TEMPERATURE CONTROL AND MOUNT SELECTION

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As you operate your laser, only a portion of the electrical power sourced from your laser driver converts to light energy. The remainder turns to heat, and the build-up of that thermal energy presents a number of issues for the laser system as a whole, and for your laser, in particular.

Within your laser setup, the temperature control system is responsible for managing the heat generated by the operation of the laser. In addition to your temperature controller, careful selection of the application-appropriate laser mount will be critical to a robust laser system.

Ultimately, the most pressing issue regarding temperature control is that a change in temperature affects laser light quality, particularly wavelength. If left unchecked, excessive heat may also damage the laser's light emitting facets, degrading the quality and quantity of the light produced.

The two basic strategies for dissipating the heat produced by a laser are known as passive cooling and active cooling. In addition, this article will cover unconventional thermal management approaches for high-power applications and for applications that require a heated laser mount.

PASSIVE COOLING

A passive heat sink conducts heat away from the laser and dissipates it into the ambient air. Because this type of laser mount is simply a large thermal heat sink, it is unavoidable that the mount temperature, and that of the laser, will increase. A passively-cooled laser mount is designed so that this temperature increase occurs in an incremental and predictable manner.

The thermal performance of such a mount is rated as thermal resistance, in units of °C/W. This rating represents the amount of temperature increase, in degrees, the laser mount will exhibit at thermal equilibrium for every watt of waste heat generated by the laser.

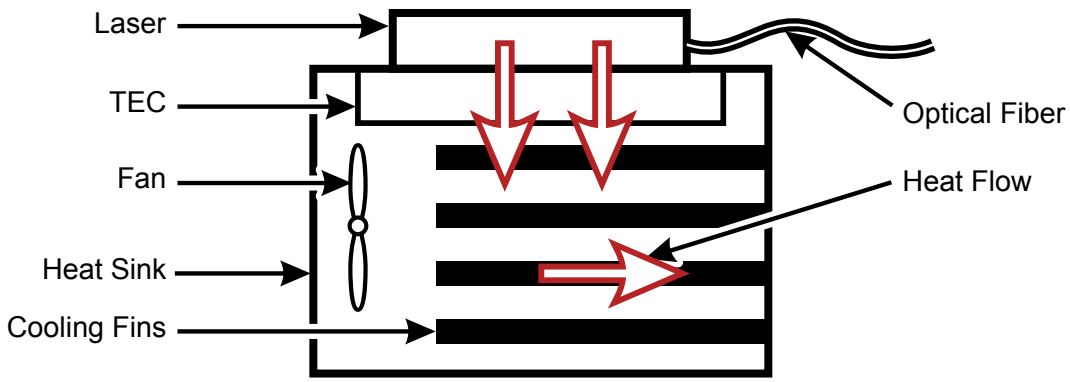

Figure 1. Anatomy and Heat Flow of a Passively Cooled Laser Mount

A fan will improve the thermal performance of a passively-cooled laser mount. Typically, the manufacturer will provide ratings for the laser mount with and without an auxiliary fan. Even with a fan, the performance and power range of a passive heat sink are limited to low- and medium-power applications, or applications where higher operating temperatures are acceptable.

ACTIVE COOLING

Active cooling is a more comprehensive, and also a more complex approach to thermal management. A device called a Peltier cooler, built into the laser mount or directly into the laser package, operates to cool the laser.

A Peltier device, also known as a thermo-electric cooler (TEC), is a small, flat, thermally-conductive ceramic that uses the electrical power supplied by the temperature controller to cool one of its surfaces while heating the opposing surface. The laser mount is responsible for acting as heat sink to the hot side of the Peltier device. The cold side of the Peltier device is applied to an aluminum or copper cold plate, which makes contact with the laser package case.

To complete the control loop, a temperature sensor provides a feedback signal to the temperature controller, which regulates the power provided to the Peltier device. In many cases, the laser mount will also be equipped with a fan to maximize thermal performance.

