Cooling high-power LEDs: The four myths about active vs. passive methods

Ed Rodriguez - October 17, 2013

In high-power lighting, needs are emerging for LED luminaires rated to 100, 200 or even 600 watts (over 60,000 lumens), to cover wide areas. The higher-power heat sinks increase in size and weight exponentially. The consequence is escalation of costs for tooling, assembly, shipping, and installation.

It turns out that active cooling (i.e., the use of fan-cooled heat sinks) can exhibit dramatic size, weight and cost reductions at those elevated power levels. A 400-watt, passive-cooled high-bay fixture might weigh 75 pounds and be the size of a two-drawer file cabinet. An active-cooled version might weigh only 15 pounds and be no larger than a pizza box. Figure 1 shows the rule-of-thumb relationship:
This shows a 2.3"×2.4"×1.4" fine-pitch extruded heat sink, with a 50 watt Bridgelux LED array. With no air flow, this has a thermal resistance of 4 °C/W, meaning it can handle only about 10 watts. When a low-speed fan is added to it as shown in the upper view, it exhibits a thermal resistance of only 0.8 °C/W, increasing its power capability to over 50 watts - a five times improvement! (Photo courtesy of Nutron Mfg Inc.)

"Why would anybody use passive cooling?"... you ask. Often it makes sense. Often it does not.

Imagine if, in 1905, the auto industry said ..."We don't want to actively cool the engine (i.e., use a radiator and fan). A V-8 engine block would now be the size of a refrigerator.

While the industry is inexorably embracing active cooling at power levels above 50 watts, there is still resistance in many "old school" quarters.

Let's review the oft-repeated myths used by those folks.

1. Fans Are Noisy
   Yessiree... that fan in your microwave oven makes a racket, as does the fan in your PC or even that window fan. But take a standard, low-speed (under 2000-RPM) DC ball-bearing, brushless fan made by one of the top fan makers, such as Delta, NMB, EBM-Papst or others, and operate it at the low end of its voltage range... and guess what? Its sound level can be less than 16-18 dB - completely inaudible in a dead-quiet room when in a fixture seven feet or more above the floor. In fact you will be hard pressed to hear it from one meter away in a quiet room. 16 dB is way below the 24-dB ANSI standard for quietest fluorescent lighting ballasts. Scratch Myth No.1.

2. Fans Are Unreliable
   DC brushless ball-bearing fans have one of the most visible and enviable field histories of any electromechanical component in the electronic industry. Millions of mission-critical computers powering the Internet and wireless communications systems have been operating 24/7 for well over a decade with fan-cooled power supplies using such fans. What does that say about their proven reliability and user confidence?Such fans are backed up by what are called "L10 reports." Such reports provide life expectancy when used at high temperature and
highest speeds. At the very low speeds employed in active-cooled LED luminaires, the life expectancies easily exceed 100,000 hours, much greater than the life expectancy of the LEDs themselves. **Scratch Myth No. 2.**

3. **Fans Waste Power** A fan such as described above, cooling a 300-watt system, and operating at low speed, will use well under 2 watts — less than 0.75% of system power... a 100-watt system, less than a watt. **Scratch Myth No. 3.**

4. **Fans Gather Dust** It turns out that there is substantial real-world evidence that if you operate a fan at high speed in a dirty environment or close to dusty carpeted floors, fan blades can indeed accumulate dust, although that dust does not actually stop things from working. However, in a commercial high-power setting things are different. First, the fan is a) ALWAYS at a substantial height, and b) ALWAYS operating at a very low speed. At very-low-air speed, the system differs little from a very-low-turbulence, passively cooled (i.e., zero air speed) heat sink system. The result, evidenced in numerous existing LED installations using active cooling, and supported by dust chamber testing, is that after multi-year usage, any dust accumulation is so little as to be irrelevant to the cooling process. **Scratch Myth No.4.**

Those previously mentioned hundreds of millions of DC ball-bearing brushless fans, operating 24/7 for years, without filters, in Internet and wireless equipment, with no degradation of cooling, are quite a myth-buster all by themselves.

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