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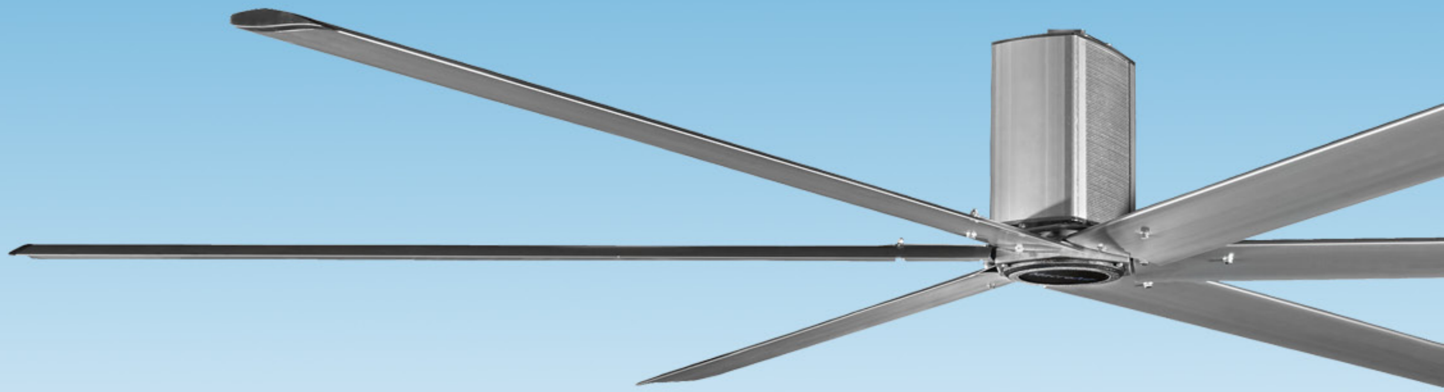
engineers of air™

How HVLS Technology Works



Introduction

Energy is expensive – especially when it comes to heating and cooling. Whether you do business in the northeast or the south, you're most likely looking for ways to lower your energy costs. In addition, businesses are under the gun from federal, state, and even supply chain partners and customers to lower their carbon footprint and implement and develop "green" practices and products. Wal-mart's stated objective, for example, is to "accelerate change towards sustainability," which means that any company doing business with Wal-mart will have to show demonstrable eco-improvements – whether it's in the manufacturing of goods or the distribution and warehousing of these goods.

In this white paper you'll learn about the history of HVLS fan technology, the physics of airflow, and why energy efficient HVLS fans can help you lower your energy costs.

History of HVLS Fans

Dairy cattle stop eating when they suffer from heat stress. When they don't eat, milk production slows or comes to a halt – a bottom-line breaking challenge for dairy farmers in an already highly competitive business. Previous to 1995, dairy farmers used small high-speed fans to help keep cattle cool. These fans helped but posed their own challenges: they didn't cover a wide enough area, were considerably inefficient, consumed excessive and costly energy, and required ongoing maintenance. They also had a short mechanical life.

Taking advantage of the laws of physics, Walter Boyd designed a large overhead fan that moved a large volume of air gently down to the ground and outward 360 degrees. This large, slow moving air mass moved throughout the barn, continuously mixing incoming fresh air with stale air and minimizing the amount of ventilation required to achieve good air quality. Most importantly, the new fan design cooled the cows without causing them stress due to excessive noise or kick-up of dust – and thus increased milk production. The first High Volume, Low Speed (HVLS) barn fan models used 10 airfoil blades that incorporated design characteristics developed at NASA.

How HVLS Fans Work – The Laws of Physics

You don't need a physics degree to know that a breeze moving across your skin on a hot day feels good, especially in humid environments. The cool moving air breaks up the moisture-saturated boundary layer surrounding the body – accelerating evaporation to produce a cooling effect. People have been using fans to cool themselves long before the advent of the electric motor; it was logical then, that fans would be one of the first things to be mechanized.

At some point however, engineers became so focused on using speed to increase fan displacement – the cubic feet of air per minute (CFM) moved through a fan – that some important physics-based issues were overlooked. While having a cool breeze brush over our hot skin feels good, high velocity air movement is both unpleasant and disruptive. And, air speed beyond four or five miles per hour usually offers little, if any, additional cooling benefit as very slow moving air actually cools best in very hot, high humidity conditions.

Small high-speed fans create a pressure differential that's essential for many applications, but where slow movement of free air is the objective, pressure differential is not important. Therefore, displacement, the amount of air that actually moves through the fan, is of no real significance. It's the down-stream effects that are important.

