

# SPRAYTIME®

Published by *The International Thermal Spray Association*  
Volume 16, Number 1

First Quarter 2009

## First Announcement and Call for Papers

### *New Developments in Thermal Spray Coatings, Processes and Applications Conference*

**Conference dates:** November 16, 2009, Chicago, IL USA

**Abstract Deadline:** May 1, 2009

**PowerPoint files Due:** October 1, 2009

**Topic:** Thermal Spray Applications and Developments

The American Welding Society and The International Thermal Spray Association are organizing the first Thermal Spray and Coatings Conference at FABTECH 2009. This one-day event will be held in conjunction with the FABTECH International and AWS Welding Show. The program is intended to introduce the process and its uses to new potential users with morning and afternoon sessions focusing on actual applications and new developments in thermal spray technology. It will include a half-day tutorial Sunday, November 15th sponsored by the International Thermal Spray Association on thermal spray fundamentals titled "What is Thermal Spray?".

The International Thermal Spray Association is a professional trade organization dedicated to expanding the use of thermal spray technologies for the benefit of industry and society.

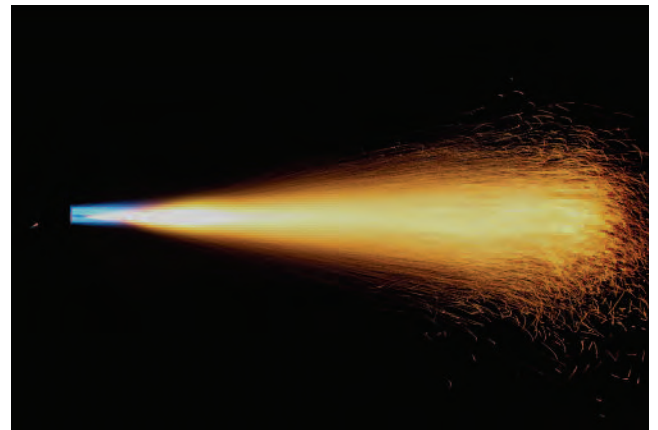
AWS and ITSA 2009 Program Organizers invite you to submit your work for consideration of inclusion in the technical program. They are accepting 150-200-word abstracts describing original, previously unpublished work. Presenter PowerPoint files will be due October 1, 2009. Topical areas suggested for presentation include the following New Developments in Thermal Spray:

- Applications
- Coatings
- Automation
- Safety
- Processes
- Spray equipment
- Ancillary equipment
- Sensors and controls.

continued on page 6

## The Vortex-Stabilized HVOF Spray System

by James Browning



### Introduction

By now, most of us know about HVOF—that it is a way to produce particle velocities so extreme that metal powder need not be melted. Impact heating raises them to the fusion point. Superb coatings result. It is not unreasonable to believe that similar strides may occur for the spraying of wire. (The low oxide coatings of powder in the "impact-fusion" mode would not be challenged. Liquid droplets attract oxygen.) But, what benefits might be expected? The answer, finer wire atomization and increased particle velocities than found in both flame and arc spray. Also, lower coating porosity and reduction of metal vaporization as often caused by arc intensity.

Recent work has resulted in a new flame-stabilization technique which eliminates the need for water cooling and internal ignition. By far the simplest possible guns are now available. And, many of these advances may apply equally well to powder spraying. Thermal spray and its equipment costs could drop dramatically.

continued on page 2

## Discussion

Vortex gas flow is an extreme case of rotary flow. From a circular zone near the axis of rotation the gas velocity is a maximum, falling exponentially lower with radial distance from the axis. Within this whirling flow is a core, or eye, of the vortex. The gas has lost nearly all its motion, with its gas pressure falling to vacuum levels—a tornado.

Current HVOF guns premix the oxygen and fuel prior to combustion. Premixed combustion is rapid, efficient, and great for lifting a rocket. But, we are not in the rocket business.

A rocket engine is “on” for only short periods. It depends on adequate cooling from the flowing propellants. Additional cooling is not an option. Present HVOF guns depend on water cooling and suffer the loss of about one-quarter of the heat produced. Water cooling is not only costly and complex but, due to heat loss, significantly lowers heating of the spray material.

Figures 1 and 2 help explain why vortex flow eliminates this undue heat loss. Fig. 1 illustrates the cold-state mode. Oxygen is forced tangentially into a tubular flow path. Tangential velocities nearing the central axis approach an unsustainable level. A low-pressure eye forms. It remains centralized through the entire tube length. The outer main flow of cold oxygen is forced against the inner tube wall. Next, the gaseous fuel is injected axially into the eye. The low pressure eye is the easiest way to reach the exit. Little

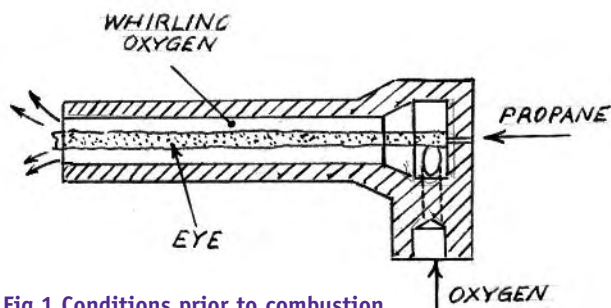


Fig.1 Conditions prior to combustion.

mixing into surrounding oxygen is evident. In turn, the oxygen flow picks up speed along its path. Beyond the exit oxygen's whirling motion is no longer restricted. It expands into the atmosphere with a strong radially outward path. A portion of combustible fuel and oxygen reverses direction passing back into and down the eye by forces imposed by the vacuum. The vortex flow emits a high-pitch squeal—which indicates everything is ready for hand-held sparker ignition. Instantly after ignition a supersonic jet flow rushes from the nozzle. Adjusting the flows produces the desired conditions for spraying.

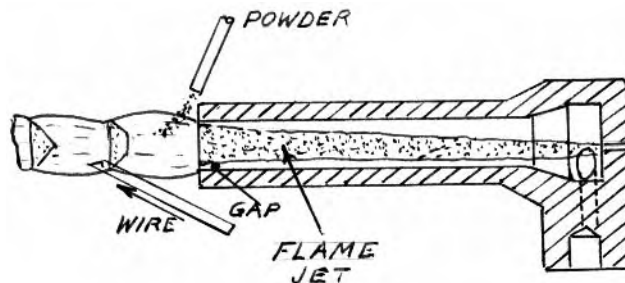


Fig.2 Conical flame condition during combustion.

Fig.2 shows the conical flame region within the tube. It happens that the rate of inter-diffusion of fuel gas and whirling oxygen is lower than the radial speed of combustion into the oxygen. Thus, the oxygen remains cold—even next to the advancing flame front of nearly 5,000°F. The flame-jet grows larger in its downstream flow. If it reaches the inner wall it may melt it. So, reduce tube length to the point where you can keep your hand on the metal. At this “safe point” a thin cold oxygen layer is present. No water cooling is needed.

If the vortex is strong enough a 1/2 in. diameter nozzle bore, 8-in. long, provides a supersonic jet which successfully sprays both wire and powder when introduced to the jet beyond the exit—a super flame spray! Obviously spray material injected beyond the gun exit leads to zero plugging of the nozzle. For wire, a simple hose loop directs the wire into and along the hot jet. The extended path within the jet provides a preheating level unobtainable in flame spray and arc processes. Increased spray rates result. For the 1/2 in. nozzle bore, 1/8 in. aluminum wire sprays at rates up to 30 lb/hr—3/16 in. wire to over 40. Stainless wire has comparable rates. Compared to the twin wire-arc, a single wire of the vortex HVOF gun replaces both wires of the arc process. Excellent coatings of molybdenum are easily obtained.



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**Mission:** To be the flagship thermal spray industry newsletter providing company, event, people, product, research, and membership news of interest to industrial leaders, engineers, researchers, scholars, policy-makers, and the public thermal spray community.

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SPRAYTIME (ISSN 1532-9585) is a quarterly publication of the International Thermal Spray Association.



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Article submissions (subject to acceptance and edit), advertising insertions, address correspondence, subscription request, back issue copies, and changes of address should be sent to:

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continued from page 2

Too little work (to date) has been done in the powder spray area. Exterior injection appears to produce coatings of zinc, aluminum, and copper equal to, or superior to, HVOF conventional straight-through gas flow. Oxide levels are lower than their wire counterparts. Densities are equivalent. Although higher melting point powders produce good coatings, deposit efficiencies may be low. Among the latter, stainless steel and chromium carbide/nickel chrome spray easily. [With preheating more difficult using powders, longer nozzles than possible in the un-cooled dry vortex gun will probably need water cooling which at the present time has not been studied sufficiently. Suffice-to-say,

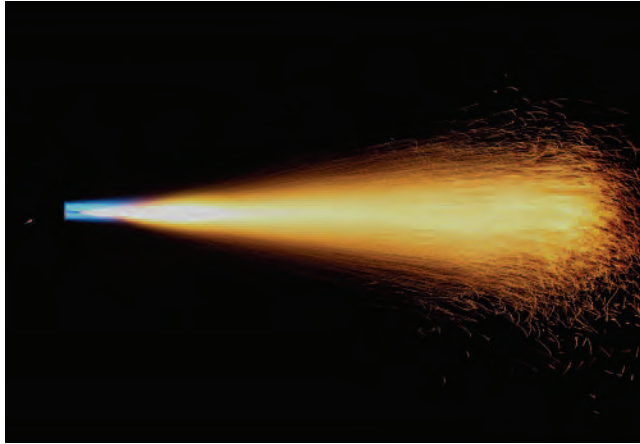


Fig.3 The droplet plume.

quench water injection into the flame has produced superb results using impact-fusion. In some cases, grit-blasting and other surface treatments were not needed.]

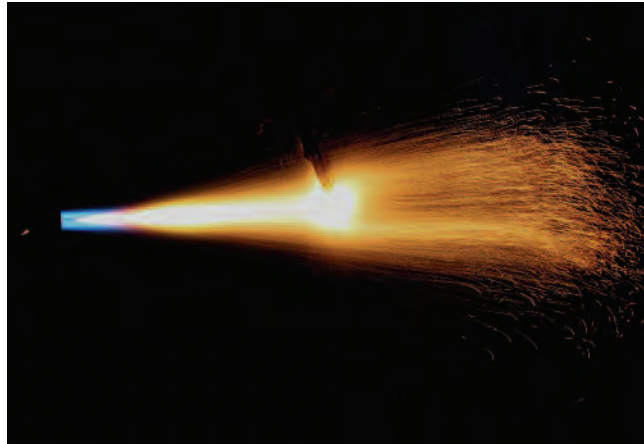


Fig.4 Coating in progress.

Figures 3 and 4 are photographs of the 1/2 in. bore unit in operation. Fig. 3 was decided upon to show plume narrowness compared to twin wire-arc. 1/16 in. 308 stainless wire at a spray rate of 20 lb/hr is shown. Apparently nearly all the molten particles reach high velocity. Few "satellites" are seen. Fig. 4 shows the 308 wire sprayed against a 2 in. diameter steel coupon hand-held at a stand-off distance of about 2 ft. Velocities of impact of the very small droplets eliminate most of the

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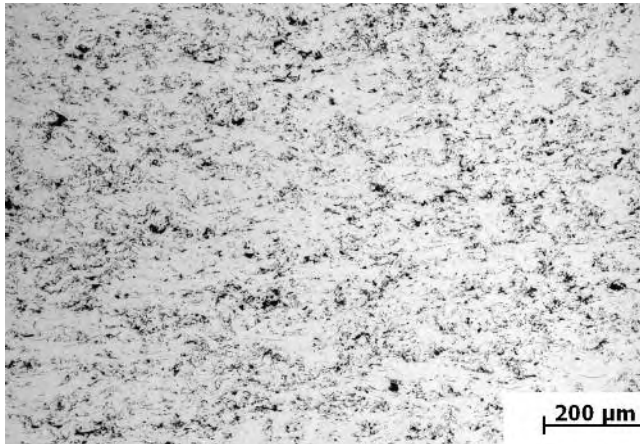
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"splash" and bounce-off of lower velocity arc spraying. The photos, in places, are overexposed. The test coupon is the circular image appearing about halfway along the plume path. The increase of brightness of the coupon may result from the release of impact energy raising each particle to higher temperature.



**Fig.5 Dry coating.**  
(1/16 in. diam Al wire) 1% Porosity

#### The Results

As aluminum is, perhaps, the most popular metal wire sprayed, vortex-sprayed coatings of it have been studied the most. Samples were sent to Prof. Heinrich Kreye in Hamburg, Germany. His resulting photomicrographs are quite revealing. Fig. 5 shows a coating produced using TAFE's 1/16 in. diameter O1T aluminum. The sample disk was positioned 8 in. downstream of the wire's atomization point. The coating is quite good, even compared to plasma spray. Porosity levels appear acceptable for most corrosion-protection applications.



**Fig.6 Quench water coating.**  
(1/8 in. diam Al wire) 0.1% Porosity

Work is currently being carried forward to study the effect of jet temperature reduction. By adding a quench flow of water to the combustion oxygen using a 16 in. long composite nozzle—the first 6 in. dry vortex flow—the remaining nozzle length water cooled. This "hybrid" arrangement led to startling improvements over the dry case of Fig. 5. Fig. 6 shows these improvements. TAFE 1/8

in. O1T was used. 2.4 lb/min of quench water was added to the oxygen. The exit flame changed in color from a blue-white to orange. The spray rate had to be reduced to 13 lb/hr. Stand-off distance was 16 in. Note the oxide reduction and the surprising 0.1% porosity reported from Hamburg. (That is one-tenth of one percent!)

Oxides are reduced as quenching lowers the flame temperature to below dissociation levels. As discussed by Prof. Horst Richter, Dartmouth College, at an HVOF meeting, Erding, Germany, such cooling essentially eliminates the main culprits—OH, CO and O. Added impact velocities result from a doubling, or more, of mass flow with jet momentum increases of about 30%. To speed up a slow moving particle, gas density outweighs the gas velocity.

#### Conclusions

No product is successful if not used. A comparison of substituting V-Gun wire spraying for other methods follows. Some biases could be expected, but no one can fault the low equipment and operating costs of these new devices.

#### V-Gun/Flame Spray

Wire—The V-Gun, using much higher flows of oxygen and fuel gas, more than makes up for this by increased spray rates, as well as reducing both coating porosity and oxidation. Compressed air acceleration is not used. Initial costs are about the same.

