Of the myriad challenges brought about by the continuing implementation of Tier 4 interim and final diesel engine emissions regulations, none has been more persistent and perplexing than heat. The onset of tougher new emissions standards inspired technologies such as cooled exhaust gas recirculation systems, variable geometry turbochargers and complex exhaust aftertreatment systems, all of which can contribute to net engine heat rejection increases of between 10 and 40%, depending on the installation.

The most obvious answer — simply adding more cooling capacity in the form of larger or additional radiators, charge-air coolers, etc. — is a nonstarter in most cases for a variety of reasons, including higher cost and insufficient space in a machine or vehicle to accommodate a wider or taller cooling module.

So the typical solution has been to pack more cooling within the same area by stacking higher-capacity cooling modules together, which brings yet another obstacle — how to force air through a more densely packed maze of tubes and fins at flow rates sufficient to ensure enough cooling in even the worst ambient conditions.

That’s the challenge that Multi-Wing International, the global specialist in fan technology for engines and HVAC/refrigeration markets, was determined to solve. After more than two years in development, the company launched a line of engine cooling fans with an entirely new blade profile engineered specifically to meet the demand of Tier 4/Stage 3b engines. The PressureMAX fans, first unveiled at ConExpo-Con/Agg in March, are designed to generate as much as 20% greater static pressure than standard fans while maintaining a narrow axial depth intended to allow them to fit into space-constricted engine compartments.

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Along with being a specific solution for Tier 4, the development of the PressureMAX design was also a validation of Multi-Wing’s significant investments in engineering and research capability. Over the last several years, the company has spent heavily to acquire new hardware such as rapid prototyping systems and wind tunnel enhancements. Investments in new software targeted computational fluid dynamics (CFD) and advanced flow diagnostics programs critical to understanding key design variables such as mean velocity, turbulence intensity and the effect of contraction ratios in the working section of the fan blade.

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TAKING TIER 4 FAN TECHNOLOGY TO THE MAX

Multi-Wing’s new PressureMAX fan engineered to meet cooling challenges of low-emissions diesel engines

BY MIKE BREZONICK

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“When we started this, we were looking to really find out what Tier 4 was going to mean to us as a fan producer,” said Bernhoft. “We quickly realized that this was going to challenge us more than anything else ever had. Tier 3 was really more about noise emissions and there were solutions that were already in the market that were open to us.

“This time, we really had to start from scratch because it became clear we weren’t going to be able to reach it with standard technology. We really had to stretch ourselves. “We found out when we started working that this was only the beginning — there was much more to come for us, using these techniques. So Tier 4 is helping us move forward and break some of the barriers that had confronted us.”

The key aspect of PressureMAX is a blade design engineered to deliver 20% more pressure than a standard airfoil fan at normal engine speeds. “The whole thing is about getting more pressure,” said Toni Stannov, R&D engineer at Multi-Wing International. “The radiator and intercooler and other coolers are all stacked, meaning that you have higher pressure in the cooling section. Of course, you also have to look at better efficiency because that’s part of Tier 4 and how you reduce the emissions.

“We addressed that by looking into the details of how the fan works, looking more closely to the aerodynamics. Fan design has been very traditional for many years and this is kind of breaking the rule in that it was looking more into the fundamental aerodynamics.

“What we learned is that you can easily throw away good energy without even noticing what’s going on. But by means of very advanced flow measurement techniques — we were using data sets based on 24 million samples taken at a high data rate — we were able to go into detail and look at every little section of the blade and see how it performed, how much energy is wasted, and in what way is it wasted.”

Along with the high pressure, the PressureMAX blade profile is also five to seven percent-points more efficient than typical airfoil blade designs, the company said, which reduces parasitic loss and helps improve fuel economy.

“One of the things we discovered when we got into this process is that we had to address power consumption through entirely new designs,” said James J. Crowley.
Jr., president of Multi-Wing America Inc., the North American subsidiary based in Burton, Ohio. “Multi-Wing has always been noted as a high-efficiency design. Our fans have always been known as probably the most efficient engine cooling fans on the market.

“But when the R&D team began the process of developing the PressureMAX fan, they discovered ways to improve the efficiency above what we were achieving with what were already market-leading efficient designs.”

The PressureMAX profile also reduces airflow turbulence across the blade, resulting in a lower noise signature, the company said. Further, Multi-Wing’s proprietary R&D process produced a profile with virtually zero blade deflection, resulting in a narrow axial depth to fit in tight engine compartments.

“We were able to achieve almost zero deflection because of the way the blade was pre-bent using special techniques to forecast how the blade would behave,” said Stannov. “It’s a three-step procedure using a very highly advanced optimization tool to construct the blade shape. Our optimization techniques are so much more advanced than before and we can now do blade designs and then pre-qualify them by using CFD to see if there are any hotspots or bad performance sections that we can improve. Then we can also look at the performance curves to see how well we succeeded. We have all the tools to be a pretty advanced partner to our customers.”

Multi-Wing will offer PressureMAX fan configurations using 5, 6, 7, 8, 9, 12 and 16 blades in diameters from 24.5 to 51 in. Pitch settings are adjustable between 25° and 50° and the glass-reinforced polyamide blades are symmetrically positioned on pressure die-cast aluminum alloy hubs.

“It’s our intention to scale this design up and down so when it’s complete, we’ll have a full range of fan blades that would run from the very smallest diameters up to the very largest engine sizes,” Crowley said. “We have an application that has been given to us for a 72 in. diameter fan that’s outside of the current PressureMAX range. We have been looking to see if it would be possible to do a scaled-up version of the PressureMAX. It’s quite challenging because of the extremely high pressure range — in the neighborhood of 4 in. of water — but sure enough, the numbers came back and we can do it with the PressureMAX design. That gives you an idea what’s possible with this design.”