Fluid Cooled Adapter

Heat Reduction for Motor/Gearbox Combinations: updated with vortex cooling

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Abstract

Servomotor/gearhead combinations are often limited by temperature. The higher the torque load and/or rpm, the higher the temperature. To improve performance the temperature must be lowered which can be accomplished through better extraction of heat from the motor/gearhead combination. This paper discusses the method used by WITTENSTEIN to accomplish the task of removing heat from the motor/gearhead combination.

An adapter which is typically a solid piece of aluminum is used to connect the servomotor to the gearhead. WITTENSTEIN's specially developed adapter has an internal channel with an input and output port, allowing circulation of fluid (air or liquid) to better remove the heat.

Testing was performed on a Rockwell MPL-B540K servomotor mated to an alpha SP140-MC1-3 gearhead at 50% torque load and 3000 rpm. The output bearing of the gearhead reached a steady state temperature of 87°C (189°F) with natural convective cooling. When 23°C (73°F) air was run through the internal adapter channel, a steady state temperature of 63°C (145°F) was achieved, representing a reduction of 24°C (44°F) over the natural convective air cooling. With the added Vortex tube, the air cooling was improved and a steady state temperature of 54°C (129°F) was realized. When 7°C (45°F) water was run through the internal adapter channel, a steady state temperature of 53°C (127°F) was achieved - a reduction of 34°C (62°F) over the natural convective air cooling.

Test Setup

The equipment setup is shown in Figure 1. The mounting plate dimensions were taken from Rockwell Automation's *MP-Series Low-Inertia Servo Motor with 100mm to 165mm Frame Size* (MP-IN001F-EN-P, Dec 2008). This document states, "To obtain the specified motor thermal rating, mount the motor on a surface with heat dissipation equivalent to a 12 x 12 x .05 inch aluminum heat sink". The MPL-B540K servomotor/SP140-MC1-3 gearhead combination on the left in Figure 1 is considered the Unit Under Test (UUT). The servomotor/gearhead combination on the right supplies the required torque to the UUT.

Eight thermocouples were used to monitor temperatures. The limiting temperature would be the output bearing of the gearhead in the UUT, shown as T2,4. This is the thermocouple location that was monitored to determine when "steady state" had been achieved. Steady state was defined in this test as no more than a 1°C (1.8°F) rise over a 15 minute period. The ambient air (T1,3) was recorded as 22°C (72°F) during the test.

After the data was collected for Convective Air Cooling, the test setup was modified as shown in Figure 2. The only change was the removal of the standard adapter and the addition of the fluid cooled adapter. All thermocouple locations were consistent. Three different tests were then run - one with compressed air being run through the channel in the adapter and a second with compressed air and a vortex tube, and third with water being run through the channel in the adapter. The compressed air test used air at a constant supply temperature of 22°C (72°F). The water test used water at a constant supply temperature of 7°C (45°F).

Figure 3 shows the results of the testing using four different methods of cooling. The absolute temperature being reported is not as significant as the delta, or difference, between the different methods of cooling. If the ambient temperature in the manufacturing plant is higher than the ambient during test (22°C, 72°F), the temperatures will be higher, but it will have approximately the same deltas achieved during this testing.

Using compressed air as the cooling fluid, a temperature reduction from normal convective air cooling of approximately 24°C (44°F) was achieved at the output bearing on the gearhead. Using water or air with a vortex tube as the cooling fluid, a temperature reduction from the normal convective air cooling of approximately 33°C (62°F) was achieved.

