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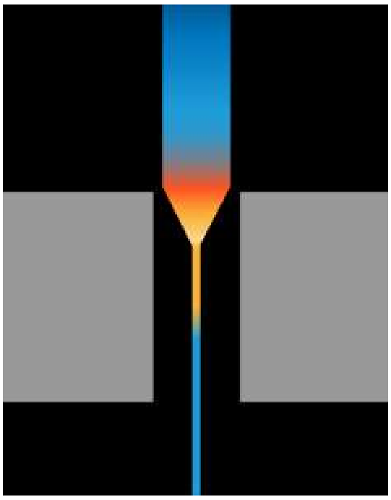
Flow Measurement & Calibration

## Fibers - as thin as a human Hair



In the optical fiber industry, manufacturers' needs center around precision and repeatability. It's somewhat analogous to archery, where accuracy means hitting the bullseye. If you can hit the same point on the target every time, that's precision. Repeatability is being able to demonstrate the same precision every time you walk up to the line and shoot. Let's take a look at how optical fibers are manufactured, and where Alicat fits into the picture.

## How Optical Fibers Are Manufactured

The fiber optic manufacturing process begins with the creation of a preform, where layers of very pure glass are built up on a rod. Different types of gases in very specific amounts are used to deposit a new glass layer on each pass, and every layer that is laid down on the base will give the end fiber a different property. A flame uses fuel gases, operated by a mass flow controller, to maintain a certain temperature and ensure the process is running optimally. The layering process sometimes takes place over the course of many hours depending on the size of the preform.

After the preform is created, it is then placed into a drawing tower. As one end of the preform is heated, inert gases are used to keep the heating element from burning up during the process. As the first drop falls from the melted end, a thin fiber is produced and then cools in a cooling tube filled with nitrogen as it descends through the tower.

The thickness is measured, quality is checked, and depending on the end use of the product, a coating process may apply a very thin polymeric or acrylic layer on the outside of the glass. This coating helps to protect the pure glass from environmental conditions and preserve the important properties within the glass fiber itself. Pressure control regulates the flow of this liquid polymer. In an extrusion-like process, it coats the fiber. Flow pressure needs extremely precise and repeatable control to provide a consistent coating over the product. Even a tiny amount of pressure fluctuation could lead to microns of variation in the overall thickness, which could dramatically affect the overall performance of the fiber. During the UV or Thermal curing, the material is keep in an inert atmosphere to help the curing process. These gases are again controlled by mass flow controllers.

Depending on the size of the preform, it's possible to run a fiber that spans anywhere from thousands of feet to hundreds of miles. We're talking about pulling something to the width of a human hair and spooling it at 90 feet per second for hundreds of miles, while still maintaining uniformity. This is why the initial phase of making the preform is so important—to make a uniform product, the mass flow controllers must offer precise, repeatable controls of the gases that are used to deposit the different layers of glass.

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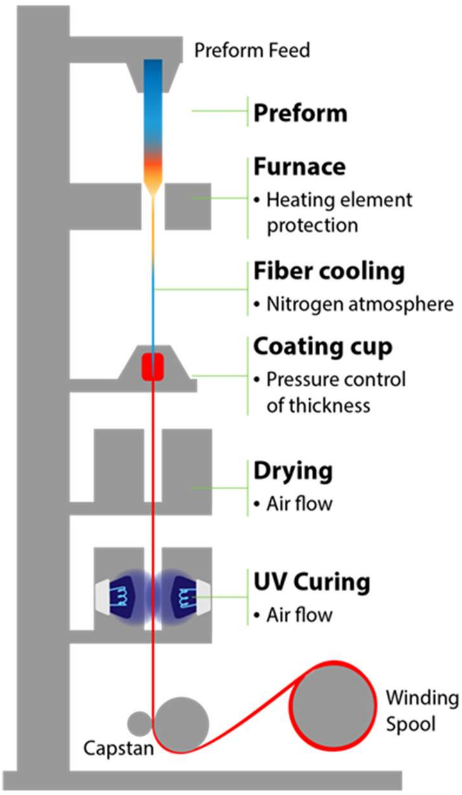
## Alicat's Role in Fiber Optic Manufacturing

Fiber optic companies use Alicat products in several different aspects of the preform process and drawing process. During creation of the preform, we can be used for the burner control application, which controls the fuel gases which heat up the preform and help to control the deposition of each thin layer. We can also control the actual gases being used to create the very pure glass being deposited. And our mass flow controllers are used in the drawing process, where argon is being fed into the furnace area to keep the element from burning up. (The end result depends on the shape of the cone.)