*continued on page 6*



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To submit your work for consideration, visit our website at [www.thermalspray.org](http://www.thermalspray.org), and then follow the instructions at the right hand corner "[Call for Papers Click Here](#)". All abstract submissions must be completed by close-of-business on Friday, May 1, 2009. Before submitting your abstract, we ask that you carefully consider your ability to present your work at the conference. Speakers are required to pay a (reduced) conference registration fee, and are totally responsible for their travel, housing and any related expenses.

This premier event is truly one that anyone involved in the thermal spray and coatings community should plan to attend.

Mark your calendar now, and if you are interested in presenting your work at the conference, ***submit your abstract no later than May 1, 2009.***

**A Poem by Jim Browning**

*It's HVOF and weighs but a pound  
That doesn't mean it makes no sound!  
No threads, no gaskets, no O-rings;  
Costs so low you'll want to sing.  
No water, no air, no electricity,  
The V-Gun's proud of its simplicity.*

**V-Gun/Plasma Spray**

Wire-Plasma, except for the transferred-arc case is not an effective wire gun except above 200kw! Plasma is hot—so hot that jet momentum is low. And, who sells 200kw units? Case does not apply.

**V-Gun/Conventional HVOF**

Wire-Conversion of existing HVOF equipment for the spraying of wire is simple. But, none of the manufactures (except for the early J-Guns) provide even simple front-end adaptors. With the development of the V-Gun, changes to existing units could cost more and would not be as effective.

**Closure**

If not practiced, the best inventions are not worth the paper they're written on. I believe keeping the equipment simple may reduce costs so significantly that a much larger-than-present market could be developed. Times are tough—"nothing new for us"—may be nearly universal. To me, let's get going and make and use new stuff that will sell more wire and powder. (Razor blades are where the profits lie.) Bridge construction and maintenance, without adequate corrosion protection is next to criminal. Europe is 50 years ahead of us. Check the history of the "new" Firth of Forth suspension bridge where Bill Ballard made his mark.

**For more information**, contact author Jim Browning, DRACO, tel: 603.632.7900, Post Office Box 6, Hanover, NH 03755



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## APMI Celebrates 50 Years!

In the late 1950s, restlessness within the ranks of the PM industry began to develop. Though MPIF was effectively serving companies in the industry, there was not an organization devoted to individuals, many of whom were not employed by MPIF-member companies or which were otherwise not eligible for corporate membership; and many were located outside North America. An opportunity arose to give such individuals a forum to exchange views and discuss technology as PM industry technologists and PM professionals.

So, in 1959 APMI International (formerly the American Powder Metallurgy Institute) was established with the support and collaboration of MPIF, sharing a common headquarters operation and governing body that was vital to the future of powder metallurgy. Whereas MPIF represented parts and raw material producers, industry suppliers and consultants; APMI represented individuals pursuing a career path in the PM technology.

After 50 years, APMI continues to be a global organization, an example of what happens when people with common interests band together. APMI remains the only global professional society representing individuals of the entire PM industry: parts fabricators, powder suppliers, equipment manufacturers, end users, and academia—



everyone who is anyone in this business.

To help celebrate the 50th anniversary of APMI, founding Executive Director Kempton H. Roll has put into words why and how APMI was created. You are invited to discover the tribulations and triumphs behind its creation. This historical article appeared in the January/February issue of the *International Journal of Powder Metallurgy*.

**For more information**, visit [www.mpif.org](http://www.mpif.org)

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### ITSA Announces "Supporting Societies" Membership Category

The International Thermal Spray Association is pleased to announce a new "Supporting Societies" membership category. The purpose of this category is to establish communication with other associations/societies involved in thermal spray and surface engineering activities.

This is an ideal method for membership exchange between organizations. If your organization is interested in a membership exchange to belong to the International Thermal Spray Association, please contact Kathy Dusa at the headquarters office via email to [itsa@thermalspray.org](mailto:itsa@thermalspray.org)



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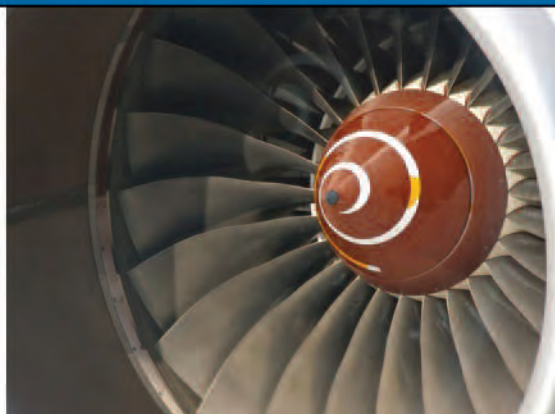
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## Sprayed Particle Diagnostics – Part 5

By Mo VandenBergh – VandenBergh & Associates

This series of articles focuses on the return of investment of particle diagnostic equipment. The first three articles focused on the “easy” applications – applications that proposed payback through comparison of results, recognizing questionable results compared to ones of a “known preferred or specified result”. A thorough understanding of each measurement or the measurement process and the precision of the measurements to some extent could be overlooked. Subsequent to the first three articles, articles 4 and 5 require more precise measurements and will require a better understanding of the measuring processes.

Part 4 of this series started the discussions of the more complex use of particle diagnostics in R&D Applications in examining payback by first presenting basics of the most common measuring devices. This was approached by posing a series of seven questions followed with a brief presentation for each of the first five questions. This article will attempt to provide answers to the last two questions. All seven questions are provided below:

1. What diagnostic equipment is available?
2. What are the physical setup capabilities and limitations?
3. What characteristics are measured?
4. How are the measurements collected?
5. How are the measurements treated?
6. What measurements can be collected and stored?
7. How can the information be used?

In answering the last two questions this article will focus around only one measurement system; the one most familiar to the author and perhaps the one with the most detailed information. With the discussion for each of the last two questions, an early experience will be used to demonstrate the collection and use of stored data.

### What measurements can be collected and stored?

The diagnostic system used for this discussion (Oseir SprayWatch™) records information at the command of the operator in addition to an automatic log system that will record a limited amount of data any time the system is in operation and taking measurements or when there is a change in the system (on, off, change in profile, etc.) This automatic recording is made on selectable intervals, recorded in a folder named “log” and consists of entries similar to:

```
21:32:42
Spray detected

21:32:52
SprayTemp (deg C) 1810.84
Velocity (m/s) 649.93
Flux (a.u.) 37.46
Position (mm) 5.70
Heading (deg) 0.79
Width (mm) 7.75
Divergence (deg) 1.38.
```

As other measurements are only recorded when prompted, this is a valuable tool in looking back to see when a process may have undergone a significant event or change.

While required to start the diagnostic system for recording or playback, the “profile” of the camera and display settings will be chosen. Some of the information can be changed for ease of viewing; some is for information only while some of the settings will dictate how the system will perform. The Profile Pages chart on page 10 illustrates examples of some of the pages of the profile.

continued on page 10

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Reference	Camera	Profile Pages		Log	Display	Report
	Pexp	Selections for:		Frequency (time)	Ranges for	Report Period (time)
	Texp	Interval for averaging		Included?	Temp	Heading
	Aperture	Filters		Alerts	Velocity	Strip Charts
	Focus	Particle Count Threshold		Data	Flux	Distributions
	PhBin	Surface Temp.		Distributions	Heading	
	Pvbin			Settings	-	
	Thbin				-	
	TVBin				-	
	Gain				-	
	Control				-	
	Measure				-	
	Distance				-	

or during the playback of recorded images. The report can be named and is stored in a reports folder with a date and time stamp. Time and date as well as a description of the report can be added but are not shown here.

2. A recording of one or more of the following can be collected any time during the spray process for any number of images. Recordings can be made on either individual particle data or the compound rolling average of the data.

- Images
- Running averages, from a selected number of images and or particles,

The profile information is recorded along with the image and will be present when in playback mode. If care is taken in correctly entering system information for a specific event, subsequent events under the same situation, barring any process change, will show the same results.

Beyond the recordings indicated above, the operator chooses when and what to record and has basically two choices:

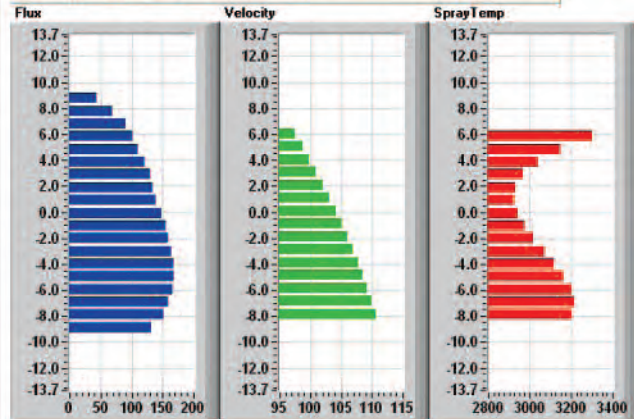
1. An html report - information similar to that shown below. This information can be collected and printed any time during monitoring of the thermal spray process

for:

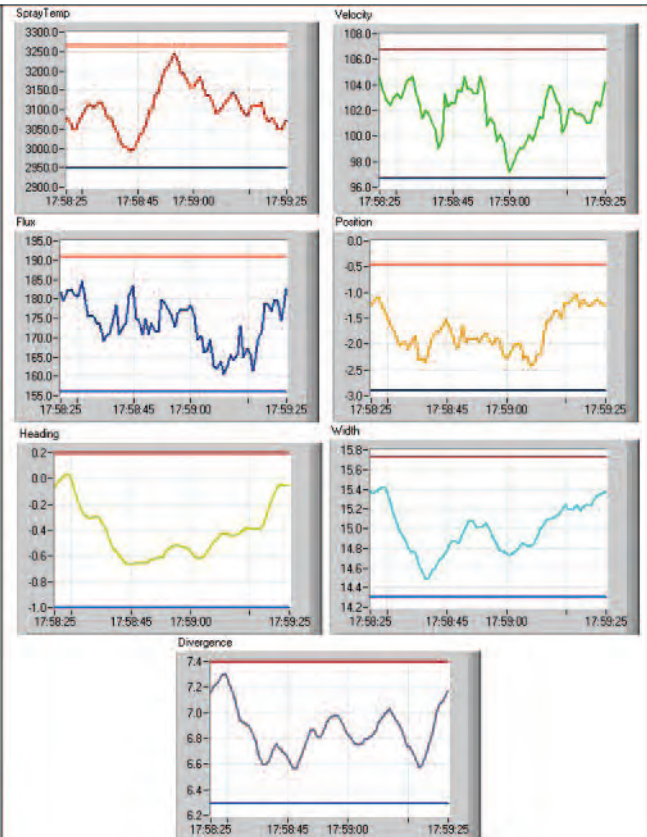
- Particle Temperature
- Particle Velocity
- Particle Flux/Count
- Plume Position (vertical distance off center line of gun axis at target)
- Plume Heading
- Plume Width
- Plume Divergence
- Particle Temperature Standard Deviation
- Particle Velocity Standard Deviation

#### Data Channels:

	Unit	Mean	Std	Limits	Status
<b>SprayTemp</b>	degC	3105.17	58.55	2946.84 - 3263.35	
<b>Velocity</b>	m/s	101.82	1.82	96.71 - 106.70	
<b>Flux</b>	a.u.	173.38	6.10	155.94 - 190.86	
<b>Position</b>	mm	-1.75	0.40	-2.91 - -0.45	
<b>Heading</b>	deg	-0.42	0.21	-1.00 - 0.19	
<b>Width</b>	mm	14.98	0.25	14.30 - 15.73	
<b>Divergence</b>	deg	6.86	0.19	6.29 - 7.40	



Vertical Distributions of Particle Characteristics through the plume



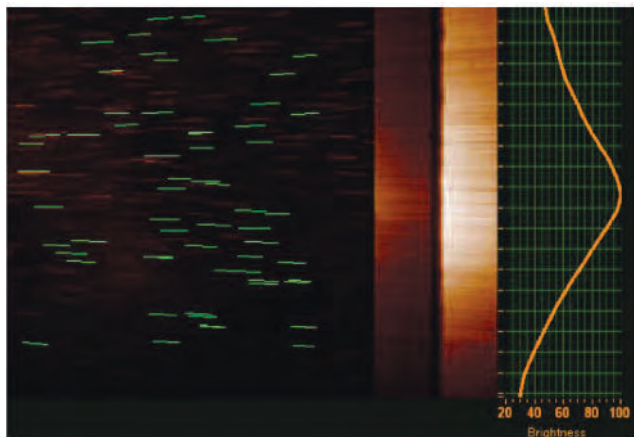
Strip Charts of Particle or Plume Characteristics



- Particle Flux/Count Standard Deviation
- Plume Position Standard Deviation
- Plume Heading Standard Deviation
- Plume Width Standard Deviation
- Plume Divergence.

• Data from each particle highlighted in each image collected.

Below is a typical image with measured particles highlighted. The vertical strips are wave length filters by which the temperature of the particles is measured using two color pyrometry. The curve on the right indicates the relative brightness distribution of the plume.



The following are examples of several lines of data that are recorded in text files for "Average Data" and "Particle Data".

Time	SprayTemp	Velocity	Flux	Position	Heading	Width	SprayTemp	VelocitySTD	FluxSTD	PositionS	Heading	WidthSTD	Divergence
51:20.2	3373.46	138.51	131.69	0.42	-0.13	14.31	46.56	2.62	31.45	0.53	0.24	0.25	6.62
51:20.9	3340.63	136.94	126.69	0.41	-0.12	14.3	42.66	2.55	32.85	0.53	0.24	0.25	6.51
51:22.2	3360.93	137.59	128.4	0.39	-0.11	14.3	35.55	1.73	33.45	0.55	0.25	0.26	6.43
51:23.5	3346.3	135.59	128.57	0.34	-0.15	14.28	21.61	2.01	35.01	0.52	0.21	0.26	

Time	x1	y1	x2	y2	Length (pix)	Velocity (m/s)	Brightness	Angle	DoF (mm)	Pix width (um)	Pix height (um)
51:20.2	304.6	426.8	324	428.2	754.21	94.3	230.2	-4.36	43.3	38.7	38.7
51:20.2	270.8	424.2	293.8	425.9	894.64	111.8	305.5	-4.36	43.3	38.7	38.7
51:20.2	288.9	361.9	307.6	362.9	726.92	90.9	273.3	-3.16	43.3	38.7	38.7
51:20.2	279	345.4	305.5	346.7	1025.01	128.1	277.7	-2.85	43.3	38.7	38.7
51:20.2	276.4	342.6	300	343.7	912.08	114	257.9	-2.8	43.3	38.7	38.7
51:20.2	279.6	289.9	305.7	290.7	1011.59	126.4	328.3	-1.8	43.3	38.7	38.7
51:20.2	283.3	258	307	258.5	917.64	114.7	332.2	-1.19	43.3	38.7	38.7

#### How can the information be used?

Once images are saved they can be replayed. During replay, Images, Running Averages and Particle recordings can again be recorded with some changes in the profile such as the number of images to include in the averaging calculations or filters may be added in analyzing the images. The obvious restriction in the replay is one cannot change the image itself or the area or volume for which the image was taken was captured.

