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Portescap

How Autoclavable Brushless DC Motors Can Simplify the Design of Powered Surgical Instruments

An introduction to the powered surgical instruments design challenges and selection of electric motors technology

Background

Today, powered surgical hand tools are used in almost all surgical specialties: ENT, Orthopaedics, Neurology, Eye, and Plastics. Initially pneumatic powered, all tools have now migrated to electric energy. Electric instruments offer greater performances than pneumatic ones and allow better power control, lower noise level and improved portability. They only require a simple electrical outlet or small battery, whereas pneumatic tool need complex, bulky and high maintenance air supply system.

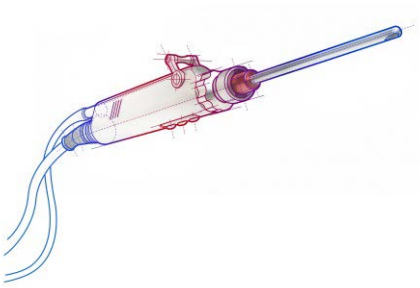

Figure 1. Arthroscopic electrical bone shaver

The conversion from pneumatic to electrical power was made possible due to significant innovation made in the field of electric motors. The main challenges resided in designing a brushless DC motor that would be powerful enough, be extremely compact and survive the repeated sterilization cycles that surgical hand tools are subject to.

What is an autoclave cycle?

The most common sterilization method used in hospitals is autoclaving, also called steam sterilization. During autoclaving, surgical hand tools are exposed to 100% humidity, 275ºF and pressure variations for up to 18 minutes. Most autoclaves also have additional vacuum cycles to facilitate steam penetration and kill bacteria, viruses, fungi, and spores that can eventually hide inside the tool. Repeated exposition to moisture is what gives tools and electric motors manufacturers the most problems causing significant electric failures.

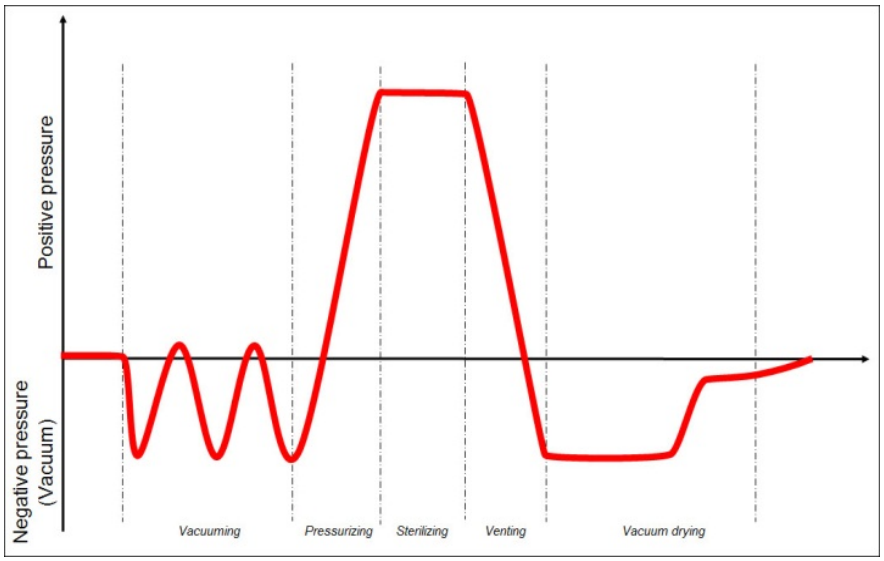

Figure 2. Pre & Post vacuum class B autoclave cycle

Different approaches
Below are four various approaches taken by surgical hand tool manufacturers for the selection of DC motors for powered surgical hand tools**.**

- ***The disposable tool***
  One approach is to use very inexpensive DC motor and plastic components. These single use tools must be disposed after surgery. Hospitals have been very concerned of increasing their amount of hazardous waste and impacting their green initiatives. In addition, disposable tools are not always the most economical option, especially for surgeries that are performed multiple times per day.

