Energy Efficient Coil Coating Process

Reporting

Project Information

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Coordinated by
KARLSRUHER INSTITUT FUER TECHNOLOGIE
Germany

Periodic Reporting for period 2 - ECCO (Energy Efficient Coil Coating Process)

**Reporting period:** 2019-04-01 to 2021-03-31

Summary of the context and overall objectives of the project

Coil coating is a continuous process for providing coating to a metal strip. In 2017, a total area of 1.37 billion m² of aluminium and steel was coated with 219 kt of paint in Europe, representing one third of the worldwide production. The coil coated products are mainly used in the construction market as building envelope. Consumers encounter coil coated products in everyday life for example as casing in a variety of size from fridges, washing machines to toasters and wireless speakers. In the coil
coating process, a paint, mainly consisting of pigments, chemical crosslinkers and solvents, is applied to a metal strip. In a following step the paint is dried while the solvents evaporate. Afterwards, the paint is cured up to a certain temperature where the crosslinkers increase the adhesion between pigments and metal strip. In the conventional process the required heat is provided through convective heat transfer using hot air. In order to prevent the creation of an explosive atmosphere in the process, operation at a solvent concentration below the lower explosion limit by using an excess amount of air is inevitable. Prevention of VOC emission entails either recovery or thermal decomposition of the solvents, which can be stated as being technically complex and expensive due to the high dilution of the solvents.

In the ECCO project the proof of concept of a novel curing oven will be performed in a pilot scale coil coating line. In ECCO, the curing oven is operated at elevated solvent concentration which allows the direct utilization of solvents as a fuel for heat generation. Therefore, the oven system is separated in two sections: The radiant burner section, where intense radiation in the IR-spectrum is emitted at high temperatures resulting from combustion inside of a ceramic porous structure, and the curing oven section which is operated over the upper explosion limit or, in other words, below a critical oxygen concentration. The prevention of a thermal decomposition of the solvent loaded atmosphere at high temperatures is ensured through separation of the two oven sections by an IR-transmissive material.

Starting from previous activities at TRL 4, an interdisciplinary approach is foreseen, based on advanced-materials, combustion technology and prediction tools for system design/optimization, with active participation of key industrial stakeholders, to bring this technology to TRL 6 and realize a prototype curing oven at industrially relevant size and environment. ECCO proposes an oven concept which leads to a drastically reduced size and increased energy efficiency as well as a higher production flexibility due to a fuel-flexible, modular and potentially energetically self-sustainable process. In comparison to existing conventional convective curing systems, ECCO presents a less energy demanding, environment-friendly and economical technical curing oven concept.

In ECCO, the specifications needed for a pilot coil coating line covering all equipment for batchwise processing of steel strips are defined. Three target products are identified and the corresponding coating formulations are specified in detail. A novel curing oven system operating under an oven atmosphere above the upper explosion limit incorporating radiant porous burners is specified. An IR-transmissive material is identified that separates the ECCO curing oven in a radiant burner section and curing oven section. Catalytic coatings avoiding the deposition of carbonaceous substances on the IR-transmissive material at high temperatures are developed.

A strategy for the insulation of the curing oven section from ambient air based on pre- and post-inertisation chambers has been developed. For the porous burners, SiC based composite materials have been developed and tested under operating conditions exceeding the maximum operating temperature of current products. Novel additive manufacturing methods are investigated to directly print SiC based material with defined structures in a selective laser sintering process. Numerical simulations are applied to identify key mechanisms that have to be considered in the technical oven design. A detailed chemical kinetic mechanism based on surrogate fuels for the simulation of solvent combustion is developed and validated. An experimental facility for the
characterization of solvent combustion in structured porous media is developed. Thermophysical and combustion properties of solvent formulations are investigated. A process model for the ECCO oven is established and operating conditions are derived. Computational tools for simulation of combustion coupled with radiative heat transfer in porous media are identified. A customized set of Key Performance Indicators is identified and the information carried in the KPIs is enhanced by incorporating a life cycle approach. Few business models for each solution implemented in ECCO can be developed using a Business Model Canvas. A dissemination strategy for the project runtime and after the project is developed.

Progress beyond the state of the art and expected potential impact (including the socio-economic impact and the wider societal implications of the project so far)

- Further development and optimization of porous radiant burners for premixed combustion of solvent vapours
- Development and availability of long-term stable IR-transparent windows for the radiation heat coupling, which are not deteriorated by potential deposits of carbonaceous species
- Establishment of a safety concept, especially for the start-up and shut-down procedure of the oven
- Adaptation of the paint solvent to the process requirements, i.e. absorption of IR radiation
- Establishment of a pilot facility for testing and demonstrating the process under industrially relevant conditions
- Volume reduction of 70% for the curing oven in comparison to the conventional system assuming the same production-capacity
- Drastic reduction in energy consumption of significantly over 50% in comparison to average even new installations and 40% in comparison to the best installations
- Capex reduction of at least 40% and an Opex reduction of at least 40%
- Reduction of natural gas consumption and complete and clean combustion of the solvent vapours without VOC emissions
- Establishment of long-term collaborations and integration between industrial and academic institutes
- Improvement of new competences and jobs will be generated along the entire chain across the various stages of manufacturing of innovative components, to the new furnace technologies, to the complete coil coating production line and to the producers of coated metal.