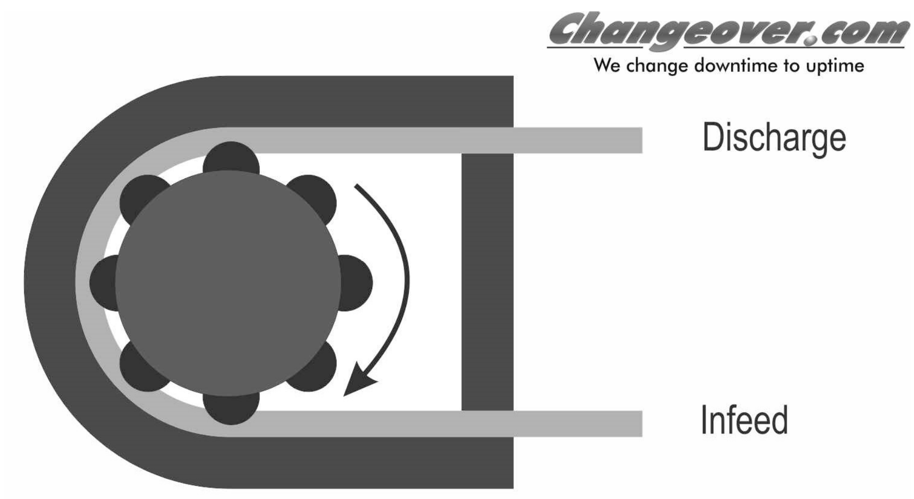
The following essay on how Peristaltic filling pumps work is extracted from chapter 5 of John Henry's Secrets of Liquid Filling book.

The book may be purchased on Amazon at https://amzn.to/4cuSIgF

Peristaltic Filling Pumps

Peristaltic pumps use external rollers to squeeze product through a resilient tube. Rotary peristaltic pumps are more common but linear peristaltic pumps are also used in product dispensing.



1.1 Rotary Peristaltic Pump
Courtesy Changeover.com

A rotary peristaltic pump consists of a semi-circular housing into which a section of resilient tubing is laid. The critical requirements of the tubing are its ability to resist repeated deformation without damage or particulate shedding. It must also have sufficient resiliency to repeatedly spring back to its circular cross-section after being flattened by the roller. Rubber, silicone and other elastomeric tubing in various grades are commonly used.

Centered in the pump housing is a rotor with rollers. The clearance between the housing walls and the outer diameter of the roller is normally slightly less than twice the wall thickness of the tubing to be used. This allows the roller to squeeze the tubing completely closed without overstressing it. Spring loading of the rollers maintains a constant pressure on the tubing, compensating for potential variation in wall thickness or stiffness. The number of rollers may vary from as few as two, to a dozen or more. Fewer rollers will cause reduced precision of the volume dispensed and, in some cases, may cause unacceptable pulsation, resulting in foaming or splashing. More rollers will improve accuracy and reduce pulsation but at the cost of increased wear on the tubing.

As the rotor turns, the roller squeegees the product forward to the discharge. Behind the roller, the tubing springs back to its circular cross-section, drawing product into the tubing. The tubing's resiliency may not be enough to overcome a product's resistance to flow. As always, a positive inlet head pressure from the reservoir is helpful. Care must be taken not to provide excessive head, as this can expand the tubing past its normal diameter. Inlet pressure must be kept constant for best performance.

When used for product filling, control of the peristaltic filler is similar to that described above for the gear-pump filler. The amount of product dispensed is directly proportional to the amount of rotation of the pump. Unlike the gear pump, there is normally no slippage of product back through the gears. Changes in speed, acceleration/deceleration and infeed head pressure, within certain limits, will have minimal effect on the amount of product dispensed per revolution.

A big advantage to the peristaltic pump is that it forms a completely closed system from reservoir to fill nozzle. There are no dynamic seals to allow product to leak out or air to leak in. Another advantage is that, because the tubing is inexpensive, the need to clean a pump, valves and the fluid path between products can be eliminated. Instead of cleaning, the tubing with remnant product is discarded and new tubing is used every job. This is particularly useful when filling chemical products that may require special solvents to clean or products where even trace amounts of the previous product may contaminate the succeeding one.

One use of peristaltic pumps is for aseptic filling of sterile products. The entire fluid path, including reservoir, tubing and nozzle, can be assembled and sterilized then transported and mounted aseptically without fear of contamination.

