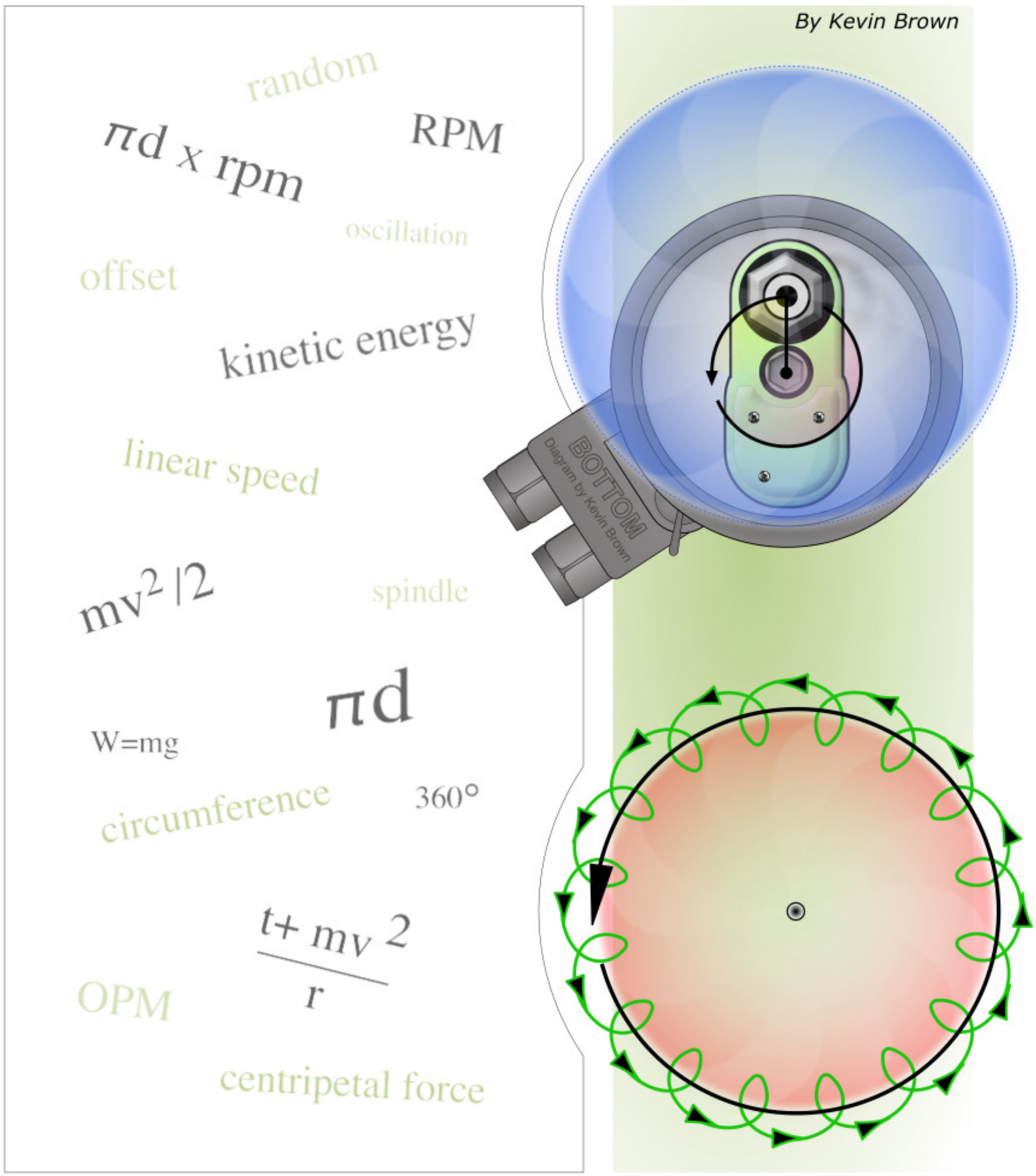
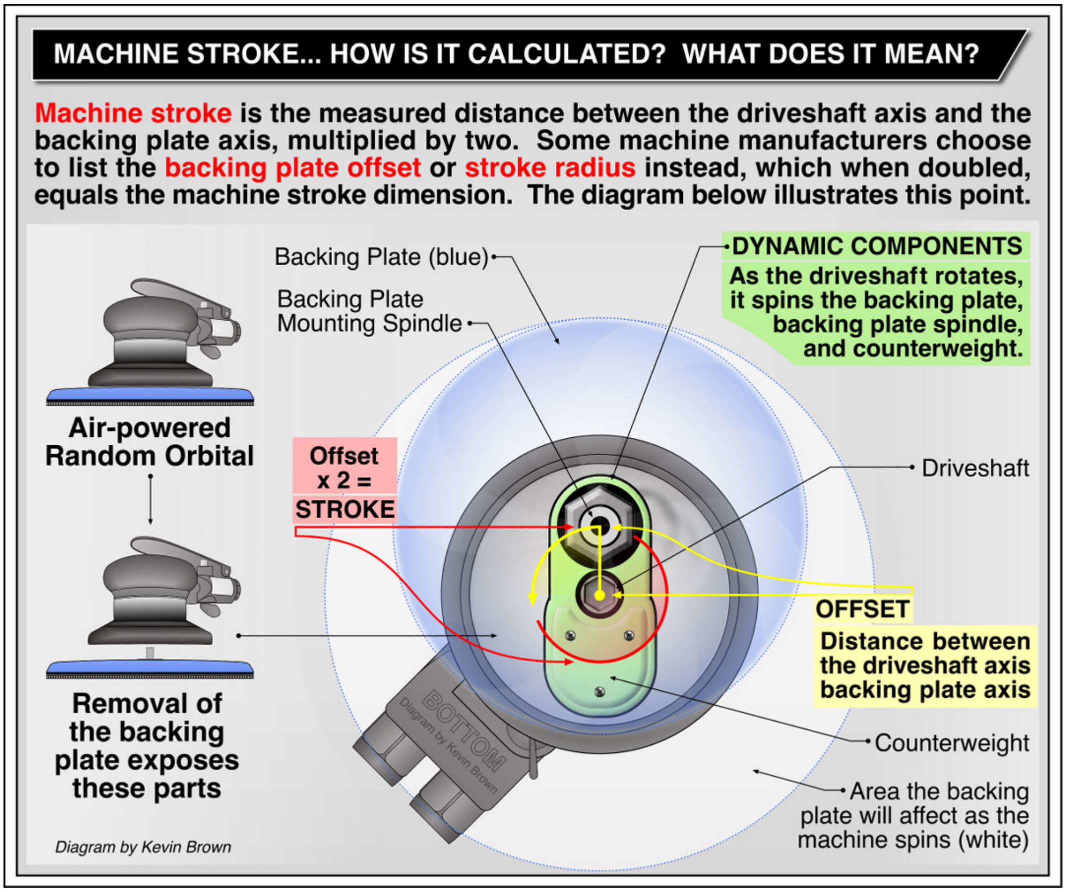
The Random Orbital

