Economics and Sustainability of UV Coatings

on Pipe and Tube Applications

By Michael Kelly

In today's manufacturing environment, it is critical to utilize leading-edge technology to drive cost savings and deliver a Return on Investment (ROI). This article details a financial and technical case study on the implementation of ultraviolet (UV) coatings on cylindrical pipes. In this case, the customer transitioned to UV coatings technology and was rewarded with both the economic benefits and the sustainability of this green technology.

The former coating system utilized by this customer was based on solvent technology, which contributed to the following problems:

Customer's Problems with Former System

- Escalating energy costs
- Need to increase production
- Continued quality problems
- Large factory space footprint
- Continuous environmental issues

Figure 1

Examples of coated parts

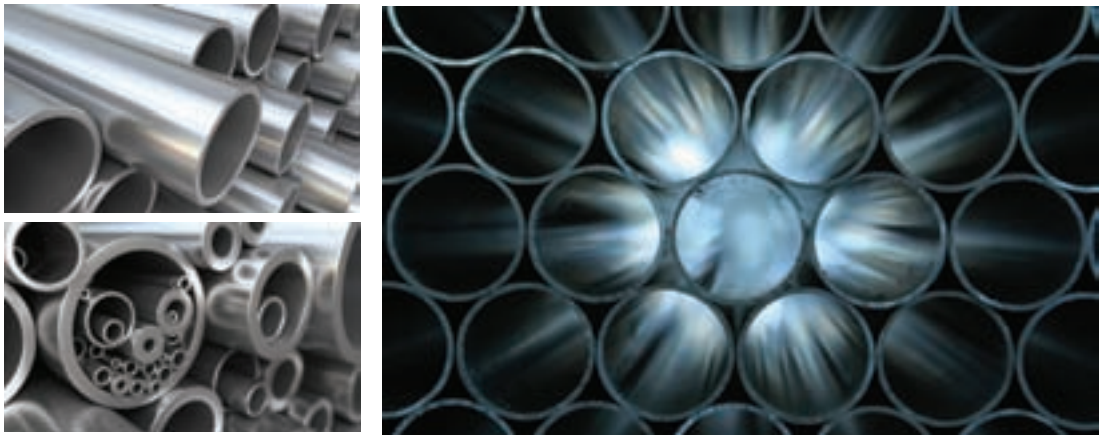
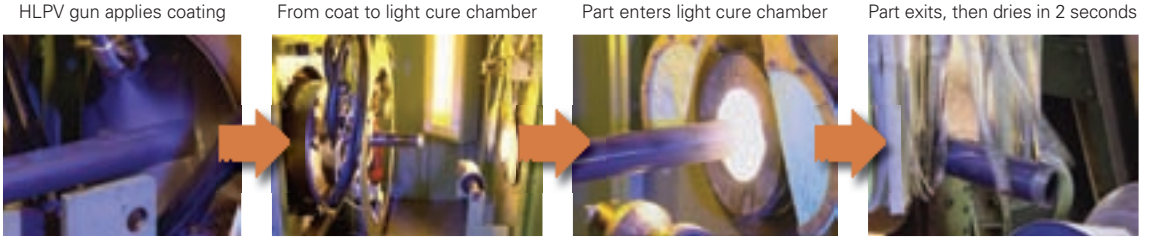


Figure 2

UV coating, cure and finished handling of the UV coating process



The customer looked at a variety of potential solutions, including:

- Water-based coating
- Solvent-based coating
- UV coating-and-curing technology

Each coating technology review provided the customer with details on the most recent changes and updates to the respective technology.

Water-based coating technology limitations included:

- Overall footprint too large
- Oven length and cool-down time required
- High capital costs

Solvent-based coating technology limitations included:

- Volatile organic compounds (VOCs)
- Hazardous material
- Health and safety issues

UV coating-and-curing technology did not have similar limitations, but demonstrated the following benefits:

- No VOCs or hazardous air pollutants (HAPs)
- Small footprint
- Energy efficiency

Overall UV Process

Outlined in Figure 2 is a pictorial representation of the UV coating, cure and finished handling of the UV coating process.

Faster Line Speed

UV coatings typically will deliver much faster line speed than conventional water- and solvent-based coating technology, mainly due to the fact that the coating cures in typically 1-2 seconds. This customer was able to increase their line speed from 220 ft. per minute to 245 ft. per minute. (Speeds of up to 290 ft. per minute could be achieved, but will be tested at a later date.) UV technology delivered a faster line speed which resulted in higher system throughput, increased

Table 1

Linear foot comparison

Description	Solvent-Based	Water-Based	UV–100% Solids	Comments
Line Speed (feet/minute)	220	140	245	Continuous pipe production
2 shifts per day—10 hours each shift/total production	18	18	18	18 hours of production/day
Minutes per shift—Total of 18 hours	1,080	1,080	1,080	
Linear feet per day—Total of 18 hours production	237,600	151,200	264,600	
6 days/week	1,425,600	907,200	1,587,600	
52 weeks/year	**74,131,200**	**47,174,400**	**82,555,200**	

