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Functional surfaces – Development of innovative products

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Surfaces and their properties are playing an increasingly important role in industry application. In general, materials are used according to their property requirements such as elasticity, strength, heat resistance or to meet other requirements such as corrosion resistance. However, traditional surfaces are often not able to meet the ever increasing demands of today´s applications in automotive, textile, medical and food industry. Thus, in recent years, advances have been made using functional coatings to exceed limitations of material to make surfaces more attractive for specific industry applications. Hygienic and efficient automation technologies are key aspects for a successful production process for example in the food and beverage industry. Requirements regarding the cleanability and durability of surfaces that are in food contact are important factors. The approach of this study was to design functional surfaces with easy to clean and/ or self-cleaning coatings that enable automation components to be easily or less cleaned. For coating procedure physical vapor deposition was carried out in order to facilitate separation of the vaporized coating material to the substrate. Substrates used are aluminum, stainless steel and plastics for example polyamide or polyethylene. Analytical description of surface characteristics was performed using scanning electron microscopy, contact angel and roughness. Different surfaces were successfully coated with easy to clean coatings and characterized analytically. In addition, coating of automation components consisting of different materials was realized and coating adhesion was improved. First application tests showed a clear improvement of material properties relating to chemical resistance and cleanability compared to today's standard materials used.

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Coupled thermal-mechanical simulation for continuous casting of lightweight alloys

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The numerical simulations of industrial continuous and semi-continuous casting process for lightweight alloys have been used extensively to investigate the optimization of casting billets with high quality within relatively low operating cost and energy. The thermal evolution during the casting process and the industrial trend to control the rate of heat transfer coefficient (HTC) during both start-up and during-casting phases has been broadly studied. However, the estimation of HTC values during air, contact and water/oil cooling and the implementation of thermal and mechanical phenomena during casting process have relatively received little attention. The development of advanced numerical techniques (including multi-physical and evolving domain techniques) for thorough process simulation of the melt flow, heat transfer and evolution of stress/strain and damage during casting process has promoted many new opportunities. However, smarter and broader improvements are needed to capture the underlying physical and chemical phenomena including multi-physical transient fluid-thermal-mechanical coupling and heat-transfer changes during the process. For the starting-cast condition where most of mechanical cracking and damage are initiating, there have been many efforts to control mechanical defects by optimizing casting recipes. The concerns about cast billet quality and the minimization of hot tearing, cold cracking, and shrinkage dimensional control are part of casting quality control. Within this framework, the cooling system numerical simulation including its fluid flow and its characteristics (turbulence, free surface boundaries, etc.) heat transfer have to be modeled. In the research work herein, parallel experimental-numerical studies of coupled transient thermal-mechanical phenomena including HTC estimation using empirical and reverse analyses are presented. The phase change modeling during semi-continuous casting process including liquid and solid interface, and also implementation of dynamic HTC curves are also considered. One of the main contributions of this paper is to show the applicability and reliability of newly developed coupled thermal-mechanical numerical simulation approach for the optimization of continuous and semi-continuous casting process.

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