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Manufacturing & Technology

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Web Cleaning Efficiency Using Contact Cleaning Roll (CCR's)

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Contact Roll Web Cleaner

Particulate contamination on base film is a major source of product waste in the converting industry. In order to reduce web and sheeted product contamination, it is common to install web cleaning equipment ahead of the coating / printing stations. Conventional non-contact web cleaners such as ultra-sonic, or air impingement types are not effective because they can not overcome the boundary layer air on the web surface which captivates the dirt particles.

Boundary Layer Air

The thin film of air attached to all moving webs is known as boundary layer air. Small particles (< 50 microns) on the web surface are trapped in this air layer. High velocity air knives and ultra-sonic devices can be used to remove this layer of air at low web speeds (<100fpm). For small particles at higher web speeds, non-contact methods of web cleaning are not effective.

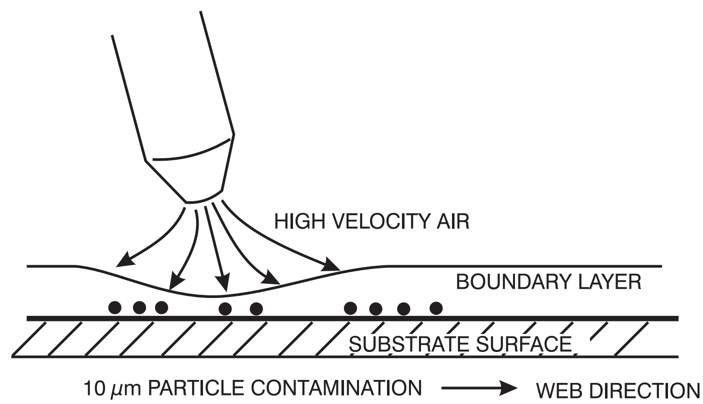

Figure #1
Typical Air Knife / Vacuum systems
Courtesy Andrew R. Gutacker, clean room consultant

Contact Cleaning Roll Efficiencies

Contact Cleaning Rolls (CCR'S) are polymeric covered rollers which offer an efficient method of web and sheet cleaning. As the particles attached to the substrate make physical contact with the CCR, the particles are transferred to the CCR surface. With a nip style arrangement, the CCR also squeezes out the boundary layer air attached to the substrate surface. As a result it is possible to achieve high efficiency cleaning (96%+)of small particles (<50 micron) at higher web speeds. Typical CCR installations are as follows:

