TechTalk

MOGAS scientists investigate claims comparing HVOF and Spray & Fused coating process methodology

What Causes Coatings to Fail?

In addition to selecting the right coating method, a successful coating application includes several key aspects, which offer the desired service life to the end user. These key aspects include proper surface preparation, selecting the correct material, qualifying the material, operator qualification, process/parameter control, and stringent quality control procedures.

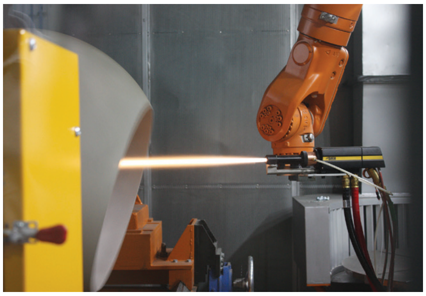

Figure 1. JP-8000 HVOF applying chrome carbide coating to 24-in valve.

CLAIM	RESPONSE
Robotic coating optmized for valve ball and seats provides the best quality coating application.	Agree. Since 1980 MOGAS has developed HP HVOF coating methodology. In 1999 MOGAS robotically coated their first ball valve. 2008 began their program of robotic laser spraying. **Figure 1**.
Traditional coating processes such as HVOF and Spray & Fuse often use manual spray guns and cause uneven coating when applied to parts. The uneven application of coating becomes a greater issue lapping the ball to the seat to make it round again. This causes the center of the coating shell and the center of the ball not to be aligned and creates high and low stress areas in the coating shell at higher temperatures due to thermal expansion. This often shows up in delaminated and cracked coatings when a valve experiences thermal cycling.	**Not a valid claim**. The coating thickness change due to lapping on the entire ball is very gradual. There is no abrupt/uneven coating thickness change, i.e. there is no stress riser at the coating and base metal interface. Therefore, stress generated due to gradual coating thickness change will not be enough to cause coating delamination or cracking. However, the residual stress inside the coating can cause delamination or cracking. MOGAS has preheating processes to prevent it from happening. Also, MOGAS is not aware of any Tier One manufacture who still manually sprays.

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CLAIM	RESPONSE
Common industry acceptance in coating porosity is up to 2%, but unfortunately many customers do not specify a need and it can become much worse. Common results from HVOF coaters can range up to 6% when not properly controlled. Experimentation has shown that <2% porosity is typically acceptable for shutoff.	MOGAS achieves less than 0.5% porosity in most instances. Less than 2% is the commercial preference.
The hardness of a coating is particularly important when dealing with severe service applications. There are often abrasives or high velocity flow that damage the coating if it is not hard enough at operating temperature. Coatings such as Stellite and Spray & Fuse have lower hardness and become dangerously low at higher temperatures.	That abrasion and erosion resistance are only affected by hardness **is not a valid claim** Published technical papers (**Figure 2**) on MOGAS patented M7 and ML-381 coatings state that abrasion and erosion resistance are proportional to the combination of toughness and hardness. This conclusion is also applicable to HVOF and Fused coatings for both room and high temperatures. As a matter of fact, Fused coating should have much higher toughness than HVOF coatings, i.e. HVOF coating is much more brittle than Fused coating. Although hardness is a key factor for abrasion and erosion resistance, if the coating is brittle such as the commercial CrOx, which has much higher hardness than M7and ML-381, its abrasion and erosion resistance is much lower.
One of the most significant advantages of the HVOF process is the lower temperature at which it is applied. The low temperature of the part maintains the integrity of the base metal to which the coating is applied. During the spray and fuse process the coating is generally applied as a low velocity spray (LVOF), not HVOF and then heated to over 1800˚F (980˚C).	The low velocity spray (LVOF) **claim is not valid**. MOGAS uses JP HVOF to apply coating and then fusing using our proprietary automated vacuum fusion process. Our coating chemistries are also tailored to meet corrosion resistance for different applications.
The Spray & Fuse process will damage the base metal, leaving it in a state with reduced mechanical properties and often worse corrosion resistance. The material cannot be heat treated back to its original condition because the spray and fuse coating will flake off if thermally shocked by heat treating.	The claim for fusing process destroying base metal properties **is not valid**. After fusing, 718 and Grade 660 are reaged and restored back to their original properties. This process is also well controlled with heating and cooling rate in a vacuum to prevent coating cracking or flaking off.

