Greenhouse AxiCool

with KAVA Technology Integrators

1 Introduction

KAVA formed to exploit and fulfill the demand in both the agricultural industry and industry at large by providing ways and means of correcting the application of technologies within the operational infrastructure of said industries.

KAVA is engaged with Randhawa Farms to resolve issues that Randhawa Farms has, beginning with air circulation within the various greenhouse structures.

Randhawa Farms' sole focus and concern is crop quality. To achieve this, they require homogeneity and optimization of the natural airflow throughout the greenhouse. Their experience illustrates that preservation of the greenhouse environment increasingly requires an accounting for minimizing thermal variations all the way through the greenhouse.

As such, the objective is to maintain a uniform meandering airflow climatic condition, with a steady air velocity distribution through the greenhouse, while avoiding conditions such as air sinking, static pockets and turbulent air transfers.

Greenhouses aspire to produce a constant integrated air movement through the application and precise control of targeted airflow streams running north to south, then back south to north, and then repeated snaking from one end to the other within the greenhouse. It is logical to assume that this could be accomplished via air transfer functions from one air circulation fan to the next and so forth that combined form controlled air streams throughout the greenhouse from one compartment to the next.

To that end they looked to KAVA and fan expert ebm-papst to review the fans that Randhawa Farms currently had in use, noted the issues they had with those fans, and developed a fan system solution specific to greenhouse needs.

This is an illustration of one of the fans developed and tested onsite. Note: Further in this paper the mounting bracket is now slimmer and adjustable, see pg. 7 and our latest fan is also white, see pg. 5.

2 Motivation

KAVA realized that most fans for the North American Greenhouse Industry were being supplied outside of North America. The product from these International suppliers was not up to the standards required by Kava.

For example, the International mfg or sourced fans:

- use too much energy
- are not CSA or UL approved
- operate differently for 50 and 60 Hz
- have parts that are expensive to stock
- limited range of speed control (min to max)
- can be loud, creating an unpleasant working environment
- create worker safety issues moving around the fan mounts
- provide limited volume of airflow that is not conducive to our needs
- are often supplied at the wrong frequency – 50 Hz when we require 60 Hz
- are difficult to service in place due to poor access, and difficult to remove easily
- have wiring harnesses that must be changed to comply with North American code
- come with voltage rating of 240 VAC when we require 208 VAC and 230VAC options
- require larger more expensive electric conductors due to their higher power consumption
- are difficult to mount and the mounts typically show signs of rust over a short time–period
- limited throw ability – the distance for which the fan can throw the air out past the fan exhaust

In addition to the above, it takes several weeks to order greenhouse circulation fans because there is no company in North America which distributes or keeps inventory of these fans. Any delay with availability of a fundamental greenhouse component, such as even a single fan, has a direct and often immediate negative consequence upon the progress of plant production in that area of the greenhouse where such a component is inoperable. Any loss of plant production cannot be recovered. Plant production loss directly equates to supply issues relating to quota issues which factors into the following year's market share.

Greenhouse air circulation fans are consistently in need of repair. High humidity levels, high temperatures and applications of acidic soaps during our annual clean up creates a harsh environment for greenhouse air circulation fans. Greenhouses require a fan more versatile to tolerate the greenhouse environmental conditions. Part of the issue is that fans are not easily removed to get them out of the way while the facility is being cleaned and prepared for next year's crop.

Most importantly current industry standard fans do not create an even climate environment throughout greenhouses. Convection of heat transfer through the greenhouse glass creates cold spots primarily by the exterior walls. Plants in the cold spots do not grow well and usually do not establish well and are more susceptible to virus and disease. Along with virus and disease, crops in cold spots do not produce good quality fruit.

Given the above, KAVA is motivated to provide higher quality, better designed, more efficient, and all around leading technology in fan applications, for not only the greenhouse industry, but also industry at large.