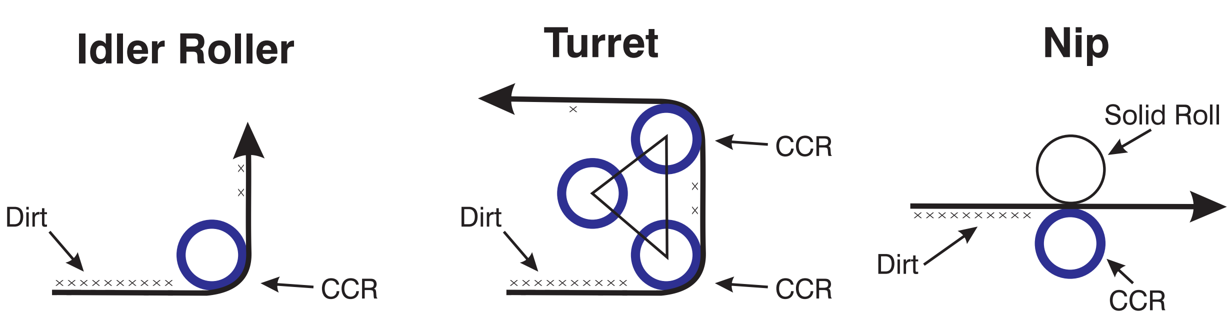

Figure #2

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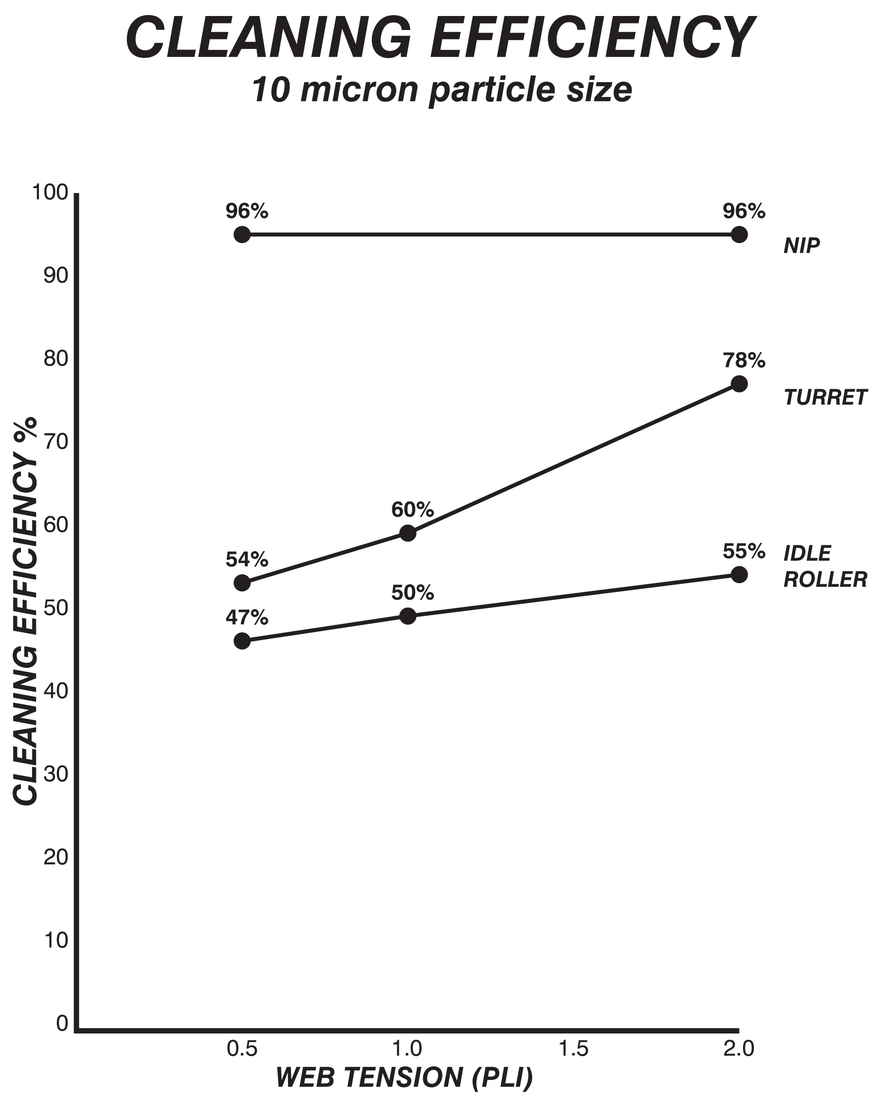
Contact Cleaning Roll efficiencies for 10 micron dirt particles are shown on the following graph. The data was generated by photographing film samples contaminated with 10 micron dirt. The samples were photographed before web cleaning and after web cleaning (Attachment A). The ratio of remaining particles were then used to plot graph #1.



Graph #1

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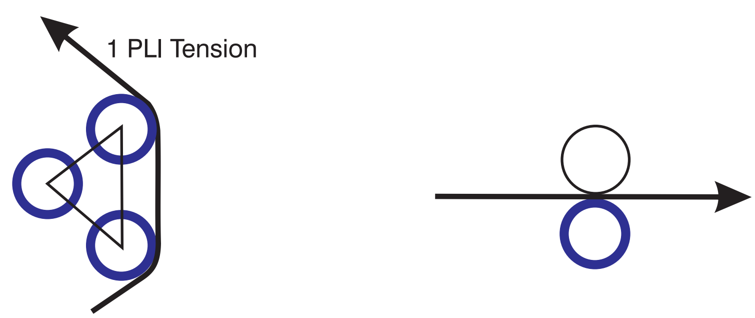
Contact Pressure
An important factor for high cleaning efficiency is the Contact Pressure between the substrate being cleaned and the CCR surface. The turret and idle roller CCR arrangements rely on web tension and wrap angle to create the contact pressure between the web and the CCR. Graph #1 illustrates that for these configurations, lower web tension results in lower cleaning efficiency. The nipped CCR cleaning efficiency is not affected by web tension. Figure #3 shows the difference in contact pressure between a nipped CCR and a turret arrangement. The nipped CCR has *8 times* the contact pressure of the turret. (2.0psi vs 0.25psi).



TURRET
CONTACT PRESSURE = 0.25 PSI

CCR NIP (1/4" FOOTPRINT)
CONTACT PRESSURE = 2.0 PSI

Figure 3

The thick compliant (soft) surface of the CCR attracts the contamination without causing dimples or damage to fragile substrates. The CCR "Nip" arrangement has been successfully used on photographic films, copper foils, and magnetic tape products, to name a few.

