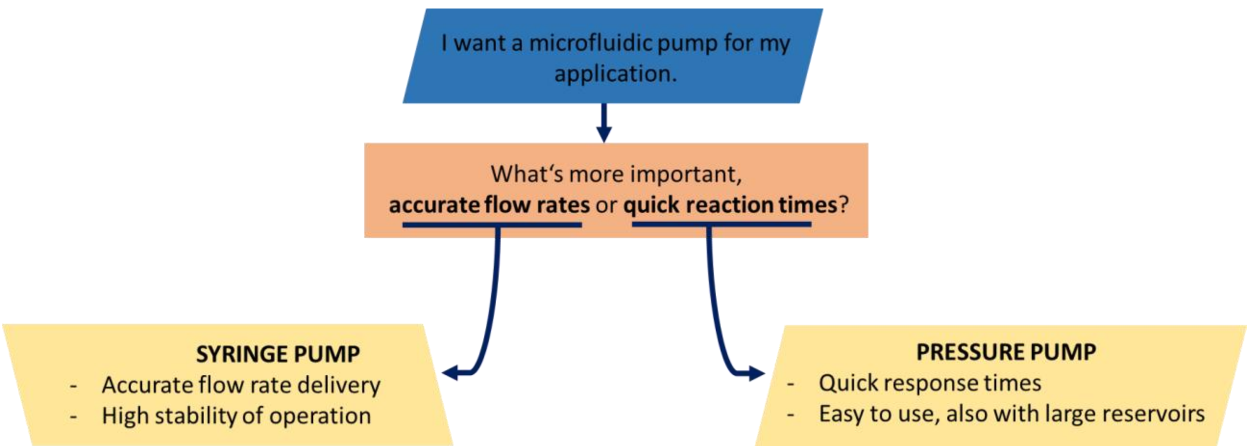
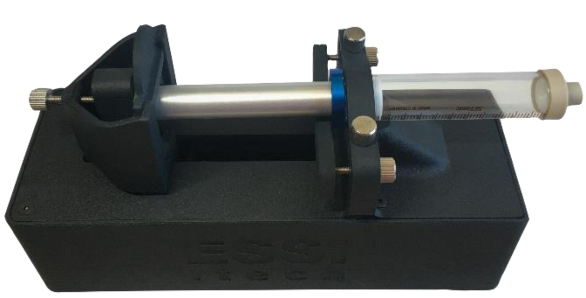
Syringe vs Pressure pumps

A comparison by a company that produces both.

Syringe and pressure pumps are two of the most common pumping systems used in the field of microfluidics where they are both appreciated for their pulseless flow delivery at very low flow rates. The technological difference is fundamental and both come with their advantages and disadvantages. This guide is here to help you identify the most suitable pumping system for your application.





1. Syringe pump

A syringe pump works by displacing the volume inside the installed syringe. The pumped volume equals to the distance travelled by the piston multiplied by the surface area of the syringe plunger. As the only medium that the system is exposed to is an incompressible liquid, the volumetric accuracy of a syringe pump is unparalleled. For that reason, **syringe pumps are essential for applications where an absolute volumetric precision is required**.

Disadvantages

The major disadvantages of syringe pump include limited volumes availability and some effort that is required to install a syringe onto a syringe pump. Additionally, dispersed samples (non-dissolved) are difficult to mix within a syringe pump.

Advantages

Syringe pumps are not disturbed by pressure fluctuations of the system – debris, changes in height between the pump and the system, temperature, changes in the viscosity of the liquid etc. will not disturb the flow rates and the pumping accuracy. Syringe pumps are highly robust and can be trusted to pump with absolute precision for months without human intervention. The syringe pumps can handle liquids with high precision: it is possible to achieve very small flow rates and also stop the liquids without the possibility of them flowing backwards.

Major considerations

In order to achieve an optimal accuracy of a syringe pump a glass or metal syringe is required with plunger seals made of non-sticky, hard sealing materials like PTFE. In this manner the movements of the piston will be translated into accurate flowrates; on the other hand, large plastic disposable syringes are more susceptible to deformations – causing delays in the establishment of the desired flow rates – and stick-slip conditions of rubber and plastic seals – causing fluctuations of flow rates.