#### An early experience!

During an exercise, in 2006, of comparing process cells of an early model plasma gun (Torch 1), using nitrogen/hydrogen and a fluidized feeder; according to the manufacturers' recommended parameters; two interesting

trends were observed:

1. A relatively high particle temperature for the material being sprayed
2. A highly variable range in the particle temperature measured.

Both cells exhibited the same trend along with variations between the cells.

In an attempt to understand the process further the plasma gun and powder feeder were swapped with an internal feed, plasma gun (Torch 2), and a volumetric feeder using suggested parameters and hardware which called for argon/hydrogen gas. Also a much lower feed rate of material was used (approximately  $\frac{1}{2}$ ). This combination produced a much lower and stable average particle temperature (one only a couple of hundred degrees above the melting point of the material) as well as a higher velocity. The desired coating property measured 150% of the product being produced, while doing so at greater energy efficiencies, deposition efficiencies, and longer hardware life. No real effort was made to optimize the parameters.

In order to compare data obtained from the two systems, recording of images, running averages and particles were collected and the average data was graphed for particle temperature, velocity and flux. The running average at the time was 10 images. On page 12 you will find the graphs of particle temperature, velocity and flux/count shown after analyzing the images at a running average of 1 and 60 images. Following the graphs is a table showing the results

of all the measurements under those conditions.

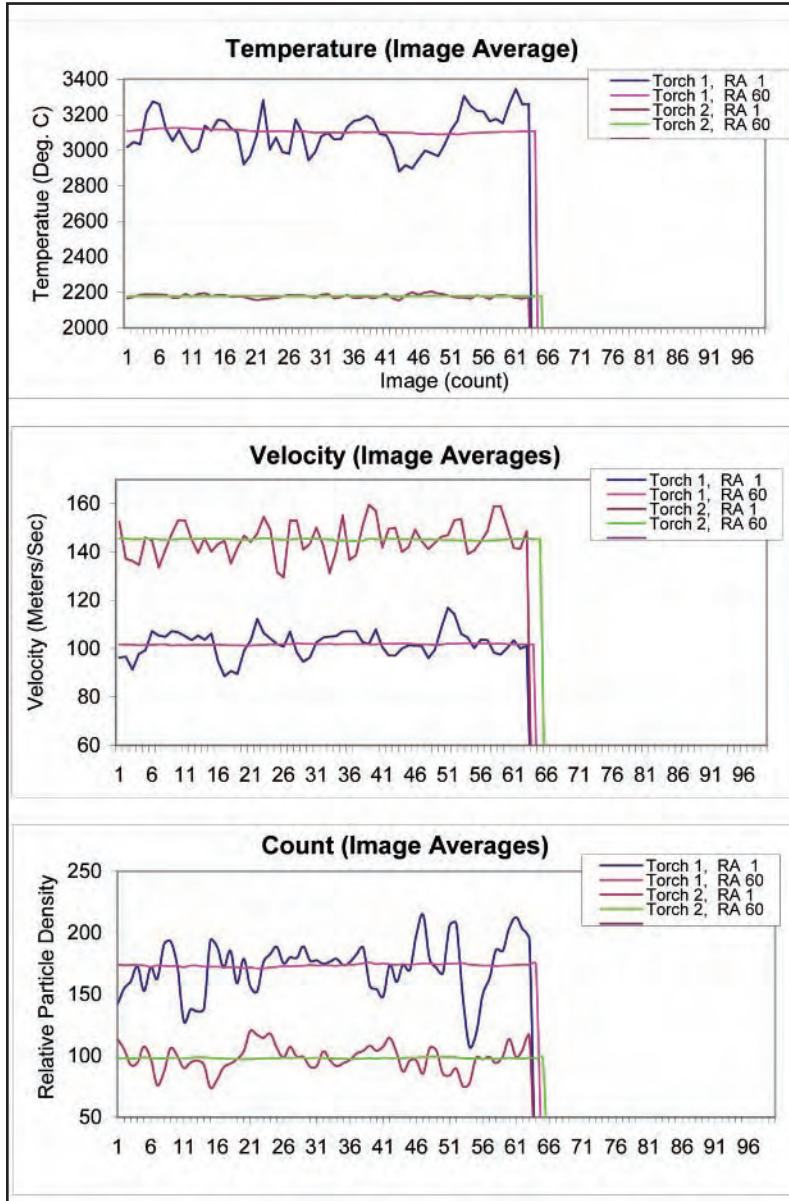
One will notice from the graphs how long running averages of the data can hide the variability of the process as was suggested in the discussion in article 4 under the question of how is the data treated.

This experience is just a hint of the kind of information that can be obtained through particle diagnostics. Only temperature and perhaps variability to some extent were of major consideration in this example and while there were many other reference points, many seem to place emphasis on only two reference points:

1. Particle Temperature
2. Particle Velocity .

continued on page 12

continued from page 11



The other reference points are mostly being ignored and that may in some cases be sufficient for monitoring results. It was confirming recently to see a supplier incorporate particle flight characteristics in their product data sheet. For roughly the same material chemistry as examined in the experience shared in this article, the supplier, using AccuraSpray, reported the following with their equipment and suggested parameters.

Particle Velocity (m/sec) 150 to 155

Particle Temperature (°C) 2150 to 2200

This might suggest that the two available measurement processes, SprayWatch (described in this article) and Accuraspray, may be able to produce similar results if all that is needed to define or check a process is particle temperature and velocity? With lack of extensive data for the many materials available, the added information of plume dimensions, particle count, and particle distributions could prove valuable.

In keeping with the theme of payback, changes made through this experience provided significant savings in material, energy, labor and hardware while adding to the quality of the product. Unfortunately at the time, little effort was placed on optimizing the process or developing a quantitative return on investment.

Articles to follow will share more field experiences as well as new developments.

**For more information** or if you have any questions or suggestions, please contact Mo VandenBergh at VandenBergh & Associates, Inc., 5641 Station Hill Dr., Avon, IN 46123, e-mail [Mo\\_VandenBergh@earthlink.net](mailto:Mo_VandenBergh@earthlink.net), tel: 317.718.8403, [www.MoVandenBergh.com](http://www.MoVandenBergh.com)

INDUSTRY NEWS

Test Runs		Data at Reported Running Averages												
Variable Changes	Spray Temp	Velocity	Flux	Position	Heading	Width	SprayTempSTD	VelocitySTD	FluxSTD	PositionSTD	HeadingSTD	WidthSTD	Divergence	
Spray System														
Torch 1, RA 1	3,100	102	172	-1.72	-0.40	15.02	56.58	2.77	30.67	1.43	0.13	0.23	6.86	
Torch 1, RA 60	3,105	102	173	-1.74	-0.41	15.00	8.83	0.58	34.35	1.58	0.33	0.49	6.87	
Torch 2, RA 1	2,178	144	99	-1.67	-2.46	12.59	6.76	4.94	13.16	0.75	0.09	0.12	6.05	
Torch 2, RA 60	2,178	145	98	-1.64	-2.55	12.61	0.36	0.22	16.07	0.80	0.33	0.35	5.78	

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## Cold Gas Spraying Increasingly Accepted in Industry

New cold gas spraying technology utilizing rare materials has opened up many new industrial applications.

After years of research efforts in the field of cold gas spray techniques, the first fruits can now be harvested. As an addition to tried and tested processes, this new technique provides access to markets which had hitherto been excluded.

Today's state-of-the-art technology has generated a wealth of opportunities to discover new and innovative applications on a scale never seen before. Those coating contractors who have realized this and have come on board are already pioneering applications in industrial sectors and in processes that would have been impossible with conventional thermal spraying.

### Focus on process cost

In the context of their research and development on hardware and substances, Linde has built up many new contacts with companies and so is constantly dealing with exciting and challenging questions. Process cost has always been at the center of our research. Our ultimate ambition in advancing cold gas spray technology has been to use nitrogen as a process gas. Applications requiring helium will continue to be employed, but only where the high cost of the gas and its expensive recycling method justify this.

Currently there are 50 such systems in operation worldwide, installed in job shops and at research facilities; coating job shops account for about 30 percent of these. Within the last two years however, 80 percent of the equipment sold has been acquired by industry – evidence that the benefits of potential new applications have been reconsidered.

### New materials and applications

Copper is nowadays of minor importance in cold gas spraying. Meanwhile, expensive rare metals such as niobium, zirconium, tantalum or titanium have been increasingly in demand. Also, iron- or nickel-based materials as well as copper-based alloys allow for new applications.

The tasks are of a wide variety. Only some of the new possibilities will be mentioned here as examples: for instance, the fabrication of geometrically complex sputter targets, and their maintenance and repair; or bearing

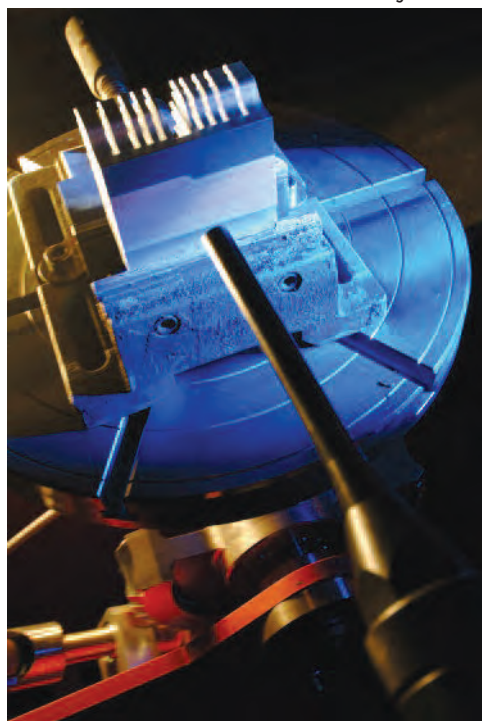
carriers made of bronze alloys, which have far better gliding properties due to their low oxide content; or iron alloys for cooking pots designed for inductive ceramic cookpots; or contact surfaces on toggle switches.

### Latest developments

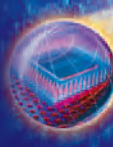




Tantalum and zirconium have great potential as anticorrosive protective layers for special appliances due to their extremely low oxygen content. Many more novel applications will be added in future. Some of the most recent areas of research attempt to produce cold gas sprayed zinc coatings which can be etched by laser beams. These would substitute for the thick copper layers which require machining by diamond-tipped tools.

A technology with a future is the coating of heat sinks for heavy-duty electronic components.

**For more information**, contact Werner Kroemmer, Research and Development Department, Thermal Spray laboratory, Linde Ltd., email: [Werner.Kroemmer@linde-gas.com](mailto:Werner.Kroemmer@linde-gas.com), web: [www.linde-gas.com](http://www.linde-gas.com)



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## CenterLine-SST Receives NRC-IRAP Support for New Advanced Solid State Spraying Process

CenterLine (Windsor) Ltd. is pleased to announce that it has received a contribution from the National Research Council Canada Industrial Research Assistance Program (NRC-IRAP). Subject to the terms of the agreement, CenterLine (Windsor) Ltd. will receive approximately \$400,000 over one and a half years in support of CenterLine's efforts to develop a novel solid state spraying process.

Dr. Julio Villafuerte, head of research and development at CenterLine, says that "the NRC-IRAP support represents yet another milestone for the company whose strategy is to diversify its customer base by creating innovative products and services". For over 50 years, CenterLine has been a leader in welding and joining for the automotive and mass transportation industries.

In 2003, Centerline made a decision to develop and commercialize low-pressure cold spray equipment. Cold spray technology, invented in Russia in the 1980s, allows the user to spray metals on virtually any surface at low temperatures thus avoiding oxidation, material degradation and residual stresses, typical of traditional metal spraying processes. The NRC-IRAP program was paramount to push the initial implementation of low-pressure cold spray technology by Centerline for field applications. Centerline recently adopted the commercialization of a novel method invented at the University of Ottawa. This new project represents yet another milestone for solid-state spraying. This novel method also allows the spraying of harder materials such as titanium, steel, nickel, and cermets at incredible deposition efficiencies and rates while being more cost effective than current high pressure cold spray technology. The benefits of this method are similar to Centerline's portable technology but for a wider range of materials at higher deposition efficiencies and rates. Working directly with CenterLine, NRC-IRAP will provide a range of both technical and business oriented advisory services, along with financial support to help the enterprise achieve its financial goals.

**For further information**, please contact Julio Villafuerte, Director of R&D, CenterLine (Windsor) Ltd., 595 Morton Drive, Windsor, Ontario, N9J 3T8, Canada, email: [Julio.Villafuerte@cntrline.com](mailto:Julio.Villafuerte@cntrline.com)

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## CO<sub>2</sub> Cooling for Thermal Spray Advances

By David Jackson, Cool Clean Technologies and Maurice (Mo) VandenBergh, VandenBergh & Associates

### Something old is new again (only better)

Conventional carbon dioxide (CO<sub>2</sub>) cooling and snow spray or pellet blast cleaning technology has been available to thermal spray coating engineers for many years. Today, newer, much more capable and versatile CO<sub>2</sub> technology is being introduced as new thermal spray process tools. Industries worldwide have investigated and implemented advanced CO<sub>2</sub>-based clean manufacturing technology as an alternative to energy-intensive, resource-wasting and polluting industrial processes. Western Digital, Pentel, Gillette-PaperMate, Raytheon, Seagate, Hughes, and TRW are examples of businesses that have implemented advanced CO<sub>2</sub> manufacturing technology in one form or another and have improved the productivity, environmental quality, and profitability of their operations (1-4). Although new to most thermal coating engineers, advanced CO<sub>2</sub> technology promises several benefits. Advanced CO<sub>2</sub> composite sprays provide a unique combination of thermal spray process tools including surface preparation (i.e., both etching and precision surface cleaning), temperature control during coating to increase target efficiency (increased percentage of time on the part) and cooling-lubrication during post-finishing (i.e., machining) processes.

