Distinguishing R2R surface treatment techniques

Two technologies are relevant for Industrial plasma systems: Vacuum or low pressure plasma treatment, and Atmospheric plasma treatment. An in-depth comparison provided by Plasmalex (Fuveau, France).

As opposed to vacuum plasma systems, atmospheric plasma systems do not require airtight vacuum chambers. Materials can be moved through a treatment zone via a conveyor belt (Niemira, 2012). For this comparison to Corona only atmospheric plasma is relevant to consider. Corona is a specific type of atmospheric plasma. At first glance atmospheric plasma and corona treatment seem to be very similar. Despite their shared objective of enhancing material properties, and similar operational principles, the impact control of Corona and atmospheric plasma treatments, is different yielding distinct outcomes in various applications.

Both in Corona and plasma the gas is decomposed into a mixture of neutral and charged particles that interact with exposed surfaces of the material. When the object is an open cell structure, the plasma particles will interact with the inner surface as well. By understanding the underlying mechanisms and effects of both Corona Discharge and technologies that rely on precise surface modifications, we can better appreciate their contributions to industries. In this article, we will delve into the disparities between Corona and Atmospheric Pressure plasma, unravelling their distinct characteristics and effects.

Corona treatment: Illuminating material transformation

Corona treatment is a technique frequently employed in industries such as printing and packaging. It is commonly used to activate (or functionalise) the surface of many plastics. It increases their surface energy and therefore improves properties such as printability, adhesion etc. Corona discharge involves the creation of a controlled electrical discharge in the air surrounding a material's surface. This discharge generates a highly energetic plasma, composed of ions, electrons, and excited molecules.

A corona is actually a particular type of atmospheric plasma: It is an atmospheric plasma using ambient air (approx. 78% Nitrogen, 21 % Oxygen, 1% Argon) as plasma gas. It, therefore, does not require gas injection systems and has no running cost associated with gas consumption. The main difference between corona and atmospheric plasma treatments lies in the fact that chemistry is not a parameter when working with corona. The operator has no control over the gas mixture used for the treatment, it will always be approx. 78% Nitrogen, 21% Oxygen 1% Argon with various amounts of water vapour, depending on the humidity level at the moment of the treatment.

High humidity levels are an issue for plasma treatment as it destabilises the discharge and can lead to arcing. An arc is when small sparks of hot plasma are created in the discharge. Those arcs can damage the treated material, even puncture holes in it.

Benefits

When the plasma interacts with the material's surface, it leads to several beneficial application effects:

1. Surface Modification: Corona treatment can induce micro-level changes in the material's surface topography, resulting in enhanced print quality, reduced ink spreading, and improved overall appearance. The energetic plasma breaks molecular bonds on the material's surface, creating functional groups that enhance its wettability. This is particularly valuable in improving the adhesion of inks, coatings, and adhesives.

2. Cleaning: The reactive species present in the plasma can effectively clean contaminants and activate the surface, making it more receptive to subsequent treatments.

Challenges

The chemistry of the corona treatment is dominated by oxygen, even though there is almost four times less oxygen than nitrogen present. This is explained by the extremely high reactivity of oxygen in the plasma state. It completely masks the other possible chemistries and leads to strong oxidation of the polymeric substrate material. Actually, Corona treatment can be seen as a controlled destruction of the surface (Figure 2). It is this oxidation that leads to the surface modifications and the increased surface energy.