White Paper

Vibratory feeders

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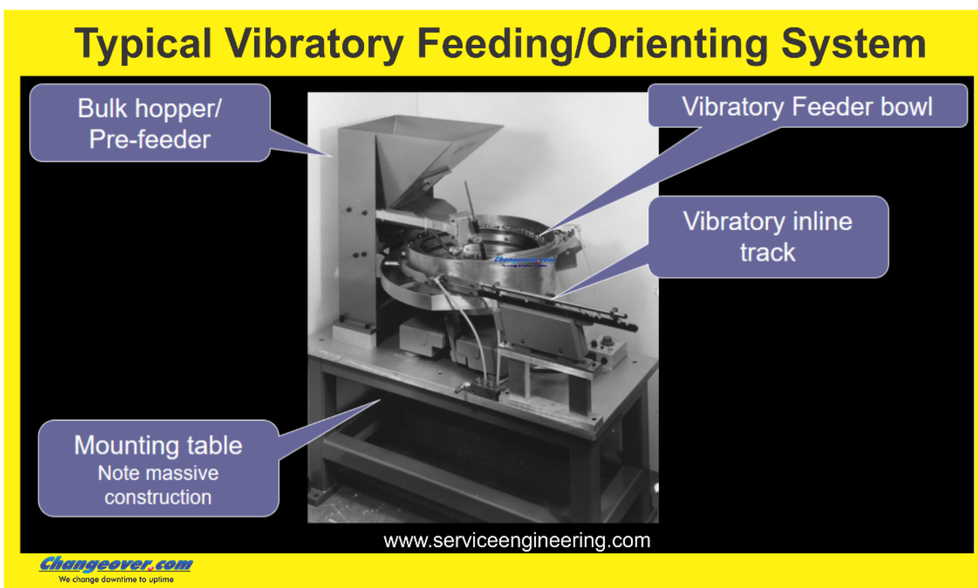
Vibratory feeders have many applications in packaging. One common use is orientation and feeding of caps and stoppers on capping machines. Other common applications include feeding components into cartons and tablets into blisters or bottles. Large vibratory troughs are used to gently convey and feed bulk product like potato chips. Vibratory feeders are used in combining scale fillers to meter product into the weighing buckets. Vibratory feeders are often used in clean rooms because, not moving, they generate few particulates.



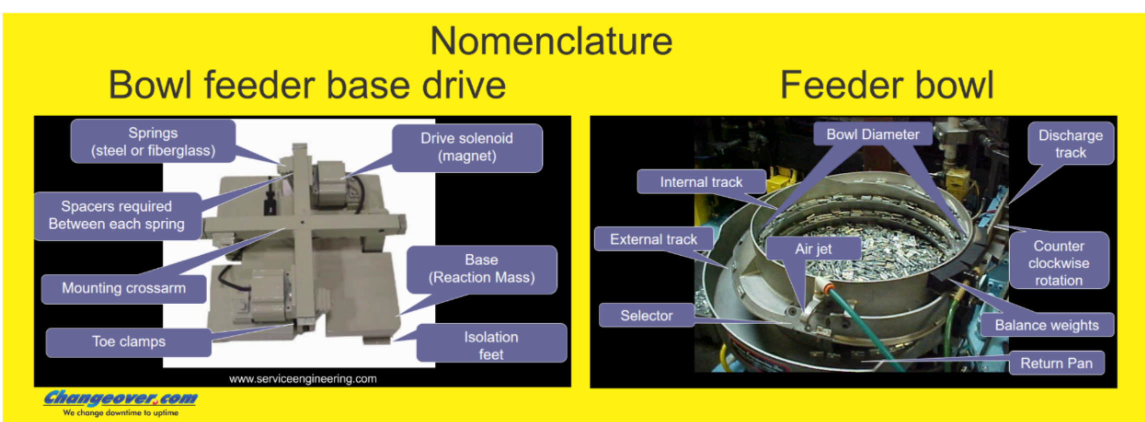
Vibrators are used in hoppers to break up clumps of product, prevent bridging and otherwise assist in gravity flow. These provide an undirected vibration and are outside the scope of this white paper. Vibratory feeders provide a directed vibration to move and orient products.

Other than back and forth vibration, vibratory feeders do not move. Unlike the jiggling vibrators used on hoppers, they cause the product to move in a controlled manner. They do this by combining both vertical and horizontal elements in their motion. They can be circular, generally called vibratory bowl feeders, or linear, often called inline feeders or vibratory conveyors.

How they work

Most vibratory feeders are driven magnetically. The bowl or track is mounted on 2 or more flexible steel or fiber springs. The other ends of the springs are mounted to a steel block. This allows the track to vibrate back and forth. The steel block must be sufficiently more massive than the track so that the track vibrates instead of the block. The entire assembly must be mounted to a heavy table or support for the same reason.