2. Pressure pump

A pressure pump works by pressurizing a liquid reservoir to a pressure greater than atmospheric, causing the liquid to be displaced. Pressure pumps can not control flow rates as they are governed by the pressure resistance of the system downstream – the same pressure that can cause a flow rate of a couple of microliters per minute through a microfluidic will propel liquid at liters per minute through a large diameter tubing. For that reason, **pressure pumps work best for applications where easy and gentle handling as well as quick response times are required and volumetric accuracy is non-essential.**

Disadvantages

The major disadvantage of a pressure pump is the lack of control of flow rates. A change of pressure resistance in a system (e.g. a piece of debris blocks a channel) will cause a substantial fluctuation of the flow rate. The flow rates and regimes within the downstream system are affected by the change of height difference between the reservoir and the downstream system, by temperature and viscosity fluctuations as well as debris that block channels. If improperly controlled the liquids can also flow backwards (e.g. if the pump is turned off and the reservoir is below the downstream system, the liquid will be sucked into the reservoir; or, e.g., if the system is connected to two pumps with one operating at a higher pressure, a blockage of an outlet can cause the liquid to flow into reservoir with lower pressure.

Advantages

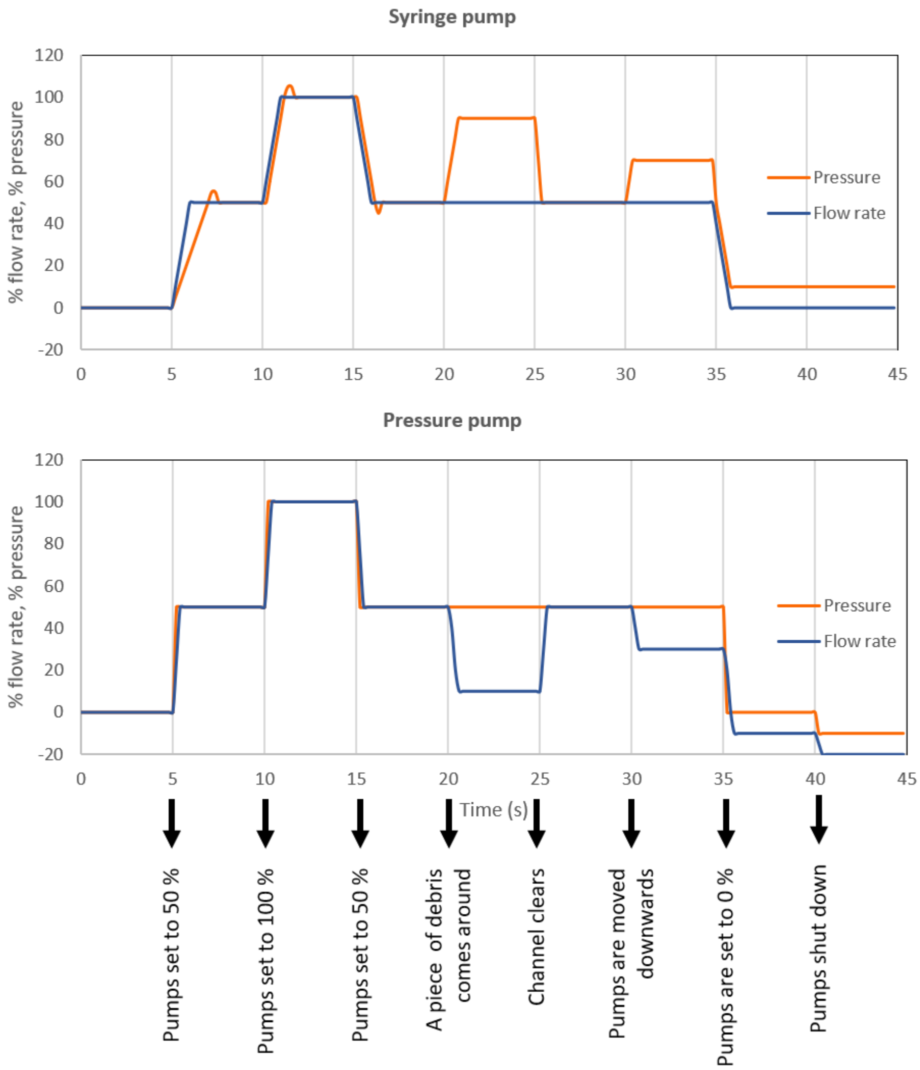
The response times of pressure pumps are excellent, at a fraction of a second, usually regardless of the size and material of the liquid containers. The reservoirs can be easily installed and replaced, and what is more, they can be very large without substantial changes in the operation of the pump. Pumping emulsions and non-dissolved liquids is simple as the reservoirs can be mixed with a magnetic mixer.