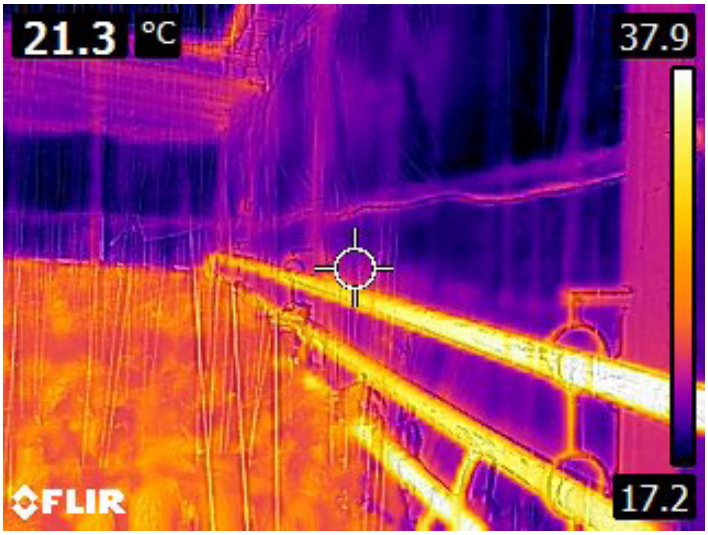
3 Objective and Scope

KAVA partners with companies that lead the way with innovative technologies, are not afraid of research and development to get things right, and are cost reasonable with their product supply to enable sales entry into markets that break from the status quo.

4 Research Work Description

KAVA will test and tweak whatever is necessary to provide as much information as is possible and deliver solutions that excel. Having a viewpoint from every aspect will give us the necessary tools to find the right fit with either existing technology, or enable us to develop solutions accomplish our end goal; producing the best solution for the task at hand.

4.1 Thermal Differences



Pictured right: Illustrates temperature variances from the head of the plants, the heating pipes on the right, and the walls rear and right. The range in temperature is between 17.2 and 37 degrees Celsius. Note the different temperatures within the crop itself.

4.2 Turbulence

To reduce turbulence, each fan must be set at a custom speed. Fans by smooth walls can be set at higher rpm's while fans by a geometrical wall should be set at lower rpm's.

Not all greenhouse walls are smooth. Some of the walls as you see in the picture have numerous posts along the wall. These posts deflect the air onto the plants.

The above picture is a smooth wall. The smooth wall decreases the air turbulence and allows for the fans to have a higher rpm with less deflection of air that carries on to the plants.

5 Setting Goals for the Basis of Design

To achieve the goals, ebm-papst worked with KAVA to develop an entire fan system solution. The ultimate design would have the following characteristics:

a. A design developed for North America that also works internationally just as well
    - Operates the *same* performance at 50 and 60 HZ
    - Operates on wide voltage range at least 208 V through 240 V
b. North American design with a wiring harness to comply with North American code
c. Significant energy efficiency gains of 50% or more
d. Service-free design
e. Additional efforts to avoid visible rust
f. Beyond being safe: for workers, easy to use and comfortable environment
    - Easy ergonomic height fan adjustment
    - Low fan noise
g. Substantially increase fan effecitveness
    - Providing adequate volume of airflow
    - Providing the flow at long distances
    - Placing the air exactly where desired
    - Doing so all with little turbulence (losses)
    - Providing a simple and reliable means of speed control

6 The Fan System Solution

An EC motor driven fan, with an adjustable mounting bracket engineered to provide easy adjustable low profile mounting, with a custom designed superior air guiding system, solves many of the problems noted regarding fans in a greenhouse. Air flow in multiple vectors provides short, medium and long air flow distance. This best emulates natural air movement and results in an overall better movement of air throughout the greenhouse. Low power consumption means smaller wiring and smaller electrical burn rate reducing installation and operating costs. Variable speed at the fan housing or remote for convenience is standard.Local speed control helps during installation to adjust flow and distance for what works best in each area.

The technology for greenhouse fans spills over to most fans in agricultural use today and, as such, the market upside potential is high. Fans and fan housings that are specifically designed for a variety of environments such as greenhouses, dairy, poultry and so forth means the fan fits the application, rather than having to compromise. The solution here hits target air flow and capacity efficiently and most importantly with high level of effectiveness.