Table 2

Cost analysis between solvent, water and 100% solids UV

Description	Solvent-Based	Water-Based	UV –100% Solids	Comments
Coating Cost	$29	$39	$89	
Solid by Volume	38%	48%	100%	
Theoretical Coverage @ 1mil (sq ft)	610	770	1,604	
Average Film Thickness (mils)	0.5	0.5	0.6	Solvent and water dry film thickness was 0.1 mils less
Actual Coverage (sq ft)	1,219	1,540	2,673	
% Material Utilization (Electrostatic)	65%	65%	65%	Both have the same efficiency
Actual Applied sqf (sq ft)	792	1,001	1,738	
Coating Recovery of Collection	n/a	n/a	95%	UV Coating is reclaimable /Solvent is not
Additional sqf through Recovery (sq ft)	0	0	889	Reclaim material is refiltered/re-used
Total sqf	792	1,001	2,627	Total square feet per gallon of coating
1.5 inch tubing/outer dim 1.25 inch - 5.10 inch diameter	1,864	2,355	6,180	Linear foot of 1.5 inch diameter pipe per gallon
Cost of coating per linear foot of 1.5 inch dia pipe	**$0.015554**	**$0.016560**	**$0.014401**	**Cost per linear foot of 1.5 inch diameter pipe**

overall production and better utilization of capital.

Cost Analysis—Increasing Production

Outlined in Table 1 are the details of actual production capabilities based on solvent-based versus 100% solids UV coatings. The 100% solids UV offers the ability to produce a significant amount of additional product:

- UV 100% solids compared to solvent-based had almost 11% additional product in the same production time.
- UV 100% solids compared to water-based had almost 75% additional product in the same production time.

This time savings allows the customer to fully maximize their production line and available financial capital.

Coating Optimization

UV coatings are typically 100% solids, which is defined as containing no solvents or water. The 100% coatings are fully reclaimable and offer a great opportunity to reduce coating costs. In this case, the customer was able to reclaim and achieve total system efficiency exceeding 95%.

Cost Analysis—Coating Savings

Table 2 outlines the financial details comparing solvent-based coating versus 100% solids UV coating.

As shown in Table 2, UV coatings are more expensive per gallon, but (after reviewing the percent solids and the ability to recover 100% solids UV coatings, etc.) the UV coatings are less expensive per linear feet.

Inventory Usage and Handling Costs

Production is 74,131,200 linear feet (based on solvent production numbers—see Table 3).

- UV coatings would save the customer from needing to receive more than 27,000 gallons of coating (or 550 drums of coating) over solvent-based.
- UV coatings would save the customer from needing to receive more than 18,000 gallons of coating (or 260 drums of coating) over water-based.

Incoming Freight Savings

Estimated cost for receiving one drum of coating will vary by the respective location of the customer and coating supplier, but in this case cost per 55-gallon drum was $65.50.

Table 3

Inventory review/gallons utilized

Description	Solvent-Based	Water-Based	UV–100% Solids	Comments
Production (yearly number/based off solvent numbers)	74,131,200	47,174,400	74,131,200	Continuous pipe production
Number of linear feet—1.5 inch diameter tubing/gallon	1,864	2,355	6,180	18 hours of production/day
Number of gallons used	39,761	20,031	11,995	18 hours of production/day

Total Cost Savings

- The customer saved $36,025 in incoming freight costs using UV versus solvent-based materials.
- They saved $23,580 in incoming freight costs using UV versus water-based materials.

Incoming Receiving Savings

Costs are also incurred for receiving material, storing material, cash flowing materials and transitioning materials.

Floor Space Savings

At the time of the project review, a water-based coating system was not economically feasible and was eliminated from the review process.

A floor space comparison between solvent-based system and UV coating system consists of the following:

- *Solvent-based system:* 80 ft. x 15 ft. = 1,200 sq. ft.
- *UV-based system:* 42 ft. x 15 ft. = 630 sq. ft.
- *Plant floor savings:* 570 sq. ft.
- *Cost savings per square foot:* $1.20/month x 570 sq. ft. x 12 months = $8,208 savings/year

Energy Cost Savings

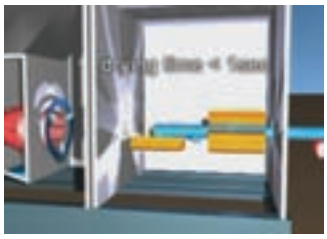
Energy costs continue to be a major expenditure for manufacturers, especially during the past 24 months. UV coatings offer significant energy savings over solvent-based coatings.

