APPLICATION NOTE

Use of MagneMotion Motors in Environments that Exceed Rated Operating Temperature

Purpose

This application note presents several methods by which a MagneMotion (MMI) motor can be protected from temperatures outside of its allowable operating range.

Introduction

MMI motors are a very adaptable platform that can be used in a number of different applications in a number of environments. This can include applications where the product must be exposed to a high temperature. Like most industrial systems, the motors and magnet arrays have limits on the temperature of their operating environment. This document will discuss methods to protect or isolate the motors from environments that exceed the limitations of the motors while still allowing the payload to experience those temperatures.

For the purposes of this document we will define the environment that exceeds the specifications of the motor as the "hot" environment. Most of these methods can also be applied to a cold, corrosive, toxic, pressurized, or otherwise hostile environment.

Temperature Limits

The MagneMover LITE (ML), QuickStick 100, and QuickStick High Thrust (QS HT) systems have different temperature limits. Each unit has an internal temperature limit, the limit of the temperature inside the sealed motor unit, dictated by the electrical components used. Based on this limit and the heating of the motor during operation, a limitation of the ambient temperature in which the motor can operate is established.

Table 1: Allowable Internal and Ambient Motor Temperatures

Motor Type	Internal Temperature Limit (°C)	Ambient Temperature Limit (°C)
ML	80	50
QS 100	90	50
QS HT Motor Controller	60	50
QS HT	90	50
QS HT Submersible (in water)	90	50

Additionally, the magnet arrays also have a temperature limit based on both the temperature at which their magnetic properties begin to degrade and the temperature limitations of the Epoxy coating (QS100 standard magnets) or the plastic puck top (ML standard).

Table 2: Allowable Magnet Array Environment Temperatures

Magnet Type	**Ambient Temperature Limit (°C)**
ML	50
QS 100 Standard	50
QS 100 High Temperature	150
QS HT Standard	50
QS HT High Temperature	150
QS HT Submersible	50

Inserting Material between Motor and Array

Several of the protection concepts below rely on using the ability to place material between the motor and the array. Because the motors do not need to contact the array to detect the vehicle or to drive it, material can be placed between the two components.

Any material placed between the motor and array must meet three requirements:

1) It must not be ferromagnetic. This will interfere with the system's ability to both sense and drive the vehicle.
2) It must not be conductive. Moving a magnet array over a sheet of conductive material will result in eddy current braking.
3) It must not contact the underside of the array. If the magnet array touches down on the material, both the material and the array may be damaged. The bottom of the array is not a wear surface.

Please consult the system user's manual for the maximum separation between the motor and the array, as well as the effects on thrust and attractive force of increasing this gap.

Isolation Methods

The following protection methods rely on isolating the motor, magnet array, or both from the hot environment.

Method 1: Offset Payload from Vehicle

Through design of the vehicle and track, isolate both the motor and array from the hot environment. Offset the payload vertically or horizontally from the vehicle and through shielding.

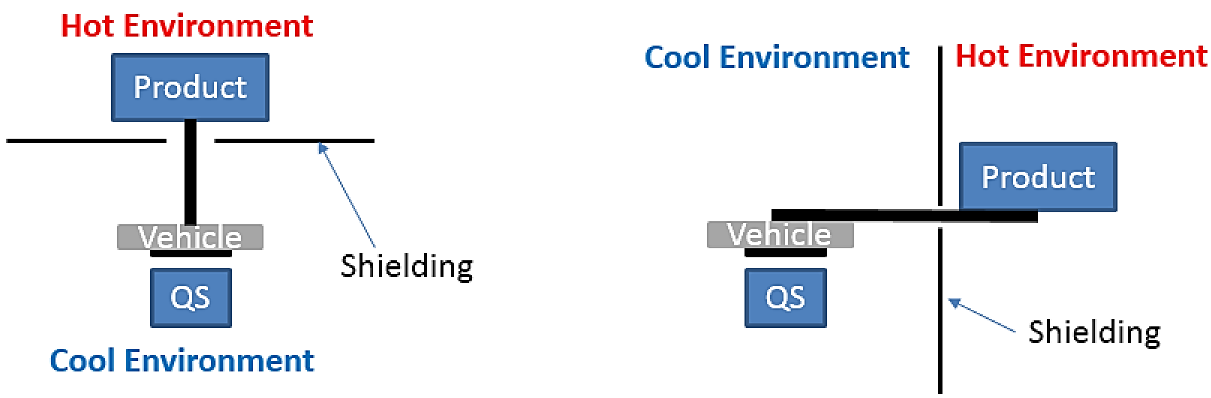

Figure 1: Offset Method

This method will remove temperature limitations on both the motor and magnet array. Because the vehicle must protrude through the chamber wall, this method does prohibit a fully sealed hot or cool side. This means environmental systems on both sides of the shielding will need to compensate for bleed through and that neither side can be sealed and pressurized. Maintaining a slight positive pressure on the cool side will reduce heating of the cool area due to any inflow of air from the hot side.

Method 2: Separate Motor and Array

Through design of the vehicle and track, isolate the motor from the hot environment. This can be done by placing material between the motor and magnet array. The magnet array will still be within the hot environment.

