Power Tool Tech: Brushless Motors 101

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What the heck is a brushless motor, and why are brushless power tools better than ones with brushed motors?

While brushless motors aren't exactly a new technology, power tool brands have only recently begun to explore their full potential in power tools. Many brands are designing their brushless tools from the ground up, and adding in other premium features to deliver more for the step up in price.

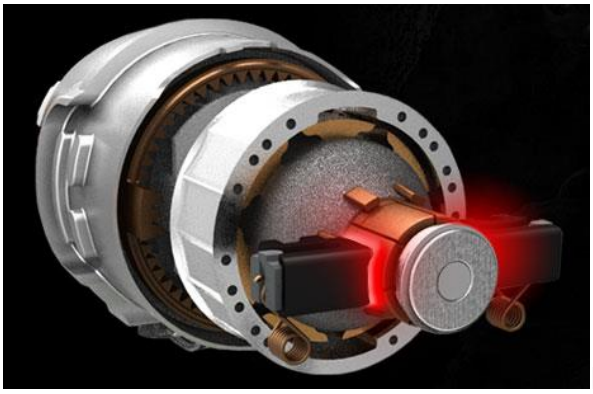
Milwaukee's M12 and M18 Fuel brushless tool lineups seem to be the fastest-growing, but other brands are starting to catch up with fantastic innovations of their own.

Now, towards the end of 2014, there are brushless drills, impact drivers and wrenches, saws, rotary hammers, and oscillating tools. There's even a brushless band saw, and another brand came out with a brushless framing nailer.

With new brushless tools coming out all the time, even by consumer brands such as Craftsman, you're probably hearing *brushless* thrown around a lot in product descriptions and marketing, and wondering what it all means.

Here's a quick primer into brushed motors, brushless motors, and why tools equipped with brushless motors are so darned good.

DC BRUSHED MOTORS

 Dewalt Brushed Motor

A basic brushed motor has an armature (rotor), commutator, brushes, axle and permanent magnets. Current is applied through the brushes, which are in physical and electrical contact with the commutator. Current then passes through the coiled armature, creating a magnetic field.

The created magnetic fields interact with those of the permanent magnets that surround the armature, causing the armature to rotate around the axle. If you apply greater current, such as when you squeeze the trigger of a cordless power tool harder, you will create stronger magnetic fields in the armature, resulting in greater interaction forces and thus faster rotation.

As you can see in the diagram, highlighted in red, the brushes are in contact with the commutator. Friction between the brushes and the commutator results in a slight drop in speed and thermal energy losses. In addition, the brushes may need to be replaced periodically as they wear out over time with use.

DC BRUSHLESS MOTORS

 Dewalt 1st Generation Brushless Motor

In a brushless motor, there are no brushes, and thus no physical contact that could lead to frictional energy losses. Instead of the armature being located on the rotor with permanent magnets fixed to the surrounding shell (stator), permanent magnets are located on the brushless rotor with the armature's electromagnetic coils in fixed positions surrounding it.

In a brushed motor, the commutator reverses the current flow through the armature coils, flipping the magnetic fields so that the rotor continues to spin. In a brushless motor, an electronic control switches the phase of current through the armature windings at precise timings to accomplish the rotational response.

BRUSHLESS VS. BRUSHED MOTORS

Brushless motors are more expensive to design and manufacture, but they are typically much more efficient than brushed motors. This leads to:

- less maintenance and longer life
- more power
- longer runtime

Often, brands have a choice in how they balance a tool's power and runtime for optimal performance. Some might lean towards making a more powerful tool, others might lean towards making one that's longer lasting before a battery swap or recharge is needed.

Brushless motors have become powerful enough to where brands boast about their premium brushless cordless tools having “corded-like performance.”

And, combined with latest generation high capacity Li-ion battery packs (we’re now at 5.0Ah), brushless tools provide better than ever cordless runtime as well.

BRUSHLESS CORDLESS POWER TOOLS

When this post was first published in early 2012, Dewalt and Milwaukee were the first two mainstream brands to come out with brushless power tools. We predicted that other brands would follow the trend, and that brushless motors would be incorporated into other tools beyond drills and drivers.

Now, there seems to be no limit as to the types of tools that can be redesigned with brushless motors. Also, as mentioned earlier, power tool brands occasionally build other premium features into their brushless tools.

For example, Milwaukee’s M12 Fuel brushless drill has a 1/2″ chuck instead of 3/8″. Many brands’ brushless impact drivers and wrenches now offer electronic speed and torque settings that allow you to dial down the power depending on the application and fastener size.

With all the benefits of brushless power tools, it’s no wonder why they top brushless tools in many areas.

In our best cordless drills, best impact drivers, and best cordless oscillating tools recommendations, brushless tools earned highest honors.

There is a downside to brushless cordless tools – they’re pricey. They’re more expensive to design and manufacture, and so they cost more to end users. The bright side is that brands often design brushless tools with premium features and improved capabilities to help you see past the higher pricing. Kits are often bundled with the latest-and-greatest Li-ion battery packs to make them even more compelling.

ADDITIONAL CONSIDERATIONS

A brushless vs. brushed motor comparison is not exactly as black and white as described. For example, moving the armature from the rotor to the stator also results in a decrease in mass and radial mass distribution of the rotor. In other words, the rotor of a brushless motor often has a much lower moment of inertia than that of a brushed motor. This means that a brushed motor rotor is more resistant to rotation. (Visualize a spinning ice skater with their arms reaching out vs. at their sides.)

So it’s not just about boosting efficiency by reducing brush-commutator frictional energy losses. Additional fundamental advantages of brushless motors include improved heat dissipation, flatter torque, reduced electrical noise, and greater power output.

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