Increasing Production Output with Pulsed-DC Accessories

Commonly, insulating films are deposited on architectural glass using reactive processes with older DC power supplies. With the simple addition of a DC pulsing accessory, architectural glass coaters can realize increased production output through reduced cleaning cycles, increased production campaign length, and increased yield. Investments that improve any one of these areas are easily justified by the increase in production output that they provide. This paper takes a closer look at the financial benefits of adding a DC pulsing accessory to existing DC power supplies for architectural glass coaters.

Reduced Cleaning Cycles

Depositing insulating films such as ZnO_2, TiO_2, SiO_2, ITO, or Cr_2O_3 with DC power supplies requires running a cleaning cycle on a periodic basis. This prevents buildup of the insulating film on the target material and anode, which would eventually extinguish the plasma and halt the deposition process. The cleaning cycle requires production to be temporarily suspended and switched from a reactive deposition mode to a metallic deposition mode. During the metallic mode, debris is cleaned from the target material. Upon completion of the cleaning cycle, the process changes back to the reactive mode and production resumes.

Unfortunately, the implementation of each cleaning cycle utilizes valuable coater production time. The production time utilized for cleaning cycles during a production campaign can be defined as

Ucc = Cd/(Cd+Cf)x100%

Ucc = Active production coating time utilized for the cleaning cycle

Cd = Cleaning cycle duration

Cf = Cleaning cycle frequency

Cleaning cycles typically are implemented every 30 minutes to two hours and last from two to 12 minutes. Adding a DC pulsing accessory can reduce the rate of insulating material buildup on the target and hence decrease the frequency of cleaning cycles without increasing cleaning cycle duration. The result is more time available for production.

A DC pulsing accessory can decrease the frequency of cleaning cycles without increasing cleaning cycle duration. The result is more time available for production.

Using an industry estimate that an architectural glass coater can produce approximately $6000 worth of coated glass per hour, the following table summarizes the potential financial benefit of DC-pulsing accessories. This potential benefit is based on modest improvements in the cleaning frequency.

Cleaning Cycle Comparison: DC vs. Pulsed DC

	Example A	Example B	Example C
DC			
Cleaning cycle duration with DC (Cd)	12 min	2.25 min	1.5 min
Cleaning cycle frequency with DC (Cf)	120 min	30 min	40 min
Coating time spent cleaning with DC (Ucc)	9.09%	7.46%	3.61%
Pulsed DC			
Cleaning cycle duration with DC pulsing accessory (Cd)	12 min	2.25 min	1.5 min
Cleaning frequency with DC pulsing accessory (Cf)	240 min	60 min	240 min
Coating time spent cleaning with DC pulsing accessory (Ucc)	4.76%	3.87%	0.62%
Improvements			
Increase in production capacity with DC pulsing accessory	4.33%	3.58%	2.99%
Increase in production output with DC pulsing accessory	$6224/day	$5160/day	$4310/day

The implementation of DC pulsing accessories with existing DC power supplies for reactive processes has a potential payback of $4310 to $6224 per day in increased production during an active production campaign.

The implementation of DC pulsing accessories with existing DC power supplies for reactive processes has a potential payback of $4310 to $6224 per day in increased production during an active production campaign.

Increased Production Campaign Length

Architectural glass coating production campaigns typically run from one to three weeks between venting cycles, and each venting cycle may last from 24 to 48 hours. Oftentimes, the length of a production campaign is defined by the ongoing buildup of debris and contaminants that cannot be removed during normal cleaning cycles. Venting frequency and duration have significant impact on the overall utilization of an architectural glass coater over the course of a year.

The percentage of time available for production, taking into consideration the frequency and duration of venting cycles, can be defined as

$U_{pc} = T_{pc}/(T_{pc}+T_{vc})x100\%$

U_{pc} = Utilization for production campaign

T_{pc} = Time of typical production campaign

T_{vc} = Duration of typical vent cycle

The addition of DC pulsing accessories can reduce the rate of debris buildup and hence increase the length of a typical production campaign. Each additional day the coater is available for production can mean $144,000 of additional production output at an industry-estimated value of $6000 per hour.

The following table summarizes the potential impact of increasing the average production campaign length with the addition of DC pulsing accessories to reduce the venting frequency.

Campaign Length Impact: DC vs. Pulsed DC

	Example A	Example B
DC		
Campaign duration with DC (Tdc)	8 days	12 days
Venting duration with DC (Tvc)	1 day	1 day
Production utilization with DC (Upc)	88.89%	92.31%
Pulsed DC		
Campaign duration with DC pulsing accessory (Tdc)	10 days	14 days
Venting duration with DC pulsing accessory (Tvc)	1 day	1 day
Production utilization with DC pulsing accessory (Upc)	90.91%	93.33%
Improvements		
Increase in coater utilization with DC pulsing accessory	2.02%	1.02%
Additional production days available per year	7.37 days	3.72 days
Estimated annual value of additional production	$1,062,000/year	$536,000/year

The implementation of DC pulsing accessories with existing DC power supplies may contribute to extending average production campaign length for architectural glass coating. Each 1% improvement in overall coater utilization can mean an additional $500,000 of production output over the course of a year.

Each 1% improvement in overall coater utilization can mean an additional $500,000 of production output over the course of a year.

Increased Yield

Reduced defects and increased production yield have an immediate impact on the bottom line. The addition of DC pulsing accessories to existing DC power supplies for reactive processes can reduce overall debris buildup, the number of hard arcs, and the amount of energy delivered into an arc. These all contribute to reduced splatter, reduced defects, and higher yields.

An increase in production yield will result in the following increase in production output:

$\Delta_{output} = [(Y_{dc}/Y_{p\text{-}dc}) - 1]$ x production value per period

Δ_{output} = Change in production output per period

Y_{dc} = Yield with DC power supplies

$Y_{p\text{-}dc}$ = Yield with pulsed DC power supplies

Using the previous estimate in which the typical production output has a value of approximately $6000 per hour, moving from a production yield of 97.5% to 98.5% would result in the following increase in production output:

$[(98.5/97.5) - 1] \times \$6000 = \$61.54/hour = \$539,000/year$

Hence, a 1% improvement in production yield could result in additional output of approximately $500,000.

Summary

Adding DC pulsing accessories to existing DC power supplies that deposit insulating films on architectural glass with reactive processes can provide a significant return on investment. DC pulsing accessories implemented with DC power supplies are relatively low cost compared to the price of new power supplies and/or cathodes. This implementation also can result in increased production capacity. The increase in production output, which results from reduced cleaning cycles, longer campaigns, or increased yields, provides significant returns when analyzed individually and even greater returns when analyzed collectively.

Specifications are subject to change without notice.

ADVANCED ENERGY®

Advanced Energy Industries, Inc. • 1625 Sharp Point Drive • Fort Collins, Colorado 80525
T: 800.446.9167 or 970.221.4670 • F: 970.221.5583 • *support@aei.com* • *www.advanced-energy.com*
Please see *www.advanced-energy.com* for worldwide contact information.

ENG-PULSEDDCROI-270-01 0M 11/06