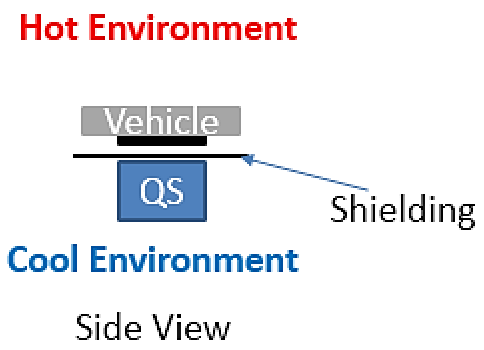

Figure 2: Separating the Motor and Magnet Array

This method will remove temperature limitations on the motor only. The array will still be subject to temperature restrictions. This design does allow for a fully sealed chamber. The thickness of the shielding will be limited by the allowable gap between the motor and the magnet array. Some air flow is required on the cool side to counteract heat radiated from the shielding.

Method 3: Remove Vehicle from Motor

This method applies to QuickStick motors only. Using terminus nodes, the vehicle can be driven off the end of the track and onto a propulsion method that can tolerate the hot environment. The vehicle can then be reintroduced to the system once it leaves the hot area.

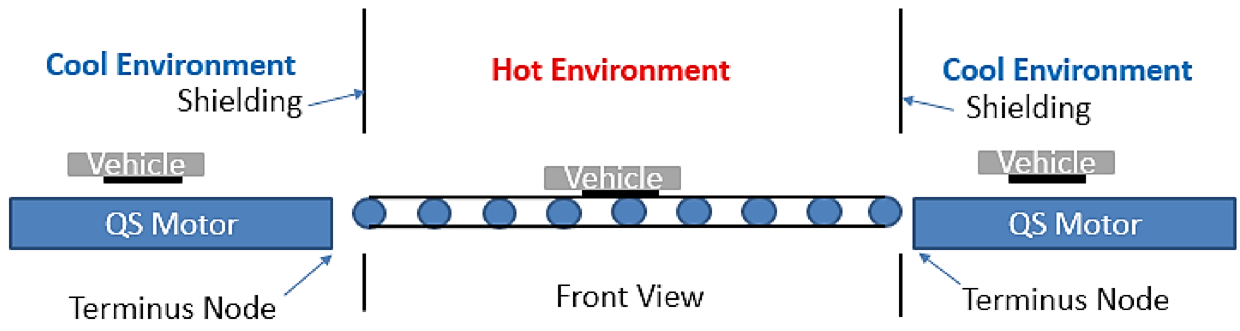

Figure 3: Removing Vehicle from Motor

This method will remove temperature limitations on the motor only. The array will still be subject to temperature restrictions. This design does allow for a fully sealed chamber if airlocks are used. While the vehicle is removed from the MMI system, it will no longer be tracked. Third party sensors will be required to track the vehicle and trigger its reintroduction to the system.

Method 4: Remove Payload from Vehicle

In this method, the payload is unloaded from the vehicle, moved through the hot area using an alternate transport method, then loaded onto the vehicle again. Alternately, the payload can be unloaded into a fixed environment and then returned to a vehicle when the process is complete. A payload does not need to be returned to the same vehicle it was removed from.

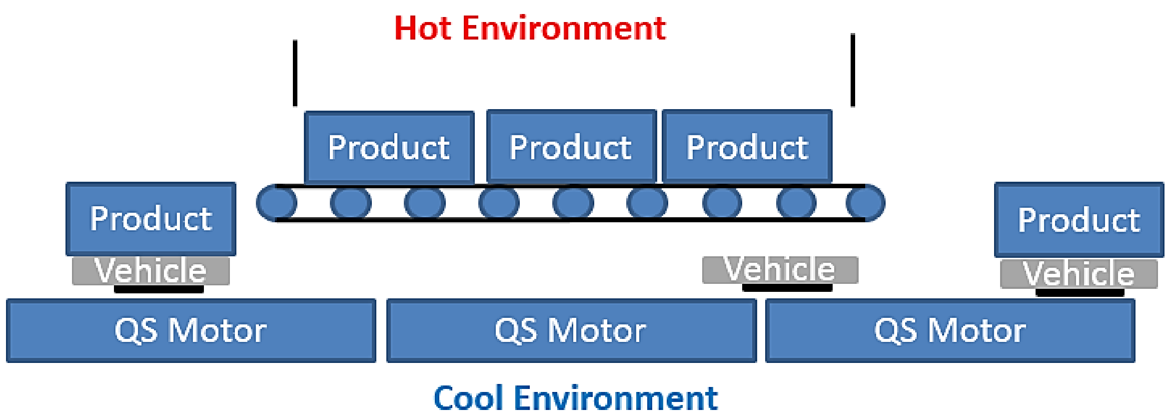

Figure 4: Remove Payload from Vehicle

This method isolates both the magnet array and motor from the hot environment. It also has the added benefit of letting the hot area and empty vehicles move at a different rate, potentially substantially decreasing the number of vehicles and motors required for a system if the product must remain in the hot environment for a long period of time. The tradeoff is that a two transfer systems and a second handling system are required to remove the payload from the vehicle, move it through the hot environment, and reload it onto the vehicle.

