Atmospheric pressure plasma spray deposition of multi-component, graphite- and MoS_2-based low-friction coatings for wear-protection of polymers

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Polymer based materials provide excellent properties including high specific strength and stiffness due to their relative low weight in comparison to metals. However, in applications such as bearings or gear wheels with contact to metals, the polymeric compounds lack in sufficient wear resistance, which result in rapid material failure. A possible method to solve this issue is applying lubricants or – more sustainable and cost-efficient – wear protecting coatings. Although many commercially established coating techniques and materials are available, coating techniques enabling high wear resistance at low deposition temperatures are scarcely found especially for polymers. Organic paints tend to wear out at even mild mechanical strains, while electrochemically or galvanic deposited metal coatings often have too less flexibility to adapt to the deformation of the polymer under applied loads, which results in fracture. Physical vapor deposition (e.g. arc evaporation, sputtering) is limited to smaller parts due to generally used batch coating machines with costly vacuum chambers. Plasma spray coatings overcome these restrictions given by vacuum chamber sizes, but the temperature load on the polymer substrates is often too high.

Atmospheric pressure plasma spray deposition (APPS) is one of the few spray coating processes, which can be operated even at low substrate temperatures, especially by novel plasma jet sources with high process controllability and advanced substrate manipulation. The advantage of APPD does not only refer to saving costs and enabling local deposition independently on substrate size by its operation in ambient air, but also opens possibilities to new materials, e.g. multilayered thick coatings. Thus, the main priority of this work is to apply APPS with a novel hot gas plasma jet (InoCoat 3) and powder-based spray coating to protect polyamide 12 (PA12) by low friction and highly wear resistant coatings. Therefore, we selected graphite and molybdenum disulfide (MoS_2) as solid lubricants as well as additional binder matrix to study impact of increased coating flexibility and toughness. In linear and revolving Al_2O_3 ball-on-disc testing with 2 to 10 N load on 6 mm balls, even rough substrates showed improved tribological performance with coefficients of friction (COF) below 0.1, if high coating thicknesses was achievable and no roughness tips were exposed during the ball-on-disc reciprocating sliding. However, exposing these roughness tips results COF increase and similar sliding behavior as found for uncoated PA12. Graphite in the coatings generally reduces wear to about 1/20 of the uncoated substrates by its transfer to the exposed roughness tips.

Keywords: Atmospheric pressure plasma spraying, Graphite, MoS_2, wear protection of plastics

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