Web Speed
Even with CCR web cleaning, the effects of web speed and boundary layer air must be considered. The idle roller and turret arrangements rely on web tension to squeeze out the boundary layer air between the substrate and the CCR. At higher speeds, the boundary layer air will tend to float the web on the surface of the CCR which reduces the contact area, and thus the cleaning efficiency. A nip style arrangement squeezes out the boundary layer air so that cleaning efficiency is not reduced at higher speeds.

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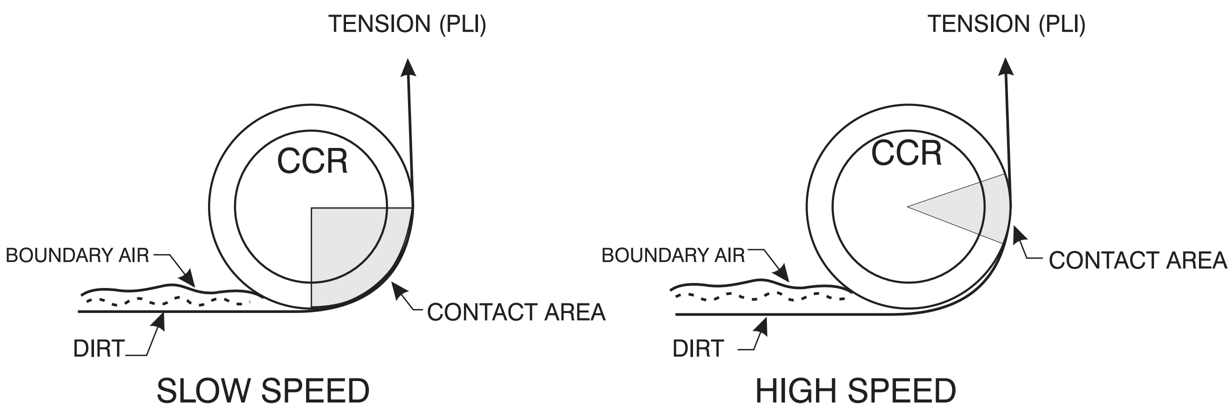
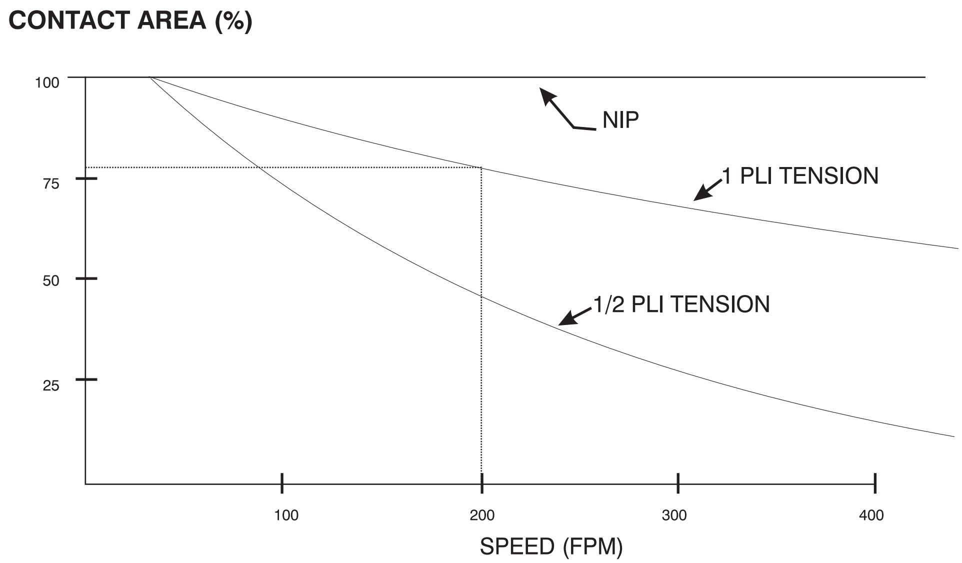


Figure 4

CCR Traction Curves

The CCR traction curves on Graph #2 show the relationship between boundary layer air and web slip for an idle roller arrangement. The slip curves were plotted by measuring the amount of brake torque required to cause a 1% speed reduction in the CCR. At higher speeds and lower tensions, the boundary layer air reduces the contact area between the web and the CCR causing a drop in CCR cleaning efficiency.

The nipped CCR has a much higher contact pressure between the web and the CCR. The nip squeezes out the boundary layer air at higher speeds so that the cleaning efficiency does not deteriorate.