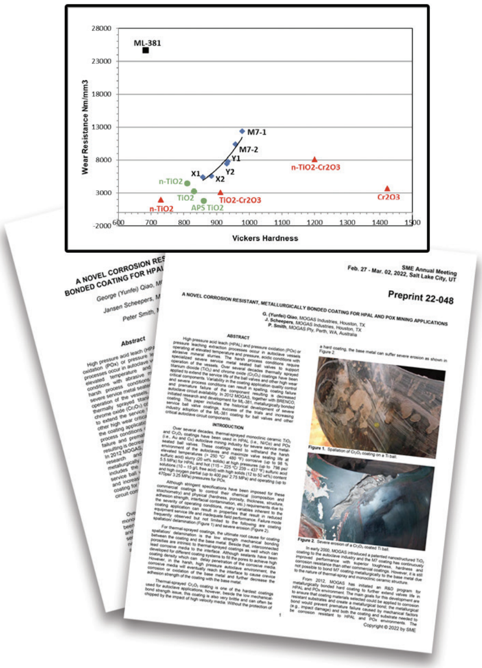

Figure 2. Published technical papers explain coating failures and successes in severe service applications.

Below: The accepted method for measuring the bond strength of an unfused thermal sprayed coating is ASTM C-633. If the coating does not fail adhesively or cohesively during the test, the maximum reported bond strength is stated as a bond strength greater than the glue test reference sample. This strength will be a maximum of 12,500 psi.

Comparison of HVOF vs Spray & Fuse

	HVOF	Spray & Fused
Bonding Mechanism	Mechanical	Metallurgical
Bond Strength	> 12,500 psi	> 45,000 psi
Toughness	Good	Superior
Corrosion Resistance	Good	Superior
Porosity	Good	Superior
Hardness	Superior	Good

Performance Comparison — HVOF vs Spray & Fused

HVOF coatings are used in the less severe areas and the spray and fuse coatings are used where high temperature thermal cycling, thermal shock and / or high cycle count is expected. HVOF coatings are much more likely to fail prematurely under these conditions due to fact that they are mechanically bonded to the substrate. The severe strain from these conditions can cause the coating to crack and spall. MOGAS experience has shown that the spray and fuse coatings, due to their metallurgical bond, perform better in these environments than conventional HVOF.

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Conclusion

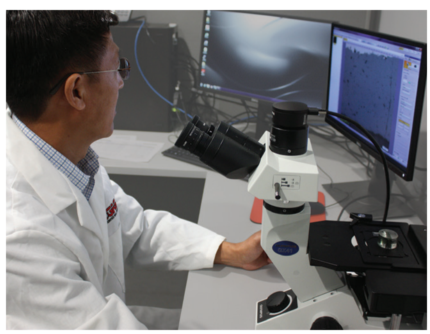
Both the HVOF and the Spray & Fuse processes produce very good coatings when proper protocol and parameters are followed. Service conditions play a key role in making the proper selection. The coating system chosen must provide for the best possible outcome with respect to the life of the valve and meeting customer expectations.

1970 | 1980 | 1990 | 2000 | 2010

- **1973** Louis Mogas founded MOGAS Industries, Inc.
- **1980** Development of Applied HVOF Chromium Carbide
- **1985** Advancements Applied HVOF Chromium Carbide
- **1987** Advancements Applied HVOF Chromium Carbide
- **1992** Established certified coater and began R&D coating program
- **1993** Developed Fusion Chromium Carbide
- **2000** Advancement on coating development targeting HPAL applications
- **2000** First to apply TiO_2 in the HPAL applications
- **2001** US patent issued to MOGAS for nano-structured TiO_2 (M1)
- **2002** Converted and repaired competitor's valves in POx for autoclaves with superior coating
- **2004** Awarded major POx autoclave order for valves with patented coating
- **2005** Awarded significant order to supply valves with n-TiO_2 (M5) coating
- **2007** Developed customized coating for major customer qualification
- **2008** Began development of laser coating technique
- **2010** M5+++
- **2011** M6 development
- **2014** M7 development
- **2017** ML381 Plant scale testing
- **2018** 18,000 sq ft coating facility

Above: With more than 40 year's experience, MOGAS is the leader in coating technology.

Right: Staffed with R&D industry experts with doctorate degrees in metallurgy and fluid dynamics, and career coating professionals, MOGAS has developed specialized coatings for multiple services.



Right: MOGAS investment in surface technology is a continuous process as evidenced by our dedicated facility.

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