Machine Stroke- *How It Affects Sanding and Polishing Performance*

By Kevin Brown



Machine stroke is a term that identifies the diameter of the path the backing plate travels as it circumnavigates the driveshaft. Since the machine's driveshaft is rarely level with the backing plate, machine stroke actually refers to the driveshaft axis and the *backing plate* or *backing plate mounting spindle* axis. The diagram below illustrates this point:



Machine manufacturers also refer to machine offset using terms such as backing plate offset, stroke radius, and stroke diameter. Regardless the terminology, these terms are all identifiers of the machine's movement.

To clarify:

- ***Machine offset*** *or* ***backing plate offset*** *or* ***stroke radius***
  The distance between the driveshaft axis and the backing plate axis

- ***Machine stroke*** *or* ***stroke diameter***
  The distance between the driveshaft axis and the backing plate axis multiplied by two

- ***A longer offset*** *or* ***stroke***
  Places the ***backing plate axis*** *farther away from the* ***driveshaft axis***

If the machine's driveshaft is rotated *once*, the backing plate shaft will travel *around* the driveshaft axis *once*, creating a perfect circular pattern. This motion is referred to as an **orbit**. Machine manufacturers often refer to operating speeds using "Orbits Per Minute" or an "OPM" rating. Some manufacturers refer to operating speeds using a "Revolutions Per Minute" or "RPM" rating. This is completely **accurate**, but can cause confusion because this rating is sometimes thought of as referring to the backing plate's rotational speed.

Since the backing plate rotates independently of the machine's driveshaft and does so at a random rate, an accurate RPM rating cannot be easily confirmed. The diagram below compares ***orbit speed*** to ***orbits per minute***:

ORBIT SPEED VS. ORBITS PER MINUTE - WHAT'S THE DIFFERENCE?

Orbit speed is the **rate** in which the backing plate mounting spindle travels around the driveshaft. This figure is typically identified using a **distance x time** rating, such as **miles per hour**.

Orbits per minute or **OPM** is the **number of times** the backing plate mounting spindle revolves around the driveshaft axis. Some manufacturers use a **revolutions per minute** or **RPM** rating.

When machine offset is increased, the backing plate mounting spindle travels a **longer distance** as it rotates, so it will move at a **higher rate of speed** than a similar machine featuring a shorter offset. Regardless the RPM setting, the backing plate spindle will move at a higher rate of speed than a similar machine featuring a shorter offset.

The diagram below illustrates how a pencil, pushpin, and string create a motion similar to the type created by the random orbital. For the purpose of explanation, the distance between the backing plate mounting spindle and driveshaft axis has been exaggerated . Typically, the distance between the two axis is not more that 3/8", which effectively positions the spindle over and above the driveshaft. In addition, random rotation of the backing plate is not accounted for.

If pulled taut and rotated, the pencil, pushpin, and string create a motion that is similar to the one created by the random orbital. Although it looks as if the random orbital is creating an oblong pattern as it moves the backing plate, it is not. This illusion occurs because the backing plate spins off-center while rotating at a random rate. In fact, the pattern it creates is perfectly circular. The math formula for finding the circumference of a circle dictates that:

If the string length is increased, the distance the pencil travels increases.
If the machine offset is increased, the distance the spindle travels increases.