Total cost savings per hour of operation:

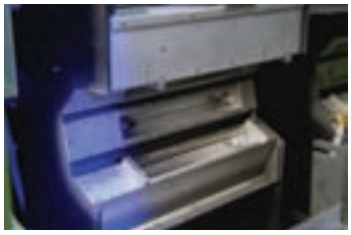
- Solvent-based energy costs: $3.57/hour
- UV 100% solids energy costs: $2.18/hour

Figure 4

UV light system graphic and photo of actual system



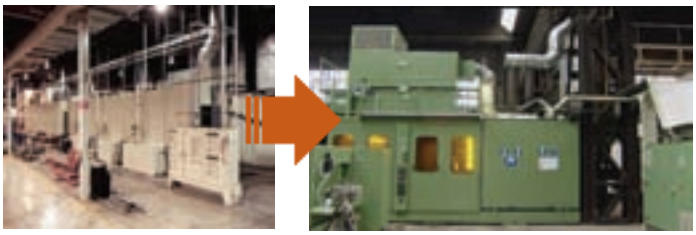
Graphic of UV light system



UV light system in operation

Figure 3

Floor space comparison



Solvent thermal system

UV light bank

- Total hours per year at 18 hours/day x 6 days/week x 50 weeks/year = 5,400 hours saved

Total energy savings

The delta between solvent-based materials versus using UV 100% solids is $1.39/hour for a total savings of $7,506.

Quality Cost Reductions

Based on the two technologies and the end product, there is no significant difference in the output quality. Since

the 100% solids UV coating cures typically in less than two seconds, there are less overall quality issues with the end product when compared to solvent-based technology. This is mainly due to the elimination of variation in the overall coating and drying process.

The 100% solid UV systems will typically have less scrap than competing technologies. This is mainly based on the ability to conduct an immediate ASTM 3359D-adhesion test on the coated-and-cured material. In the competing technologies, there is more coated material in-process and it can be potentially flawed.

Capital Cost Considerations

Overall capital costs between the solvent-based system and the UV 100% solids system were comparable, with the solvent-based system being overall less costly.

Tubing end of line.

- Solvent-based system: $465,000
- UV 100% solids UV system: $527,000

  (Note: Both include chemical wash, chemical rinse and air dry systems.)
- Total capital cost savings: $62,000

Work-in-Process (WIP)

UV 100% solids will provide:

- No excess inventory
- A reduction in inventory costs
- Elimination of WIP
- The ability to quickly coat, cure, package and ship

Environmental Considerations

A critical component of this customer's decision was their need to eliminate almost all VOCs as their location would not allow for any new VOC emissions. The customer also wanted to minimize their carbon footprint to the lowest possible output and UV 100% solids was the best solution. With the solvent system, an expensive Regenerative Thermal Oxidizer scrubber system would have been required.

Table 4

Overall cost comparison

Description	UV–100% Solids	Comments
Faster line speed—Increased output	$3,790,800	8,424,000 add'l @ est. $0.45 profit/foot UV 100% Solids is 11% more efficient than solvent
Coatings savings per foot	$0.001153	$0.001153 savings per foot with UV 100% solids
Additional linear foot/UV 100% solids coating/savings	$95,186	82,555,200 UV 100% solids production/year
Coating optimization/reclaim savings		Incorporated into per foot coatings savings
Smaller incoming freight savings	$36,025	Both have the same efficiency
Incoming receiving savings	TBD	Fewer overall handling/550 drums
Smaller floor space	$8,208	
Smaller energy costs	$7,506	
Smaller quality costs	TBD	Fewer quality issues due to immediate inspection
Capital cost considerations	$(62,000)	
Work-in-process	TBD	Fewer WIP/Can be calculated
No VOCs, HAPs or NVPs	TBD	No RTO expenditure and operational costs
Reduction in reporting	TBD	Subjective to local and EPA regulations
Cleaner health and safety	TBD	Overall, a good thing for the workers
	TBD	**Additional work required to define actual savings**

TABLE 5

Graphic comparison of solvent versus UV 100% solids coating

Financial/Economic Details	Solvent-Based	UV–100% Solids
Line speed flexibility		
Ability to reclaim		
Floor space		
Work-in-process		
Energy consumption		
Maintenance costs		
Capital costs		
Quality costs		
No VOCs, HAPs and NVPs		
Reduce reporting		
Improved health and safety		
Coating cost per linear foot of mat'l		

COLOR CODE CHART:	COLOR
Poor	
Acceptable	
Number of Gallons used	

UV 100% solids coating systems also have no normal vinyl pyridones or hazardous air pollutants which are harmful to the environment.

Reduction in Reporting

Reporting issues will be significantly reduced with the UV 100% solids coating systems when compared to solvent-based coatings. Please consult your local environmental organizations for more details as this will be dependent on your location.

Cleaner Health and Safety

In addition to the reduction in their carbon footprint and reporting, the customer was able to promote a safer workplace environment for its employees and also for the local community. As with any coating, proper handling procedures should be followed.

Overall Cost Savings

In the comparison between solvent-based coating and UV 100% solids, the actual cost savings calculation for each individual application requires a full understanding of internal costs and the allocation of these costs. Outlined in Table 4 are some of the cost savings that were calculated by this customer. The items "to be determined" were more difficult and time consuming to calculate so, for this exercise, were not calculated, but notes indicating this were added.

Conclusion

The implementation of UV coatings technology for this customer offered significant overall cost savings for their operation. The UV process delivered a significant increase in production; actual coatings cost savings and benefits per-square-foot of production; and significant overall cost savings. Not only did UV coatings deliver operational efficiencies, but it also delivered true ROI—as well as sustainability.

—Michael Kelly is CEO/president of Allied PhotoChemical, Kimball, Mich.