### Advanced "CO<sub>2</sub> composite spray" technology

CO<sub>2</sub> sprays have been used commercially for cleaning and cooling applications for many years. Properly designed conventional systems can be effective for a limited number of cleaning or cooling applications. However, operating cost is always a prime concern, along with a need for effective process control, both of which have proven to be a challenge for conventional CO<sub>2</sub> processes. This is particularly true in high capacity applications. Moreover, adaptability to process tools has been very difficult.

Advanced CO<sub>2</sub> composite spray technology addresses the drawbacks and limitations of conventional CO<sub>2</sub> spray cleaning and cooling processes. CO<sub>2</sub> composite spray technology provides several process control and performance advantages. These include CO<sub>2</sub> conservation, impact stress control, precise temperature control, additive technology, and easier adaptability to automation and process equipment. Moreover, CO<sub>2</sub> composite spray technology has been adapted to address the needs of modern machining, providing near-dry to dry cooling-lubrication functions during processes such as turning, milling, stamping, and drilling. Figure 1 on page 16 illustrates the patented, Coanda nozzle and composite spray technology used in combining the components of the cooling spray. While Figure 2 presents a graph of the cooling spray temperatures as the system is adjusted.

continued on page 16



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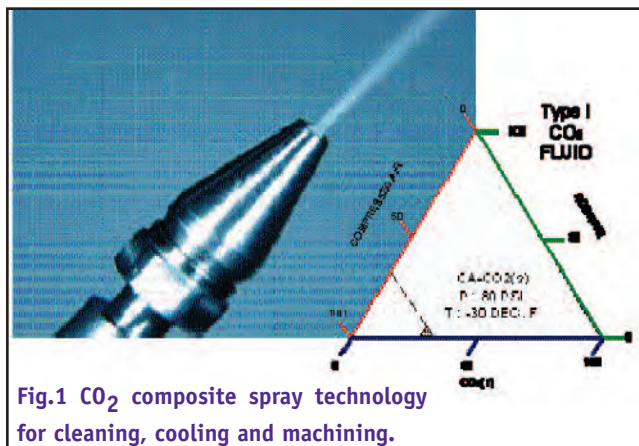
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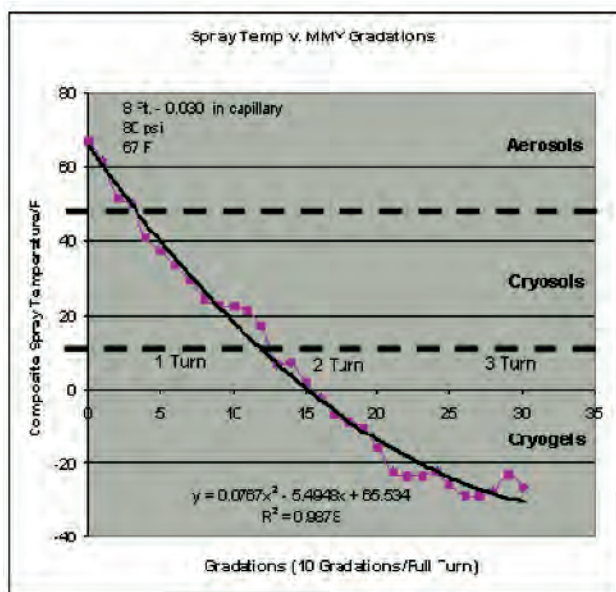






**Fig.1 CO<sub>2</sub> composite spray technology for cleaning, cooling and machining.**

Referring to Figure 1, a CO<sub>2</sub> composite spray has three ingredients; 1. CO<sub>2</sub> particles having a certain size and concentration, 2. clean compressed air (CA) having an adjustable pressure (P), temperature (T) and flow, and 3. optional additive component comprising an adjustable microscopic flow of liquids (i.e., lubricants) or solids (i.e., micro-abrasives). The patented, Coanda nozzle technology is used to combine the ingredients and deliver the spray composition to a surface. The ternary diagram above suggests a 70% air-30% CO<sub>2</sub> composition.

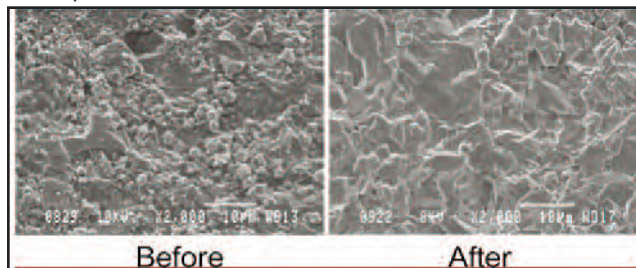


**Fig.2 Precise spray temperature control.**

Figure 2 shows an exemplary temperature profile for a CO<sub>2</sub> composite spray given the setup indicated in the top left corner (air at 80 psi and 67°F). As the percentage of CO<sub>2</sub> is increased, the temperature of the cooling stream decreases. Spray temperatures as high as +300°F to less than -70°F can be produced depending upon a particular composition employed.

Unlike high pressure liquids and gases, a CO<sub>2</sub> composite spray can generate impact stresses as high as 60 MPa, and much higher if micro-abrasive, solid additives are incorporated within the spray composition. It is this physical property, as well as the unique chemistry of CO<sub>2</sub>, that

provides the basis for its excellent cleaning, cooling and lubricating performance. For example, Figure 3 is a SEM photomicrograph showing the ability of a CO<sub>2</sub> composite spray to remove sub-micron aluminum oxide particles from a complex surface.



**Fig.3 Precision sub-micron particle and film removal.**

CO<sub>2</sub> technology is a clean manufacturing solution for thermal spray engineers

Clean manufacturing practices are continuous preventive measures that concentrate on optimizing manufacturing resources and processes to minimize or eliminate wastes of various forms. Advanced CO<sub>2</sub> technology reduces waste generation at the production operation level (source) by modifying the manufacturing processes themselves. For thermal spray processes, advanced CO<sub>2</sub> composite spray technology provides a combination process modification capabilities, as follows:

1. Surface preparation: micro-roughening, etching and precision cleaning,
2. Temperature control: maintenance of substrate surface temperature during coating within an upper and lower control boundary, and
3. Post-operations: precision cleaning and machining operations for following manufacturing procedures or dimensional requirements.

Replacing conventional surface cleaning agents with CO<sub>2</sub>'s green chemistry eliminates process inputs such as liquid cleaning solvents, aqueous clean agents, detergents, dionized rinse water, and heated air dryers, among other waste-producing inputs. For temperature control, the remarkable cooling efficiency of solid carbon dioxide particles due to three-phase heat extraction involving sublimation, boiling liquid and gas provide superior heat capacity for maintaining surface temperatures during thermal spray coating as compared to cold air or nitrogen.

Another benefit is that the cooling spray is also a very energetic cleaning spray, which simultaneously dislodges loosely adhering coating particles during the coating process. In post-coating operations, CO<sub>2</sub>-based advanced minimum quantity cooling lubrication (AMQCL) replaces flooded cutting fluids and associated waste-producing operations such as metalworking fluids management, waste hauling and air pollution control. In particular CO<sub>2</sub> machining fluid technology enables the economic use of advanced cutting tools employing diamond or CBN for machining hard or abrasive substrates, while delivering improved surface finish and cleanliness.

continued on page 18





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continued from page 16

Since there are a number of potential applications for the CO<sub>2</sub> beyond just cooling parts during thermal spray and because there are a number cooling processes and associated costs, the next article will discuss the benefits of using CO<sub>2</sub> vs. other gases and cleaning processes from an environmental and cost basis.

#### Summary

#### Benefits of Using CO<sub>2</sub> Cooling With the Thermal Spray Process

##### Thermal Spray Coating Benefits

- Decreased cleaning and handling cost  
Time, materials and disposal
- Increased target efficiencies  
Powder savings  
Energy savings  
Faster coating times  
Increased production  
Greater capital utilization  
Decreased labor per part
- Improved coating characteristics  
Cleaner interface  
Controlled coating stress

##### Improved Post-Coating Benefits

- Longer machining tool life
- Higher machining speeds/feeds



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**For more information** please contact: David Jackson, Chief Technology Officer for Cool Clean Technologies by e-mail: David.Jackson@coolclean.com or telephone: 661-775-5964 or Mo VandenBergh by phone: 317-718-8403, e-mail, mo\_vandenbergh@earthlink.net or by web: www.MoVandenBergh.com

#### New Brochure Describes HemiPleat® Retrofit Dust Collector Cartridges

A new brochure from Farr Air Pollution Control (APC) makes it easy to retrofit existing dust collection equipment with Farr HemiPleat® filters for upgraded performance. The four-page brochure describes the full line of "HemiPleat Retrofit Cartridges", using a simple cross-reference table and ordering chart to facilitate filter selection for virtually any type of cylindrical cartridge-style collector.



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**For further information**, contact Farr APC at (800) 479-6801; fax (800) 222-6891; or write to Farr APC, 3505 S. Airport Road, Jonesboro, AR 72401; e-mail filterman@farrapc.com; web www.farrapc.com. For a downloadable copy of the brochure, go to: <http://www.farrapc.com/literature/data-sheets/retrofit-cartridge.pdf>.

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Story on page one.

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## Praxair Surface Technologies Introduces Closed-Loop Controlled Powder Feeders That Boost Productivity and Improve Consistency

Praxair Surface Technologies Inc., a wholly-owned subsidiary of Praxair Inc. (NYSE: PX), today introduced TAFE models 1264i and 1264WL closed-loop controlled powder feeders. The 1264i powder feeder is a major redesign of the world renowned model 1264 feeder that includes latest generation electronics, improved ergonomics, and enhanced features current 1264 feeder users desired to help boost productivity, reduce costs, and improve consistency. The 1264i feeder includes a sophisticated touch-screen operator interface terminal (OIT) pendant that can be remotely located, a programmable logic controller (PLC) for powder feeder control, state-of-the-art electronics, and a removable, expanded-capacity powder hopper.

Based on the proven, volumetric-feed technology of the model 1264 feeder, the 1264i feeder increases powder feed accuracy by close-looping rpm control of the feed wheel. For even more improved powder feed accuracy and reliability, the model 1264WL feeder offers weight-loss control capability.

### Increased spray time

The 1264i feeder incorporates a quick-change hopper that holds 30 % more powder than previous generation hoppers.

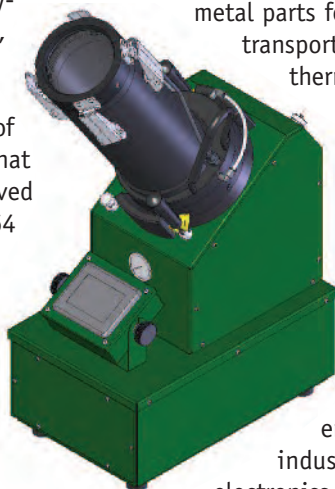
The new hopper has a capacity of 300 in.<sup>3</sup> (4916 cc) and is rated for pressures of up to 125 psi (862 kPa). The design allows for rapid hopper replacement reducing downtime when switching between powders and preventing cross-contamination by dedicating a hopper for each type of powder. Spare hoppers can be used for storage of

Optional spare hopper storage rack.

excess powder. An optional hopper storage rack allows safe storage of spare hoppers and includes receptacles for heater blanket plug-in.

### Control powder feed rate by weight

The model 1264WL powder feeder includes all the features of the model 1264i feeder as well as load cell technology that delivers an enhanced level of reliability in weight-loss control of the powder feed rate. Through rapid weight-loss over time calculations, the 1264WL feeder automatically calibrates the powder feeder to the pre-programmed powder feed rate and maintains that feed rate for the duration of the spray run.



Model 1264WL powder feeder.

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Praxair produces and markets high-performance coatings that reduce the harmful effects of abrasion, oxidation, corrosion, erosion, wear and extreme temperatures on metal parts for the aviation, power generation, oilfield, transportation, and printing industries as well as thermal spray equipment and powder.

Praxair Inc. is the largest industrial gases company in North and South America, and one of the largest worldwide, with 2008 sales of \$10.8 billion. The company produces, sells and distributes atmospheric, process and specialty gases, and high-performance surface coatings. Praxair is a recognized leader in the commercialization of new technologies that bring productivity and environmental benefits to a diverse group of industries, including aerospace, chemicals, electronics, energy, food and beverage, healthcare, manufacturing, metals and others.

For more information on Praxair, visit [www.praxair.com](http://www.praxair.com) or [www.praxair.com/thermalspray](http://www.praxair.com/thermalspray).

## International Thermal Spray Launches New Website

The ITSA website now includes an "employment" and "for sale" area.

*SPRAYTIME* issues are included in this website with content search capability.

Visit [www.thermalspray.org](http://www.thermalspray.org) to see our new look and valuable industry information.

## Would You Prefer to Receive *SPRAYTIME* Electronically?

If you would prefer to read the *SPRAYTIME* newsletter online, please send an email to [spraytime@thermalspray.org](mailto:spraytime@thermalspray.org) and let us know your preference.

You can request an online version only (no print copy will be sent to you) or both an online and a print copy. We will then send you an email message when the next *SPRAYTIME* issue is ready to be viewed online.

## Creative Thermal Spray Coating Solutions

- Met Lab for Testing, R&D, Material Applications
  - Spray Booth devoted to R&D
  - Coating Technology includes HVOF, Plasma, Arc Spray
- Aerospace, Military, Power Generation, Automotive, Petrochemical, Pulp & Paper, Printing, General Industrial

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## Sulzer Celebrates 175th Anniversary

(Following is the introduction to new Sulzer publications.)

"Dear readers,

Experience Sulzer: This is the motto with which our company celebrates its 175th anniversary in 2009. We want to show what the Sulzer name stands for. Our vision is to be a recognized leader in innovative, sustainable, engineered, and customer-focused solutions for performance-critical applications in six main markets: the oil and gas, hydrocarbon processing, power generation, pulp and paper, aviation, automotive and other selected industries. The focus of this anniversary publication is how Sulzer products and services provide solutions to make our customers more competitive.