Single-use systems, consisting of a plastic reservoir bag, filters, tubing and filling nozzles are particularly well suited to peristaltic fillers. They can be assembled, sterilized and tested by the supplier. At the filling machine, a single connection is made to the product supply tank, tubing is run through the peristaltic pump and the nozzles are placed in their holders. It remains a completely closed system until time of use. At the end of the run, the entire system is discarded with no cleaning required of the fluid path.

Replacing rather than cleaning the tubing will save time on changeover between products. It may not seem like a lot, but it does not take much. Always remember 10W-40: 10 minutes of wasted time daily is 40 hours of lost production annually (single shift). Forty hours at 200 cpm is almost half a million unmade and unsold products.

Peristaltic tubing will lose resiliency over time. Fortunately, this is predictable. Once the breakdown point is determined, say at 75,000 cycles, the filler can be stopped when it has reached 50,000 cycles. The pump housing is opened and the tubing is moved 8-12 inches so that a fresh section of tubing is in the pump exposed to the rotors. If this is necessary, be sure to include extra tubing length when setting up the filler.

Linear peristaltic pumps are similar to rotary peristaltic pumps, but the tubing is straight. The resilient tubing is laid across a flat, rigid backing plate and clamped in place at each end. The tubing should be stretched slightly to assure that it remains straight at all times. Excessive stretching must be avoided as it will reduce the inner cross section of the tubing. Pneumatically actuated pinch bars press the tubing closed at each end. An articulated roller is mounted on a pneumatic cylinder.

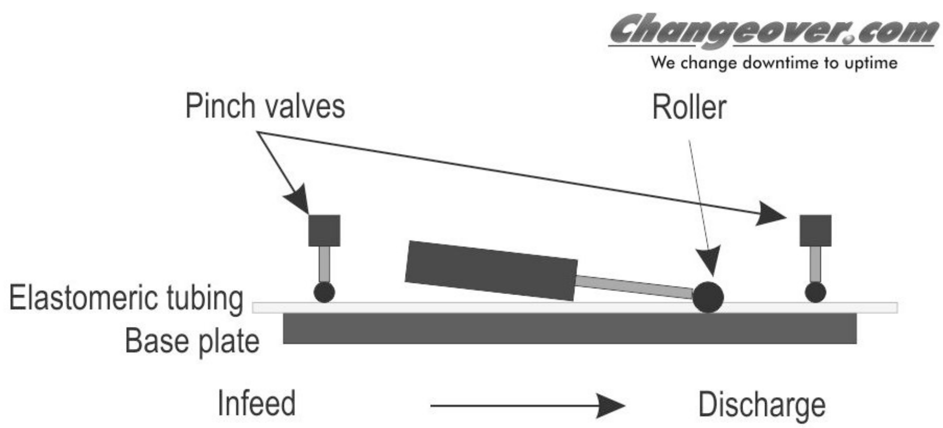
On a signal from the pump controller, the roller is pressed down on the tubing near the infeed end. Simultaneously the pinch bars at both ends open. The roller is pushed along the tubing. As the roller squeegees the product through the tubing and out the discharge it also pulls product into the tubing behind it for the next cycle. As with the rotary peristaltic pump, this may need to be assisted via positive inlet head pressure. As with rotary peristaltic fillers, excessive inlet and discharge head pressure must be avoided.

When the roller reaches the end of its stroke, the inlet and discharge pinch bars seal both ends of the tube. The roller is lifted from the tubing and retracts to the infeed end of the pump in readiness for the next cycle.

Linear peristaltic pumps can use multiple tubes arrayed side by side. One pair of pinch bars and one roller serve for all. These may be manifolded together to allow for greater throughput. Each tubing can go to a separate filling nozzle or multiple tubes to a single nozzle or multiple tubes to multiple nozzles. For example, four tubes feeding two nozzles.

Volume in the linear peristaltic pump is determined principally by controlling the length of the roller stroke, similar to a piston pump. This can be done with mechanical stops or via electrical controls. A servomotor can be used in place of a pneumatic cylinder, in which case the stroke may be controlled electronically.

If multiple tubes are used with a single roller, there may be some volume variation between tubes. To allow individual adjustment, the tube holding clamps may be provided with adjustments allowing each tube to be stretched slightly. Stretching the tube decreases its internal diameter and, for a constant stroke, the amount of product dispensed each cycle.



1.2 Linear Peristaltic Pump
Courtesy Changeover.com