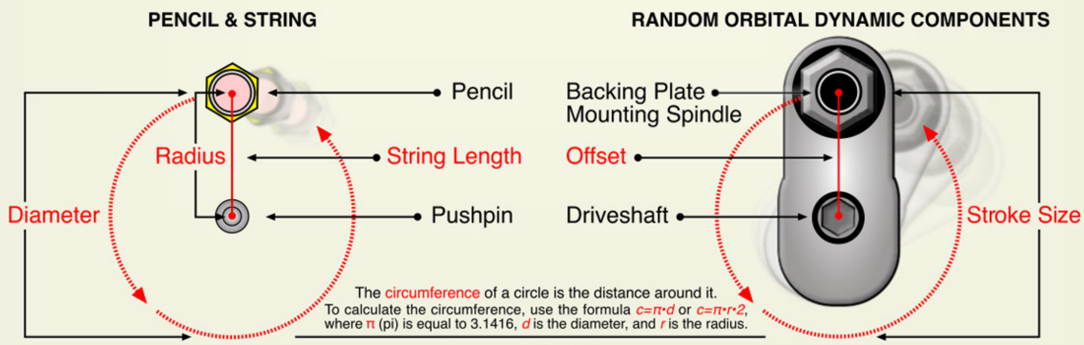
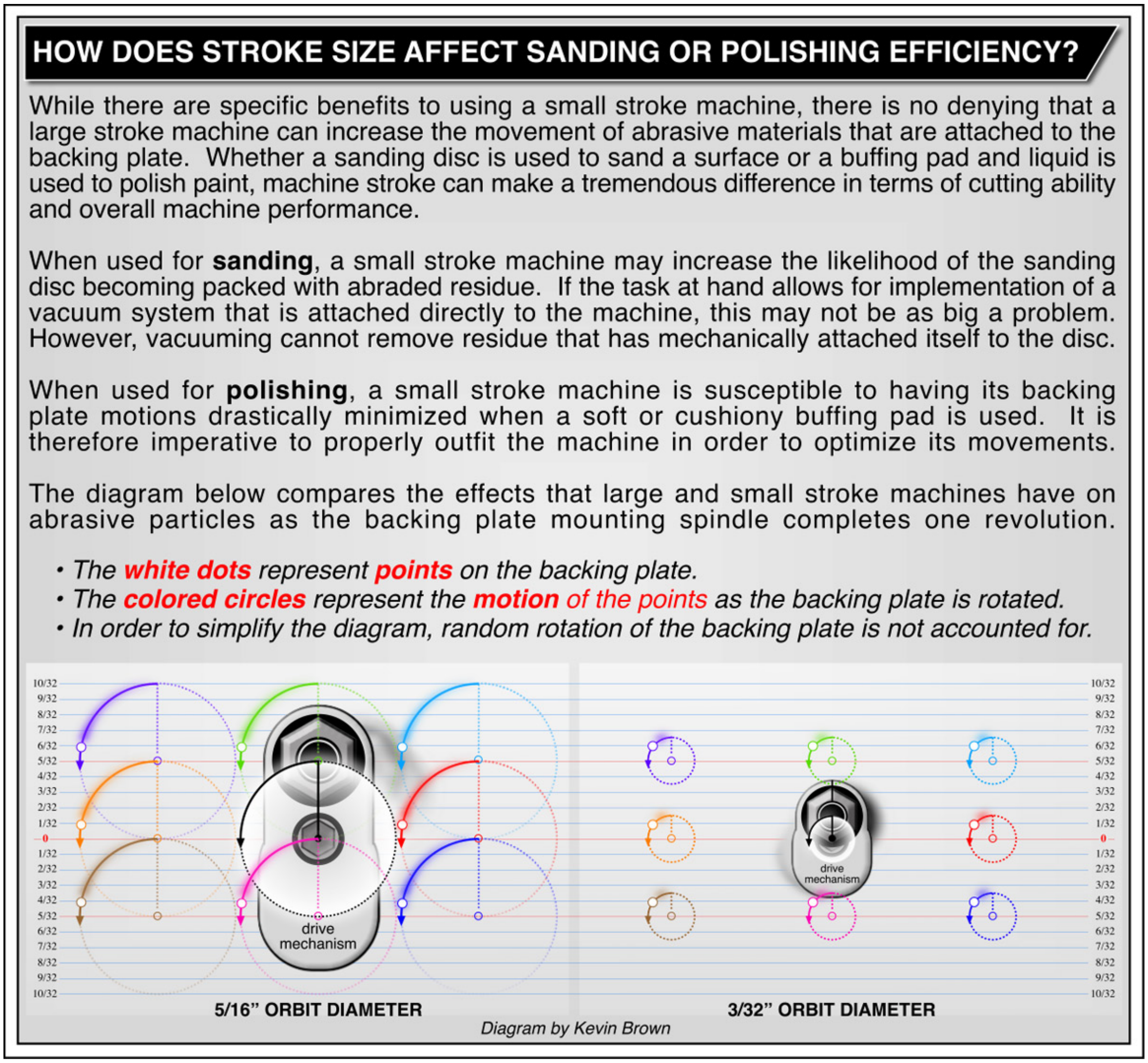