An electromagnet is mounted on the base block. This magnet pulls against a corresponding plate mounted to the track. As the electromagnet is energized it pulls the track towards it, against the spring pressure. When the track is deenergized, releasing the springs, they move the track forward to its neutral or rest position. Total movement will vary depending on the design but is typically in the range of 0.01 to 0.50”



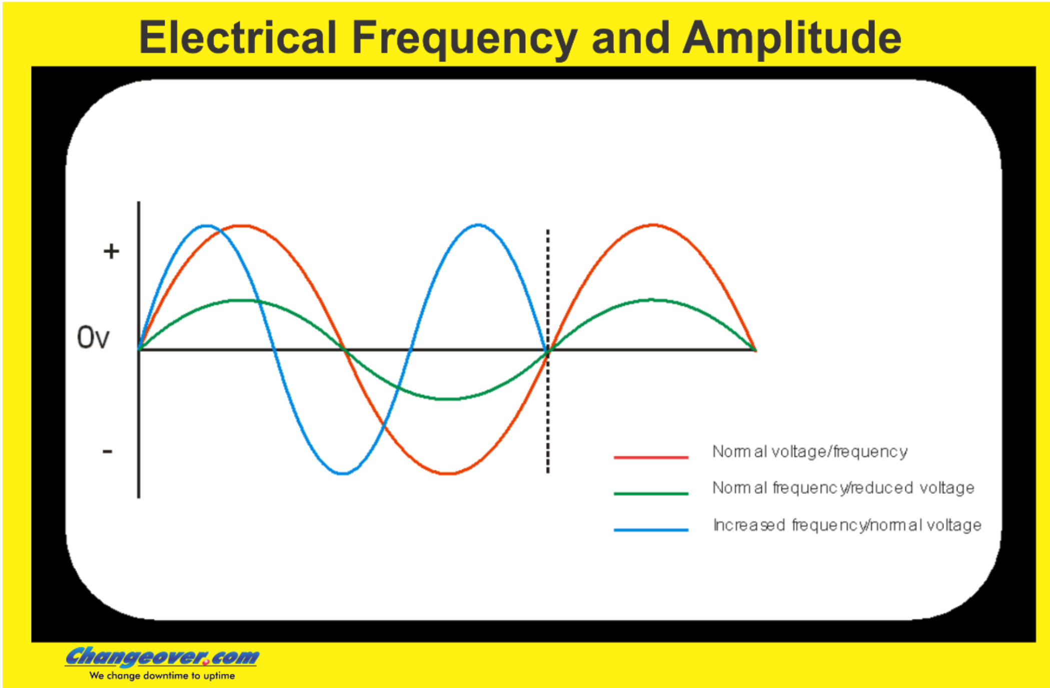
If the springs were mounted vertically, this back and forth movement would merely jiggle the product without causing motion. Instead, the springs are mounted on a slight angle opposite the direction of flow. As the magnet pulls the track back, the angle causes it the track to move down. As the magnet releases, the track moves up as it moves forward.

As the track moves back and down, the part, now unsupported by the track, tends to fall vertically. As the track moves forward and up, it is in contact with the product and pushes it forward. The actual movement of the part is a bit more complex and influenced by various factors.

The speed at which the part or material moves is determined by the horizontal displacement of the track and the number of cycles. At track vibrating 120 cycles per minute with a displacement of 0.5” will move the part at the rate of 60” per minute. This will not usually be achieved in practice since there is slippage between the track and the part. This slippage will be greater if the track is polished smooth or coated with oil or silicone. It will be less if the track has a rougher surface.

The magnet can be activated by DC current being turned on an off at short intervals. More commonly it is powered by alternating current (AC). In the US, normal AC frequency is 60 Hertz, giving 120 total pulses per second. In some other countries, 50HZ, giving 100 pulses is standard. The use of AC eliminates the need for any frequency control of the magnet and simplifies the electronics. There is normally a voltage controller. This adjusts the amplitude of the voltage to control feed rate but does not affect the frequency.

Caution: Turning the voltage up too high may cause the magnet and spring to make contact or crash. When this happens, you will hear some horrible noises.



