Improving the Economics of Plasma Spray

PROGRESSIVE TECHNOLOGIES' 100HE

Due to globalization, industry is under intense pressure to lower costs and improve quality. The thermal spray industry is not immune to these demands. In order to achieve these goals, better process control and plasma guns offering improved performance are required. In addition to closed-loop control of the process, monitoring systems that measure particle temperature and velocity are also beginning to be used. Although the algorithms have not yet been fully developed to close the loop on the plasma process using this data, it has proven itself as an excellent tool for parameter development, process monitoring and gun hardware design.

In 2001, Progressive Technologies introduced the 100HE High Enthalpy Air Plasma System. The performance attributes of this gun include consistently high quality coatings, superior deposition efficiencies and high spray rates. The design features for this gun include: enhanced plasmatron, single anode and cathode, operates with ternary gas mixture, and three different modes of powder feeding (axial, radial and external).

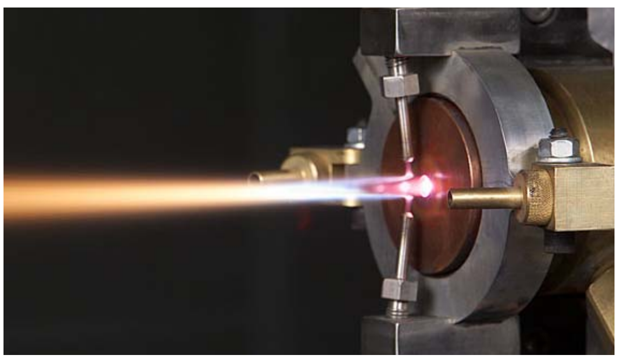

Figure 1. 100HE plasma with high velocity nozzle using Helium as the third gas.

A major influence on coating quality is the stability of the plasma. The unique design of the 100HE achieves this with an anode-cathode design that produces an elongated and stabilized arc. The high voltage, low amperage arc reduces anode-cathode wear and improves the thermal efficiency of the torch. The anode consists of three tungsten rings separated by annular grooves whose depth and width are designed to cause the arc to attach to the anode bore and prevent migration past the rings, thus stabilizing the arc length. This design provides an uniquely stable plasma plume thus significantly improving coating quality and deposit efficiency.

The robust design of the anode and cathode combined with the use of a high voltage, low amperage arc and the utilization of a ternary gas mixture consisting of two diatomic gases (N_2 and H_2) plus Argon achieves maximum enthalpy resulting in high deposition efficiencies and consistently high quality coatings at high spray rates. The 100HE can also utilize Helium instead of Hydrogen as the third gas to increase particle velocity. An example is spraying Tungsten Carbide / Cobalt and achieving an average particle velocity of 527 m/sec (see Figure 1).

Performance Analysis

In January 2003 the 100HE was subjected to a sixteen hour durability run and was stopped every hour and then restarted. Stainless Steel powder (316SS, 22µ to 53µ) was sprayed at 100 grams/minute, every hour for a period of one minute. Particle temperature and velocity were measured and plume deviation was also recorded utilizing the SprayWatch™ System from Osier Ltd. (Figure 2).

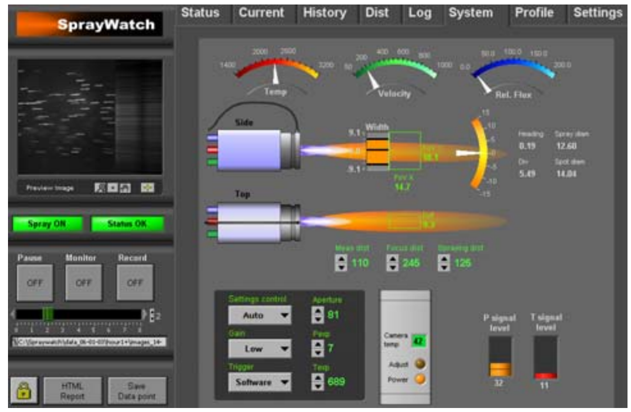

Figure 2. Temperature, particle velocity, relative flux and plume deviation measurements as shown on the SprayWatch™ system.

100HE gun parameters were data-logged every second on Progressive Technologies' CITS closed-loop controller (Figure 3).

Figure 3. CITS Closed-loop process control screen.

Table 1 shows set points, as well as measured minimum, maximum and average values for the gun parameters. The extremely small standard deviation from setpoint for all parameters over the 16 hour run demonstrates the robust nature of this 100HE system. The gun consumables for this test, i.e., anode, cathode and radial nozzle already had 20 hours of service life.