Diagram by Kevin Brown

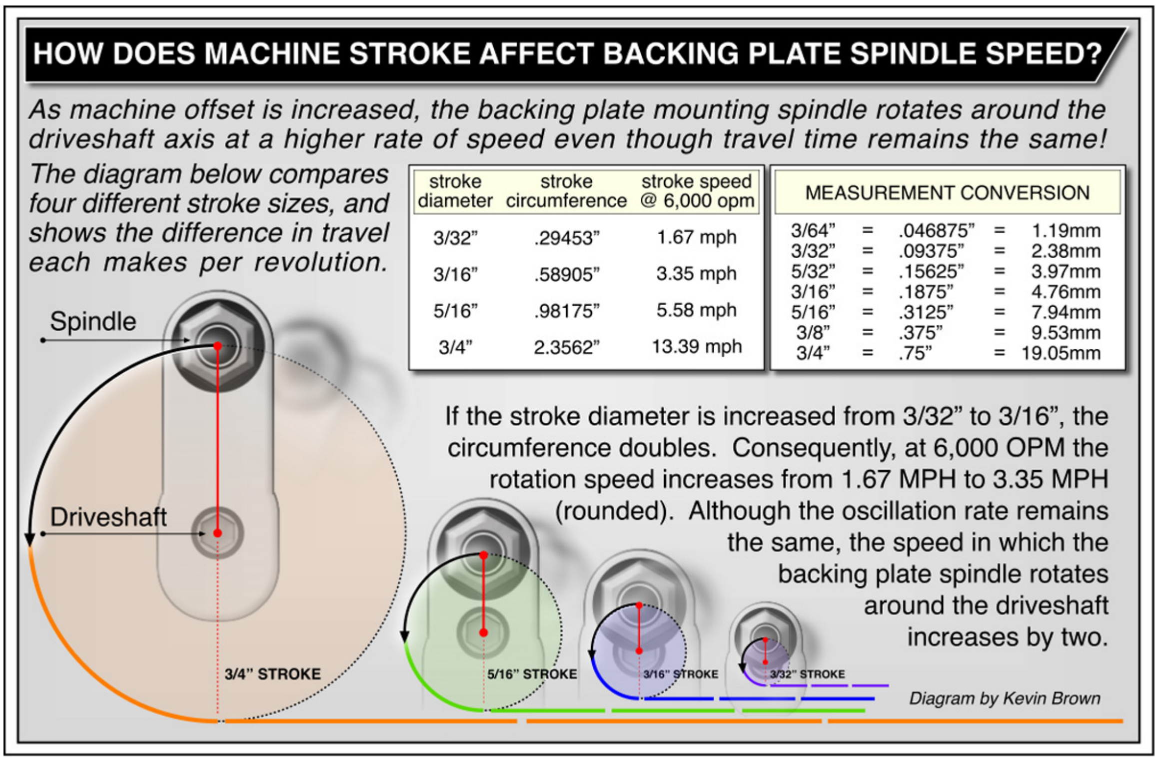
A majority of random orbital machines use a stroke diameter that measures somewhere between 1/8" to 5/16" (approximately 3.0mm-8.0mm). It is generally accepted that a smaller stroke leaves a more refined finish, but reasoning and experience tell a different story.

After all, if the sanding disc being utilized features consistently sized particles that are evenly placed *and* proper sanding techniques are used while sanding, a satisfactory result will be realized regardless the stroke. The diagram below illustrates this point:



Factually, a small stroke machine *does* confine sanding to a smaller area. This means that for a given amount of time, sanding of any one point will be multiplied. If you plan on using the machine to sand or polish items diminutive in size, a small stroke machine is the way to go. A small stroke machine is also a great choice if you will be using the machine to work on small areas (such as touch-up jobs or similar tasks), or on confined areas that may limit machine movement. In addition, a small stroke machine is generally easier to control because the backing plate *orbits* around the driveshaft axis along a smaller circular path. This equates to less lateral motion of the machine as it is held in your hand (versus a similarly outfitted large stroke machine), and is therefore easier to grasp while the machine is in use.

Otherwise, a machine featuring a large stroke delivers increased speed of backing plate motion using the same RPM setting. A large stroke also increases movement of the sanding disc, so "leveling" of the area is more consistent. Increased movement may help abraded residue more readily escape from between the disc and sanded surface, so consistent sanding results and extended life of the disc may be realized. The diagram below illustrates the differences between four of the most popular stroke sizes in relation to ***spindle speed***:



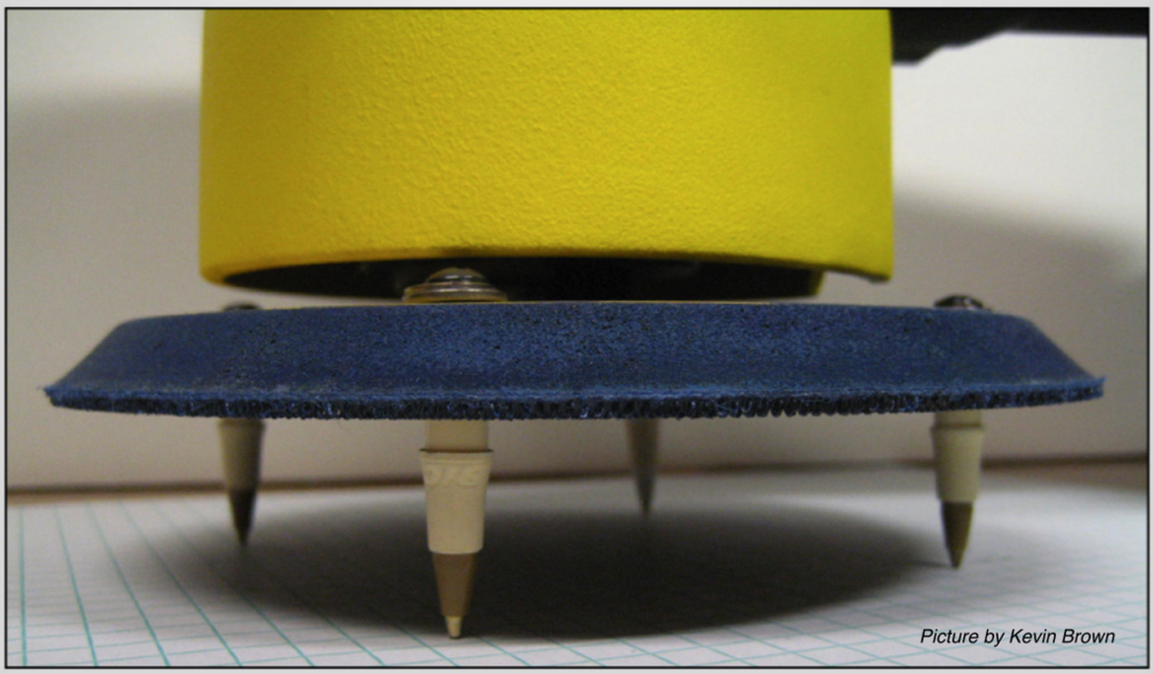
By now you may be wondering if a small stroke machine could deliver the best of both worlds by simply increasing the RPM of the machine. While this would likely increase random rotation of the backing plate, there would be several drawbacks. Most noticeable would be a decrease in user comfort, as the machine would be more difficult to control. Vibration would also increase, making the machine uncomfortable or unusable for users susceptible to fatigue. It is important to also note that since the backing plate would not have extended movement as would a long stroke machine, abraded residue and sanding debris (such as dislodged abrasive particles) might not clear away from beneath the sanding disc. The list goes on, but the most important issue that might occur due to an increase in RPM has to be a potential decrease in overall sanding performance. The following three diagrams illustrate this point:

HOW DOES THE ORBITS PER MINUTE SETTING AFFECT PERFORMANCE? 1

The pattern created by the random orbital varies constantly. This is because the backing plate mounting spindle is set inside a free spinning bearing. When the machine is turned on, the driveshaft rotates the backing plate mounting spindle around the driveshaft axis. As the backing plate moves, it also rotates in a clockwise or counterclockwise direction, and does so at a random rate. This is because the backing plate mounting spindle is set inside a free spinning bearing, and several factors affect its rotation.

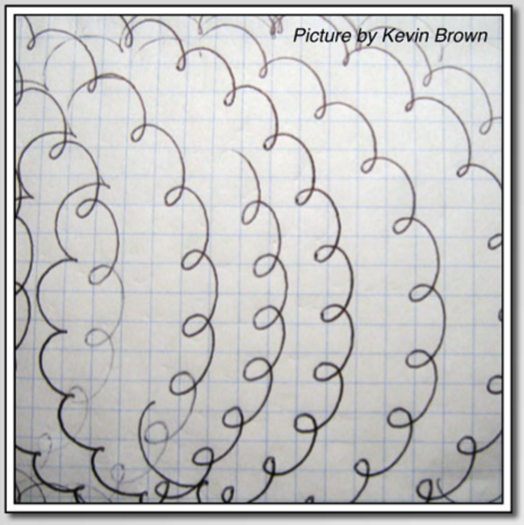
By adjusting the orbit-speed dial, rotation of the backing plate can increase, too. In many situations, increased rotation equals more cutting power. How does increased rotation affect overall performance?

To better understand the net effects of increased orbit and rotational speeds, a Meguiar's Dual Action Polisher was outfitted with a backing plate using four modified ballpoint pens in place of a sanding disc or buffing pad. The movement of the machine was transferred from the pens directly onto the paper. ***Note: the stroke diameter created by this machine is 5/16”***.

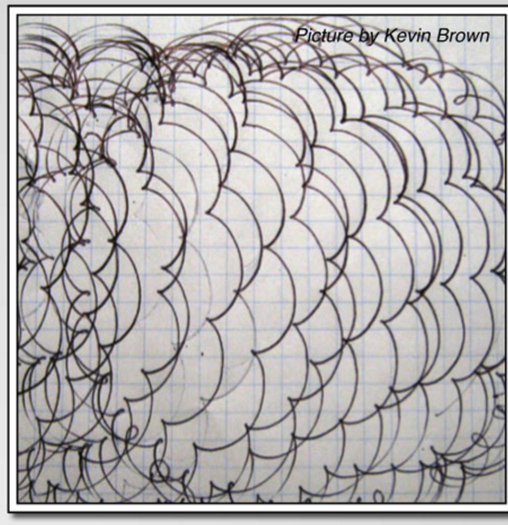


The circle created by the rotating pens measures 4-3/8” in diameter.

HOW DOES THE ORBITS PER MINUTE SETTING AFFECT PERFORMANCE? 2



This pattern was created using the machine on speed setting 1, which equates to approximately 2,560 orbits per minute.



This pattern was created using the machine on speed setting 6, which equates to approximately 6,700 orbits per minute.

- ***Machine creates a fixed-orbit size of 5/16"***
- ***User controlled linear movement was approximately one inch per second (left to right)***
- ***Applied pressure was controlled by the user, so it may have varied a small amount***
- ***Measurements are based upon the grid size of 1/4"***

The markings made by the machine tell an interesting tale. When the machine is adjusted to speed setting 1, the transition pattern shows that when one oscillation ends and another begins the ballpoint pen's movement is very smooth and curlicue in shape. However, when the machine is adjusted to speed setting 6, the transition pattern becomes very pointy and obviously abrupt.

