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Power Generation is a multi-disciplined subject. A generator system is a sum of numerous parts requiring knowledge of many subjects including, but not limited to, electrical generation, engine mechanics, digital control, power distribution, principals of electricity, and switchgear control. This information sheet is Part 3 of a series addressing some electrical basics and terminology used in the generator system industry either as a buyer, specifier, user, technician or sales person. While these sheets will not qualify you as a mechanical or electrical engineer (who if consulted will provide more in-depth explanation) they provide a general overview for a 101 comprehension of the subject. This information sheet series discusses the terminology Brushless Generator in relationship to other designs and the advantages of a brushless generator to both manufacturers, supplier, and user.

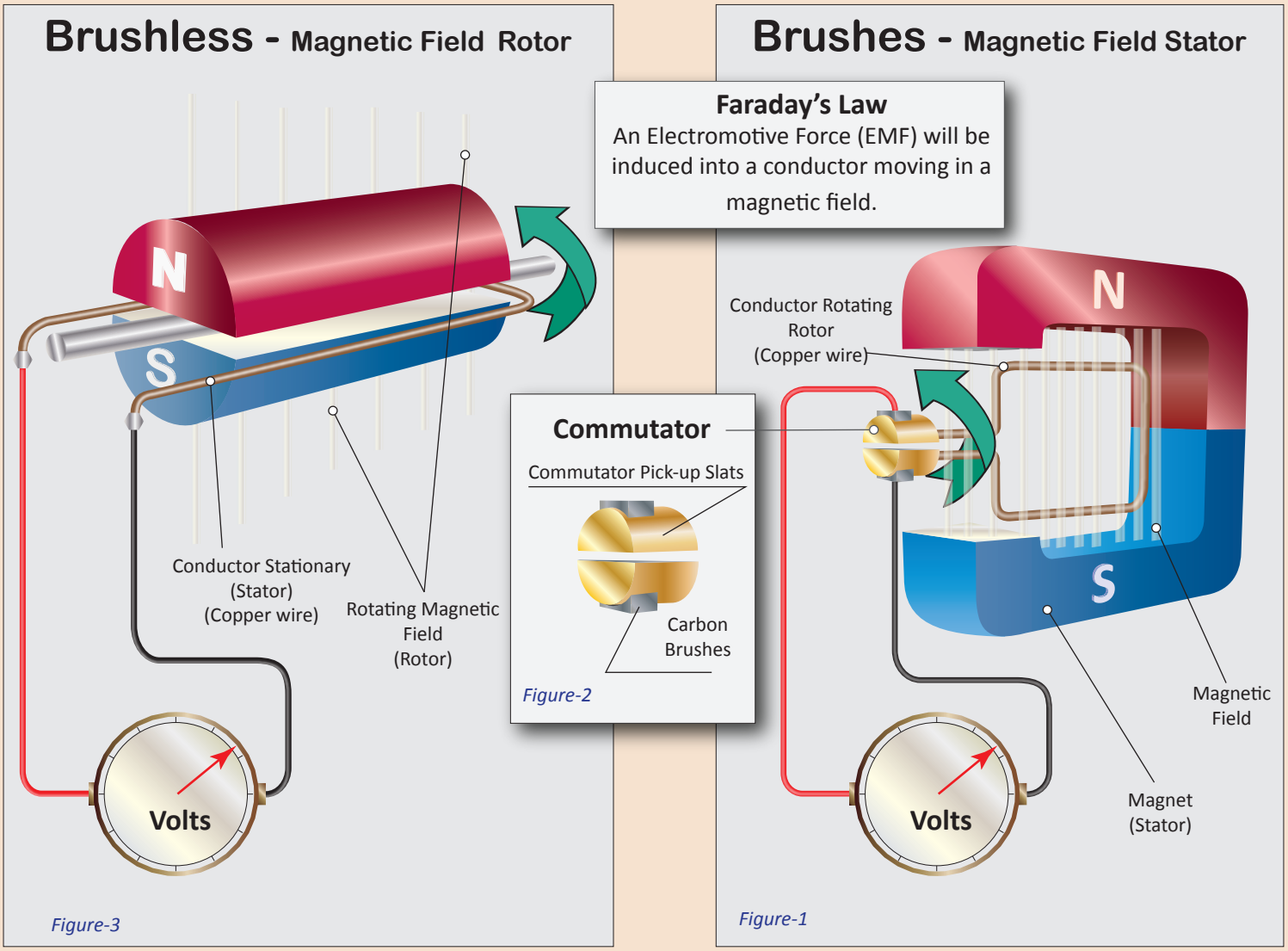
1.0 WHAT ARE BRUSHES:

To understand the term brushless, we have to return to the basics of generating electricity.

1.1 FARADAY'S LAW – Named after Michael Faraday, who defined the principal of Electromotive Force (EMF). Faraday's law states, "An electromotive force will be induced into a conductor moving through a magnetic field," as illustrated in ***Figure-1***.

As shown in ***Figure-1*** the rotor (the wires rotating in the magnetic field) is where the EMF is induced.