Heat Exchange Methods

The following protection methods rely on more efficiently removing heat from the motor to keep the internal temperature below the maximum limit. These methods can also be used to prevent heat generated during operation from overheating the motor in demanding applications.

Method 1: Convection Cooling to Environment

This method involves enhancing the ability of the motor to dissipate heat to its environment. This can be accomplished by securing fins to the outside of the motor or by increasing the airflow within the environment over the motor. This method will limit the difference between the internal temperature and the ambient environmental temperature due to motor operation. Please note this will only work if the environmental temperature is less than the motor internal operating temperature limit.

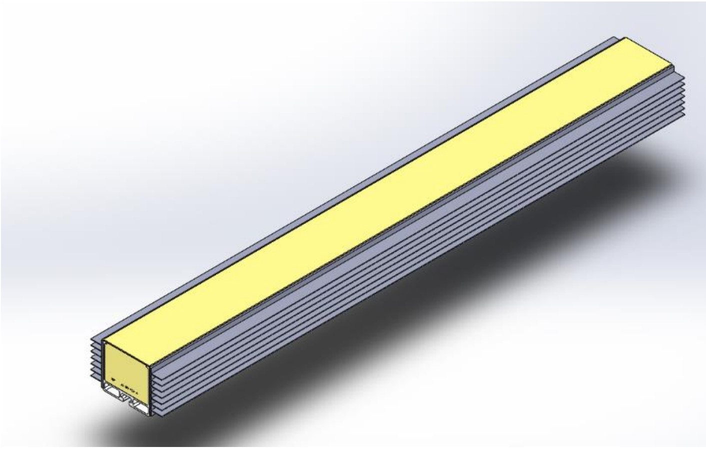

Figure 5: Motor with Fins Attached

Method 2: Convection Active Cooling

In this method, the motor is cooled by moving air cooler than the hot environment over the motor. This would be done by either isolating the motor from the hot environment in a channel or creating channels that are sealed against the side of the motor. Cool or cold air would then be blown though these channels. The body of the motor will be cooled by convection to this air, which will then reduce the internal temperature of the motor. Adding fins or other devices to enhance convection cooling to the sides of the motors will increase the effectiveness of this method. The convection cooling must be able to remove heat energy from the motor at the same rate or faster than it is added to the motor from the hot environment.

Figure 6: Convection Active Cooling

This method will protect the motor, but not the magnet array. It requires less material than fully isolating the motor from the hot environment, but does require the application of forced cool air. Effectiveness will vary on a case by case basis depending on the temperature in the hot environment and operating heat generated by the motor. This method can be used in conjunction with the isolation methods to improve effectiveness.

Method 3: Conduction Active Cooling

This method involves placing conduits filled with cool air or liquid in contact with the motor body. Heat will be transferred from the body of the motor to the body of the cooled conduit by conduction. If in a hot environment, the conduit should be shielded except where it contacts the motor to prevent it from absorbing environmental heat. The conduction cooling must be able to remove heat energy from the motor at the same rate or faster than it is added to the motor from the hot environment.

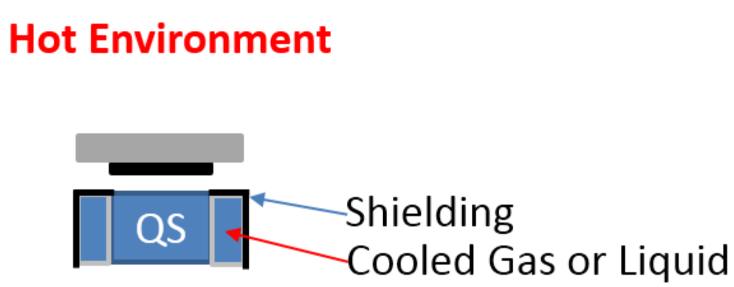

Figure 7: Conduction Active Cooling

This method will protect the motor, but the magnet array will remain exposed. It can be more effective than convection cooling, but requires liquid or air cooling and handling system.

Effectiveness will vary on a case by case basis depending on the temperature in the hot environment and operating heat generated by the motor.

Summary

The temperature of a component affects its operating performance and life span. The closer a motor is to its internal thermal limit, the less energy it can put into the coils before it reaches the over temperature threshold and has to shut down. This will in turn limit thrust and the maximum allowable acceleration of a vehicle for a given duty cycle. Additionally, operating at temperatures outside of the nominal range for a component will reduce the lifespan of that component. Temperatures that are well beyond the operating range can result in immediate failure.

These risks can be mitigated by keeping the motor within its operational temperature limits. This document outlined several strategies that can be used the prevent the internal temperature of the motor from rising as a result of its environment or heat generated during operation. If the temperature of the motor is controlled to within the rated limits, it will be subject to its normal expected lifespan.

Related Documents:

990000410 – MagneMover LITE User's Manual

More Information

MagneMotion Website: www.magnemotion.com

Questions & Comments: www.magnemotion.com/about-magnemotion/contact.cfm

Revision History

Rev.	Change Description
A	Initial release