Considerations

Pressure pumps are excellent for applications like droplet generation where the behavior of liquids is monitored under a microfluidic microscope. Some companies offer flow rate sensors that can be connected to their pressure pumps, however flow rate sensors are tricky to use as they require fresh calibrations for each liquid and offer very limited accuracy. If accurate flow rates are required, a syringe pump is a simpler, cheaper and more reliable solution.

3. Comparison

What to expect? Here's are two graphs that sum up most common encounters in microfluidics.



A side by side comparison (illustration) of syringe and pressure pump shows how the flow rates (as detected within a microfluidic chip) and pressures (as detected at the pump) react to different settings and situations. The behavior depends heavily on the settings – the illustration predicts a typical microfluidic chip with Essi pressure pump and Essi syringe pump with a glass syringe.

1. Pumps set to 50 %
   - Pressure pump is expected to reach the set pressure within 0,1 s and the flow rate follows within the next 0,1 s (the delays are caused by the flexibility of containers, tubings and chip materials).
   - Syringe pump will immediately push with a set flow rate, however the expansion of tubings and chip materials is slower than in case of the pressure pump as the pressure builds up more slowly. A syringe pump with a glass syringe will reach the desired flow rate in one second and a pump with a disposable plastic syringe might take several seconds more.

2. Pumps set to 100 %
   The same phenomena as in previous situation governs similar reaction times.

3. Pumps set to 50 %
   - Pressure pump will allow quick relaxation of materials and the flow rate usually drops within 0,1 s.
   - Syringe pump relaxes the materials more slowly so the flow rates drop in a matter of seconds.

4. A piece of debris comes around
   - Pressure pump will continue providing the same pressure, however as the pressure resistance within the microfluidic chip drops due to the piece of debris the flow rate may drop significantly.
   - Syringe pump provides undisturbed flow rates regardless of the pressure resistance. Pressure will increase and the flow rate will remain the same.

5. Channel clears
   As the channel clears both pumps will resume the state of operation as before the debris got stuck.

6. Pumps are moved downwards
   - Pressure pump provides a constant pressure within a reservoir. By moving it downwards, the height difference causes the pressure within the chip to drop (undetected by the pressure pump) and the flow rate follows.
   - Syringe pump is undisturbed by the event – the pressure within the syringe might build up slightly, however the flow rate will remain steady.

7. Pumps are set to 0 % - while the pumps are below the chip
   - Pressure pump will keep the 0 % pressure setting, however because it is below the microfluidic chip the height difference will cause a negative pressure within the chip causing the flow to move backwards into the container.
   - Syringe pump will stop the flow rate regardless of the pressure fluctuations.

8. Pumps are shut down
   - Pressure pump will not control the pressure within the reservoir, causing it to drop further and the backwards flow rate within the microfluidic chip will increase.
   - Syringe pump holds the stopped flow in the same manner if it's shut down or set to 0 %.

4. Tell us about your application

We're keen to learn about your application and happy to help you tailor a pumping system to fulfill your needs. Send us an email to info@essi.tech and mention that you've read the guide (have you?) to get 5 % discount for our pumping systems.

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