Since its founding in 1834, Sulzer has been a reliable partner, satisfying high expectations and delivering what it promises. From the beginning, Sulzer has transformed the latest engineering know-how into innovative solutions to serve customers' needs. From very early on, Sulzer has taken a global approach, building a worldwide client base while establishing a multi-local presence. This is how Sulzer has become what it is today: a technology company that continually renews itself, resulting in leading positions in important global markets.

From the industrialization of the 19th century to the high-technology society of the 21st century, priorities and challenges have changed dramatically. In the past, Sulzer's steam and diesel engines contributed significantly to these changes—replacing the need for heavy human labor with machinery. Today, the challenge is to satisfy an increasing demand for oil and gas, electricity, mobility and paper while ensuring that natural resources are used efficiently in order to minimize the environmental impact.

Reliability, innovation and global thinking remain essential for Sulzer to master the challenges of the future. In doing so, we thank our 12,500 employees for their sustained dedication and our clients around the world for their continued trust.

Enjoy the reading."



**Ton Büchner, CEO**

**For more information** on these publications, visit [www.sulzer.com](http://www.sulzer.com)

## PAS Technologies Received Best Emerging Business Improvement Deployment Award

PAS Technologies announced today that it has been selected as the winner for the Global Six Sigma and Business Improvement Awards in the category of "Best Emerging Business Improvement Deployment." The award was accepted on behalf of all PAS Technologies' employees by **Robert Weiner** (right), President and CEO at the WCBF 2008 Gala Awards Dinner and Ceremony on Wednesday, October 15th at The Gaylord Palms Resort and Convention Center in Orlando, Florida.

Robert Weiner, President and CEO said. "This award is a testament to the hard work and dedication of our employees. The great thing is that when PAS Technologies wins awards for process improvements, it is an indication that

our customers are winning, too – through the best delivery times, quality and customer satisfaction. "

The Global Six Sigma and Business Improvement Awards are given to companies and individuals who demonstrate the most outstanding organizational achievements through the deployment of business improvement programs. The focus of the awards program is to demonstrate to the global business community the real results and excellence that organizations achieve through the successful deployment of Six Sigma and other business excellence programs.

A privately held corporation headquartered in North Kansas City, Missouri, PAS Technologies Inc., specializes in providing cost-effective repair and overhaul solutions for the aerospace, oilfield and industrial markets. By using innovative and proprietary high-technology repair processes, along with repair solutions licensed from OEMs, the company saves its customers from having to purchase costly replacement parts. It services a broad range of components, including gas turbine engines, critical airframe parts, gates and seats used in oil fields, specialized provider of services to the power generation industry, and components used in other industrial high-wear, high-heat and highly corrosive environments.

**For more information**, visit [www.pas-technologies.com](http://www.pas-technologies.com)



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**[www.spraytime.org](http://www.spraytime.org)**

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***New Developments in Thermal Spray Coatings,***  
***Processes and Applications Conference***  
**Story on page one.**



## Praxair Surface Technologies Unveils 8830MHU Arc Spray System with Enhanced Features and Improved Controls

Praxair Surface Technologies Inc., a wholly-owned subsidiary of Praxair Inc. (NYSE: PX), today unveiled the TAFE 8830MHU arc spray system featuring state-of-the-art features and controls.



The 8830MHU arc spray system, the latest generation design of the world renowned model 8830 system, uses advances in arc spray technology to enhance quality, repeatability, and versatility of arc spraying. The 8830MHU system control console can now be unbundled for maximum application versatility. Enclosed wire covers and console-mounted voltage control and amperage readout allow for easier use, and safe, precise operation.

### Enhanced Power Supply

An optional, enhanced power supply developed exclusively for arc spray operation results in smoother operation, higher deposit efficiencies of most materials, and improved coatings. The TAFE 353ECV power supply utilizes sophisticated control technology that minimizes operating arc voltage to reduce coating oxide levels and, depending upon material being sprayed, significantly increase deposit efficiency.

### 25-Years Later: TAFE 8830 Arc Spray Gun Remains the Industry Standard

The extra heavy-duty, 350-amp TAFE 8830 arc spray gun, featuring precision spray rate, has been the industry standard for reliable arc spraying for over 25 years. Design features include reliable air turbine driven wire drive motor, integrated high velocity, focused spray pattern alignment housing, quick disconnect wire conduits, and a proven, robust drive design. Options include ArcJet® spray attachment for aircraft quality coatings as well as fan-spray and antiskid attachments.

For more information on Praxair, visit [www.praxair.com](http://www.praxair.com) or [www.praxair.com/thermalspray](http://www.praxair.com/thermalspray).

ArcJet® is a trademark of Praxair Technology, Inc. in the United States and/or other countries.

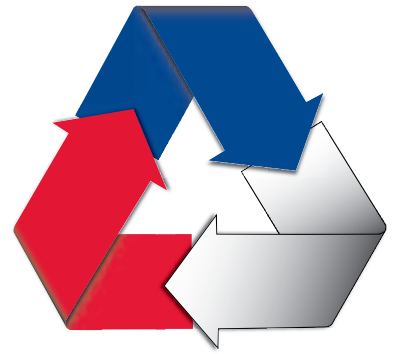
### Prefer to Receive SPRAYTIME Electronically?

If you would prefer to read the *SPRAYTIME* newsletter online, please send an email request to [spraytime@thermalspray.org](mailto:spraytime@thermalspray.org)

You can request an online version only (no print copy will be sent to you) or both an online and a print copy

We will then send you an email message when the next *SPRAYTIME* issue is ready to be viewed online.

**WHERE IS YOUR ARTICLE?** The *SPRAYTIME* Editorial Staff encourages and welcomes your contribution.



## ONE-STOP RECYCLING FOR THE THERMAL SPRAY INDUSTRY

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**Progressive Technologies, Inc.** - Grand Rapids, MI USA  
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## SUPPORTING SOCIETIES

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### International Thermal Spray Association

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email: itsa@thermalspray.org

web: www.thermalspray.org



The **International Thermal Spray Association** is closely interwoven with the history of thermal spray development in this hemisphere. Founded in 1948, and once known as Metallizing Service



**Chairman Froning**

Contractors, the association has been closely tied to most major advances in thermal spray technology, equipment and materials, industry events, education, standards and market development.

A company-member trade association, ITSA invites all interested companies to talk with our officers, committee chairs, and company representatives to better understand member benefits. A complete list of ITSA member companies and their representatives are at [www.thermalspray.org](http://www.thermalspray.org)

### ITSA Mission Statement

*The International Thermal Spray Association is a professional trade organization dedicated to expanding the use of thermal spray technologies for the benefit of industry and society.*

### Officers

Chairman: **Marc Froning**, BASF Catalysts LLC  
 Vice-Chairman: **Dan Hayden**, Hayden Corporation  
 Treasurer: **Bill Mosier**, Polymet Corporation  
**Executive Committee** (above officers plus)  
 Corporate Secretary: **Kathy Dusa**  
**John Read**, National Coating Technologies  
**Scott R. Goodspeed**, H. C. Starck, Inc.  
**John Hayden**, Hayden Corporation  
**Joseph Stricker**, St. Louis Metallizing Company

### ITSA Scholarship Opportunities

The International Thermal Spray Association offers annual Graduate Scholarships. Since 1992, the ITSA scholarship program has contributed to the growth of the thermal spray community, especially in the development of new technologists and engineers. ITSA is very proud of this education partnership and encourages all eligible participants to apply. Please visit [www.thermalspray.org](http://www.thermalspray.org) for criteria information and a printable application form.

### ITSA Thermal Spray Historical Collection

In April 2000, the International Thermal Spray Association announced the establishment of a Thermal Spray Historical Collection which is now on display at their headquarters office in Fairport Harbor, Ohio USA.

Growing in size and value, there are now over 30 different spray guns and miscellaneous equipment, a variety of spray gun manuals, hundreds of photographs, and several thermal spray publications and reference books.

Future plans include a virtual tour of the collection on the ITSA website for the entire global community to visit.

This is a worldwide industry collection and we welcome donations from the entire thermal spray community.

### ITSA SPRAYTIME Newsletter

Since 1992, the International Thermal Spray Association has been publishing the **SPRAYTIME** newsletter for the thermal spray industry. The mission is to be the flagship thermal spray industry newsletter providing company, event, people, product, research, and membership news of interest to industrial leaders, engineers, researchers, scholars, policy-makers, and the public thermal spray community.

For a free **SPRAYTIME** subscription, visit [www.spraytime.org](http://www.spraytime.org) and complete the short questionnaire.

### ITSA Headquarters

208 Third Street, Fairport Harbor, Ohio 44077 USA  
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[itsa@thermalspray.org](mailto:itsa@thermalspray.org) [www.thermalspray.org](http://www.thermalspray.org)

### SCHOLARSHIP OPPORTUNITIES

**Up to three(3) Graduate scholarships worth \$2,000.00 each to be awarded each calendar year.**

Since 1991, the ITSA Scholarship Program has contributed to the growth of the Thermal Spray Community, especially the development of new technologists and engineers. The International Thermal Spray Association is very proud of this education partnership and encourages all eligible participants to apply.

#### New Application Dates:

**Scholarship applications are now accepted annually April 15 through June 30 ONLY.**

**Please visit** [WWW.THERMALSPRAY.ORG](http://WWW.THERMALSPRAY.ORG) Scholarship area for details and a printable application form.



Bringing Technology and Technique Together





## Become a Member of The International Thermal Spray Association

Your company should join the International Thermal Spray Association now! As a company-member, professional trade association, our mission is dedicated to expanding the use of thermal spray technologies for the benefit of industry and society.

ITSA members invite and welcome your company to join us in this endeavor.

Whether you are a job shop, a captive in-house facility, an equipment or materials supplier, an educational campus, or a surface engineering consultant, ITSA membership will be of value to your organization.

The most valuable member asset is our annual membership meetings where the networking is priceless! Our meetings provide a mutually rewarding experience for all attendees - both business and personal. Our one day Technical Program and half day business meeting balanced by social activities provide numerous opportunities to discuss the needs and practices of thermal spray equipment and processes with one another.

As an ITSA member, your company has excellent marketing exposure by being listed on our website, in every issue of *SPRAYTIME*, as well as in our free edition of "What Is Thermal Spray?". ITSA members also receive an additional 10% advertising discount in the *SPRAYTIME* newsletter. ITSA member companies are also highlighted in the ITSA booth at several trade shows throughout the year (International Thermal Spray Conference ITSC, Fabtech International and AWS Welding Show Thermal Spray Pavilion, Weldmex Mexico, and TurboExpo in 2008).

*If you would like to discuss the benefits* of your company becoming a member of the International Thermal Spray Association, we suggest you contact Kathy Dusa at our headquarters office or our membership chairman Jim Ryan at [james.ryan@hcstarck.com](mailto:james.ryan@hcstarck.com) or visit the membership section of our [www.thermalspray.org](http://www.thermalspray.org) website.

### International Thermal Spray Launches New Website

The ITSA website now includes an "employment" and "for sale" area.

*SPRAYTIME* issues are included in this website with content search capability.

Visit [www.thermalspray.org](http://www.thermalspray.org) to see our new look and valuable industry information.

## ITSA Announces "Supporting Societies" Membership Category

The International Thermal Spray Association is pleased to announce a new "Supporting Societies" membership category. The purpose of this category is to establish communication with other associations/societies involved in thermal spray and surface engineering activities.

This is an ideal method for membership exchange between organizations. If your organization is interested in a membership exchange to belong to the International Thermal Spray Association, please contact Kathy Dusa at the headquarters office via email to [itsa@thermalspray.org](mailto:itsa@thermalspray.org)

### International Thermal Spray Association Welcomes New Member

*Ecka Granules of America LLC* has joined the International Thermal Spray Association.



ECKA Granules is one of the world's leading manufacturer of non-ferrous metal powders, with 18 production units around the globe. ECKA's performance is based in the areas of Metal Powder- Technology, Alloying-Technology and Application-Technology. Our direct proximity to customers can be seen in our global network with over 38 sales offices.

The production program comprises the manufacture of non-ferrous metal powders from the pure metals of copper, aluminium and magnesium and their alloys; Ecka® Powders such as gas/air and water-atomized copper and



copper-alloyed powders, powders of nickel and cobalt based alloys for thermal spraying applications (including HVOF, Plasma, PTA and Coldchay applications). ECKA® Standard powders gives a wide choice of alloy compositions and hardness values to satisfy customer needs. The products are supplied as powders, granules and finished mixed products.



*For more information*, contact ITSA company representative Nic Veloff, General Manager of Sales and Technical Support, Eckagranules of America L.L.C., 500 Prosperity Drive, Orangeburg, SC 29116, tel: 803.536.0215, fax: 803.536.0516, email: [info@eckagranules.com](mailto:info@eckagranules.com), web: [www.ecka-granules.com](http://www.ecka-granules.com)

## Upcoming, Low Worker Safety Numbers and Your Thermal Spray Process California OSHA Update

Barbara Kanegsberg, BFK Solutions LLC

As is evident from the impact of the decreased allowable exposure levels for Cr(VI), worker inhalation numbers that are set for airborne chemicals can have a major impact on thermal spray operations. While companies and professional organizations may recommend worker exposure levels, OSHA (Federal OSHA) can set legally-enforceable inhalation levels such as a PEL (Permissible Exposure Limit); so can some state agencies such as Cal/OSHA (California OSHA, please see "A Brief Guide through the Alphabet Soup"). I have been attending Cal/OSHA PEL process meetings for several years now. Now that a new PEL process that was adopted in March, 2007 is underway, I am starting a series of articles to keep ITSA and the thermal spray industry informed about pertinent events in the Cal/OSHA PEL process and about specific chemicals of interest.

### Low California PEL's

The new Cal/OSHA PEL process may impact your thermal spray operation. Cal/OSHA uses a risk assessment paradigm that increases the likelihood of much lower PEL's and related worker safety numbers. Because the lower numbers will be legally-enforceable throughout California, in my estimation, there is almost certain to be a "ripple effect",

an impact on industry throughout the United States, whether or not the levels are adopted nationwide by OSHA.

The lower the PEL, the lower the amount of chemical that employees can be exposed to. Low PEL's tend to translate to increased controls and more reporting requirements, as well as higher capital and process costs. If the number is low enough, companies may be impelled to chemical substitution. Especially for components and products that are critical to health, public safety, and/or to mission-readiness; research and validation are required to minimize risks related to such substitution.

