Fluid Flow Trends and Regulation in Syringes

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Special thanks to Andrew S. Dejong, Kartik V. Bulusu and Michael W. Plesniak

Background

We investigated the feasibility of pressure-independent, syringe flow regulation.

Our experiments demonstrate the effects of orifice area on syringe plunger velocity and determined the appropriate orifice occlusion for various desired flow rates

Methods

We tested five occlusion levels ranging from closed to fully dilated using three weights. Each trial was completed five times and averaged (Figure 1).

The weight was placed in a container attached to the syringe and the syringe was filled to 25 mL with distilled water. The amount of time it took the water to completely evacuate the syringe was recorded. This time was used to calculate flow rate in mL/s.

Results

Flow rate (Q) is a function of fluid velocity (v) over flow area (A). Figure 1 shows Q may be effectively controlled via the manipulation of reaction forces.

Regulated and pressure independent syringe flow may be realized by adjusting the syringe's orifice area in response to changes in applied pressure to the plunger.

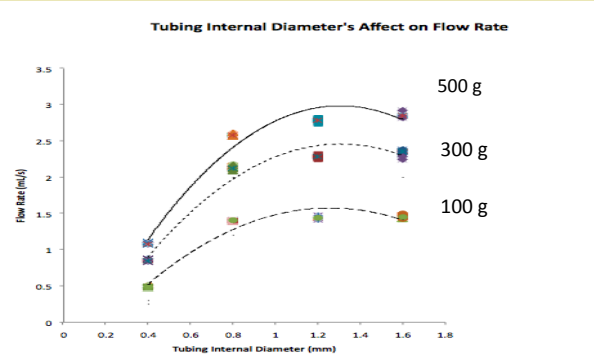

Figure 1

Discussion

Our experiments showed that the fluid in a syringe, moving at velocity (action force), experiences a velocity decrease as it passes from the syringe barrel into the syringe hub – the hub has a smaller diameter than the barrel, so fluid that strikes the barrel's distal end and does not enter the hub is sent in the opposite direction (reaction force). Subsequently, this slows the velocity of fluid upstream as the opposing forces contact. This phenomenon, called the reaction force, causes the dilation and contraction of the throat orifice area to affect plunger velocity given constant pressure.

Confounding factors (Figure 2):

- Tubing's low hardness (60A)
- Poor-fit between tubing and pinch valve walls

Tubing Dimensions and Surface

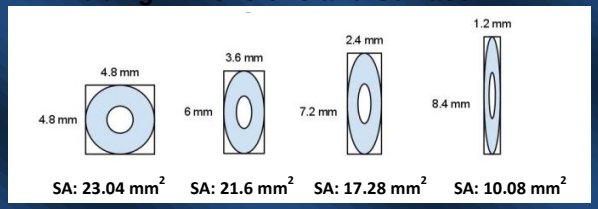

Figure 2

However the data points from the experimental trials (Figure 1) correspond to the appropriate surface areas (Figure 3)

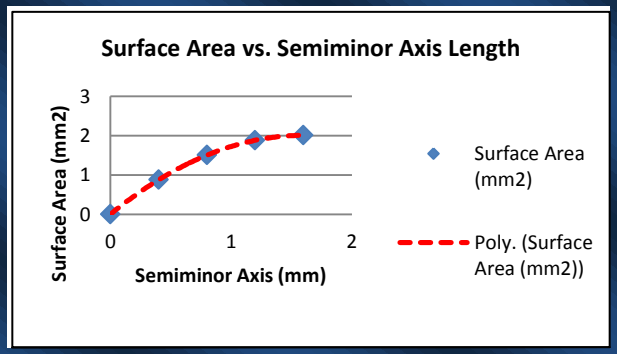

Figure 3

Application

Pressure-independent flow regulation is desirable for medical and research procedures. Human administered medicine delivery is the most common method of medication delivery and the only option for out-of-hospital health service providers. IV push medications are responsible for many patient deaths resulting from incorrect infusion rates. Field-based research and special experimental procedures may demand human administered delivery and/or draw. Without a costly and unwieldy "bench top" syringe infusion pump it is nearly impossible to achieve highly regulated flow in these environments.

Figure 3 is one embodiment of a device to regulate syringe flow. This schematic represents the next generation of biomedical flow regulators to replace and improve today's constant-velocity type pumps. This Reaction Force Flow Regulator (RxnFR) stabilizes fluid delivery and withdrawal independent of the pressure exerted on the syringe plunger.

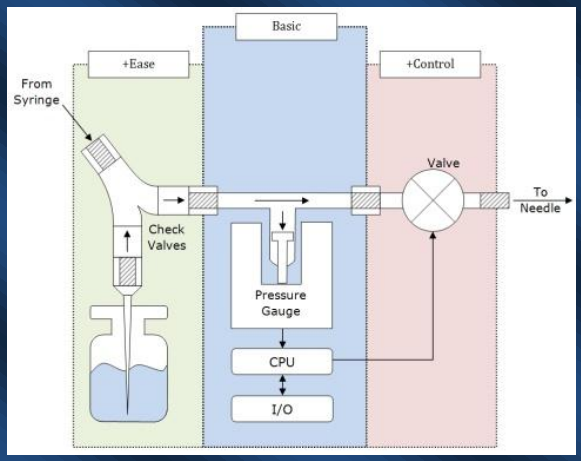

Figure 4

- Portable
- Cost-effective

Contact

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