Portescap

WHITE PAPER

CUSTOMIZED AND RELIABLE STEPPER MOTORS FOR DAMPER APPLICATIONS

HVAC System in Commercial Buildings

Miniature motors are used for various purposes, such as the control of dampers in HVAC systems. Dampers are a simple mechanism that regulate the flow of air inside a duct. Manual dampers are turned by a handle on the outside of the duct, whereas automatic dampers regulate airflow constantly, operated by electric or pneumatic motors that are controlled by a thermostat or building automation system. When designing an external mount electrical damper actuator, there are major miniature motor design elements that should be considered.

Electrical damper rotary actuators are categorized into three different types:

1. **Spring Return.** With the help of a spring, the damper can return to the required position (closed/open)
2. **Non-spring Return.** Will hold their existing position on loss of power
3. **Electronic Fail-safe.** Use supercapacitors that discharge stored energy to the motor, and the actuator is driven open or closed upon a loss of power.

We can further classify damper actuators into two-position or modulating for more precise control. If the operation of the damper is seasonal (twice or thrice a year), a two-position, manual control is the right choice. In case the operation is required more frequently (daily, for example), an automated electric damper with electrical motors becomes the better choice.

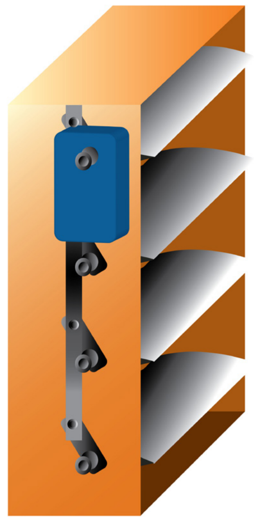

Figure 1 - External Mount Electrical Damper Actuator

When deciding on a miniature motion solution for an electric actuator we first review if the motor can be customized for necessities such as:

- How much torque/force must be delivered by the motor/linear actuator to hold the damper in position with the required control precision
- Can the motor can withstand a range of temperatures
- If the motor components are able to be customized to withstand HVAC cycles
- Are the motors proven to work reliably in an HVAC environment?
- Does the motor offer feedback to achieve integrated damper position feedback?

ROTOR DESIGN FOR EXTREME TEMPERATURES AND CYCLIC LOAD

For customized motors specific to damper actuators in HVAC applications, the design of the rotor is critical. Within the damper actuator, the motor will start and stop under varying thermal conditions which applies additional thermo-mechanical stresses on the rotor and other internal components. The mechanical properties of nonlinear material used in rotor design are temperature dependent. Thus, the reliability of the rotor for high temperature or sub-ambient temperature conditions depends on the material and their thermal properties, particularly the Coefficient of Thermal Expansion (CTE).

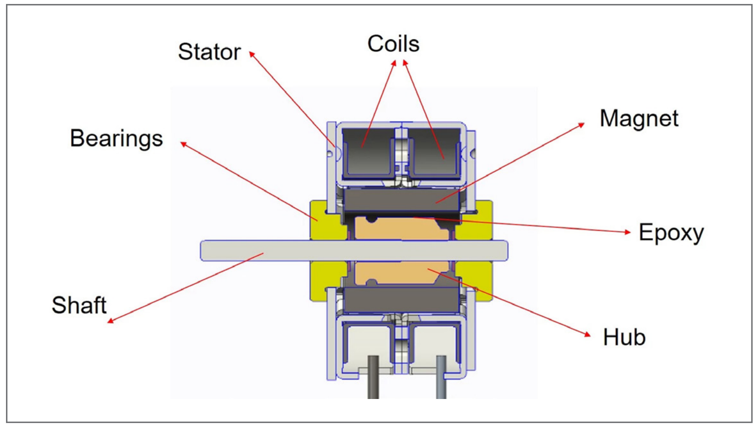

Figure 2 - Stepper Motor Cross-section

The choice of linear and nonlinear material-based assemblies is challenging; the performance of nonlinear materials, like adhesives for example, highly depends on the material's chemistry and processing parameters. The choice of specific ceramic magnet grades makes the situation complex.