### Risk Assessment

In the California process, a Health Experts Advisory Committee (HEAC) first evaluates the chemical under consideration and recommends a PEL or some other worker exposure level. Table 1 shows the worker exposure levels that are currently under discussion by the HEAC; exposure levels set or recommended by other groups are shown for comparison. Please note that "under discussion" is not the same as "done deal." Table 2 on page 26 shows selected chemicals that would be expected to be of particular interest to ITSA members and to those involved in thermal spray and/or engineered coatings. These chemicals have been prioritized as "1" or "2" by Cal/OSHA staff, so they are likely to be discussed sooner rather than later. The prioritization list seems to be rather fluid; and because some priority 2 compounds have already been assigned to HEAC



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members, they are likely to be discussed in the near future.

The HEAC evaluation is based on risk assessment, typically using animal studies. Generally, studies on worker populations have not been accepted because of the presence of "confounding factors." That is, despite what you may think, industry does not keep workers caged up like lab rats. Further, people at work are typically exposed to a larger variety of chemicals than are animals in a controlled study, so it tends to be more difficult to pin down cause and effect. However, employing a rigorous risk assessment approach means that even where a chemical has been used industrially for decades and decades without apparent ill effect, the absence of observable problems in the worker population is not considered in the risk assessment. If a published animal study indicates an effect, even at a high concentration of chemical, this impact is considered in recommending a PEL.

### OEHHA Influence

The HEAC process is heavily assisted by an agency that is separate from Cal/OSHA, OEHHA (Office of Environmental Health Hazard Assessment). OEHHA is a California agency involved with environmental and community, risk assessment. Among other things, OEHHA sets the risk assessment numbers that are used to establish the Proposition 65 list. Proposition 65 requires businesses to post warnings if a listed chemical might be present; the signs are ubiquitous and are found at such establishments as the local supermarket. OEHHA uses an academic, risk assessment approach to setting community standards based on published animal studies. Extrapolating from the OEHHA risk assessment numbers for communities and adjusting to an 8 hour work day would result in very, very low allowable worker inhalation numbers. This represents a more purely academic approach than may be taken by other agencies.

In fact, proposed California legislation, AB 515, would have mandated the use of the OEHHA numbers to set worker safety numbers. I considered the legislation to be ill-advised; and I provided technical information in opposition. The legislation did not pass. However, the general expectation is that it will be reintroduced. Even in the absence of legislation, OEHHA continues to have a very strong and a very influential presence at HEAC meetings. OEHHA does have extensive resources; and I have utilized some of their reports. However, in my opinion, a strong, independent Cal/OSHA, would be desirable for workers and for industry.

### Feasible?

After the HEAC has recommended a worker exposure level, the compound under consideration goes to the FAC, the Feasibility Advisory Committee. Thus far, there have been no appointees to a FAC. The HEAC recommendation appears to be the dominant one. One might note that in the course of planning the new PEL process, the FAC was originally called the FRAC; but the "R" for "Reasonable" was removed.

Many factors traditionally considered important by Industrial Hygienists and others involved in setting worker safety are being consigned to consideration by the FAC, in a manner that is secondary to the risk assessment.

In Table 1, I have attempted to summarize the status of various compounds under consideration. Levels are presented as they appear in the "5155 Substance Status List 1-09." The documents are available on the Cal/OSHA website.

**Table 1 Cal/OSHA Health Expert Advisory Committee (HEAC)**

Substance	Cal/OSHA HEAC Discussion (a) Or Recommended (b)	Examples, other Worker Exposure Numbers
N-methyl pyrrolidone CAS 872-50-4	1 ppm TWA with skin notation & required monitoring (a)	TWA 10 ppm (AIHA); < 5 ppm HESIS (2006) 25 ppm (UK) 20 ppm (Germany) 50 ppm (Sweden)
Naphthalene CAS 91-20-3	OEL 0.25 ppm (a)	TLV 10ppm (ACGIH); 10 ppm (OSHA) 15 ppm STEL
Sulfuric acid CAS 7664-93-9	TWA 0.1 mg/m <sup>3</sup> TWA (b)	TLV 200 mcg/m <sup>3</sup> (thoracic particulate mass), ACGIH
Toluene CAS 108-88-3	10 ppm TWA & skin notation (b)	TWA 200 ppm (100, 1989, vacated level) OSHA; 100, 10hr TWA (NIOSH); 20 (ACGIH); 50 ppm (UK)
Trichloroethylene CAS 79-01-6	PEL 0.32 ppm (a)	10 ppm TLV (ACGIH); 25 ppm REL (NIOSH)
Hydrogen chloride CAS 7647-01-0)	STEL 2 ppm (15 min) (a); Ceiling 5 ppm (a)	TLV 2 ppm ceiling (ACGIH, 2003); TWA 5 ppm, 10 ppm ceiling (EU, 2000) 6ppb (extrapolated, OEHHA)
Hydrogen fluoride CAS 7664-39-3	PEL 0.4 ppm (b); STEL 1.0 ppm (b)	3ppm (OSHA & Cal/OSHA); 0.5 ppm ACGIH
Carbon Disulfide CAS 78-15-0	PEL 1 ppm (b) STEL 12 (b) Ceiling 30	PEL 4 ppm (OSHA proposed, 1989); 1 ppm (ACGIH 2006)
Dichloroacetic acid CAS 79-43-6	0.1 ppm TWA (b)	0.5 ppm TLV/TWA (ACGIH)

(a) = under discussion

(b) = recommendation made, closer to becoming a PEL, will move to FAC

continued on page 28

## HEAC Members

The HEAC is composed of volunteers, selected by Cal/OSHA. Some HEAC members are associated with Worksafe! Worksafe! is a non-profit advocacy group, with the stated purpose of protecting workers. They strongly support the low exposure limits suggested by OEHHA and were heavily involved in the effort to pass AB515. However, at least two HEAC members are Industrial Hygienists with practical, real-world experience in supporting worker safety. One of them, Jim Unmack, CIH, (Certified Industrial Hygienist), is a long-time advisor to Plasma Technology, Inc., a long-time and active member of ITSA.

## Keeping you Posted

My intent is to continue to attend the HEAC meetings and to continue to alert the International Thermal Spray Association and those involved in thermal spray and other engineered coatings to issues of concern. Worker safety is of critical importance. To achieve a safe work environment, a correct, reasonable, and practical evaluation of all data and studies needs to occur as part of setting worker exposure limits. I am concerned that many of the levels

currently under discussion at HEAC are inappropriate and could be detrimental to the work environment.

While the HEAC discussions are complex and convoluted for everyone involved, I am able to critically follow the discussions and reasoning, because I have a somewhat checkered past. In addition to being "The Cleaning Lady," I have extensive education and experience in biology, biochemistry, clinical chemistry, and analysis of toxicological studies. For this reason, I have been reporting events at Cal/OSHA to interested groups, including an inter-agency military group.

Some chemical manufacturers have sent advocates or lobbyists to the HEAC meetings. With rare exceptions, those individuals attend only to observe discussion of the chemical(s) of immediate interest. I think this is a mistake; it is like attempting to provide significant input to the policies of a foreign land without understanding the culture or the ground rules. Cal/OSHA tends to downplay any input from industry. Better opportunities for providing productive comment will be achieved by participating in the Cal/OSHA PEL process and by showing ongoing interest.

I will keep you posted. Continuing to have observers physically present at HEAC meetings sends a very clear message that organizations like ITSA are aware of the Cal/OSHA activities, understand the approaches used by Cal/OSHA, and that ITSA as well as other concerned professional organizations and companies reserve the option to make public and/or written comments where appropriate.

**For more about the Cal/OSHA PEL process,** see the Kanegsberg & Kanegsberg column, "Contamination Control In and Out of the Cleanroom" in the December, 2008 issue of *Controlled Environments Magazine*, web: <http://www.cemag.us/>

Barbara Kanegsberg, BFK Solutions, is an independent consultant in critical cleaning processes and surface quality.

**For more information,** contact her at [Barbara@bfksolutions.com](mailto:Barbara@bfksolutions.com)

## A Journey Through the Alphabet Soup

**AB 515**, a now-defunct but seemingly perennial California proposed legislation that would proliferate an array of exceedingly low Cal/OSHA PEL's

**ACGIH**, American Conference of Industrial Hygienists, a professional organization

**AIHA**, American Industrial Hygiene Association, a professional organization of CIH's, and professionals concerned with worker safety

**Table 2. Some Cal/OSHA Prioritized Chemicals of Interest to the Thermal Spray and Engineered Coatings Industries**

Chemical Name	CAS	Priority	Status
di(2-ethylhexyl)phthalate (DEHP)	117817	1	Assigned to HEAC, not yet discussed
dibutyl phthalate	84742	1	Assigned to HEAC, not yet discussed
hydrogen chloride, hydrochloric acid	7647010	1	Under discussion
hydrogen fluoride, hydrofluoric acid	7664393	1	Under discussion
n-Methyl-2-pyrrolidone,	872504	1	Under discussion
naphthalene	91203	1	Under discussion
sulfuric acid	7664939	1	Under discussion
tetrachloroethylene (perchloroethylene)	127184	1	Assigned to HEAC, not yet discussed
toluene	108883	1	Under discussion
trichloroethylene	79016	1	Under discussion
antimony oxide		2	
butyl glycidyl ether, n-	2426086	2	
carbon black	1333864	2	
chlorinated paraffins	108171262	2	
cobalt and certain cobalt compounds *	7440484	2	Assigned to HEAC, not yet discussed
cyclohexane	110827	2	
isopropanol TLV now 2-propanol	67630	2	
kerosene jet fuel, total HC vapor	8008206	2	
methyl chloride	74873	2	
n-propanol	71238	2	
silica (crystalline quartz & cristobalite)		2	

- at the Federal level, a draft report by National Toxicology Program was distributed in December, 2008.

continued on page 30





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**Cal/OSHA**, California OSHA, can set legally-enforceable worker safety standards

**CAS Number**, Chemical Abstract Society Number, sort of a social security number for chemicals, useful for unambiguously identifying chemicals

**CDC**, Center for Disease Control, a Federal agency

**CIH**, Certified Industrial Hygienist, a worker safety expert

**FAC**, Feasibility Advisory Committee, part of the Cal/OSHA PEL process

**HEAC**, Health Expert Advisory Committee, part of the Cal/OSHA PEL process

**HESIS**, Hazard Evaluation System and Information Service, another California agency with a mission to help prevent workplace illness and disease

**NIOSH**, National Institute of Occupational Safety and Health, a Federal agency

**OEHHA**, Office of Environmental Health Hazard Assessment, performs risk assessments related to environmental exposure

**OEL**, Occupational Exposure Limits, may be set by manufacturers, professional organizations, government agencies, the limits are not legally-enforceable but are often used as guidelines

**OSHA**, Occupational Safety and Health Administration, a Federal agency, conducts research and makes recommendations, part of the CDC

**PEL**, Permissible Exposure Limit for workers, legally-enforceable

**REL**, Recommended Exposure Limit or NIOSH REL, recommended by NIOSH scientists to OSHA

**STEL**, Short term exposure limit for workers, usually 15 minutes

**TWA/TLV**, Threshold Limit Value/Time Weighted Average, the amount of a substance that an "average" worker can be exposed to without ill-effect, day after day, with a normal work schedule

#### Technical Editor's Note

On the US federal level, cobalt-tungsten carbide powders (as well as hardmetals/cemented carbides) are the subject of a review in the National Toxicology Program (NTP) for their inclusion in the "Report on Carcinogens" (RoC). In a recent action, the Expert Review Panel recommended that

these be listed as "reasonably anticipated to be a human carcinogen". Such a listing is almost certain to eventually result in the adoption by OSHA of a PEL for these materials and probably a TLV by the ACGIH. Currently there is no TLV or PEL for cobalt-tungsten carbides. Related TLVs and PELs are:

-TLVs: tungsten metal - 5 mg/m<sup>3</sup> and cobalt

- 0.02 mg/m<sup>3</sup>

-PELs: cobalt - 0.1 mg/m<sup>3</sup>, tungsten is not listed.

The ACGIH (2008 edition) also lists cobalt as a Class A2 carcinogen—confirmed animal carcinogen with unknown relevance to humans. The International Agency for Research on Cancer (IARC) lists cobalt metal without tungsten carbide in Group 2B (possibly carcinogenic to humans) and cobalt metal with tungsten carbide in Group 2A (probably carcinogenic to humans).

Adoption of an OSHA PEL is likely to require actions by producers, sellers and users of cobalt-tungsten carbide powders. For more information on the NTP and IARC go to their web sites at: <http://ntp.niehs.nih.gov/> and <http://www.iarc.fr/>.



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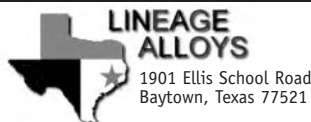


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## New "MEC" High-Tech Two Axis Manipulator

"MEC" has developed a new automatic two-axis manipulator with job rotation arrangement for coating on piston rings, which is designed for high volume production with uniform coating thickness to economize the coating cost in terms of the consumption of powder and time. The system assures controlled two-axis gun manipulation for consistent and precise coating.

The two-axis manipulator is fitted with two servo motors and a spray distance adjustment slider. The tail stock has a special feature which takes care of the



increase in the mandrel length due to thermal expansion during the coating operation. The machine is packed with lot of flexibility and safety features.

The spray gun is mounted on the manipulator to cover the entire mandrel length of the piston rings. All the sequence of operations is controlled by a touch

screen PLC. The job spray length and spray angle can be varied by feeding the data into the MMI.

The programmed sequences in the system take care of all major aspects of thermal spray which include:

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- Powder ON/OFF control and stabilizing delay.
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For different jobs and sizes MEC can provide special manipulators that integrate with thermal spray systems like plasma, HVOF, flame and arc spray, etc.

