RECOBA – REal-time sensing, advanced COntrol and optimization of BAtch process saving energy and raw materials – a project aiming to improve product quality and enhance efficiency and flexibility of batch processes using state of the art solutions

RECOBA is an EU project in the SPIRE 1 initiative. The project consortium consists of BASF SE as coordinator, ThyssenKrupp Steel Europe AG, ELKEM AS Technology, University of Cambridge, RWTH Aachen, University of Chemistry and Technology Prague, University of the Basque Country, VDEh-Betriebsforschungsinstitut GmbH, Cybernetica AS and Minkon Sp. z o.o.

The project aimed to optimise the efficiency and flexibility of different batch processes in comparison to standard operation, thus improving the competitiveness of a significant portion of the EU batch process industry. The project delivered state of the art control mechanisms which influence process variables to track the optimal process trajectory in real time, achieving desired product properties. Project comprised of three different processes to demonstrate the cross-sectorial applicability of developed sensors and real-time optimization. The control objectives were optimization of product quality, energy consumption, raw materials utilization and production costs for batch processes. Fig. 1 shows RECOBA's objective and challenges schematically.

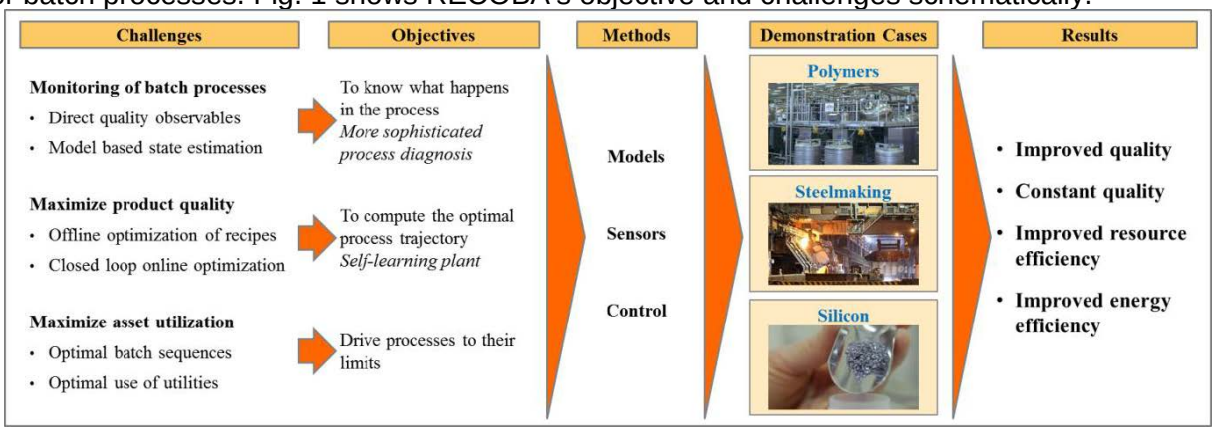

Fig. 1. Summarizing visualization of RECOBA's objectives.

It can be concluded that the project targets have been met:

- Innovative sensors were developed, tested and applied for real-time observation of batch composition, temperature, polymer morphology, etc.
- Robust process models were developed and reduced in complexity for online applications in emulsion polymerization, liquid steelmaking, and silicon refining.
- The novel sensors and models were implemented and demonstrated for model-based predictive control and optimization of processes.

RECOBA

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RECOBA - successful consortium work from project start

Benchmark processes were specified in detail with respect to reaction conditions, composition of the feed material, reaction or treatment time, safety limitations etc. Using these defined specifications, hard and soft sensors and models were developed, optimisation frameworks were implemented and demonstrated in the benchmark processes.

Sensor developments

Hard sensor development for real-time process observation was a key objective of the project. Project partners developed temperature sensor for continuous steel melt temperature measurements, DynTemp®. The sensor consists of a consumable optical fibre which is immersed into the melt. Compared to a contactless optical measurement, this immensely increases the measurement accuracy as the sensor is not affected by slag. The sensor allows an in-line temperature measurement with higher accuracy and measurement dynamics, which was proven in a steel plant. Additionally, the sensor was modified and successfully tested for the silicon refining.

Dispersions from emulsion polymerisation have many applications in which particle size and morphology at the nano-scale are important parameters. Different sensor technologies were developed to get online information about these parameters. Though a use for industrial emulsion polymerization is too early for acoustic sensors and inline TEM measurements, the developed Raman technology was successfully implemented at lab and pilot scale.

Process model developments

One of the important work-packages of the project includes development of process models which are based on physical principles, i.e., on heat and mass balances coupled with thermodynamic relations describing, e.g., phase and chemical equilibria. The different models for the three industrial use cases have been fully developed and successfully tested.

- For polymerisation, process models were developed to predict and optimize the polymer structure, particle size and morphology based on real-time Raman and heat-balance measurements.
- For liquid steelmaking, a process model predicting the temperature evolution along the entire chain of batch processes was developed, validated with industrial online temperature measurements and integrated within model predictive and iterative learning control tools for process optimization.
- For silicon refining, a model predicting the dynamic development of the refining process with respect to the chemistry and temperature evolution in real-time was developed.

Demonstration of the developed tools for optimization and process control

The developed sensors and process models were to a large extend implemented in the industrial environments. For all use cases, online monitoring and non-linear model-predictive control were demonstrated successfully.