CCR TRACTION CURVES
90 DEG WRAP

Graph #2

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CCR Cleaning Efficiency Calculation (10 micron particle dirt)

For idler roller and turret installations, the cleaning efficiency is related to web tension and speed. The CCR efficiency can be calculated from the data on graphs numbered 1 and 2

Example #1: CCR Idle Roller at 1PLI tension (30" web at 30lbs tension)
From Graph#1 1CCR @ 1PLI = 50% cleaning efficiency
From Graph#2 200FPM @ 1 PLI = 80% Contact Area
Total Cleaning Efficiency = 50% * 80% = 40%

Example #2 **Nip Style CCR** at 1PLI tension (30" web at 30lbs tension)
From Graph #1 Cleaning efficiency = 96%
From graph #2 200FPM @ 1PLI nipped = 100% contact area
Total Cleaning Efficiency = 96% * 100% = **96%**

Cleaning 1 Micron Particles
Particles as small as 1 micron can be removed with a Contact Cleaning Roll. Attachment "D" shows a 1000x magnification of a CCR surface after cleaning 1.6 micron spheres from a film sample. This photograph was taken with a scanning electron microscope at the Rochester Institute of Technology.

Conclusions:

1. Nip Style CCR installations offer the highest cleaning efficiencies. The nip offers the highest contact pressure between the CCR and the web, which eliminates the effects of web tension and speed without damage to fragile substrates.

2. Non-Contact web cleaning devices have lower small particle cleaning efficiencies because of boundary layer air.

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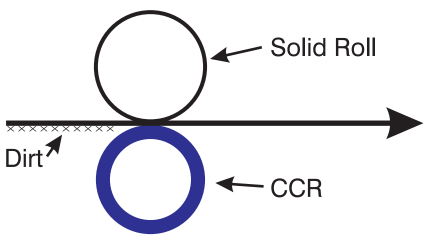
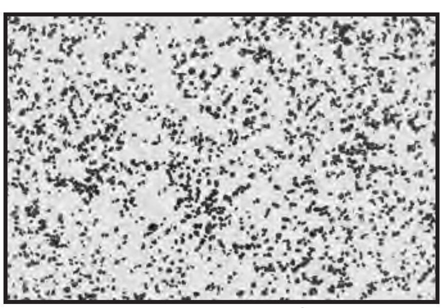
Attachment A

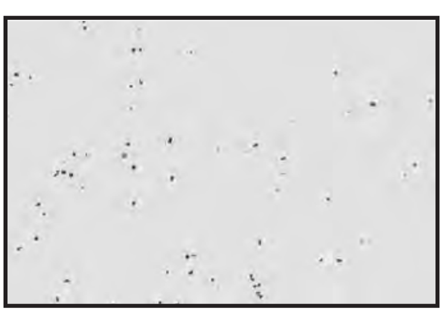
Nip Efficiency Test

(10 micron particles on film)
Photographed at 125X magnification





Before Cleaning
Particle Count = 2828

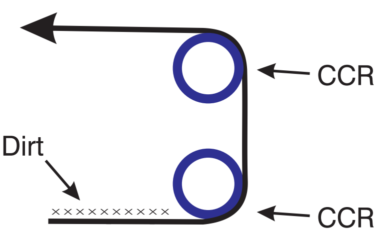


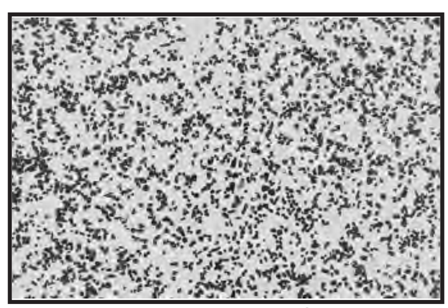
After Cleaning
Particle Count = 87

Cleaning Efficiency=96.9%

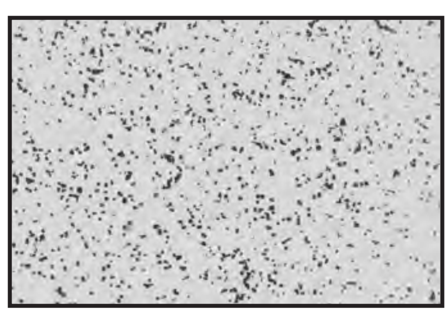
Turret Efficiency Test (1 PLI)

