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Demonstration: Winding Roll Electrification

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Electrostatic Answers

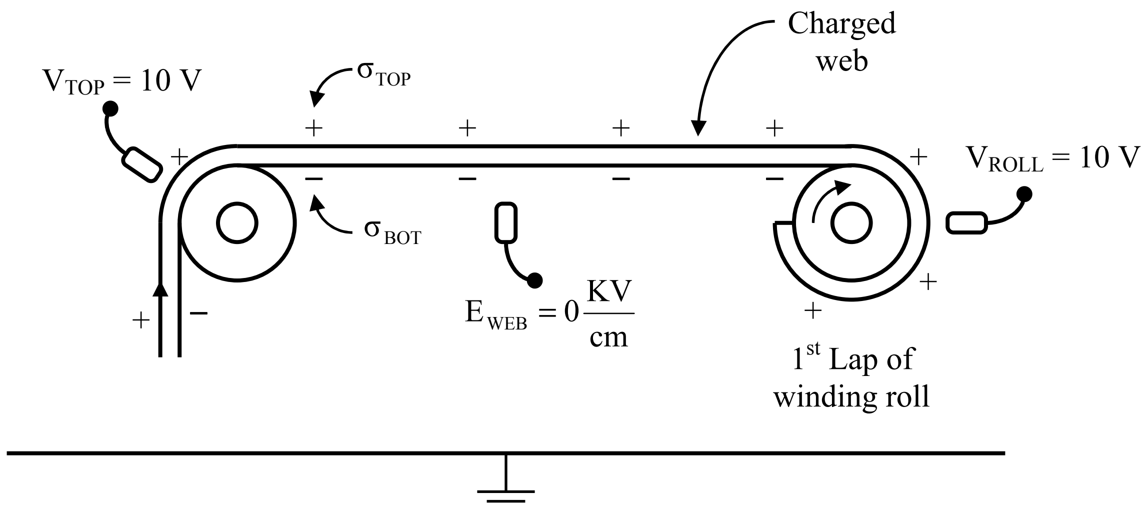

Figure 1: The web has positive charge on the top surface and an equal amount of negative charge on the bottom surface. While electric fieldmeter reading E_{WEB} confirms that the web is neutral, the voltage V_{ROLL} increases with each wound lap.

Abstract

In production operations, it is very common for the web in Figure 1 to have positive charge on one surface and an equal amount of negative charge on the other surface. The electrostatic fieldmeter reading E_{WEB} taken on a span confirms that the web is electrically neutral. However, a non-contacting electrostatic voltmeter reading V_{TOP} taken with the web wrapped on a grounded conveyance roller shows that the charge causes a voltage difference across the web. A voltage difference of 10 volts is very common and I have measured voltages exceed 1000 volts.

At the end of a process, the charged web is wound into a roll. The voltage on the exterior surface of the roll increases with each lap because the voltage is additive. Suppose the voltage difference is +10 volts. The voltage of the exterior surface of the winding roll with 1000 laps will be 10 KV. When winding a 1 mil (0.001 inch) thick web onto a 4-inch diameter core, a roll with 1000 laps will have a 6-inch diameter. The diameters of many winding rolls will exceed several feet.

Winding this electrically neutral web into a roll with a diameter of several feet will result in electrical discharges and audible crackling.

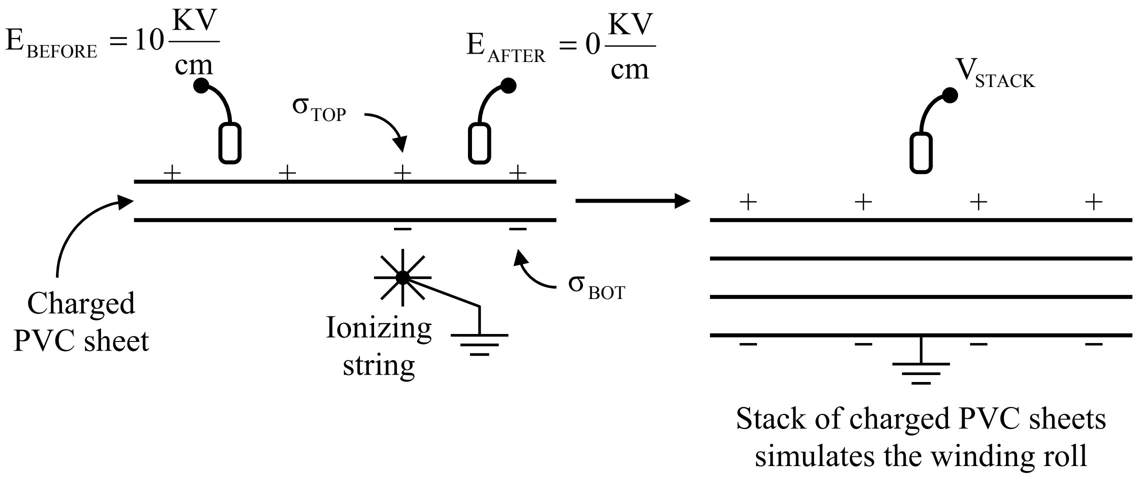

Figure 2: Initially, the PVC sheet has positive charge on the top surface. The ionizing string deposits an equal amount of negative charge on the bottom surface. While electric fieldmeter reading E_{WEB} confirms that the web is neutral, the voltage V_{STACK} increases with each added sheet.

In this demonstration, I will use insulating 5 cm × 20 cm PVC sheets to simulate the laps on a winding roll. Positive charge will be deposited onto the top surface of the first sheet. An electrostatic fieldmeter will be used to confirm the charge.

Next, an ionizing string will be used to neutralize the sheet with the charged top surface facing away from the string as in Figure 2. The string responds to the charge on both sides of the sheet just like a fieldmeter, and it will generate negative ions to neutralize the sheet. However, the negative ions will deposit on the bottom surface of the sheet. An electrostatic fieldmeter will be used to confirm that the sheet is neutral.

Finally, the charged sheets will be stacked to simulate adding laps to the winding roll. A non-contacting electrostatic voltmeter will be used to measure the voltage of the top of the stack as each sheet is added to demonstrate that the voltage is additive.

Two important insights are:

1. A fieldmeter reading of zero confirms that that a web is electrically neutral. However, the web is not necessarily free of static. The web may have positive static on one surface and an equal amount of negative static on the other surface.
2. When the web being wound has positive charge on one surface and an equal amount of negative charge on the other surface, the voltage of the winding roll increases with each lap even though the web is electrically neutral.