

Web cleaning choices

Combination static-neutralization, vacuum and contact-cleaning system removes particulates down to 1-micron size.

By Jay Perry, Marketing Manager, SIMCO

Industrial static-control producers and converters of paper, film, and foil materials have struggled for years to deliver the cleanest product possible. Their quest is constantly thwarted by the very processes they perform to produce the end product.

Slitting, sheeting, coating, laminating, bagmaking, and other production processes create the particles that contaminate the web. Transporting the web through the production process causes a boundary layer of air that essentially traps the smaller particles. Contact and separation of the web material with the machine rollers generates static electricity that results in an electrostatic adhesion bonding contaminants to the web surface. The complication: the faster you try to operate the more complicated these problems become.

Contaminated surfaces cause defects in printing, coating uniformity, etc. resulting in quality problems, costly rejects, and ultimately dissatisfied end-user customers. This article will discuss the basic theories of the boundary layer of air and static electricity, explain the effect that they have on converting processes, and what equipment is necessary to control those effects to deliver a clean material, and consequently a satisfied customer.

Boundary layer of air

The boundary layer of air is the result of the directional movement of a flat surface—in this case, a moving web—and the friction that is created between that surface and the air. As the substrate accelerates, the surrounding air is drawn along, entrained, by the influence of the moving surface. The faster the surface travels, the more air is entrained. As an example, if a web travels at 600 mpm (approximately 1,950 fpm) the resultant boundary layer would be about 50 mm thick (2 in.)

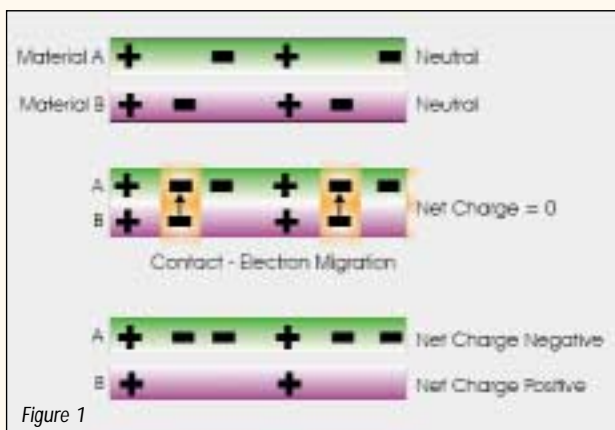
The intention here is to explain why the boundary layer is problematic for web cleaning, not to explain the science of the boundary layer. For our purposes it is relevant to concentrate on the laminar layer, within the total boundary layer, which is that layer closest to the surface of the web. The turbulence of the air within this layer is such that it literally traps very small particles (<20 micron). The layer of air acts somewhat as a suction to hold particles, and it is impossible to remove them without penetrating, or eliminating, the laminar layer.

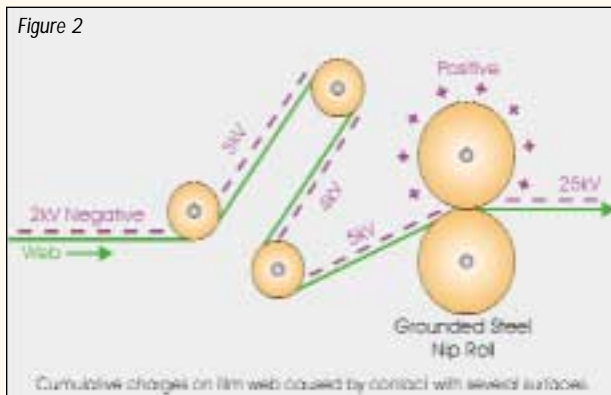
Static electricity

Static electricity is an electrical charge on a surface. The charge is usually on an insulative material, such as the film web, and may be on a conductive surface if it is isolated from electrical ground. When two surfaces are in contact, an exchange of electrons (negative charges) takes place between the two surfaces (See Figure 1). When the surfaces separate, the surface that has gained electrons becomes negatively charged. The surface giving up the electrons becomes positively charged.

The materials involved and the pressure and speed of contact and separation affects the magnitude of the charge. This contact and separation process, or friction, is known as “triboelectrification,” or “tribocharging.” It is the same phenomenon as when you walk across a carpet, touch a light switch, and get a shock.

Because static charges are cumulative, charge poten-





tials can continue to increase each time the web contacts another surface (See Figure 2). This is evident in production and converting systems where the film may come in contact with several idler rollers.

Typical areas within the web transport system that tend to generate significant charges on the web include unwinds; nip rollers; accumulators; idlers with insulative sleeves; bow rollers; coating rollers; corona treaters; lay-on rollers; and rewinds.