**For further information** for above system, please contact

Ankur Modi, Executive Director, tel: (0291) 2747601/60, web: [www.mecpl.com](http://www.mecpl.com), email: [mecpl@sancharnet.in](mailto:mecpl@sancharnet.in) **See advertisement on page 6.**

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A key to the success of the articulated robot is the advanced controller software. Thermal spray operators are generally most comfortable with X-Y-Z manipulators since it is difficult to visualize a position based on the angular position of six rotary joints. The advanced robot software takes care of this transformation and allows the programmer/ operator to think in Cartesian coordinates.

continued on page 32



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Three different options are provided for the operator to manually move or jog the robot using a joy-stick or series of motion buttons:

**1. Joint coordinate system.** The joint coordinate system is used to control individual robot joints. The position and attitude of the robot are defined by angular position of each joint. The joints are numbered (one through six for a six axis robot) starting with the base or main body of the robot. The programmer often selects this coordinate system for initial positioning of the robot.

**2. X-Y-Z or world coordinate system.** This coordinate system is fixed in the work space and is generally set with the origin on axis 1 and at the intersection of the orthogonal plane of axis 2. This coordinate system uses the same nomenclature that was developed for airplanes; X towards the front (forward direction of travel), Y for motion to the left when "facing" the same direction of the robot, Z for up (altitude) and then W (yaw), P (pitch) and R (roll) for the three rotational components. Programmers often select this system for manually moving the robot to selected positions along the part to be coated.

**3. A tool coordinate system** is a Cartesian coordinate system that defines the position and the attitude of the thermal spray gun. For this system, the origin is usually the point of application on the part to be coated. This coordinate system is especially useful when adjusting the position of the thermal spray gun with reference to the part being coated.

Note that these coordinate systems are for manually jogging the robot. Once the points and path are defined for a coating program, the robot will follow the prescribed motion program regardless of the coordinate system used for manually jogging the robot during programming.

The coating program will consist of a number of housekeeping tasks (e.g., resetting counters that keep track of the number of passes), discrete commands to sequence the various units (dust collector, etc.) and a series of motion commands.

Motion commands are instructions to move the gun between two points in the coating motion program. Typically there are three motion command types available:

**1. Joint.** All joints rotate at a specified speed and will arrive at the final point at the same time. The path of motion is usually nonlinear and the attitude of the gun is not controlled. Therefore, this motion is usually not used during a coating pass.

**2. Linear.** The gun path is controlled from one point to the next and along a linear path. The attitude of the gun is also controlled. This is the motion most used in coating operations.

**3. Circular.** The circular motion mode controls the path of gun from a start point to an end point through a passing point.

Next in the series, Continuous path, *Singular Points and Tool Center Point* (TCP).

**For more information**, please contact series author, Dale Moody via email [dalermood@aol.com](mailto:dalermood@aol.com)

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## Hard Chrome Alternatives in Today's Economy

J. Scott Moore, Ph.D., President, Thintri, Inc.

Hard chrome plate has long been a crucial component of aerospace hardware, in manufacture, overhaul and repair. Chrome has long provided wear resistant coatings for such important applications as landing gear, gas turbines, hydraulics and other components. Unfortunately the hexavalent form of chrome used in plating operations has been found to cause serious injury to workers in plating plants.

In recent years growing awareness of chrome's significant health and environmental dangers has led to a gradual migration to alternative coating technologies. Increasingly strict environmental and health regulations over the last two decades have seriously disrupted the domestic hard chrome industry, driving as many as half the plating shops out of business or out of the country to places with fewer restrictions.

Meanwhile alternatives to chrome plating have steadily gained markets. The best known hard chrome alternative is thermal spray, which has established itself in the aerospace industry and also expanded markets outside aerospace in general industry and heavy vehicles. Thermal spray, however, is facing competition from some of the same technologies that compete with chrome.

The advantages offered by many chrome alternatives have gone beyond simply avoiding the environmental and health issues associated with chrome plating, and now include significant improvements in performance and/or cost. A number of new coating methods have reached or are approaching commercialization, and some new technologies are even obtaining approvals for use in aerospace.

However, a new market study by Thintri, Inc. ([www.thintri.com](http://www.thintri.com)) on hard chrome alternatives, an update to an earlier study, shows that the move to hard chrome alternatives has changed from the earlier steady progress to a more complicated picture. Issues relate primarily to the cost of migrating to new methods, reflected in the expense of procuring and setting up thermal spray cells, and uncertainty over performance, not to mention the current economic climate. Ironically, some hesitation stems from an overestimation of the capability of alternatives like thermal spray. Consequently, some sectors of the industry have continued to move from chrome to thermal spray and some are resisting. Meanwhile, new coating methods are emerging that deal with the limitations of both chrome and thermal spray, that could offer new options for manufacture, overhaul and repair.

### The Hard Chrome Market in Aerospace

Chrome plating is an important part of aerospace maintenance, overhaul and repair, and is used not only during parts manufacture, but in rebuilding parts that were not originally chrome plated in order to restore dimensional tolerance. The ease and low cost of application combined with the quality of chrome wear coatings has led to chrome's long-standing dominance in wear coating

applications.

Chrome plate's properties are generally good, but hardly ever excellent. Chrome's limited hardness and corrosion resistance are increasingly unsatisfactory in today's more demanding wear environments. Chrome coatings suffer from pitting, spalling and other failures under stress. Chrome's slow rates of deposition and long bakes add to cost of ownership and turnaround times. Coating non-uniformity often forces follow up machining to meet dimensional tolerances.

Most importantly, hexavalent chrome, a prime component in the process of hard chrome plating, is a known health hazard. Worker exposure to the mist produced during plating has resulted in not only cancers but an array of other medical problems, including irritated, ulcerated and perforated septum, dermatitis, burns and other issues. Waste disposal of the toxic bath solutions is also difficult under today's pollution control legislation.

### Chrome Alternatives

In the 1990s thermal spray, embodying a range of different coating technologies, emerged as the leading hard chrome plate alternative. Thermal spray occupies important markets not related to chrome replacement, but in providing an alternative to hard chrome, thermal spray, has become nearly indispensable in important markets like aerospace.

Thermal spray offers important advantages over chrome plating in some aerospace applications, including fast deposition rates, ability to deposit on heat-sensitive surfaces, use of portable equipment, and a wide range of coating materials. Most importantly, at least in some situations, thermal spray is comparable to chrome in cost or even less expensive.

For aerospace applications, the most common form of thermal spray in use is high velocity oxy-fuel, or HVOF.

HVOF is suitable for processing large parts. While a plating tank for a large component could be very expensive to set up and maintain, applying a HVOF coating to a large part requires no extra investment in terms of capacity, as long as the part fits in a standard cell. Small parts, like those that could be shoveled, can be processed much less expensively in a chrome plating tank.

Another important advantage of HVOF, or any thermal spray for that matter, is the reduced processing time compared with plating. Process hours for a typical HVOF application are as little as a fifth those for electroplated hard chrome.

There are of course tradeoffs in using thermal spray. Surface complexity points up some significant differences between the two methods. Chrome plating easily reaches the entire surface of a complex part, but that is not always the case with thermal spray, where complex geometries can present significant challenges. Therefore HVOF is most competitive with chrome on large, relatively simple shapes.

Given that thermal spray is a line-of-sight application, non-line-of-sight (NLOS) geometries and particularly inner diameters less than about 6-8 in. (15-20 cm) are a big problem for HVOF. Today about 20% of aerospace coating



applications are NLOS, so the inability to use HVOF on such surfaces will ultimately limit the penetration of HVOF in chrome replacement to 80% in that market.

Another big issue with HVOF is the significant up-front investment required, including consumables and equipment. However, in taking into account long term economic benefits such as faster turnaround time, greater performance and longer wear lifetime, reduced hazardous wastes, etc., thermal spray is often quite economically competitive with chrome, that advantage increasing with every added regulation on chrome plating.

In any case HVOF is so far the alternative of choice in replacing hard chrome plating, given its superior performance, favorable economics and flexibility. Large segments of the aerospace industry, as well as sectors like oil and gas, heavy equipment and other industries, have begun a large scale migration away from hard chrome and toward thermal spray and a few other alternatives. The effect of this movement on the overall volume of the chrome plating industry is fairly small, but growth in markets for alternatives has overall been strong, albeit with some inconsistencies.

#### The Shift to Thermal Spray in Aerospace

Chief among the chrome alternatives, thermal spray has made steady, solid gains in aerospace markets, particularly landing gear where it has nearly become a standard. Industry consensus was that the erosion of chrome markets would continue to the point where chrome plate was more or less a niche application, which has happened with jet engines. However, in recent years, some segments of the industry have stalled in their acceptance of thermal spray

in other important applications, like landing gear. Some important companies have given up on thermal spray for landing gear, and others rationalize delays in implementation. The current economic downturn has only complicated the picture.

Small, regional and corporate jets have largely stuck with chrome plate for landing gear. Even some larger airlines, like Lufthansa, after early initiatives to adopt thermal spray, have settled on chrome. In Lufthansa's case, the strategy rests largely on the company's decision to sell off aircraft before the type of extensive servicing that makes use of HVOF or chrome is needed. Of the smaller aircraft users, including regional and corporate jets, many report that they have no intention of moving from chrome to thermal spray for landing gear. Such companies have actually made a gamble, based on a perceived superiority of performance in HVOF coatings. As aircraft manufacturers like Boeing and Airbus move to thermal spray in manufacture of landing gear, some owners of small aircraft are betting that the HVOF coatings will last longer than the service lifetime of the component they are on, thus eliminating the need for restoring coatings. For those few that need restored coatings due to trauma or some unusual event, the repair of the landing gear will be outsourced to firms specializing in thermal spray.

While there are cases where a substrate will fail before a coating, most thermal spray experts are quite skeptical that HVOF coatings will outlast the components they are applied to. In that case, companies who have put off decisions on moving to thermal spray may find themselves forced to make uncomfortable decisions without much time for

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planning. However, the issue has not been resolved, and no one knows for sure how thermal spray coatings will last with respect to the lifetime of the part. In any event, several firms specializing in servicing landing gear for regional and corporate aircraft report that they and their customers are quite happy with chrome, even given the added regulatory burden, which has largely stabilized.

#### Effects of the Recession

The current economic crisis has precipitated a downturn in consumption of resources in aerospace markets, on top of delays in the high profile Boeing 787 and Airbus A380 production. Business cycles have been disrupted, and prices of goods and services have plunged. Air traffic, which had been expected to grow robustly for most of the next ten years (largely due to market growth in Asia), will stall somewhat, depending on the duration of the recession.

The recession has accelerated an anticipated "dip" in aircraft production and materials and resource consumption that was predicted by many in the aerospace industry for 2011 to 2012. This dip prediction was based only on historical cycles, rather than economic fundamentals. Many aerospace industry analysts now believe that this dip is taking place now, a reasonable assumption, although the extent of the decline will be greater than what was expected for 2011 to 2012. Most analysts predict an upturn beginning in late 2010. In the meantime, declining air traffic revenue will only make investment in updated maintenance, repair and overhaul equipment more difficult to justify.

#### Case Study: Wear Coatings Markets

Overall wear coating markets for thermal spray, not just those in chrome replacement, are adversely affected by troubles in the airline industry, but other factors also play an important role. With a deepening recession, companies are reluctant to embark on new capital spending. Selected markets are more depressed than others and it happens that some of the most troubled industries are those that could make the most use of wear coatings.

The strength of the wear coating sector is that even if new equipment purchases decline, coated surfaces in use must still be repaired, keeping markets somewhat active in thermal spray for wear coatings.

The portion of the wear coatings market confined to chrome replacement benefits from the migration away from chrome to alternatives like HVOF, and so can expect a substantially brighter outlook than overall wear coatings, largely at the expense of chrome plating markets (Fig. 1).

While many markets for chrome alternatives are suffering from today's economic conditions, inertia on the part of potential users, and a general reluctance to move to a process with greater up-front cost, most sectors can be expected to begin a solid advance around 2010 or 2011, given expectations on the current downturn. Most of the industries that can benefit from chrome alternatives, but particularly aerospace, deal with equipment and materials that are specified by a relatively small number of OEMs. Once the top three or four OEMs in any industry have converted to alternative processes, the rest of the industry can generally be expected to follow. In nearly all sectors discussed in the Thintri report, the major OEMs are indeed moving to replace chrome with thermal spray, although at different rates.

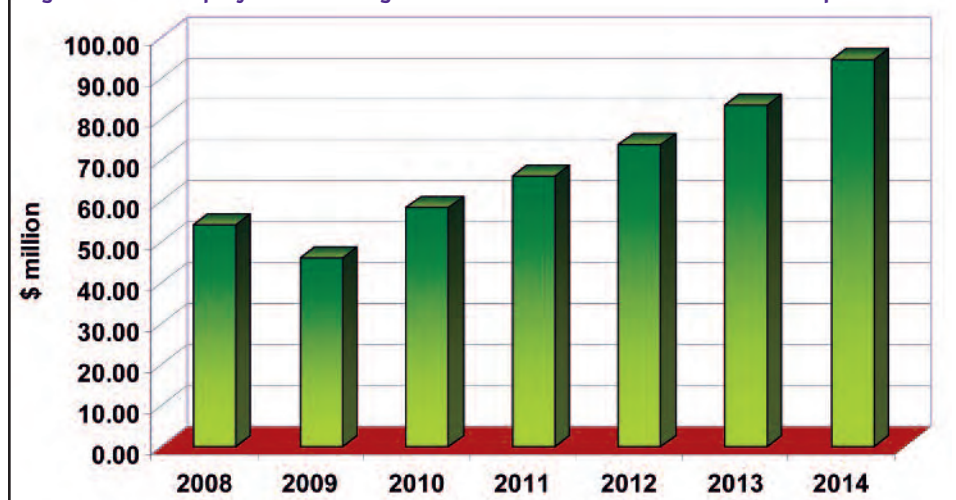
There is little likelihood at this time that HVOF will adapt to inner diameters (although some variations on plasma spray are still under investigation for that purpose), non-line of sight and other geometries that present difficulties for the method. For that reason alone, HVOF cannot be expected to capture more than 80% of its target markets in aerospace. Lack of economic competitiveness in treating small and complex parts will lead to even lower penetration targets in heavy equipment and general industry.

A number of experts in the thermal spray industry interviewed for the Thintri study believe that while large markets remain to be captured, the "low hanging fruit" has already been taken. Over the past ten years, the move to alternatives in large, well-paying and easy applications like landing gear and hydraulic cylinders began quietly but continued a solid advance. What remains are large but

highly segmented markets where potential users have to be convinced of the cost effectiveness of thermal spray, and may have little interest in switching. Other available applications are those where thermal spray has not done well, such as inner diameters, which are now the target of competing methods like electroless plating. Continued success for chrome alternatives in general will depend on penetrating a large number of smaller, more difficult markets.