The net result of these patterns may be difficult to envision, but easy to understand if the lines were imagined to be made by an ice skater, and the markings were made by a blade as it glided across the ice. Whereas the curlicue, slow speed pattern may show a smooth movement of the blade and no obvious gouging of the ice (in comparison to the overall depth of the ice track), the pointed, high-speed pattern would certainly show gouges in the ice at the transition points. Although a higher speed setting may increase cutting power or accomplish more work in a shorter period of time, the tradeoff may be an increase in pigtail marks embedded into the paint surface. If this is found to be the case, a lowering of the machine speed may help to offset this propensity from occurring.

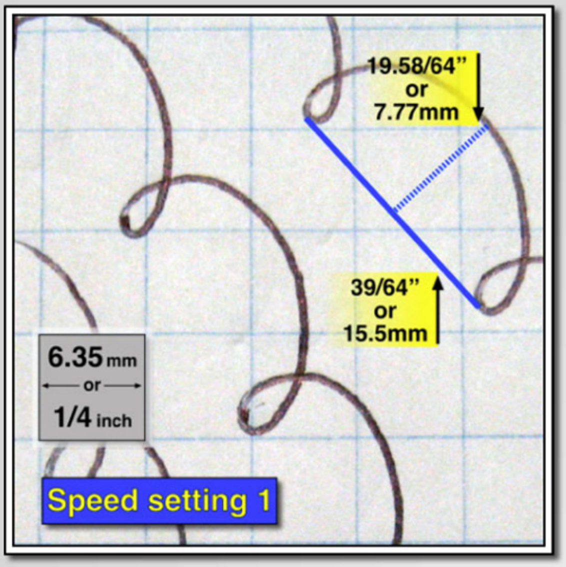
While there may be a decrease of paint leveling capability, this can often be dealt with by:

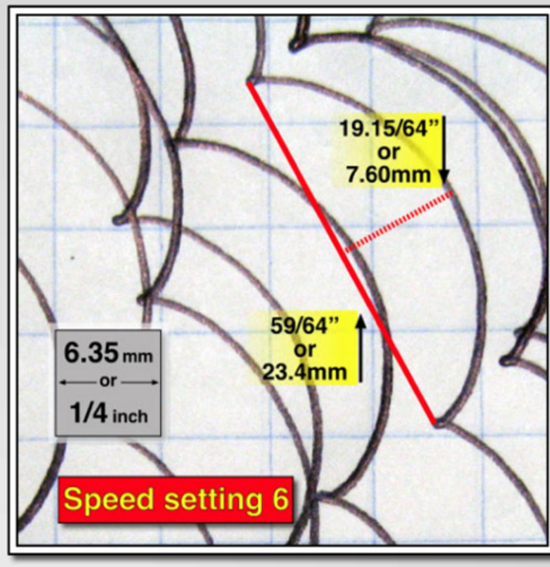
- ***Changing the sanding disc diameter or type (such as foam backed versus film backed)***
- ***Changing the backing plate diameter or type (such as one that is flexible or cushioned)***
- ***Implementing use of a foam interface pad between the disc and backing plate***
- ***Adjusting the amount of applied pressure***

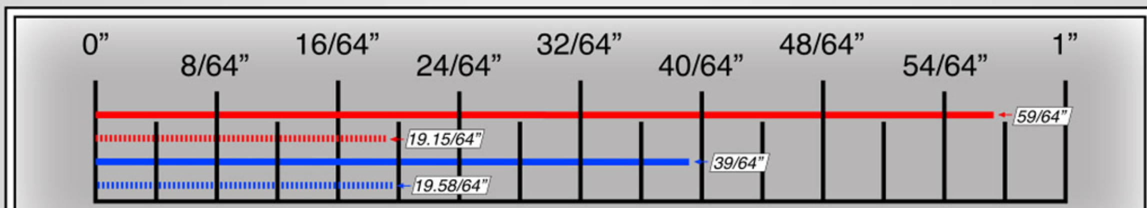
Diagram by Kevin Brown

HOW DOES THE ORBITS PER MINUTE SETTING AFFECT PERFORMANCE?

3







Measurements are accurate but not to scale.

SOLID LINE:
*This measurement compares the **overall stroke length** generated by the machine.*

*As identified by the **solid blue line**:*
*The overall created stroke length measures approximately **39/64”**, or **15.5 mm**.*

*As identified by the **solid red line**:*
*The overall created stroke length measures approximately **59/64”**, or **23.4 mm**.*