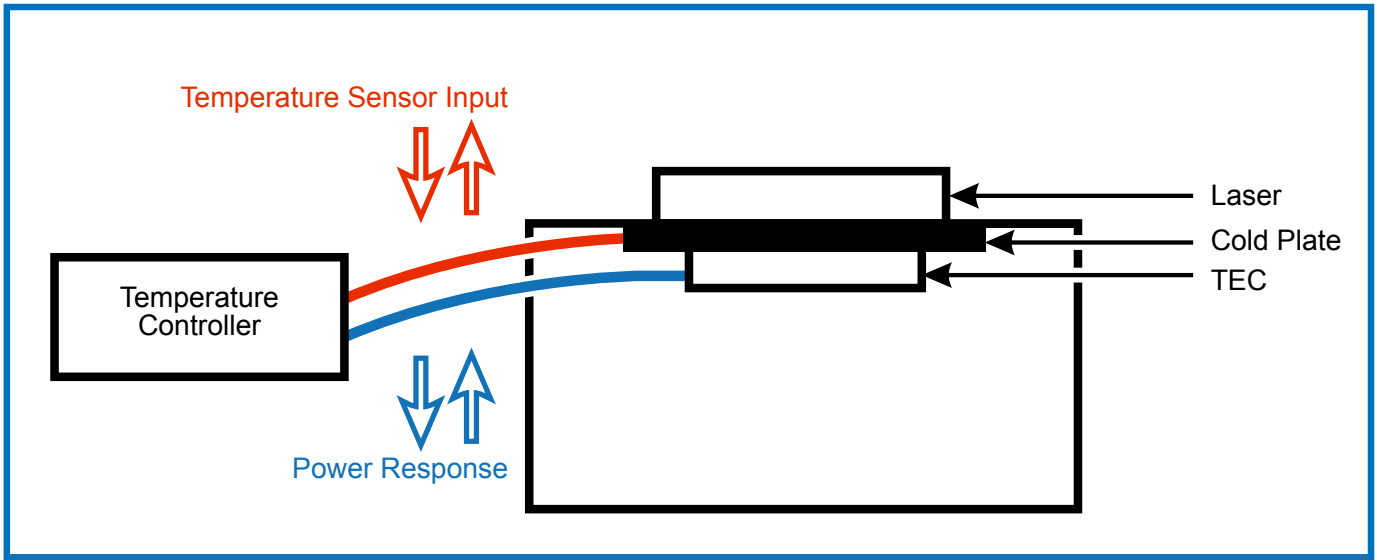

Figure 2. Temperature Control Loop Response in an Actively Cooled Laser Mount

FUNCTIONAL CONSIDERATIONS FOR MOUNT SELECTION

Aside from the basic question of sufficient thermal capacity, there are three areas of function that affect the utility of a laser mount. These are the thermal conductivity, the flexibility of the wiring harness, and the mechanical mounting of the laser.

The thermal conductivity of the laser mount, and of the cold plate in particular, is an important design aspect. While aluminum is sufficient for some applications, the preferable material for a cold plate is copper. The thermal properties of copper are superior to those of other materials.

For optimal versatility, consider the flexibility of the wiring harness built into the mount, and by extension, to the laser driver and the temperature controller. Ideally, the manufacturer should provide standard, pre-fabricated cables from the instrumentation to the laser mount. From the laser mount to the laser, connections should be easy to establish and easy to change, using a screw terminal or some other simple means. Soldered connections, or connectors that require significant setup time are less preferable.

The same principle applies to the mechanical connection between the laser and the mount. That this connection should provide a good thermal interface goes without saying. In addition, it should also provide easy disconnections and a measure of versatility for a variety of laser packages. Some manufacturers will offer customizable cold plates, allowing you to specify the mounting hole pattern you require.

PLUG & PLAY ELECTRICAL CONNECTIONS

Mounts that supply both the mounting and electrical connections to the laser greatly simplify system setup, such as the 244 HHL LaserMount, which incorporates passive cooling along with a high quality solder-less laser connector.

