Integration of Thermal Spraying into Industrial Production Processes

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1. Introduction
Coating technologies have constantly gained importance as the rising demands on components only can be met economically by applying optimized materials concerning both surface and structure requirements. The development of the shape cutting chipping and metal forming process led to adapted and well established machines for line production. Coating processes, however, are usually not sufficiently adapted to prevent interruptions of the production process. For example, thermally sprayed coatings are widely used in many industries, but in most cases the spraying is done by external job shops. The success of thermal spraying in mass production as economical process will depend on its implementation into the line production to reduce productive times. Recently plasma spraying has been integrated in the VW Lupo engine production for coating of the cylinder bores [1].

2. Development
The different thermal spray processes permit the manufacturing of any desired material with a liquid phase or high ductility. For a universal integration of thermal spraying into industrial line productions there is need for development in all steps of the production process (Fig. 1). There is a lack of databases for draftsmen to optimize the component design for the coating process and to give properties as standard solutions including the appropriate coating system and the specific costs. Processing times have to be provided for production planning - for the component preparation, the coating process itself and the finishing procedure. Information on applicable succession with other processing steps are not available, yet. There are no guidelines for the pre-treatment of the component areas, which have to be coated, which allow the reproducible manufacturing of an optimized surface state. Furthermore the coating finishing is not yet adapted to the specific properties of thermally sprayed coatings. Finally adequate non destructive testing methods have to be qualified for thermally sprayed coatings to ensure a steady production flow of high quality products.

![Diagram of the production process](image)

Fig. 1: Required development in the production process of thermally coated components
Recently one research focus in the field of thermal spraying is the development of control systems, which make the thermal spray process reliable. There is a large number of machine parameters, which have to be optimized. But the coating properties depend on the particle parameters (temperature and velocity) at the moment of impact and the substrate temperature. The fast pyrometry based DPV2000 system permits the determination of the particle parameters and their size distribution. It was initially designed for process understanding, modelling and development, and has evolved to a successfully applied monitoring tool [2]. Two CCD camera based systems have been developed and are presently introduced in series production. One system takes two successive pictures of different wavelengths allowing the determination of the temperature and velocity of individual particles as well as their spatial distribution [3]. The other approach is to monitor the process state to detect deviations from a state of optimized conditions. The torch plume and the particle jet are recorded and the pictures grey scale distribution is patterned by ellipses. Deviations in the ellipses position point at changes of the process conditions [4]. So far, all systems lack a closed loop to permit to control the process and only the CCD camera based systems work in-situ. There is a new emission spectroscopy based approach, which aims to control the process by calculating adjusted machine parameters from changes of characteristic wavelengths intensities [5]. Emission spectroscopy is also capable to detect feedstock impurities.

The modelling of the coating formation during the spraying process has been developed to a high degree of sophistication [6], but only little research has been done on the simulation of the microstructure evolution [7]. The full potential of thermally sprayed coatings will only be exploited, if the coating microstructure is tailored. Thereby new application fields in the production of functional surfaces with special electrochemical or –mechanical will be opened.

3. Summary

The thermal spray processes feature a high flexibility and a high potential for the production of functional coatings. The modelling of the coating formation has progressed strongly and a variety of monitoring and control tools are introduced to guarantee an optimized spraying process. For a universal integration of thermal spraying into line productions the development of tools for the preliminary and succeeding steps in the production process are necessary.