Brushless and Brush Generators



1.2 STATOR AND ROTOR – These words define the wiring coils of a generator.

The stator - As indicated in ***Figure-1***, the stator is the stationary coil windings that make up the magnetic field that the rotor turns within. The magnetic field is maintained and controlled by DC power via an automatic voltage regulator (AVR).

The Rotor - As indicated in ***Figure-1,***the rotor is the wires that rotate within the magnetic force generated by the stator. These rotor wires are where the EMF is induced as they cross the lines of magnetic force, or flux.

1.3 CAPTURING THE ELECTRICITY (EMF) PRODUCED IN A ROTOR – Early power generation was both Direct Current (DC) and Alternating Current (AC). The initial method for capturing DC and AC current generated in the rotor was to use a commutator. A commutator is defined as, "an attachment, connected to the armature (rotator) of a motor or generator, through which electrical connection is made and which ensures that the current flows." See ***Figure-2***.

The commutator gathers the EMF generated, but this EMF is then transferred by stationary carbon brushes that the commutator rotates within, see ***Figure-2***. This arrangement is defined as a brush generator and is still common in DC motors and generators.

2.0 DISADVANTAGES OF BRUSHES/COMMUTATOR:

As power generation developed, and standard utility power became solely AC, (some early utility power systems were DC) the disadvantage of transferring the EMF produced in the rotor via a commutator and brushes became obvious, which are:

1. **Reliability -** The action of a carbon brush contacting to a rotating commutator is a wear issue. Brushes have to be replaced at intervals to avoid poor contact due to wear and arcing between bush and commutator reduces current flow.
2. **Cost of Maintenance -** Any moving part that has to be replaced is a layer of cost for overall maintenance.
3. **Limitation of Voltage Configurations -** When EMF is generated through the rotor, see ***Figure-1***, the commutator has to be mechanically designed to pick-up and transfer the electric current via the brushes in a fixed manner as dictated by the coils connected to the commutator pick up points. This limited the voltage arrangements available to the user.

3.0 A BRUSHLESS SOLUTION:

As utility network providers established AC power as the most efficient way for electrical distribution over DC, manufacturers of generators over time looked to eliminate the requirement for brushes for two principal reasons:

1. **Reliability -** The elimination of brushes would greatly increase the running time of a generator between services.
2. **Versatility -** Manufacturers, distributors, and users of generators wanted to have machines that offered a greater selection of voltages from the same frame.

3.1 THE SOLUTION – While Faraday's law stated an EMF is induced into a conductor when rotating in a magnetic field, it did not dictate the magnetic field had to be stationary. What if the magnetic field was the rotor and the stator was where the EMF was generated.

3.2 BRUSHLESS GENERATOR – In a brushless generator design the rotor is the magnetic field, as the rotor rotates the magnetic field transverses the wires of the stator, this still follows Faraday's law, but the magnetic force is now moving across the copper wire conductors see ***Figure-3***.

With the EMF (electric current) now generated in the stator the power can be taken directly from the stator wires, not picked up by brushes taking the power from a commutator at the end of the rotor.

3.3 VOLTAGE REGULATION OF BRUSHLESS GENERATOR – An Automatic Voltage Regulator (AVR) is mounted at the end of the rotor on a brushless generator, this controls the level of magnetism within the rotor, and hence the voltage produced as the lines of magnetic force cross over the stator windings.

3.4 CONNECTED VOLTAGE OPTIONS – As electrical power is produced in the stator and does not have to be gathered via carbon brushes from a rotating commutator, a brushless generator can have the wire coils with 12-ends connected in various ways to provide several phase and voltage options.

4.0 DISADVANTAGES AND ADVANTAGES OF BRUSHLESS GENERATORS:

As for most options there are advantages and disadvantages. The following is a list of the various pluses and minuses. However, as most mainline manufacturers supply their generator systems with brushless generators, it is safe to state the industry has chosen brushless as the preferred options.

4.1 DISADVANTAGES OF BRUSHLESS – Please note the following.

1. **Cost -** The design requires more copper, so brushless are more expensive.
2. **Maintenance Skill Level -** A greater level of complexity requires a technician with higher skills to maintain the generator.

4.2 ADVANTAGES OF BRUSHLESS – Please note the following.

1. **Reliability -** Eliminating carbon brushes greatly increases operation times between service intervals and the necessity to replace worn carbon brushes.
2. **Cost of Ownership -** Reduced due to the elimination of carbon brushes.
3. **Variety of Phase and Voltage Configurations -** The stator windings ability to be connected in various configurations is useful to generator operators that need various options from the same machine, particularly rental sets. Also, manufacturers and distributors benefit from economies of scale by offering fewer generators to meet wider needs.

To fulfill our commitment to be the leading supplier in the power generation industry, the Buckeye Power Sales team ensures they are always up-to-date with the current power industry standards as well as industry trends. As a service, our Information Sheets are circulated on a regular basis to existing and potential power customers to maintain their awareness of changes and developments in standards, codes and technology within the power industry.

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