradation.

IMPROVE's condition monitoring software provides an all-round solution that could lead to a great change in the service procedures of automatic machines and will significantly improve the production process.

Our solution

We provide an innovative self-learning condition monitoring solution that prevents producers from unexpected breakdowns or product degradation. The outcome solution is translated into different software options, ready for industrial use.

Central characteristics of our data-driven condition monitoring:

- Detecting and localising anomalies from learned normal behaviour models
- Providing different types of models for the anomaly detection and localisation
- Easy implementation of additional types of models and monitoring algorithms as data acquisition for learning is flexible
- Providing information about signals, last anomalies and also a live visualisation of the model
- Allowing customers to forecast problems on the machine that could lead to production stoppages
- Available as an additional after-sales service that provides regular reports of the machine efficiency throughout the lifetime
- Carrying out short-time forecast analysis to identify wrong machine settings after a product changeover or problems related to raw material changes



Alarm Management

Alarm flooding is a persistent problem in industrial plant operation in which the operator may lose the overview on how to solve the situation. This can lead to critical alarms being overlooked, time-consuming search for the “root cause” of the problem resulting in significant downtime and irreversible damage.

Basic statistics from alarm logs show that an alarm flood condition makes up nearly 10% of plant operating time. Solving this problem is thus very important to ensure an efficient and secure production.

IMPROVE's solution is the development of an innovative algorithm, based on data-driven similarity learning and case-based-reasoning (CBR) that integrates expert knowledge.

Our solution

We provide an alarm management algorithm to prevent alarm floods or to better handle them in case they occur.

Central characteristics of the alarm management algorithm:

- Combining similarity measure learning, offline case-base construction, semi-supervised learning, online flood detection, and CBR
- Detecting alarm floods and attempting to identify them based on a knowledge base
- Suggesting solutions in case an alarm flood occurs (identification of the flood, repair instructions, etc.)
- Reducing complexity and hiding “follow-up alarms” from a previous (root) alarm
- Supporting the operator in finding the root cause for the alarm and to take the right action



Quality Prediction & Decision Support System

IMPROVE's central mission is to support the operator in taking the right decisions. By combining our tools into one approach, we develop a holistic decision support system (DSS) and a quality prediction tool. The DSS is based on the actual machine behaviour and visualises the results to assist the operator in charge.

Our solution

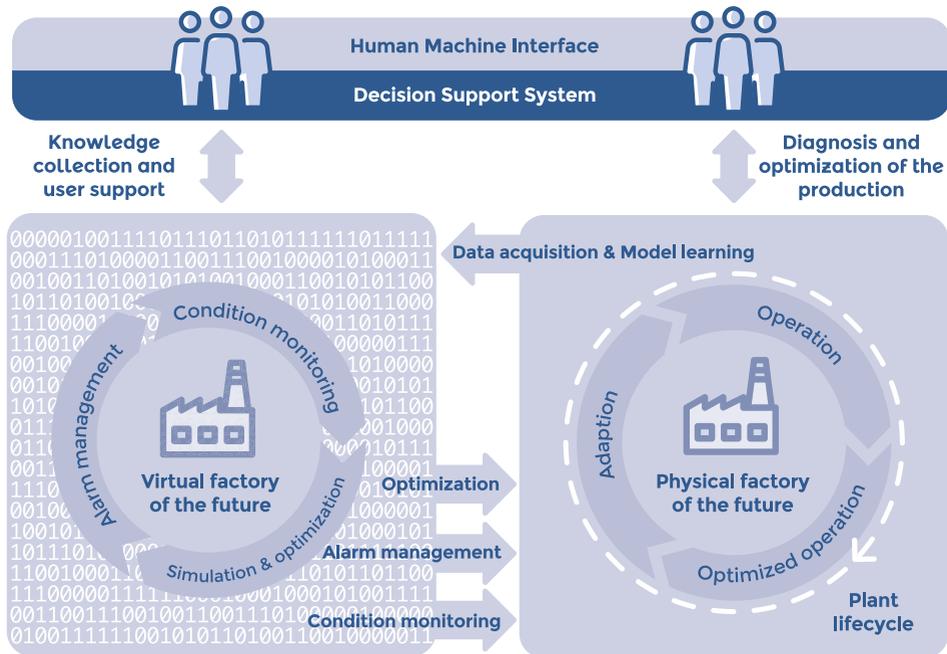
We provide a prototypical implementation of a decision support app for quality monitoring. The app includes a visualisation of cause and effect relations to support the operator in maintaining high quality. Furthermore, quality prediction models for selected material compositions are developed.

Central characteristics of our user support tools:

- Supporting operators with results from complex data analysis models
- Predicting the quality by using data-driven models based on machine parameters
- Developing of cause and effect graphs for a selected quality parameter, representing the complex causal dependencies of a total plant in regard to the quality parameter
- Preventing scrap and off-spec products due to in-line quality prediction in comparison to expensive off-line lab measurements

IN A NUTSHELL

IMPROVE's Process to Enhance Future Manufacturing



What IMPROVE's solutions offer:

- Enhancing productivity and product quality
- Reducing ramp-up phases
- Optimizing production plants
- Increasing cost-efficiency
- Optimizing supply chains including holistic data
- Reducing energy consumption and waste
- Supporting the operator using a DSS
- Strengthening industrial competitiveness and sustainability

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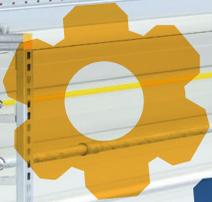


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