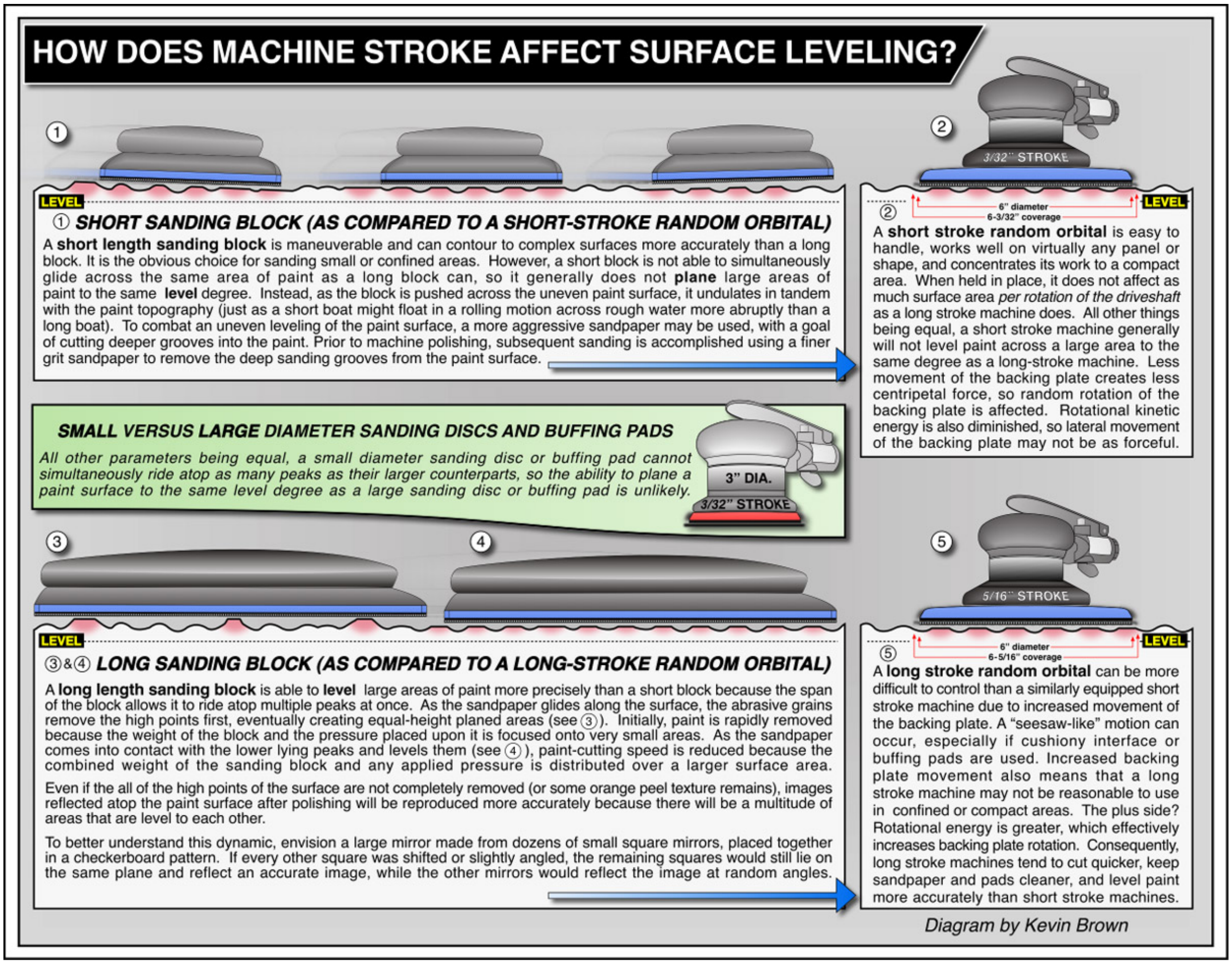
DOTTED LINE:
*This measurement helps to compare the **user-controlled linear movement** of the machine. Since the orbit size mechanically created by the machine remains fixed, this measurement should be comparably the same regardless the machine’s speed setting. In this case, the measurement shows that the machine was likely moved at a marginally faster pace on the low speed setting (blue dotted line). Therefore, when comparing this measurement to the high-speed setting diagram, the difference in stroke size is even greater than the pen mark shows. Although every stroke size varies, these diagrams clearly illustrate the difference that random pad rotation can make. Therefore:*

*As identified by the **dotted blue line:***
*The overall linear movement of the machine is **19.58/64”**, or **7.77 mm**.*

*As identified by the **dotted red line:***
*The overall linear movement of the machine is **19.15/64”**, or **7.60 mm**.*

Diagram by Kevin Brown

Keep in mind that in terms of **leveling** a large surface (one that is larger than the diameter of the pad), there is no denying that a *large diameter disc* will level that surface *more consistently* than a *small diameter disc*. Since this article pertains to machine stroke, how best to illustrate the performance differences between small and large stroke machines? A comparison of ***machine stroke*** to a typical ***handheld sanding block*** helps to illustrate the point:



What Should You Consider Before Purchasing a Machine?

There are five important factors to consider when choosing the ideal stroke size:

1.Control of the Sanding Area
2.Cushioning
3.Centripetal Force
4.Backing Plate Diameter
5.User Comfort

1. Control of the Sanding Area

User movement of the machine primarily defines the size of the sanding area. The diameter of the sanding disc has an obvious effect, too. Finally, if the machine is held in place and throttled, a large stroke machine will sand a larger area than a small stroke machine. As an example, a machine touting a 3/32" diameter stroke outfitted with a 6" backing plate will effectively sand an area 6-3/32" in diameter, whereas an identical machine featuring a 5/16" diameter stroke will sand an area 6-5/16" in diameter. Although a 7/32" variance may seem trivial, it might not be considered as such if the 6" backing plate was swapped for a 3" backing plate.

2. Cushioning

If a majority of work is going to be done using interface pads for contouring purposes, or if a lot of paint polishing will be done using the machine, it is important to note that much of the machine's motion could be affected due to cushioning from the interface or buffing pad. This is especially true if the machine is used at a high oscillation speed, as the time frame for the foam to react is dramatically shortened. Machines featuring a small stroke are certainly more susceptible to this occurrence, so this should be considered prior to purchasing a machine.