A turbulent, high velocity air jet dissipates very quickly. A large column of air, however, "travels" farther than a small one. The friction between moving air and stationary air occurs at the periphery of the moving column. The perimeter of a column varies directly with column diameter. And while the cross-sectional area varies with the square of the diameter, the large column has proportionately less periphery, and therefore less "drag." The air column from a three-foot diameter fan has more than six times as much "friction interface" per cubic foot as does the air column from a 20-foot fan. This is why a large, slow moving fan actually cools better and more efficiently than a small high-speed fan.

When the down column of air from an HVLS fan reaches the floor, the air turns in the horizontal direction away from the column in all directions. The air flowing outward is called the "horizontal floor jet." Since the height of the floor jet is determined by the diameter of the column of air, a larger diameter fan naturally produces a larger air column and thus a higher floor jet. Smaller high-speed fans of equivalent displacement are incapable of producing the same effect.

The power to drive a fan increases roughly with the cube of the average air speed through the fan. A commercial fan delivering air at 20 miles per hour (mph) requires about 64 times as much power as a similar sized fan delivering air at five mph! Airspeed, combined with fan "effectiveness," means that when the objective is to cool people or animals, very large, low-speed commercial fans are enormously more efficient and effective than small high-speed fans.

The new HVLS fan proved to be incredibly energy efficient as one HVLS fan consumed about the same amount of electricity as one high-speed fan while moving over 12 times the amount of air. A later design enhancement that added a "down wash" to the airfoil blades, in the same manner a spoiler keeps the rear wheels of a car on the road. This new addition increased airflow CFM (cubic foot per minute) by almost 30% with only a minimal increase in power consumption.

New Advancements – Reducing the Number of Blades

Extrusion is the name for the process used to manufacture objects of a fixed cross-sectional profile, including airfoil blades, plastic pipe, tubing and sheets of film, terra cotta bricks, and even food products. Basically, the material, such as plastic or metal, is heated and pushed through a die to form a specific shape. To create an HVLS fan blade, for example, an extrusion company heats up aluminum ingots, pushes the ingots through a die to create the foil, and then cuts the foil at the desired length. The larger the shape to be extruded, the more tonnage and capacity is required by the extruder.

As extrusion capacities increased, HVLS fan engineers began experimenting with larger airfoil shapes – something they couldn't do when the first HVLS fans were created. Creating a larger airfoil wasn't simply the answer to improving efficiency. The airfoil must work efficiently through a range of speeds, and engineers have to take into account that as the HVLS fan rotates, the end of the blade moves faster than it does at its fixed point at the fan hub. In addition, engineers had to consider airflow patterns and what happens when air hits the floor.

Due to the laws of physics, a larger airfoil shape means that fewer fan blades are required to achieve optimal performance; fewer blades also reduce torque (the tendency of a force to rotate an object about an axis, fulcrum, or pivot). Fan longevity is related to torque:

$$\text{Horsepower} = \frac{\text{Torque} * \text{Revolutions Per Minute (RPM)}}{5252}$$

As RPM goes up, torque goes down for the same horsepower. An HVLS fan that has fewer blades rotates slightly faster, which lowers torque. Since torque is a constant stress on a fan's motor, bearings and gear, less torque means longer fan life.

Fewer blades also means reduces the manufacturing carbon footprint. The electrolysis process used to produce aluminum requires large quantities of electrical power. When the cost of producing one ton of primary aluminum is broken down, almost one third is devoted to electrical power. The amount of electrical power needed to produce an HVLS fan with fewer blades is less than what's needed to produce a 10-blade fan.

Measuring fan speed performance

Fan speed performance is measured using CFM (cubic feet per minute) or the measurement of volume over time: the higher a fan's CFM number, the higher the volume or capacity of the fan. To measure the performance of an HVLS fan, engineers generally use the method approved by the Air Movement and Control Association (AMCA) and measure "thrust," which is the force the fan produces as a result of the air being pushed through it. The higher the thrust value, the higher the volume of air and fan performance or CFM – as seen in the table below:

Fan Size	10-Blade HVLS Fan
8 ft	39,000 CFM[2]
10 ft	74,122 CFM[3]
12 ft	91,285 CFM[3]

[1] AMCA Certified CFM
[2] Derived from Certified Thrust Data for Comparison
[3] CFM data not AMCA certified

About MacroAir, Inc.

MacroAir developed and introduced the first HVLS 10-blade fan prototype in 1998.

MacroAir, Inc.
794 South Allen Street
San Bernardino, CA 92408
T: 866-668-3247
Email: sales@macro-air.com
Web: www.macroairfans.com

Follow Us!

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