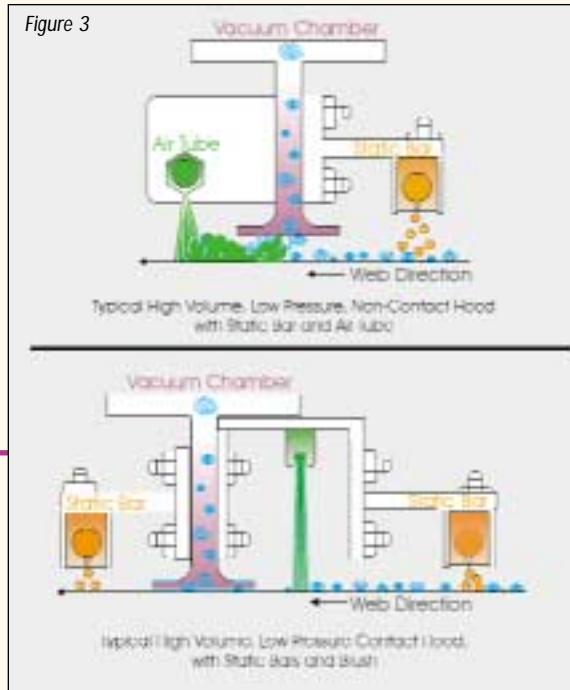
The effect of this static charge traps the particles on the surface due to electrostatic adhesion. Basically, when you have a charged web, say positively charged, it will act like a magnet to any airborne particle of the opposite polarity within the range of the electric field. The electrostatic adhesion is that bond which is the result of the completion of the opposite polarity attraction, much like the completion of the flux lines of magnets of opposite polarity.

Web-cleaning equipment choices

Static Control: Electrostatic charges can be controlled with the use of static eliminators. These ionization devices are available in either active (electrical or nuclear), or passive (conductive grounded emitters) configurations, and basically cause a breakdown of the ambient air (oxygen) molecules into positively and negatively charged particles—ions. Active static eliminators are generally more effective on webs because they will reduce charges to a theoretical zero level, as opposed to a passive device, which will reduce the charge only to a threshold voltage level, which may leave a residual charge that could cause particle attraction.

The ions, once available in an open air space, will be attracted to any opposite polarity charge or to a strong ground reference. In a web cleaning, or neu-

Figure 3



tralizing, application the eliminator should be mounted over the web in an open area (free space) where there is no interference behind the material that might suppress the field from surface charge.

With the field lines visible to the ions from the eliminator, they will be attracted to the surface and neutralize the web, as well as being attracted to charged airborne particles to neutralize any charge before they can be attracted to the surface of the web. Without the charges, there will no longer be an attraction of particles. However, this doesn't solve the electrostatic adhesion of particles that are already stuck to the surface.

This process should be addressed as part of a well designed vacuum system using either a contact or non-contact configuration. This will effectively lift particles from the target surface.

Vacuum Systems: Traditionally, producers and converters of web materials have used high-efficiency vacuum systems to remove surface contaminants. These systems have been very successful, and continue to be the most cost-effective method of web cleaning. Vacuum systems are available in various configurations from many suppliers. Basically, you need a system that can penetrate the boundary layer described above well enough to be able to vacuum the contaminants off of the surface.

There are two vacuum technologies available that

have demonstrated the ability to effectively and consistently remove contaminants from a moving web. Each is described below.

High Volume, Low Pressure: The typical high volume, low pressure system (See Figure 3) is designed to move volumes of air with a lower

well as to help maintain an enclosed area of suction. They are available with fixed brushes, and also with rotating brushes that are very effective. Mounting is critical for these units because the hoods require a solid surface behind the material to support the web, to avoid web deflec-

and squeeze out the boundary layer of air for high-efficiency particle removal. Nipped CCRs are also less impacted by changes in web speed. The nipped CCR has a higher contact pressure between the web and the CCR, maintaining nearly 100-percent contact at all times (See Figure 5).

Industrial use of the CCR has shown that, although they are very effective at small particle removal, contact-cleaner adhesive rolls require continuous cleaning to maintain efficiency. CCR rolls can be hand-washed or adhesive tape rolls can be used to extract particles from the CCR (adhesive tape rolls are generally speed limited to 1,000 fpm). There are also continuous self-cleaning systems employing automatic traversing units with water-washing capabilities that can handle high (over 1,000 fpm) web

speeds (See Figure 6). These automatic machines are very effective and will provide a cleaner product, but there is a cost for the level of cleanliness they provide.

Conclusion

Ultimately, the decision whether or not to incorporate a web cleaner into your process is based on how much it costs to be dirty. A critical application, high production rejects, high maintenance costs or a lost customer are all examples that add to that cost.