Contact Arroyo for more details.

HIGH-POWER SYSTEMS

Beyond laser mounts with an integrated fan and a Peltier cooler, managing higher thermal output levels becomes more challenging. If an air-cooled mount proves insufficient, then the next option is a water-cooled mount. Water offers a substantial increase in thermal capacity at the cost of complexity and responsiveness.

While a water-cooled plate is effective at transferring large amounts of heat, there are several drawbacks. First, your temperature setpoint must fall between the boiling and freezing points of water. Second, a water system requires a chiller, a pump, a customized laser mount and plumbing, which will add set-up time and cost. Third, some water systems may have an error range of several tenths-of-a-degree and do not react quickly to changes in temperature. This may be unsuitable for high-precision applications.

To improve the precision of a water system, the combination of a TEC with a water-cooled laser mount works well. This system relies on the TEC for fine temperature control, and uses the water cooling system to move heat away quickly. This hybrid approach is common in high-power laser applications that require good temperature stability.

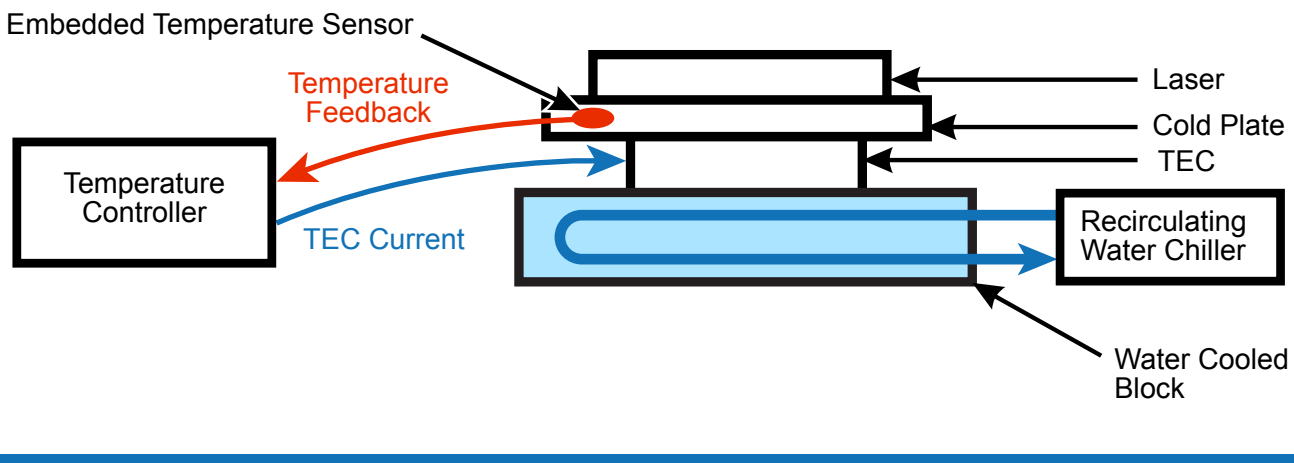

Figure 3. Layout for a Water-Cooled, High-Power Laser Mount

HIGH-TEMPERATURE SYSTEMS

As mentioned earlier in the article, if you are characterizing the performance of a device across a temperature range, or working with applications that require higher temperatures, such as LEDs, the heating capability of a Peltier device may prove useful. Higher mount temperatures require a different type of temperature sensor and a TEC suitable for high temperature operation, so discuss your application with the laser mount manufacturer. Some laser mounts also incorporate resistive heaters, although this is obviously only suitable for heat-only applications. In this circumstance, the rest of the thermal management system can remain the same, provided that the temperature controller has the capability to power resistive heaters.

FINAL WORDS

Selecting the right mount for your laser system will save time and effort while improving overall performance. Beyond the decision to use passive or active cooling, pay special attention to the additional features of the laser mount. Easy mounting, flexible electrical connections, and good materials selection are important factors to consider. In the end, the best course may be to call the manufacturer directly and ask questions regarding their mount performance for your particular application.