- For polymerization, it was demonstrated in lab and pilot scale that the morphology of the particles can be controlled at optimum batch time, energy and raw material consumption.
- For liquid steelmaking, the online working temperature sensor and real-time dynamic process models and control algorithms help to optimize the temperature evolution along the entire batch process chain, thus leading to energy and resource savings.
- For silicon refining, it was shown that the online model very well predicts the temperature evolution in the process. It is used online for real-time process monitoring and batch-to-batch corrections.

Exploitation and dissemination

Exploitable RECOBA results are new and updated real-time process control concepts for batch processes, new and better sensors, and extended knowledge on modelling techniques for batch and semi-batch processes. The new sensors and the real-time process control concepts will be offered to the market, and the industrial use case representatives plan to make use of the models and online control techniques to increase the efficiency of their processes and improve raw material and energy consumption and to be able to develop new and improved products. In the second half of the project, the RECOBA partners participated in or organized more than ten events in which the results of RECOBA were disseminated. One patent was issued, 8 journal papers and 19 conference papers were published, and teaching and training was organized in the consortium.

RECOBA - fostering European process industries

RECOBA aimed to deliver state of the art methods for growth in batch process industry intending short to medium durations. RECOBA mainly focused to improve the international competitiveness of the European process industry and indirectly also the European manufacturing industry. In addition, there are positive effects on the labor market through additional investments in R&D.

SME and academic partners in the project gain experience in the new application fields and exploiting competencies to broader customer portfolio. Developed state of the art control concepts and sensor technology result in new opportunities – which are not only limited to applications but continuous training, maintenance services within scope of the project for long term relations, too.

The social benefits for general citizens and consumers is not only limited to improved, customized products with enhanced quality but includes smaller ecological footprints for production, thus enhancing the sustainability of process industry. The project improves yield and increase process efficiency, strengthening international competitiveness of EU process industry thus securing jobs.

The illustrative overview of expected project's impact is visualized in Fig. 2.

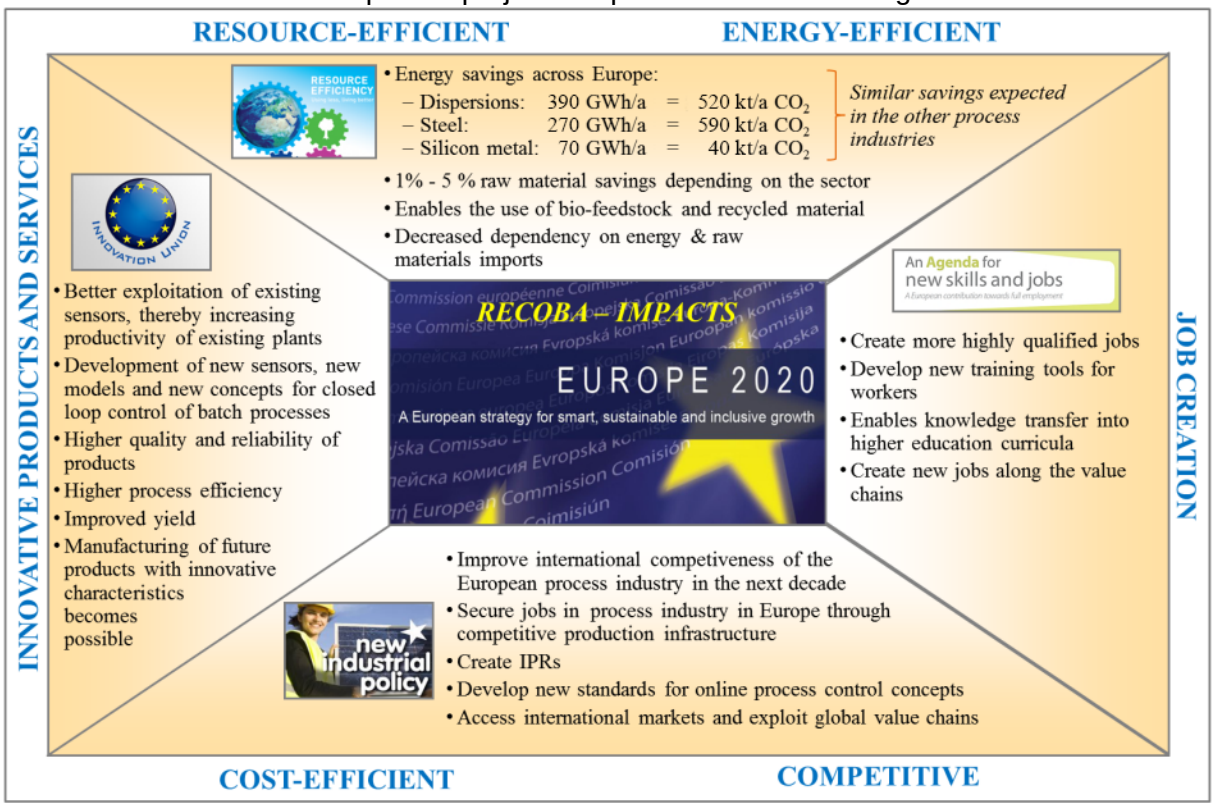

Fig. 2. Project impact on Europe 2020 objectives.