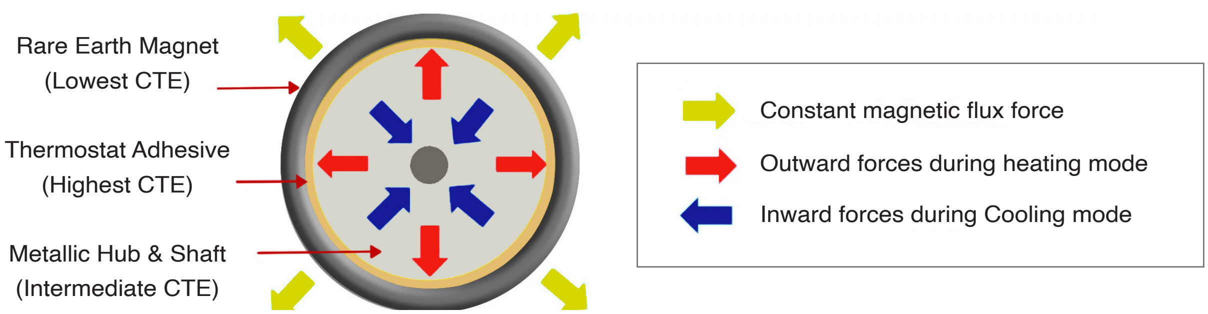

Figure 3 - Forces Acting on the Rotor Assembly

Another important aspect to consider is design validation to confirm proper performance in the field. The design can be validated at static environmental conditions such as temperature, humidity and specific load conditions. The material scheme selected in the design already considers these factors. However, their performance at dynamic conditions (rapid temperature, humidity or sudden load changes or the combination of multiple parameters) is required to determine the motor performance over time, achieved through simulation or analytical testing. As an example, at Portescap, we validate rotor assemblies at accelerated temperatures and thermal shock conditions in environmental chambers and ovens to make sure that rotor assembly will meet the application's extreme requirements. We also determine the rotor mechanical strength at a specific temperature with axial and torsion force testing. The service life of the motor in the application at specific temperature conditions can be predicted with better confidence by testing with accelerated life cycle testing. The tests are performed at loaded and unloaded conditions depending on the application needs.

DESIGN VALIDATION THROUGH QUALIFICATION TESTING

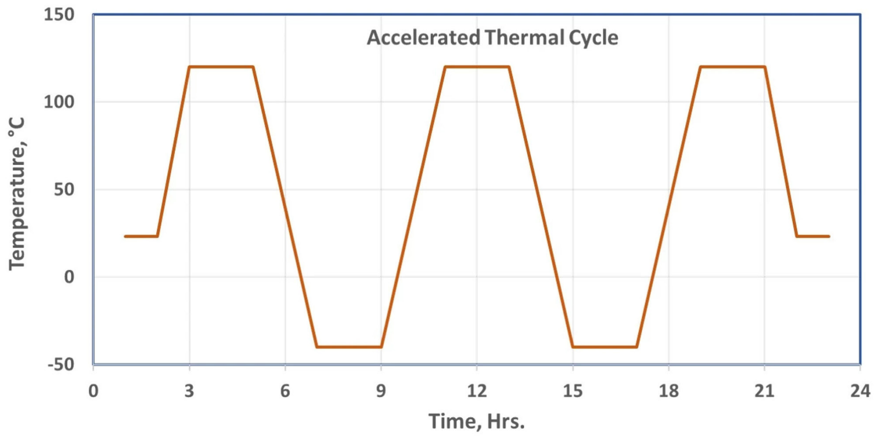

Figure 4 - Accelerated Thermal Cycle of Stepper Motor

BRUSHLESS DC MOTORS

Stepper motors represent a good technology choice for use in electrically operated dampers, for a more affordable option than brushless DC motors, and without the need for the latter's superior variable speed capability in a typical damper application.

CONCLUSION

The choice of the optimum stepper motor is important to control the airflow efficiently in damper actuation which is why multiple configurations of stepper motors are utilized. Many times, we meet such demands through customized stepper motors, making them the right choice for the HVAC actuator market because of the price-to-performance factor.

The reliability of designed motors is also of utmost importance, as the frequent breakdown in the field can increase costs and liabilities. A better understanding of the working points of the HVAC application helps to address the critical requirement in the design and validation stage. **P**

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