Conclusion

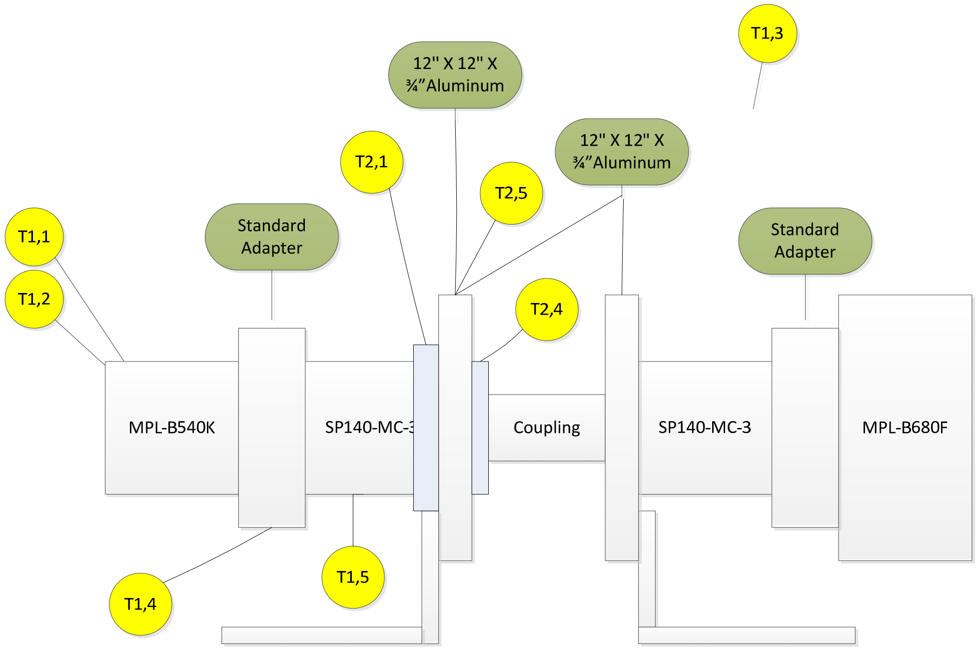
As seen in the graphical results, significant heat removal can be achieved by using a channeled adapter. Type of fluid used in the channel will depend on what is available at the location. The temperature of the compressed air is consistent with most equipment locations and can be improved with a vortex tube. The use of a chiller, however, to circulate the water through the channel will be able to reduce the water temperature. If a water/glycol mixture is used, the temperature of the circulating water can be reduced significantly. Any reduction in temperature of the cooling fluid would serve to improve the cooling effect and increase the delta between natural convective air cooling and channeled adapter cooling.

Also observed during testing was lowering of the motor winding temperatures (T1,1 and T1,2). This is accomplished because the cooling is taking place between the servomotor and the gearhead, extracting heat from both pieces of equipment.

Because the temperature is lower throughout the servomotor/gearhead, the combination can now be run at a higher torque load and/or rpm. Published maximum values by the manufacturers must still be observed. Figure 4 shows that a UUT that once ran at 500 rpm and 50% torque load can now run at up to 2000 rpm with a 50% torque load without an increase in temperature. This represents a significant improvement in performance.

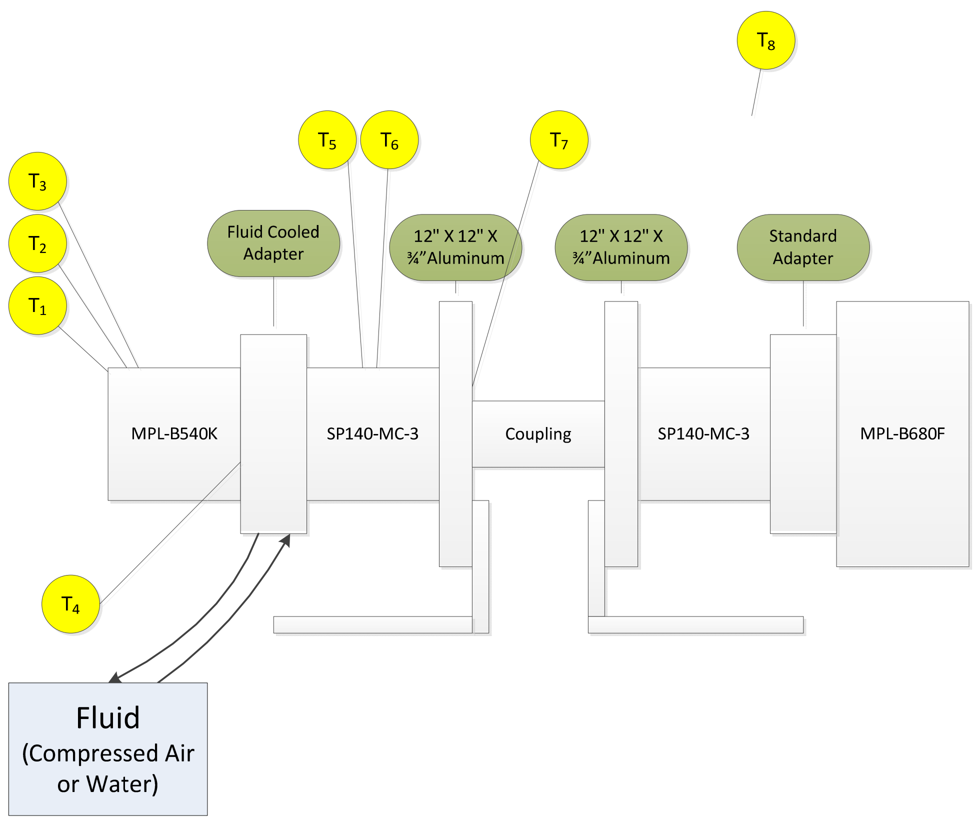
A second option with a cooled adapter also exists. Instead of operating the same size servomotor at a higher torque load and/or rpm, a smaller servomotor maybe be selected and operated at a torque load and/or rpm that was previously not possible due to temperature limitations.