16 Hour Performance Data for 100HE			
Gun Parameters	**Set Point**	**Average**	**Std. Dev.**
Argon (SCFH)	240	240	< 0.01
Nitrogen (SCFH)	100	100	< 0.01
Hydrogen (SCFH)	60	60.7	0.110
Current (Amps)	370.5	370.6	1.656
Power (KW)	80	80.0	0.095
Voltage at Gun (V)	215.7	215.9	0.949

Table 1. Setpoints and data-logged averages over 16 hour spray event using *PROGRESSIVE TECHNOLOGIES* CITS closed-loop control.

Plots of gun current and voltage (Figure 4) as well as particle temperature and velocity (Figure 5) highlight the consistency possible with advanced plasma gun hardware and controls.

Summary

The stability of the plasma process has the biggest impact on the quality of the coating. Process instability also increases the cost of spraying. It leads to many problems, e.g., rework, short gun component life and inefficiencies that increase powder and gas consumption and labor. This test of the 100HE demonstrates process stability despite using aggressive plasma parameters; 80KW power, N_2 flow of 100 SCFH and H_2 flow of 60 SCFH. Examination of the gun hardware after conclusion of the test showed no deterioration.

Process stability combined with high deposition efficiencies has enabled the 100HE to improve the economics of plasma spraying.

Progressive Technologies provides surface treatment equipment for thermal spray, waterjet, grit blasting and shot peening processes. For more information contact Progressive Technologies at 800-968-0871 / 616-957-0871 or visit our website at **www.ptihome.com**

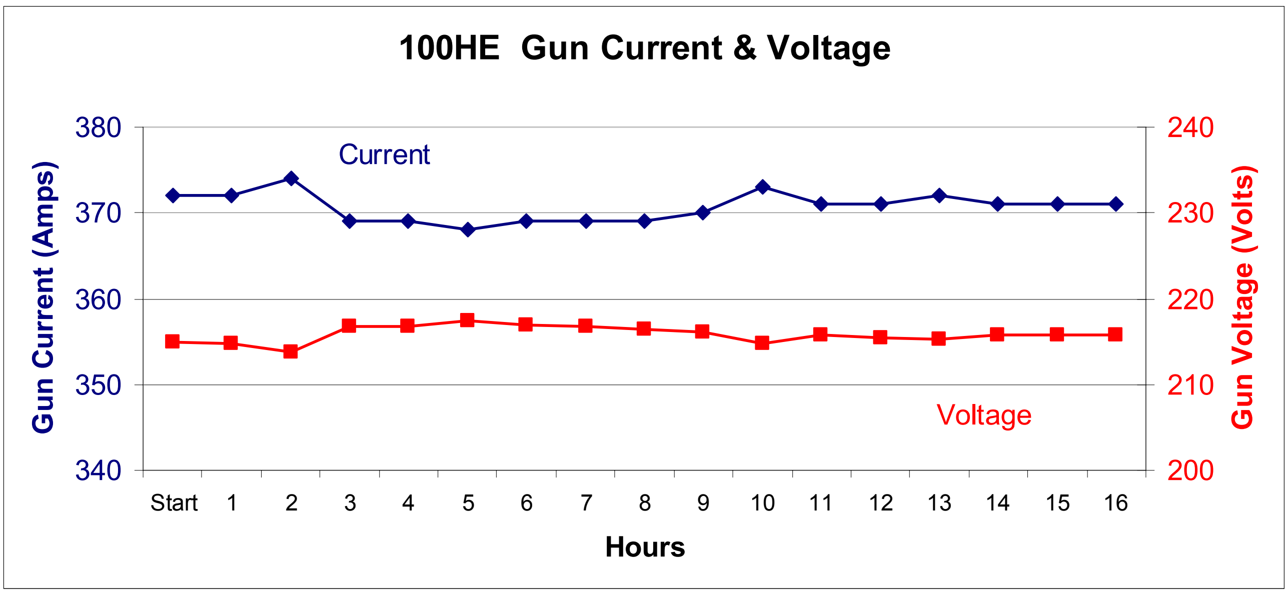

Figure 4. Graph of 100HE plasma gun average voltage and current for each hour of the 16 hour test.