About every five milliseconds, signals from our measurement sensors go through our entire processor. Depending on the type of process and operating pressures, the controller will have a control response of 50 milliseconds or less. (Sometimes we can help to tune that number down to sub-50 millisecond timeframes.) For anyone who might have a hard time imagining how fast this is, it takes the average human 300 to 400 milliseconds (thousandths of a second) to blink their eyes. Before you can even blink, our instruments have already obtained hundreds of measurements. To put that into perspective, in one second the gas burners and flow in the cooling tower may be adjusted over 200 times. That's how we're able to maintain repeatability and accuracy while a fiber is produced at 90 feet per second.

More Data Collection Means More Insight into the Process

Specialty fibers for high energy applications need to have very specific optical properties, which are shaped by the density and mix of materials. Therefore, depending on the part of the process, engineers want the ability to see as many parameters as possible. With an Alicat, you not only get the mass flow measurement, but also absolute pressure, volumetric flow, and temperature information so that you can refer back to it later. From a quality control perspective, you can use these parameters to determine what changed in the process and correlate that to a run that was rejected because of a defect.

Typically, the signals that provide this information go into some sort of a controller (a PLC) for interpretation. In case of a spike or a zero-flow condition, the Alicat controller would send a signal to the PLC, which would then be able to shut down the line. Instead of having hundreds of feet or even miles of unusable product, it gives manufacturers the opportunity to identify that there's a problem, get it fixed, and start the process again quickly.

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## Compensating for Changing Environmental Conditions

Local environmental conditions can drastically affect the optical fiber manufacturing process. Unfortunately, we still find manufacturers that are used to the old way of doing things, where they don't have the ability to adjust to changes in environmental conditions. For example, a particular manufacturer is located in an area that experiences heavy thunderstorms, which cause changes in barometric (atmospheric) pressure, and that causes an inconsistent product. With a storm in the neighborhood, they might decide not to even begin their 12-hour process, depending on the day's forecast. Alicat can overcome and compensate for those changing atmospheric conditions and allow the manufacturer to produce high quality fiber—regardless of weather—because we measure flow in the context of pressure changes.

## Other glass shaping processes

Mass flow instrumentation is used in many other glass processes besides fiber optics. Container manufacturers use mass flow controllers for regulating the gas flow to their melt process. There are also manufacturers that use mass flow to control the flame used to make fiberglass for structural components. Architectural glass is another huge consumer of mass flow controller. They have an oven that's hundreds of feet long, which requires precise temperature control to create a consistent glass product. (These are typically huge sheets of plate glass.) At any given zone of the oven, a specific temperature must be maintained with very precise flow control of fuel. Alicat mass flow controllers are deployed by architectural glass manufacturers to coat the glass to create different properties in the final product.

In the days before industrial automation was available, someone who gained years of expertise could determine the correct temperature just by looking at the color of the flame. They eventually learned how to make slight manual adjustments while walking down the line. What will the company do when those people retire? That's where digital mass flow controllers come in—automation allows people to focus on developing optimal process conditions and monitoring parameters within the furnaces. Once everything is set up, it's possible to know exactly what flow rates are needed to maintain the proper temperatures. The process is repeatable, and it provides useful data that can help identify why there may have been an inconsistency in the glass. The end result is greater repeatability, efficiency and a much better product.

**Sound-Podcast to this article:** https://soundcloud.com/alicatscientific/accuracy-and-repeatability-in-fiber-optics-manufacturing

by Danielle Adams, Alicat Scientific