(10 micron particles on film)
Photographed at 125X magnification





Before Cleaning
Particle Count = 3908

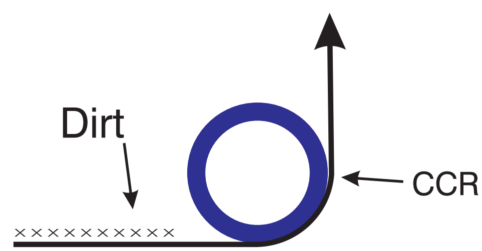


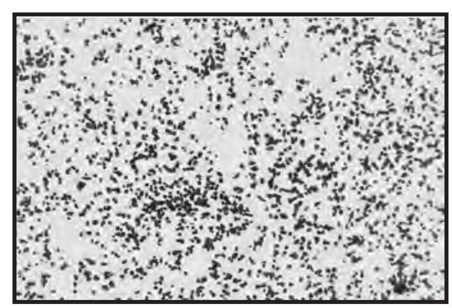
After Cleaning
Particle Count = 1567

Cleaning Efficiency=59.9%

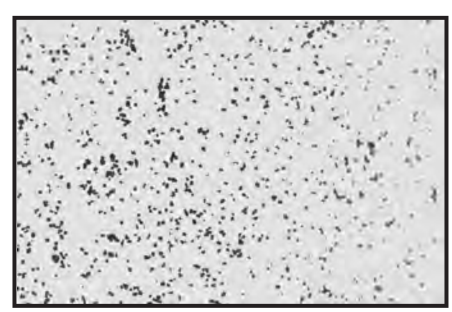
Idler Roller Efficiency Test (2 PLI)

(10 micron particles on film)
Photographed at 125X magnification





Before Cleaning
Particle Count = 3205



After Cleaning
Particle Count =1462

Cleaning Efficiency=54%

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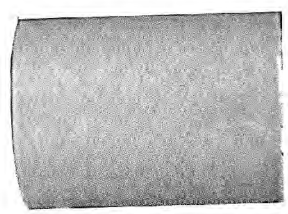
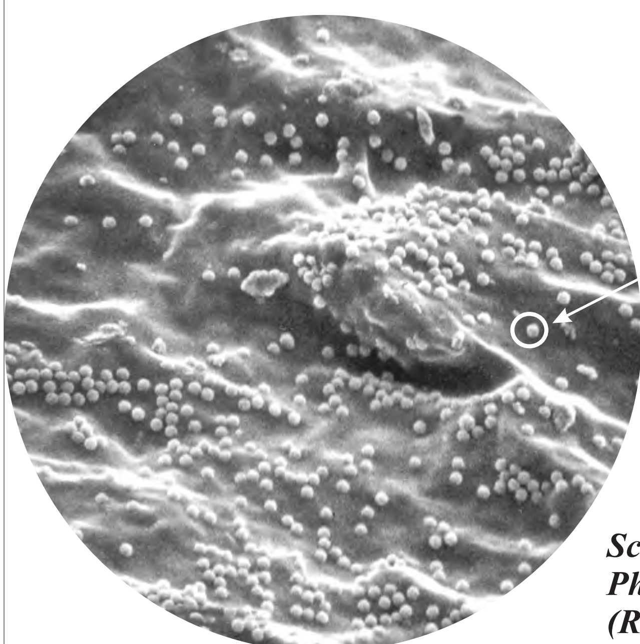
Attachment B

Polyurethane Polymer with Ground Surface



Actual Roll

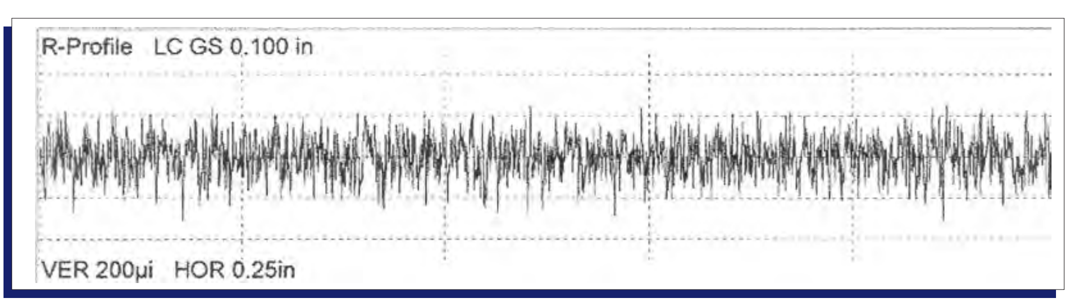
65 Microns



1.6 µm particle

Scanning Electron Microscope Photo – 1000x (Rochester Institute of Technology)

Scale = Cross Section of Human Hair (100 microns)



CCR Surface Roughness Trace – 72 µin Ra (Sandia National Laboratory)