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Fig. 1 Thermal spray wear coatings market forecast confined to chrome replacement.







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Accordingly, those marketing chrome alternatives will have to bring resources to bear on diverse applications, where potential users may have little or no familiarity with chrome alternatives and need to be convinced of the long term cost savings and performance advantages in applications where there may now be little supportive data.

#### Conclusion

A number of factors have acted in concert to delay and complicate the movement away from hard chrome coatings in aerospace and toward alternatives like thermal spray. Some are a function of current economic conditions, while others indicate a surprising resilience on the part of chrome in some applications. Chrome's appeal rests primarily on its simplicity and low cost, and most importantly its versatility. Alternatives offer narrowly defined advantages, in that no single alternative promises the capability of replacing chrome across the board. Replacement of chrome will be most likely be accomplished by simultaneous use of a number of alternatives. For example, while HVOF will replace chrome on many exterior surfaces, inner diameters and other non-line of sight applications will make use of a different alternative, such as electrodeposited nanocrystalline coatings.

In any case most in the industry believe that chrome's

usage in aerospace will, in the long run, continue to dwindle while alternatives with fewer liabilities and better performance continue to capture chrome's markets.

#### About Thintr, Inc.

Thintr, Inc., is a full-service consulting firm specializing in market research and custom consulting, covering topics in materials, aerospace, electronics and semiconductors, telecommunications, manufacturing, logistics, imaging and many other markets.

For more information, visit [www.thintr.com](http://www.thintr.com)

### Arkansas Thermal Spray Announces Hittmax Equipment Line

The thermal spray division of Hitachi Maxco (USA) has been transferred to Arkansas Thermal Spray. These Hitachi Maxco Max Jet II and Mini Max HVOF systems are now called Hittmax I and Hittmax II.



For the past three years, Arkansas Thermal Spray has been handling the sales and service of these units. They will still be offering free parameter work, free training, and installation to any customer purchasing one of these units - as well as offering a full line of replacement parts and maintenance services for all units.

New literature is available upon request.

These thermal spray systems have been sold to such customers as Pratt & Whitney-Paton, Siemens, Foster Wheeler, and The Ellison Group. These customers have been very satisfied with these systems because of the simplicity of use, operating cost and overall cost of the unit. One of the main reasons is the versatility; these units spray powder - wire or cord - all at HVOF velocity. The Hittmax II (previously Mini Max) is compact and portable for onsite use.

For more information, contact Arkansas Thermal Spray, 1216 Fulbright, Walnut Ridge, AR 72476, tel: 870.886.7060 or 870.759.1775

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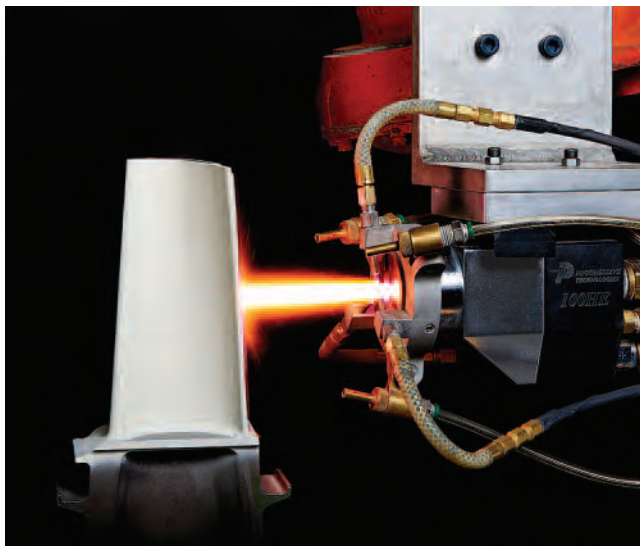
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## Progressive Technologies Launches Next Generation 100HE Plasma Spray Torch



Progressive Technologies is pleased to announce a new and improved generation of the proven 100HE Plasma Spray Torch. The sleek new body style is 1 lb (0.45kg) lighter and over 1 in. (25mm) shorter, enabling better manipulation capabilities and easier access to parts with complicated geometries. We achieved this while maintaining the high performance and quality coatings produced with the original 100HE. How did we do it? We rearranged some internal cooling water channels, shifted some "O" rings, and developed an even simpler design than the original 100HE. However, all of the patented internal hardware components and geometry remained the same.



In addition to maintaining extremely high throughput and exceptional coating qualities, reported hardware life has been a very pleasant surprise for our customers. Jay Morse of Henry Pratt, a long time user of the 100HE, recently commented "we often see anode life in the range of 1500 hr, and up to 400 hr cathode life".

The 100HE has a wide window for spraying nearly any powder, including abrasives, metalics, carbides, cermets and pure ceramics. Recent coating development programs have proven its capability to spray TBC ceramics of very dense (< 1%) to high (20%) porosity levels at spray rates up to 40 lb/hr (300 g/min) and deposition efficiencies in the 70% to 80% range. Because of the thermally dynamic plasma created by the 100HE's patented hardware design, several companies have also discovered it is a great tool to manufacture and densify thermal spray powders. High quality powders are now manufactured and densified at feed rates in excess of 66 lb/hr (500 g/min).

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**16-18 Orlando, FL USA** *International Thermal Spray Association Membership Meeting and Technical Program* - contact ITSA, [itsa@thermalspray.org](mailto:itsa@thermalspray.org), 440.357.5400

**28-29 Toronto Canada** - *Shot Peening and Blast Cleaning Workshop* - Electronics, Inc. Education Division, 1.800.832.5653, [www.electronics.inc.com](http://www.electronics.inc.com)

### MAY 2009

**3-6 Helsingør Denmark** *15th Int'l Conference on the Joining of Materials* - contact: JOM tel: +45.4835458, email: [jom\\_aws@post10.tele.dk](mailto:jom_aws@post10.tele.dk)

**4-7 Las Vegas, NV USA** *ITSC 2009 International Thermal Spray Conference & Expo* - contact ASM Int'l tel: 440.338.5151, web: [www.asminternational.org](http://www.asminternational.org), email: [customerservice@asminternational.org](mailto:customerservice@asminternational.org)

**9-14 Santa Clara, CA USA** *SVC 52nd Annual Technical Conference* - visit [www.svc.org](http://www.svc.org)

**12-15 Moscow Russia** *Essen Welding Russia 2009, 3rd Int'l Trade Fair Joining Cutting Surfacing* - Visit Messe Essen GmbH [www.messe-essen.de](http://www.messe-essen.de) or DVS [www.dvs-ev.de](http://www.dvs-ev.de)

**20-22 Vancouver, British Columbia Canada** *9th Int'l ASTM-ESIS Symposium on Fatigue and Fracture Mechanics* - contact NASA Glen Research Center tel: 216.521.3490, email: [sreerameshkalluri@oai.org](mailto:sreerameshkalluri@oai.org)

**30-2JUN Miami, FL USA** *Institute of Industrial Engineers Annual Conference and Expo* - contact Elaine Fuerst, IIE tel: 770.449.0460 x102, email: [cs@iienet.org](mailto:cs@iienet.org)

### JUNE 2009

**2-4 Monterrey, Mexico** *AWS Weldmex, Cintemex Exhibition Center, Monterrey, Mexico* - visit [www.aws.org](http://www.aws.org)

**2-4 Aachen, Germany** *Tool 09 Tool Steels* - email: [tool09@iwm.rwth-aachen.de](mailto:tool09@iwm.rwth-aachen.de), tel: +49.241.809.5255

**2-5 Shanghai, China** - *14th Beijing Essen Welding & Cutting* - Visit DVS [www.dvs-ev.de](http://www.dvs-ev.de) or Chinese Mechanical Engineering Society [www.cmes.org](http://www.cmes.org)

**7-11 Dayton, OH USA** *Aromat 2009 Novel & Engineered Materials System & Processes for the Aerospace Industry* - contact ASM Int'l tel: 440.338.5151, web: [www.asminternational.org](http://www.asminternational.org), email: [customerservice@asminternational.org](mailto:customerservice@asminternational.org)

**8-12 Norfolk, VA USA** *MegaRust Navy Corrosion Conference* - visit [www.nstcenter.com](http://www.nstcenter.com)

**8-12 Orlando, FL USA** *ASME Turbo Expo 2009* - Orlando World Marriott Resort - visit [www.turboexpo.org](http://www.turboexpo.org)

**16-18 Edmonton, Alberta Canada** - Western Manufacturing Technology Show - Visit [www.wmts.ca](http://www.wmts.ca)

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**10-12 Mumbai, India** - *4th Essen Welding India* - Visit [www.messe-essen.de](http://www.messe-essen.de)

### OCTOBER 2010

**10-14 Florence, Italy** *Powder Metallurgy World Congress & Exhibition* - visit [www.epma.com/pm2010](http://www.epma.com/pm2010)

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**2-4 Atlanta, GA USA** *FABTECH Int'l & AWS Welding Show and Metalform- with a Thermal Spray Pavilion and Conference* - organized by American Welding Society, [www.aws.org](http://www.aws.org), Fabricators and Mfgs Assoc, [www.fmafabtech.com](http://www.fmafabtech.com), Soc. of Mfg. Engineers, [www.sme.org/fabtech](http://www.sme.org/fabtech)



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**Abstract: Corrosion Properties of Cold-Sprayed  
Tantalum Coatings**

**Heli Koivuluoto, Jonne Näkki, and Petri Vuoristo**

Cold spraying enables the production of pure and dense metallic coatings. Denseness (impermeability) plays an important role in the corrosion resistance of coatings, and good corrosion resistance is based on the formation of a protective oxide layer in case of passivating metals and metal alloys. The aim of this study was to investigate the microstructural details, denseness, and corrosion resistance of two cold-sprayed tantalum coatings with a scanning electron microscope and corrosion tests. Polarization measurements were taken to gain information on the corrosion properties of the coatings in 3.5 wt.% NaCl and 40 wt.% H<sub>2</sub>SO<sub>4</sub> solutions at room temperature and temperature of 80°C. Standard and improved tantalum powders were tested with different spraying conditions. The cold-sprayed tantalum coating prepared from improved tantalum powder with advanced cold spray system showed excellent corrosion resistance: in microstructural analysis, it showed a uniformly dense microstructure, and in addition, performed well in all corrosion tests.

**Read the entire article in the March 2009**

**Journal of Thermal Spray Technology.**

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## Wall Colmonoy Announces Johnson as Alloy Products Vice President



Wall Colmonoy announces the appointment of **Craig Johnson** to the position of Vice President, Alloy Products Group.

Craig has over twenty years of service at Wall Colmonoy, most recently as the Commercial Director for the Alloy Products Group. He began his career at Wall Colmonoy as the Materials Manager for the Alloy Products Group where he was responsible for negotiating the purchase of strategic metals used to manufacture Colmonoy® alloys and Nicrobraz® filler metals.

As Vice President, Alloy Products Group, Craig will be responsible for the sales and marketing functions.

**For more information**, visit the Wall Colmonoy website at [www.wallcolmonoy.com/alloyproductsgroup.html](http://www.wallcolmonoy.com/alloyproductsgroup.html).

**Your employee should be listed here.**

## NanoSteel® Hires Mike Place as Sales Director

The NanoSteel® Company, a leader in nanostructured steel alloy surface technologies, announces the addition of Mike Place as sales director for the company's portfolio of Super Hard Steel® coating, overlay and wear plate solutions.

Place has more than 23 years experience specializing in boiler thermal spray applications for fossil power generation, oil and gas and pulp and paper covering a wide range of roles including management of field operations, projects and sales.

"Mike's breadth of knowledge and hands-on application experience is an outstanding addition to the NanoSteel team," says Mike Quinlan, vice president of sales and marketing. "As we continue to strengthen our solutions for boiler erosion protection, I am confident that Mike will add significant value to our customers."

Place arrives from Liquid Metal Coating Solutions where he was national sales director and field operations manager. Prior to this, Place held positions of increasing responsibility with other coating application companies. Earlier in his career, Place gained valuable experience understanding boiler maintenance and refurbishment by completing institutional training, serving an apprenticeship and earning a journeyman ticket as a boilermaker.

## NanoSteel® Announces Brian Merkle to Participate in ASTM International's Standards Committee on Abrasive Wear

The NanoSteel® Company is pleased to announce that Brian Merkle, director - engineering operations, will participate in ASTM International's Committee G02.30 on Abrasive Wear, a subcommittee of ASTM's Committee G02 on Wear and Erosion.

ASTM International's Committee G02.30 on Abrasive Wear develops test methods, standard practices, guides and suggested reporting procedures for tests related to the abrasion of materials caused by abrasive particles. Merkle will work on this committee's task group for revisions to ASTM's G65-04 *Standard Test Method for Measuring Abrasion Using the Dry Sand/Rubber Wheel Apparatus*, a test utilized by the wear industry to evaluate a product's resistance to abrasive wear.

"We are very pleased with the inclusion of Brian as a worthy contributor in the ongoing discussion and development of ASTM International wear testing standards," says Tom Santos, vice president of operations.

Merkle manages operations at NanoSteel's applications engineering and R&D facilities in Idaho Falls. Prior to joining NanoSteel, Merkle held positions of increasing responsibility at Superior Graphite Company in Chicago and the U.S. Department of Energy's Ames Laboratory at Iowa State University. Merkle is an Iowa State University graduate with BS and MS degrees in metallurgical engineering. In addition to ASTM International, Merkle is also a member of APMI International and the American Ceramic Society (ACerS).

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The NanoSteel Company, Inc., headquartered in Providence, R.I., develops and markets a patented portfolio of Super Hard Steel nanostructured alloy coating, overlay and wear plate solutions that effectively solve or alleviate many operational challenges faced in critical industries today, including wear, erosion and corrosion in a wide range of complex service environments.

**For additional information** contact Greg Nixon, marketing and communications manager, The NanoSteel Company, 67 Cedar Street, Suite 101, Providence, Rhode Island 02903, phone (401) 270-3549, ext. 161, cell (407) 616-5167, e-mail: [gnixon@nanosteelco.com](mailto:gnixon@nanosteelco.com), web site: [www.nanosteelco.com](http://www.nanosteelco.com).



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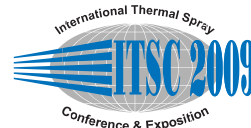
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