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Atmospheric Pressure Plasma Jets for Surface Activation Prior to Bonding and Painting

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Abstract

Nowadays the performance, quality, lifetime and most important reliability of many technical products is affected by the adhesion grade of applied coatings and adhesives on the substrate materials. However, due to production related contaminations and/or low surface free energy of the materials, the surface state of the substrate is often inappropriate to be direct bonded, coated or painted. Thus, these surfaces have to be pretreated correspondingly, e.g. cleaned and/or activated, in order to promote the desired adhesion formation.

Along with the increasing use of hybrid-materials in automobile production, aircraft structures as well as new electric engines and high power electronics, classical wet-chemical pre-treatment processes are often no longer applicable. To improve the quality and long term stability of the adhesion on different substrates, atmospheric pressure plasma (APP) jets can play a key role for many industrial applications. The activation of polymers due to the formation of hydrophilic functional groups, e.g. on thermoplastic materials, the removal of instable oxide layers, e.g. from copper lead frames, and also the precision cleaning for the removal of thin contaminations are typical applications of APP-Jets nowadays. The variety of available jet systems allows high speed treatments faster than 100m/min but also handheld applications for repair and small batch production of thermal sensitive materials. The aim of the paper is to show the spectrum of typical APP-Jets and to give an overview on possible technical applications.

Key-words: *Atmospheric pressure plasma, Jet sources, Adhesion, Adhesive bonding, Cleaning, Activation, Surface*

1. Introduction

The increasing demand for light weight construction and challenging design requirements coming in all modern industries lead to the mixture of dissimilar materials, e.g. metals and polymers, which have to be properly joined and protected against environmental degradation properly. For combined materials with different thermal expansion coefficients and/or the need to prevent electro-chemical corrosion, e.g. for carbon-fiber-reinforced polymers (CFRP) combination with aluminum, adhesive bonding in combination with adapted paint processes are a suitable way to overcome these problems.

To maximize the advantages of the adhesive bonding and painting processes, the surface status of the substrates is a critical issue. The increasing use of thermoplastic materials like PPS, PEEK in automotive industry or ETFE in architecture elements leads to the demand of flexible, inline compatible pre-treatment processes. These processes shall be easily adapted to existing production chains in order to reduce pretreatment costs, avoid the use of solvent based systems and minimize energy costs.

Thus, APP Jet systems e.g.[1,2], are highly attractive for this purpose, since these have been developed and tested successfully for real technical applications during the last decade.

These APP-jets are compact systems which can be implemented easily into existing production lines. Due to the diversity of the commercially available APP-jet systems, ranging from high power devices down to compact handheld devices, individual technical solutions can be tailored considering specific product and product demands, e.g. productivity, process cycle times, processing costs etc. In particular, the APP -Jets can be used for the activation of polymers[3] by the incorporation of chemical bonded hydrophilic groups[4], which e.g. enables the painting of PPS with water-based paints or the adhesive bonding of ETFE film materials used as cladding in the National Aquatics Center known as the Water Cube in Peking. During the last 20 years, the Fraunhofer IFAM in Bremen (Germany) has been extensively investigating different APP-jet systems and their potential applications for environmental friendly, VOC reduced and industry-relevant pre-treatment processing prior to adhesive bonding or painting.

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Dr. Christoph Regula studied physics in Hamburg (Germany) with focus on thin film deposition and processes (2002-2008), PhD for chemistry in 2011 (Bremen, Germany) in the field of deposition of thin film coatings by atmospheric pressure plasma technology. Working at IFAM since 2008 in the Plasma and Surface Technology department on surface cleaning, activation and functional coatings using plasma technologies. Special focus is the development of thin film coatings deposited by inline plasma enhanced chemical vapor deposition (PE-CVD) technologies.