Final report

for the IGF-project

INSIDE COATED PIPES (INCOPI)

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I. Summary

Tubes are affected by deposits in many industrial applications. This so called fouling is a considerable technical and economic issue. So far, the technologies to overcome fouling in industrial production as well as the procedures for mechanical and chemical cleaning are cost- and energy intensive. Suitable cleaning agents are often harmful to the environment.

DLC (Diamond-Like Carbon) and modified DLC coatings developed at Fraunhofer IST have proven to have an excellent behaviour against fouling effects. One of the targets of this project was to develop a new manufacturing approach for inside coated components that can be used in industrial process engineering. So far the direct coating of the inner walls of pipes is only possible to a limited extend and does usually not deliver the required coating quality.

Within the CORNET project, the setup of research and work distribution between the project partners was oriented on a near-industrial process chain for the production of tubes with a thin coating layer on inside walls.

In WP1, a Specification Analysis was undertaken to settle the fundamentals. This included an evaluation of fouling effects in industrial applications e.g. heat exchangers, promising approaches discussed in literature e.g. surface coating on the basis of PACVD processes and state of the art in the field of tube production processes including the forming and welding technologies usually deployed.

The Coating of metal stripes up to length of 1000 mm was central point of WP2. Different DLC (a-C:H) and SICON® (a-C:H:Si:O) coating systems were deposited on plane stainless steel strips. The work contained the application of coatings on metal strips, the coating analysis and the adaption of the coating systems to the forming process in order to avoid local failure of the coatings during the forming. Enhancements of the coating systems were reached by adapting the mechanical properties of the coatings and by increasing the coatings adhesion with different interlayer systems. Coated pre-cuts were input for the work of the project partners.

In WP3, the Pipe forming was object of investigation. In spite of the fact that roll forming is the dominant forming technology to produce tubes in industrial scale, roll bending as an alternative technology for the forming of tubes with small longitudinal dimensions was included in the work as well. Both forming processes set up for the project work proved that compressive strain on the inside wall of pipes can result in more or less severe local coating damage. In collaborate work, an optimization of coatings and forming processes was undertaken to minimize these effects. Formed inside coated and not coated pipes were delivered for further processing.

In WP4, the Pipe welding along the edge was considered and investigated. Welding with different technologies and heat inputs was conducted both with plane and with formed samples. Within the framework of this project laser beam welding (LBW) and electron beam welding (EBW) have been identified as being the most appropriate joining methods with limited heat input for coated sheets. Testing of the welds was performed both in destructive and non-destructive ways. Welded samples were provided for corrosion and flow channel testing. In result of the several tests, the continuous YAG laser was chosen as preferred welding technique.

Application tests with welded plates, half tubes and tubes were scheduled in WP2 in order to examine the fouling behavior of coated and uncoated samples. Investigation of the fusion lines figured out that fouling tendencies of all welding procedures, except for fiber laser welding, are below those of their references and that welding parameters do influence fouling. Passivation of weld seams only shows minor influence on the fouling behaviour. A big influence of the bending process in combination with the several surface conditions (plain sheet / electropolished sheet; DLC / SICON / DLC with titanium interlayers) could be seen.

The goals of the project were achieved.

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