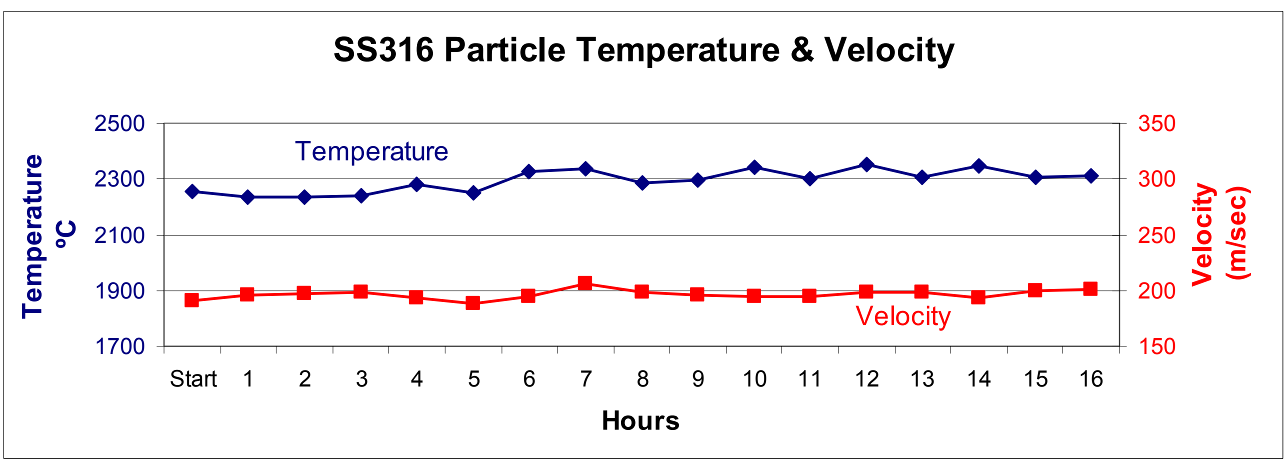

Figure 5. Particle temperature and velocity measurements for 316SS sprayed with 100HE plasma gun over 16 hour test.

Setpoint		Hour																			
		Start	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Avgs	Std Dev	
	Argon (SCFH)																				
	Min	238	238	238	238	238	238	238	238	238	238	238	238	239	239	238	238	238	238.0		
240	Avg	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240.0	**0**	**Argon (SCFH)**
	Max	242	242	242	242	242	242	242	242	242	242	242	242	242	242	242	242	242	242.0		
	Nitrogen (SCFH)																				
	Min	96	97	97	97	97	96	97	97	97	97	97	97	98	97	97	97	97	96.0		
100	Avg	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100.0	**0**	**Nitrogen (SCFH)**
	Max	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102.0		
	Hydrogen (SCFH)																				
	Min	58.5	58.9	58.4	58.8	58.9	59	59	59.1	59.2	59	58.5	58.8	59.1	59.2	59.1	59.2	59.2	58.4		
60	Avg	60.6	60.7	60.5	60.7	60.7	60.8	60.8	60.9	60.8	60.8	60.5	60.7	60.7	60.8	60.8	60.8	60.8	60.7	**0.110**	**Hydrogen (SCFH)**
	Max	62.8	62.8	62.6	62.7	62.7	62.6	62.7	62.7	62.8	62.9	62.5	62.6	62.4	62.4	62.6	62.6	62.6	62.9		
	Current (Amps)																				
	Min	370	371	371	368	367	366	367	368	368	369	369	369	370	370	369	369	369	366.0		
370.5	Avg	372	372	374	369	369	368	369	369	369	370	373	371	371	372	371	371	371	370.6	**1.656**	**Current (Amps)**
	Max	378	379	382	374	374	375	374	376	375	376	380	376	377	376	377	377	375	382.0		
	Voltage (nozzle)																				
	Min	211.7	211.8	209.6	214.3	213.8	214.2	214.0	213.5	213.7	213.3	210.5	213.0	212.9	212.8	212.4	212.7	213.7	209.6		
215.7	Avg	215.0	214.8	213.8	216.7	216.8	217.4	217.0	216.8	216.5	216.1	214.8	215.8	215.4	215.3	215.7	215.8	215.8	215.9	**0.949**	**Voltage (gun)**
	Max	216.1	215.4	215.3	217.3	217.6	218.0	217.7	217.4	217.2	216.8	216.3	216.4	216.1	216.0	216.3	216.5	216.5	218.0		
	Voltage (PS)																				
	Min	217	218	216	220	220	221	220	220	220	220	217	218	220	220	219	219	219	216.0		
	Avg	222	221	220	223	223	224	224	223	223	223	221	222	222	222	222	222	222	222.3	**1.047**	**Voltage (PS)**
	Max	223	223	223	225	225	226	225	225	225	224	224	225	224	224	224	224	224	226.0		
	Particle Velocity (m/sec)	190.6	195.8	197.6	198	192.7	187.8	195.1	205.5	198.7	196.4	194.9	195	198.5	198.6	193.2	199.4	200.5	196.4	**4.069**	**Particle Velocity (m/sec)**
	Particle Temp (ºC)	2255	2233	2236	2239	2283	2249	2327	2339	2286	2297	2342	2303	2353	2308	2346	2304	2310	2294.7	**40.371**	**Particle Temp (ºC)**