Figure 1: Convective Air Cooling



T1,1 – Motor Winding
T1,2 – Motor Winding
T1,3 - Ambient
T1,4 – Standard Adapter
T1,5 – Gearhead Case
T2,1 – Gearhead Mtg Flange
T2,4 – Gearhead Output Bearing
T2,5 – Mounting Plate

Figure 2: Channeled Adapter Cooling



T1,1 – Motor Winding
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T2,1 – Gearhead Mtg Flange
T2,4 – Gearhead Output Bearing
T2,5 – Mounting Plate

Figure 3: Increased Performance with Cooling

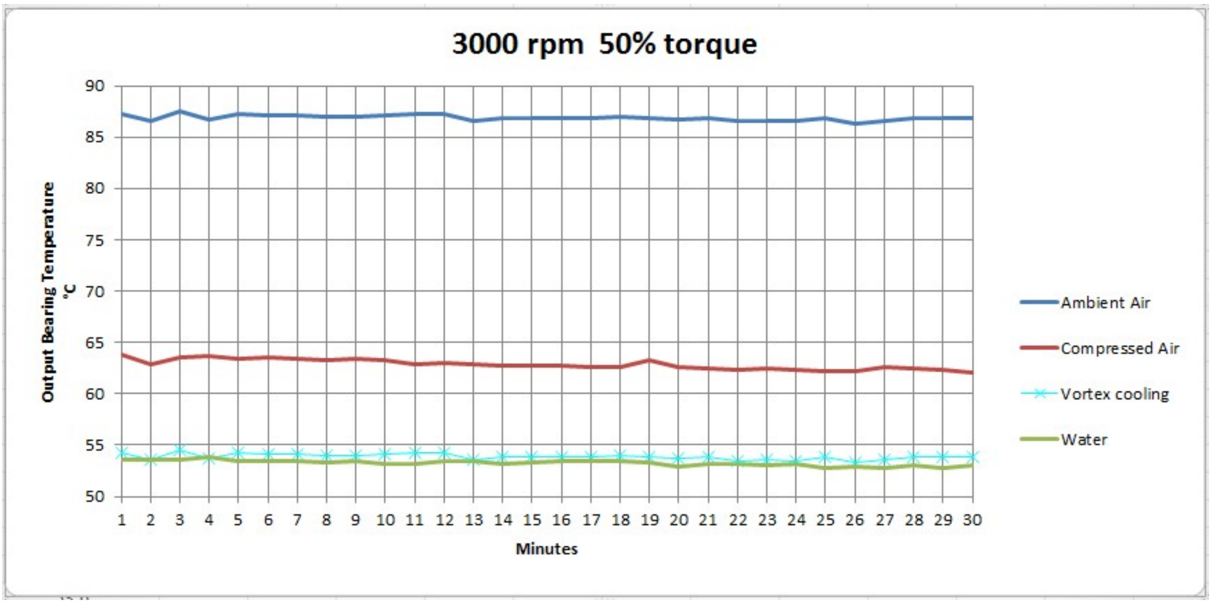

Figure 4: MPL-B540K/SP-140MC-3