3. Centripetal Force

Have patience while reading this section- it can be hard to comprehend.

Before we discuss what ***centripetal force*** has to do with machine stroke size, it is important to understand *what* it is. Do not confuse *centri**petal** force* with *centri**fugal** force*- they are different! Centripetal force, loosely defined, is a "center seeking force". This means that any entity that causes another entity to form a circular pattern of motion is placing centripetal force upon that object.

An easy to understand example of centripetal force has to do with a **boy holding the end of string** that has a ball attached to the other end. If the boy spins in place fast enough, the ball will take flight, and string tension will direct the ball in a circular pattern of motion. The boy, through string tension, is directing the ball in a centripetal manner. Ultimately, you could say that *the string* is placing centripetal force on the ball.

What if the string is lengthened?

Even if the boy spins at the same rate, the ball will be moving *faster* because it has to travel *more distance* in the same amount of time.

What if the string breaks?

The *kinetic energy* of the ball (the energy it has while in motion) immediately forces the ball *away* from the boy. This reaction is known as a *reactive centrifugal force*, often referred to as *centrifugal force*. Centrifugal force is not important for this discussion- it's just good to know the difference. To increase kinetic energy, either mass or velocity must be increased. A-ha!

What does all this have to do with stroke size?
Quite a bit! If the stroke diameter is increased, all of the parts that are mounted to the backing plate spindle will travel at a faster rate of speed because they are *traveling a longer distance in the same amount of time*. The resultant speed increase also increases the development of kinetic energy. An increase in kinetic energy means that the backing plate (which is mounted to a free-spinning spindle and rotates at a random rate) will rotate more rapidly. Further, more resistance will be required to slow backing plate rotation.

Bottom line:
All other parameters being equal (machine, backing plate, disc or pad, sanding surface, applied pressure, and RPM setting), a long stroke machine will spin the backing plate *faster or longer* than a similarly equipped short stroke machine.

4. Backing Plate Diameter

Sanding discs are available in a wide variety of diameters, ranging from 1-1/4" to 12". For the most part, 3", 5", and 6" diameter discs are the most popular sizes. Woodworkers seem to favor 3" and 5" diameter discs, while 3" and 6" diameter discs seem to get the nod for automotive sanding duties. Regardless the job, common sense should be used when pairing specific disc sizes with small or large stroke machines.

On the small side of the scale, 3" systems (backing plate and sanding disc) would likely be used for spot jobs or tasks that require small diameter discs because of space limitations. That being said, small diameter discs work well on complex or heavily contoured areas, too. While it is not unreasonable to use a large stroke machine with small diameter sanding discs (I personally use a 5/16" stroke machine quite a bit with 3" pads for the added centripetal force it creates), most times, a small stroke machine is less unnerving to use because there is less *side-to-side* or *lateral* movement of the backing plate. Therefore, the likelihood that the backing plate will come into contact with surrounding parts or surfaces is minimized.

If the machine is going to be used on surfaces that are not very wide (such as automotive A-pillars, stainless steel body trim, or thin strips of wood), then a small stroke machine will not be so apt to "ride off" the piece, possibly gouging an edge in the process.

At the other end of the scale, a machine outfitted with a 6" sanding system (backing plate and sanding disc) benefits from a larger stroke if the surface area to be sanded is large, or substantial amounts of material need to be removed. As previously discussed, increased movement of the backing plate allows abraded residue to more readily detach and then evacuate from the sanding disc, keeping it and the sanded surface clean. A small stroke machine outfitted with a 6" sanding system allows the user to strategically sand and "level" larger portions of a panel compared to a similar machine equipped with a 3" sanding system.

When might this type of set-up come in handy? A desire to remove of a long but gradual sag in a paint job without removing paint outside the edges of the sag would be a good example of this set-up working very effectively.

Parts or materials that cannot withstand lots of shaking due to lateral movement of the backing plate would also benefit from the movements developed by a small stroke machine.

5. User Comfort

A short stroke machine does not move the backing plate as much as a large stroke machine. For users that are susceptible to discomfort due to high frequency vibration (such as when a machine is run at a high speed setting), the small stroke machine may cause more discomfort than a similarly equipped large stroke machine. For users that are susceptible to discomfort due to lateral motions (such as encountered when a machine wiggles back and forth due to the weight of the backing plate and items attached to it), a large stroke machine may cause more discomfort than a similarly equipped small stroke machine.

In general:

A machine featuring a 3/32" diameter stroke *is optimal for sanding small parts, or for sanding areas that are hard to reach due to clearance restrictions. A small stroke machine works exceptionally well on delicate parts because lateral movement of the backing plate is minimized (thus delivering a gentler movement that a large stroke machine). Random rotation of the backing plate will generally be negligible unless the machine is set to a high-speed setting (which can be a benefit or drawback, depending upon the situation).*

A machine featuring a 3/16" diameter stroke *is ideal for most tasks because it delivers ample movement of the backing plate, but it can still be used in tight or confined areas without a problem. When used for polishing paint with buffing pads and liquids, a machine featuring a 3/16" diameter stroke will usually generate enough centripetal force to keep the backing plate and buffing pad rotating. Of course, a very tall pad will negate much of the machine's motions.*

A machine featuring a 5/16" diameter stroke *is the best choice if there is ample room to use the machine, and the machine is not used regularly on parts or surfaces that are not very wide.*