- ***The non autoclavable &, non sterile motor/battery pack***
  Another approach is to use regular DC motors attached to a non autoclavable battery pack and require the surgical staff to remove the motor/battery pack prior tool sterilization. The first issue is that the motor and battery are non sterile components. This means the medical staff has to follow a special process to add the motor/battery pack to a sterile tool, thereby leaving room for user error. Also, surgeons have been very concerned of using surgical tools that have non sterile components in the inside. The second issue is that it is impossible to ensure the surgical staff will remove the non autoclavable motor/battery pack prior sterilization which will ultimately result in premature electrical failure.

- ***Redundant seals***
  Another approach is to use a regular DC motor permanently attached to the tool and try to seal it from the outside environment. In most cases this results in very bulky designs due to the sealing redundancy needed to achieve satisfactory performance. The tool efficiency is also drastically reduced as dynamic shaft seals are added the tool or motor shaft. This means higher current draw which results in shorter battery life and increased tool temperature. Moreover, no sealing system is perfect; all will end up failing at some point.

- ***The autoclavable motor solution***
  The best design option is to use an autoclavable DC motor that can survive autoclave on its own, without the need of a redundant sealing system; thus reducing the tool size and keeping the sterilization procedure as simple as possible.

  Only a very limited number of motor manufacturers are able to design autoclavable motors. The brushless slotted technology has been a key reference in the medical market for more than 20 years. By design the slotted motor winding is already protected when inserted into the slots of the lamination stack. Additional coating or molding material can easily be added without impacting motor performances. *(Fig.3)*

  On the flip side however, brushless slotless motors are not a very good fit for autoclavable applications. The winding construction is such that it is very exposed to the outside environment. Efforts to protect the winding with coating or molding will result in increased magnetic air gap thus drastically reducing the motor performance and tool efficiency. *(Fig.4)*

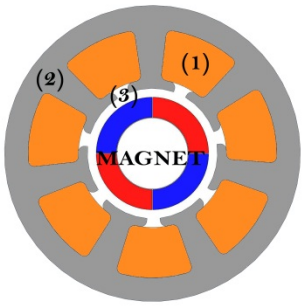

Figure 3. Brushless slotted motor cross section
(1) Winding
(2) Slotted lamination
(3) Space available for winding protection ie: coating, molding

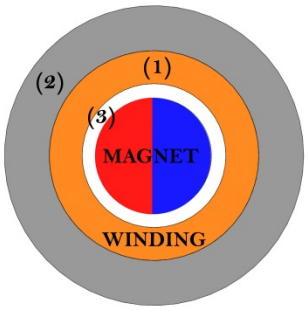

Figure 4. Brushless slotless motor cross section
(1) Winding
(2) Lamination
(3) Air gap – no room for winding protection

Conclusion

Design engineers should be very careful when selecting a motor for a surgical hand tool. While it might be tempting to select an inexpensive non autoclavable motor, it may results in a more costly end product when additional sealing costs are taken into consideration. The motor selection will also have a direct impact on the tool reliability and servicing cost. Most of the leading manufacturers of surgical hand tools now use autoclavable brushless slotted technology for their superior performances in autoclave and best in class power density.

About Portescap

Portescap is a manufacturer of brushed DC, brushless slotless, brushless slotted and stepper motors. Portescap is the leading supplier of autoclavable motors for powered surgical hand tools. Our engineering team has spent the last 20 years to perfect its autoclavable motors design. Recent test results show that Portescap motors are able to survive in excess of 2,000 sterilization cycles, which far exceeds the useful life of a surgical hand tool. In addition to the autoclavable features, Portescap offers complete motor customizations tailored around surgical hand tool manufacturer needs: shaft cannulation, cross holes, custom gear ratio, custom winding, pin connections option and motor temperature optimization. Portescap has a full product line selection with motor and planetary gearhead diameters ranging for from 12.7mm (0.5”) to 38.1mm (1.5”).

Figure 5. Portescap product offering

- Typical Portescap motor applications (medical):
  - Arthroscopic shavers
  - Sagittal saws
  - Oscillating saws
  - Orthopedic drills, medium & high speed drills
  - Wire drivers
  - Surgical staplers

- For more information, please visit www.portescap.com

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