Before selecting a system, know how clean you need to be. If particle removal down to 20 microns is sufficient, then a well-designed vacuum system is the most reliable and cost-effective solution. If you need to control contamination down to the single-micron level, then you must use a contact cleaner. Contact cleaning systems are available in a variety of alternatives ranging from simple CCRs

static pressure at the vacuum slot. Generally, the vacuum hoods will be fitted with static elimination equipment and a mechanism to penetrate the boundary layer of air for particle removal. The systems are available in contact or non-contact configurations based on the application. They have many mounting options, which may be their largest performance benefit when compared to other technologies.

Low Volume, High Pressure: The typical low volume, high pressure system (See Figure 4) is designed to produce tremendous suction with high static pressure, right at the surface. However, because of the high pressure, they are less capable of transporting debris over long distances. Consequently, collection systems must be relatively close to the vacuum hoods. These systems depend considerably on brushes to penetrate the boundary layer of air and dislodge particles from the surface, as

tion caused by the suction created by the vacuum system.

As mentioned above, vacuum systems have been used very successfully for consistent, and dependable, web cleaning in the past. Their performance has proven effective to 20-micron size particles.

Contact Cleaners: Vacuum systems, although they are dependable and cost-effective, cannot remove particles smaller than 20 microns. The most effective solution is contact (tacky roll) cleaners. They have proven abilities in cleaning 1-micron particulates consistently, which has been demonstrated in the electronics industry.

As with the vacuum systems, there have been several suggested methods of applying contact cleaners. Tests have proven that a “nipped” arrangement where the contact cleaner roll (CCR) is tightly mounted to an idler roller or another CCR, will provide adequate tension to support the web

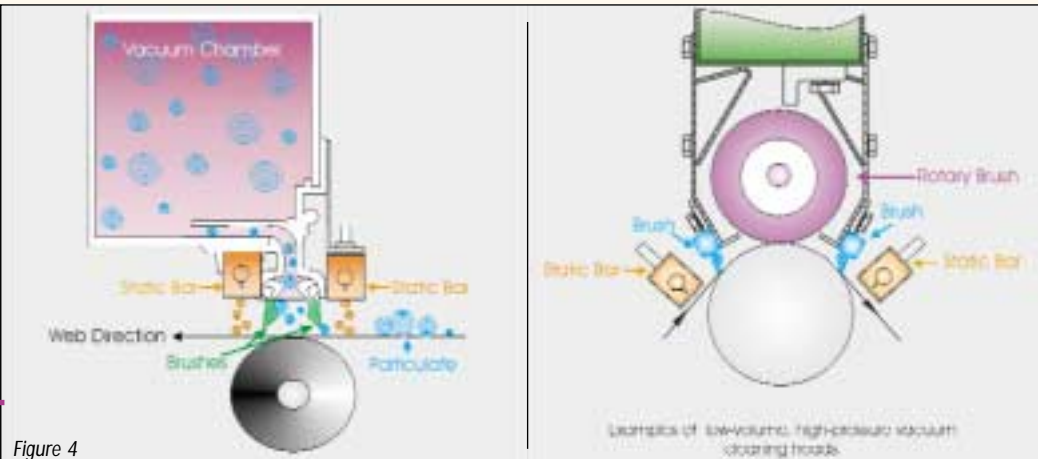
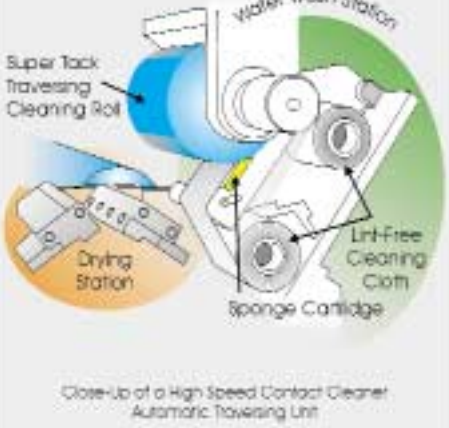


Figure 4

to combination vacuum and CCR units to the ultimate high-speed,

Figure 6

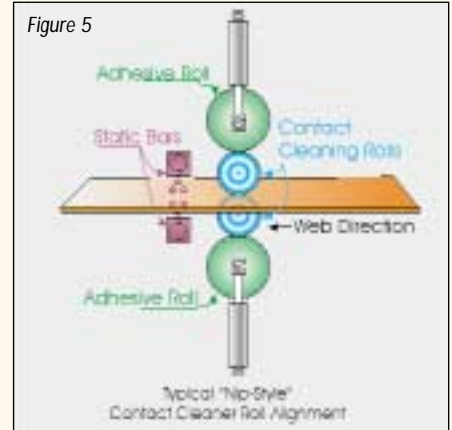


high-efficiency self-cleaning systems.

Web cleaning is complicated, but the increase in production and product quality will equal higher profits and more satisfied customers in the long run. ■

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Figure 5



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