EXTRUDE HONE®

AUTOFLOW™ AFM

Technical Bulletin

Process Controls for Abrasive Flow Machining: AUTOFLOW AFM

AUTOFLOW AFM employs a programmably controlled apparatus and process comprising of position sensors, hydraulic valves and a sophisticated control program to maintain a consistent abrasive media flow rate. During abrasive flow machining this consistent flow rate allows media to remain at a stable processing temperature, thereby maintaining a consistent viscosity. By maintaining a consistent temperature and viscosity, it significantly improves the ability to more accurately predict both abrasive flow processing times and overall process results. This ability to control flow rate, temperature and viscosity also contributes to improving the life span of the abrasive media, reduces the complexity of the process and eliminates process limitations associated with in-line media cooling structures.

Background

Conventional AFM processes are designed to maintain constant media pressure which often results in significant changes in the media temperature, flow rate and viscosity. This, in turn adversely impacts the system's ability to predict processing times and consequently, overall process results. An AUTOFLOW AFM controlled machine works to maintain a constant media flow rate, which is known to minimize fluctuations in media temperature, flow rate and viscosity and thus improve overall process results.

Summary

The primary reason for developing AUTOFLOW was to control the velocity of the media through the work piece to provide a stable, constant and predictable work rate on the work piece. The ability to fix the media flow rate helps control work rate, media temperature and subsequent processing times. The three of those, when controlled, make a simpler abrasive flow process.
The process control inputs are:

1. Extrusion pressure – driving force of advancing cylinder under normal processing conditions.

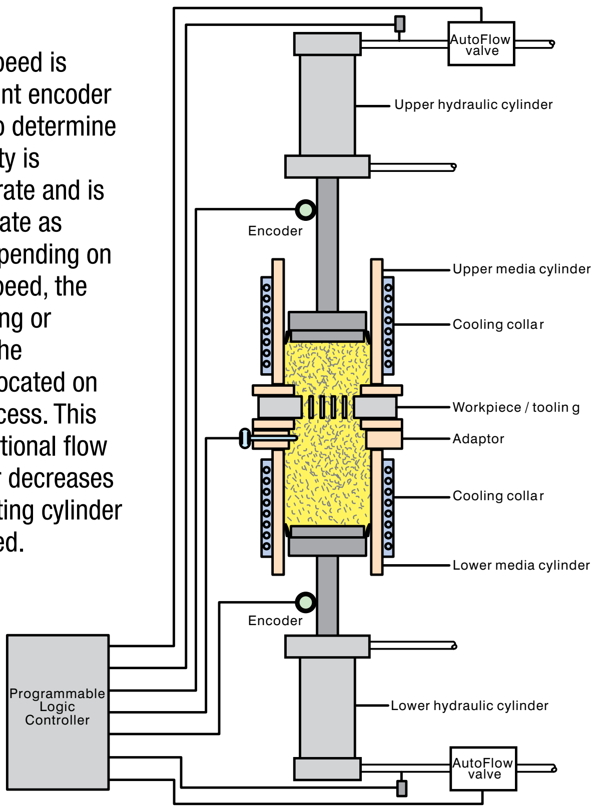
2. Flow rate – speed of the processing media slug as it passes through the work piece passage.

3. Media temperature – temperature range of the media slug during the process

4. Media volume – amount of media extruded through the component required to achieve process target

Description of the AutoFlow AFM machine

The process's advancing ram speed is controlled when the displacement encoder pulse count is sent to the PLC to determine linear velocity. This linear velocity is calculated into volumetric flow rate and is compared to the targeted flow rate as determined by control input. Depending on the actual advancing cylinder speed, the PLC responds by either increasing or decreasing the voltage sent to the proportional flow control valve located on the downstream side of the process. This opening or closing of the proportional flow control valve either increases or decreases the resistance put on the retracting cylinder which controls the process speed. This process is performed in a reciprocating fashion using the same approach just explained, in both directions.



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Process development benefits of AUTOFLOW…

Cost and efficiency

Increased media life due to controlled stresses

Controlling media temperature and media velocity prevents the media from influencing the speed of the process, as is seen with the pressure driven AFM process. When the media is forced to dictate the processing slug's velocity, it transfers more stress on the media which can both temporarily and permanently alter the media viscosity. The controlled velocity and temperature helps reduce the risk of temperature or velocity related media damage.

Decreased risk of machine and tooling failure from high flow rates and high temperatures

Many of the materials used for abrasive flow tooling are chosen due to either their wear resistance or for ease of material handling. Most of these materials are adversely affected by both high temperatures, which can degrade a material's properties, and high velocity, which can cause localized high erosion areas.

Simplification of process scale-up from single component arrangement to multi component arrangement

By reducing the process variations known to be caused by the pressure driven abrasive flow method, it is possible to easily scale the process from single cavity development trials to multiple cavity production process. Once development has identified an acceptable processing pressure, flow rate and volume it is a matter of multiplying the flow rate and volume by the scale-up factor.

Full utilization of media cylinder's cross sectional area due to media cooling collars on the outside of media cylinders

The controlled media flow rate and subsequent stable media temperature allows for thermal control of the processing slug by heating or cooling the exterior of both the upper and lower media cylinders. This approach to controlling media temperature leaves the entire cross sectional of the media cylinder open for machine to component contraction.

More room for tooling and parts by removing the media cooler in the flow path

Exterior cooling wraps on the upper and lower media cylinders prevent the need for in-line cross cooler which typically occupies 6-12 inches of open space between upper and lower media cylinders.

Less risk of water entering the media from cooler condensation or wearing through the metal cross pattern

Typical in-line cross coolers and uncontrolled media flow rate require large temperature differential because of the short residence time the dynamically flowing media spends within the cross cooler. When the warm media contacts the cold in-line cooler it can cause condensation to develop and possible enter the media slug which can change the media properties.

Quality & Range of the AFM process

More uniform flow over long passages, complex shapes and multiple part fixtures

Increase in media temperature and subsequent reduction of media viscosity leads to parabolic flow conditions. These parabolic flow conditions force most of the media flow to become concentrated close to the center of the processing slug leaving the edges of the slug to flow at slower rate. This flow characteristic results in different amounts of work done at different locations. In contrast, a controlled flow process results in more uniform media flow and more uniformly controlled abrasive work.

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Process predictability

More consistent process results

By controlling flow rate, temperature and viscosity the process results are more consistent from part to part in a production environment. The amount of work per unit of volume remains consistent from part to part as well as from day to day.

Reduced risk of large temperature changes made within short time periods

Processing temperatures are more easily controlled because the process is limited in its ability to produce heat while maintaining speed. If the speed of the media is controlled within the correct range, temperature is able to stabilize and prevent large temperature changes in short periods of time.

More predictable processing time

Processing times are more consistent by fixing the flow rate (volume/time) and choosing a target volume. Once a target volume has been established the processing times are directly proportional to the volume required.

Improved process control by stabilizing media viscosity throughout long process runs

Stabilizing media properties by controlling the media flow rate improves the process consistency both throughout long runs and multiple process runs over time.