TELEDYNE HASTINGS INSTRUMENTS
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Thermal Spray Gas Flow Control

How to Achieve a Consistent Flame and Avoid Issues Related to Gas Flow Control

Through the use of increasingly sophisticated controls and design, high-velocity oxygen fuel (HVOF) thermal spray technology has advanced in numerous ways. In particular, the ignition and control of the flame has benefited from the use of actively controlled flow rates which deliver steady, consistent and programmable flame characteristics and gas mix ratios. When compared to volumetric flow devices such as rotameters and critical orifices, thermal mass flow controllers (MFCs) are relatively unaffected by changes in pressure and temperature that routinely occur during the operation of a thermal spray coater. This unique attribute results in producing a higher-quality, and more uniform, coating.

Objectives

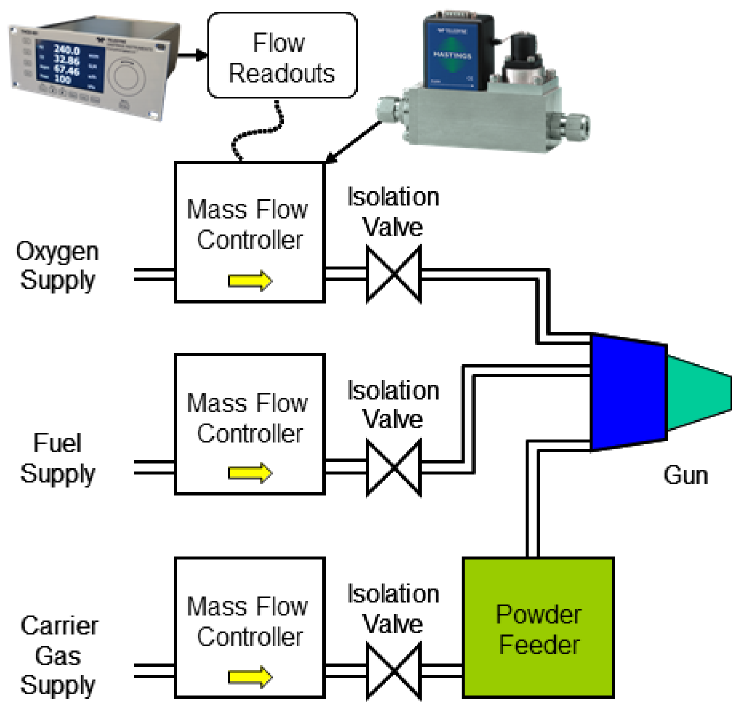
- Provide precise, stable flow rates and oxygen/fuel mix ratios to the thermal spray flame.
- Achieve controlled ignition without "popping" and "flame-out".
- Ensure consistent powder feed to the gun with controlled carrier gas flow.

Method

Most HVOF thermal spray systems use three individual flow control instruments to regulate oxygen, fuel and powder carrier gas. The flame characteristics are determined primarily by the oxygen and fuel flows, but also depend on the gun design and are affected, in part, by carrier gas flow. Precision and repeatability in the flame characteristics such as temperature, distribution and stoichiometry require that each flow be precisely controlled to well within a few percent. Flow measurement and control based on rotameter or critical orifice devices cannot routinely achieve these levels due to inherent inaccuracies and variations that occur as a result of pressure and temperature changes.

Figure 1 shows an improved flow control configuration using Teledyne Hastings products. The precision flow control of this system results in optimal modern thermal spray system performance. To allow control of the total flow while ensuring a constant oxygen/fuel mix ratio, a "master/slave" approach is implemented. This can be accomplished directly between the MFCs (see *Teledyne Hastings HFC-303 Manual Section 2.7.3*), or more conveniently using the power supply/readout functionality of a Teledyne Hastings THCD-401.

Figure 1 HVOF Thermal Spray System



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In either case, a flow set point is delivered to the "master" flow controller, while a ratio set point is automatically delivered to the "slave" MFC allowing total flow and mix ratio to be independently tuned and controlled.

Flame ignition issues are typically characterized by "popping", and in more severe cases, explosive ignition and flame-out. Both scenarios are related to oxygen start-up and fuel gas flows, and are the result of (1) incorrect sequencing of the isolation valves and flow set points or, (2) differences between the response times of the MFCs.

Sequencing problems generally occur when the isolation valves (downstream of each MFC) are used to stop the flow while leaving the set points applied to the MFCs. Because the flow has not been stopped, the MFCs naturally respond by opening their internal control valves to maximum position to achieve the set point. When flow is reinitiated by opening the isolation valves, the MFCs are still in a wide-open position allowing the gases to suddenly rush through the gun at very high rates until the MFC can respond and adjust flow. To eliminate this issue, and those related to response time differences, a typical sequence for isolation valve operation and MFC set points should be configured as such:

- The initial condition is MFC set points = 0, Isolation valves closed.
- Open isolation valves.
- Command total flow set point (maintaining ratio) from 0 to 20% of desired flow
- Wait 2 seconds for settling, then ignite flame.
- Ramp total flow set point to desired flow (either in 20% increments for 2 seconds each or as a continuous ramp for a total of 8 seconds).

Depending on the details of the system and related instrumentation, adjustments to this basic sequence may be required to achieve optimal results. Alternatively, the flows can be bypassed to a pilot light and run at a basal rate while the torch is off. Similarly, the carrier gas isolation valve and flow set point should follow a similar sequence to avoid a sudden burst that may cause a flame-out.

Instrumentation Choice

To provide accurate and stable flow control, the HFC-303 MFC is recommended for this application due to its fast response (<2 seconds), high accuracy (better than 1%) and insensitivity to local pressure and ambient temperature. The HFC-303 can be factory calibrated for any of the fuel gases, inert carrier gases or oxygen used in HVOF system applications. When converting a volumetric flow device system to MFC devices, the units of flow are converted from the ambient (room temperature) condition to standard condition reference. This means that the volumetric flow values at 20°C are multiplied by 0.932 to give the standard version of that same unit. For example, if the oxygen flow was previously controlled by a volumetric flow device at 650 lpm (liters per minute), the equivalent standard flow rate would be 606 slm (standard liters per minute). If the volumetric flow device was operating at high altitude and a local pressure adjustment was applied, the adjustment would no longer be necessary, as slm units eliminate the need for local pressure and temperature correction.

The THCD-401 is the recommended multi-channel power supply and control unit for the MFCs regulating oxygen, fuel and powder carrier gas flows. This electronic unit is capable of "master/slave" functionality between two or more channels. Additionally the THCD-401 has flow totalizer capability on each channel and can communicate via USB, Ethernet, or Analog interfaces to provide additional functions. With four available channels, the THCD-401 can also operate an alternate fuel or carrier gas to provide further process flexibility.

Producing increasingly uniform, higher-quality coatings requires advanced control of flame characteristics and powder delivery. The precision of mass flow control (MFC) of oxygen, fuel and powder carrier gas supplies ensures optimal consistency and performance from your system.

For Information on all Teledyne Hastings Vacuum Measurement and Mass Flow Instruments, visit our website:

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