Ion Delivery Efficiency with Off-Time Duty Cycles

The Problem of Recombination

Ionization is an effective tool for eliminating surface charge from objects in a clean room environment. A successful static charge control program improves yields through better contamination control, ESD damage control, and improved robotics uptime. Any implementation of ionization, however, faces challenges to ion delivery efficiency. One of the most serious is the recombination of ions. Much of air ionization delivery technology is devoted to minimizing recombination and increasing delivery efficiency.

Ionization systems must deliver both positive and negative ions to ensure that ionization discharges surface charge to zero rather than charging objects in its field. The presence of both positive and negative air ions, however, results in recombination. When a positive ion and a negative ion approach each other, they are attracted and exchange an electron, resulting in both ions becoming neutral atoms. Neutral atoms are useless for controlling surface charge. Recombination is a serious problem with ionization.

The rate of recombination is proportional to the ion densities of the two polarities. For this reason, many ionizers feature multiple emitters or fan stacks, spreading out the ions and lowering the density. Two of the more successful technologies for combating recombination are the employment of pulsed DC and bipolar ionization.

Pulsed and Bipolar Ionization Solutions

Ion Systems employs two technologies that use this delivery process: pulsed and bipolar DC ionization. The principle of both methods is to successively generate ions of alternating polarities.

Pulsed DC is a technology that uses one set of emitters to deliver one polarity of ionization and the other set of emitters to deliver the opposite polarity, with only one set of emitters turned on at a time. Ions move off in waves of each polarity, see the Figure 1. By tailoring the "on" time of the emitters to the application, delivery efficiency can be optimized.

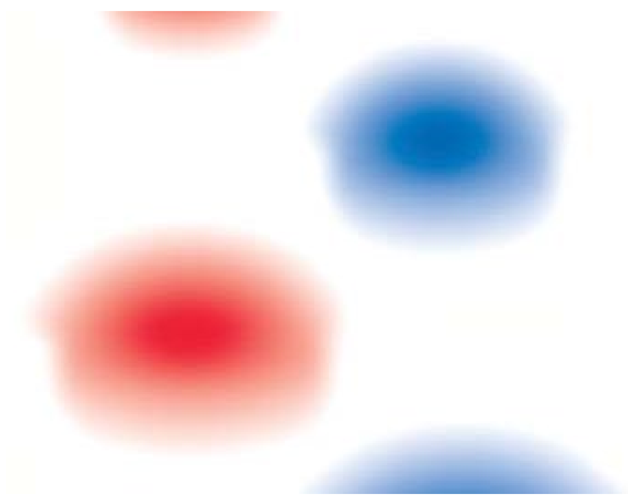

Figure 1

Ionizers using bipolar technology operate similarly to those using pulsed technology except that each emitter delivers both ion polarities from the same emitter. This system has the advantage of providing more emitters and more ionization, with each emitter providing both polarities of ions, see Figure 2. As with pulsed DC technology, bipolar technology separates negative ions from positive ions. The technology doubles the number of active emitters on at any time.

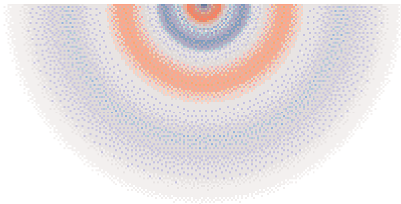

Figure 2. Bipolar Ionizer Technology

Turbulence Effects on Ion Delivery

Even with the solution of bipolar and pulsed ionization technology there exists an additional problem in the battle against ion recombination. Turbulence negatively affects ion delivery efficiency by increasing the residence time of ions in their trip from the ionizer to the target objects on the production line. In addition, turbulence increases the mixing of the two ion polarities as they travel. The result is increased recombination and relatively poor delivery efficiency.

The Programmable Duty Cycle Solution

The only technique that has shown effectiveness in improving delivery when turbulence is present is the use of a programmable off time, sometimes called a programmable duty cycle. A high duty cycle (100%) and a lower duty cycle are shown in Figure 3. By lowering the duty cycle, the positive and negative ions are separated from each other by a gap of unionized air, resulting in turbulence becoming ineffective at causing recombination.

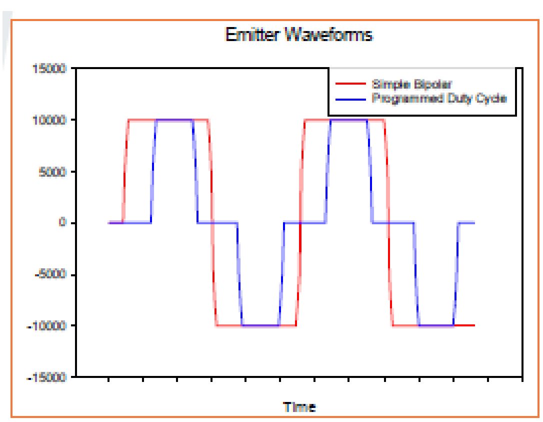

Figure 3. High and Low Duty Cycles

The use of a duty cycle to improve delivery in the presence of turbulence is an exclusive feature of Ion's pulsed DC and bipolarity products. An example of the decreased mixing resulting from off time is shown in Figure 4.

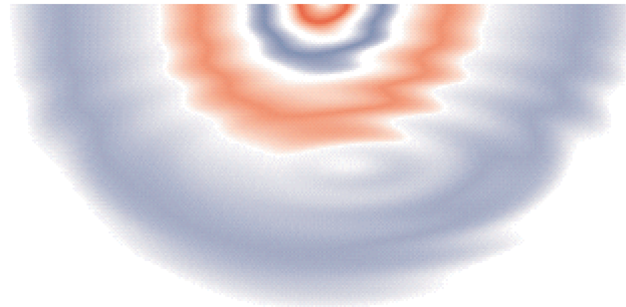

Figure 4. Varying The Duty Cycle To Increase Ion Delivery Efficiency In The Presence Of Turbulence

In some cases, laminar air flow cannot be maintained, such as near vertical walls or below horizontal structural members. In these cases, efficient delivery can only be maintained by controlling the duty cycle. Under the condition of low laminar flow, setting a duty cycle to approximately 75% often improves the discharge time of the ionizer and better controls static charge on the product.

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