Tuning

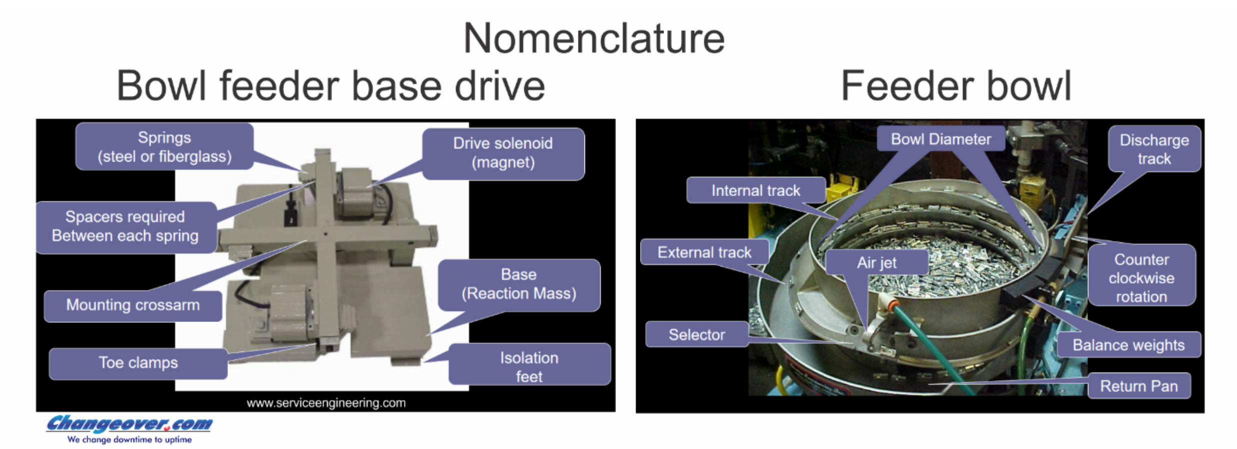
The key thing to know about vibratory feeders, whether inline or bowl, is that they are pendulums. They respond to the laws of physics regarding pendulums. Think about pushing a kid on a swing: At the top of the swing's arc when it is changing from backward to forward motion, only a gentle touch is needed to keep it swinging indefinitely. If pushed before or after the top of the arc, quite a bit of force will be required. The period of the swing, back and forth, is a function of the length of the swing and the weight.

Vibratory feeders are the same. The bowl or track, on its springs, is an upside-down pendulum and has a certain natural frequency. If the magnet pulses too early or late much of the effect is lost and the feeder is said to be out of tune. An out of tune feeder will use excessive current, will tend to be noisy and will not work effectively. The magnet's pulse frequency must match the feeder's natural frequency.

In many feeders, especially older ones, the frequency is determined by the power supply, 120 pulses/min in the US. Some feeders will use rectified AC so that only half of the cycle is used to run at 60 pulses per minute. The bowl is tuned by adding or removing springs until the bowls natural frequency is 60HZ. Tuning is also affected by the total weight so must be done with a normal load of parts.

Many modern feeders use variable frequency controls and accelerometers mounted to the feeder to tune themselves automatically. The accelerometer detects the bowl's movement and adjusts the frequency to optimize it. These can be retrofitted to most feeders and may be a solution to some feeder problems.

Vibratory bowl feeders work in the same way as an inline track but incorporate a circular track mounted in a bowl. This allows more track length for singulation, inspection, orientation or other operations in a small footprint. The bowl is usually mounted on 3 to 6 sets of springs, equally spaced for balance. This forces a circular motion as the magnets are cycled. The sawtooth motion of the part remains the same.



As the part moves along the track in the bowl it is single filed and often oriented using a static or active selector.

This photo shows a typical bowl used for cap orientation and feeding in a capper. As the caps travel up the internal track, they are single filed and laid flat with open side up or down. As the caps pass over the fingers, the caps with open side up will pass over. Caps with open side down will fall back into the bowl. Many caps have a natural tendency to orient open side up. Other parts may orient more randomly.

This photo shows an active selector. Parts are oriented lengthwise and passed by a camera. The camera detects incorrectly oriented parts and blows them back into the bowl.

Vibratory feeders may also be driven mechanically by air or electric motors. The motor turns a crank, connected by a rod to the spring, which provides the reciprocating motion. Tuning or frequency is still important but is controlled by the motor speed. This picture shows a vibratory trough conveyor for bulk feeding.

Maintenance

Since there are no moving parts, there is not a lot of maintenance required. That is not to say that vibratory feeders are maintenance free. Over time, springs will become work hardened requiring retuning in some cases. The vibration will loosen bolts and screws and these need to be checked for tightness periodically. Feeding systems should also be checked frequently for cracked welds caused by vibration over time.

The gap between magnet and spring may need to be adjusted from time to time. This gap will be larger with larger systems and should be set to the manufacturer's specifications. Too much gap will reduce magnetic force, too little may cause crashing of magnet and spring. The gap must be uniform and parallel. In some environments, rust can occur on the magnet. Even with proper gapping this can cause excessive noise.

Perhaps the biggest issue is with friction. Running surfaces will become polished over time and this will reduce the friction between part and track. This will slow feed rates. One issue that is common with plastic parts is the buildup of silicone mold release on the tracks. Tracks should be thoroughly cleaned periodically to maintain their grip.

Vibratory feeders seem like magic. They just hum and feed parts. They are not magic, just a very simple and useful machine. Understanding how they work and keeping them maintained and in tune will go a long way to keeping your plant humming.

John Henry's Secrets of Vibratory Feeding workshop is a good way to learn more about these amazing machines.