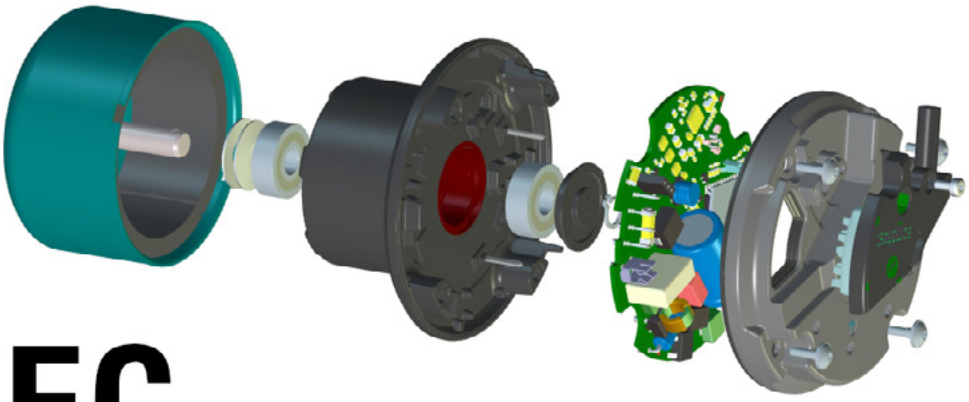
6.1 Motor Design

At the heart, traditional AC motors are not very efficient. Moreover, when one attempts to speed control an AC motor, the efficiency drops off even further. When AC motors were developed, they were designed to run at one synchronous speed. Forcing them to go slower, translates into energy

wasted and the motor converts this to unwanted heat. The heat affects the longevity of the motor life. Their range of control is limited since the motor was not designed to be speed controlled in any event.

The motor used in the **Kava / ebm-papst** design implements a modern EC (electronically commutated) technology. The motor converts the AC mains power to DC power internally. This technology naturally accommodates 50 and 60Hz with no differences in efficiency or performance. As well, the motor can operate over large voltage ranges. It ***exceeds our goal*** *of 208-240V* with a motor capable of 200-277VAC input.

The **EC based design excels** when speed controlled maintaining high efficiency over broad ranges of speed control. This provides unparalleled adjustability to the greenhouse for subtle changes to maximize the airflow effectiveness.



6.2 Fan Design and Housing

The design started with a composite fan blade and housing. With a composite blade, intricate aerodynamic designs can be accomplished improving efficiency while aiding in corrosion resistance. The result is an ultra-quiet solution providing a better working environment and a sign of the efficiency designed into it. An additional benefit of the composite material is that the exterior surface is easy to clean.

As well, there is an air-guiding system which can:

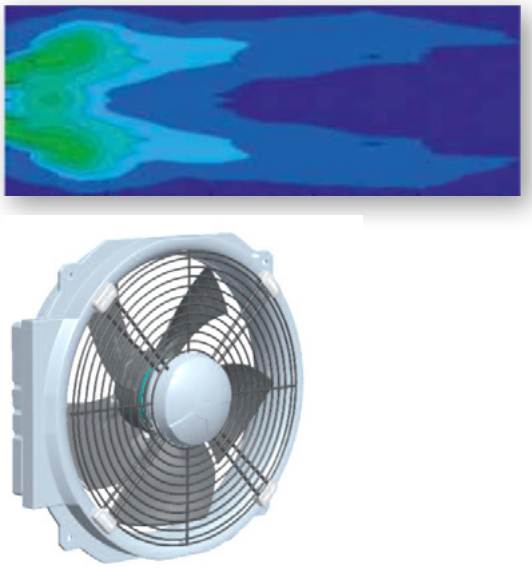
- Double fan air throw distance with comparable flow rate
- Aid in targeting air flow: directing air where you want it

Pictured right, an ebm-papst air-guiding system is integrated. The air guiding system converts energy normally lost in conventional fans.

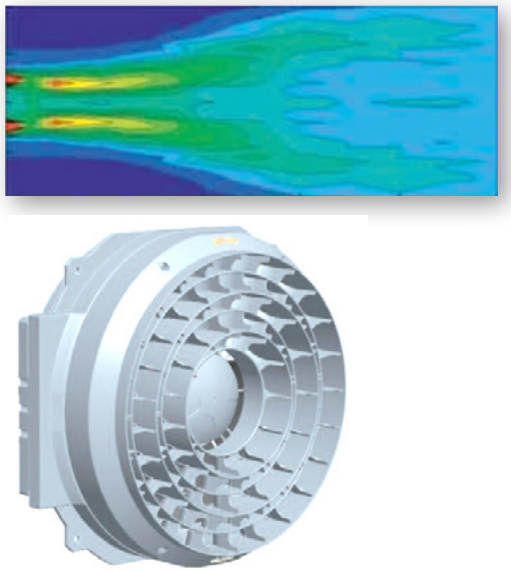
6.2 Fan Design and Housing

Illustrations represent differences with the ebm-papst air guidance system:

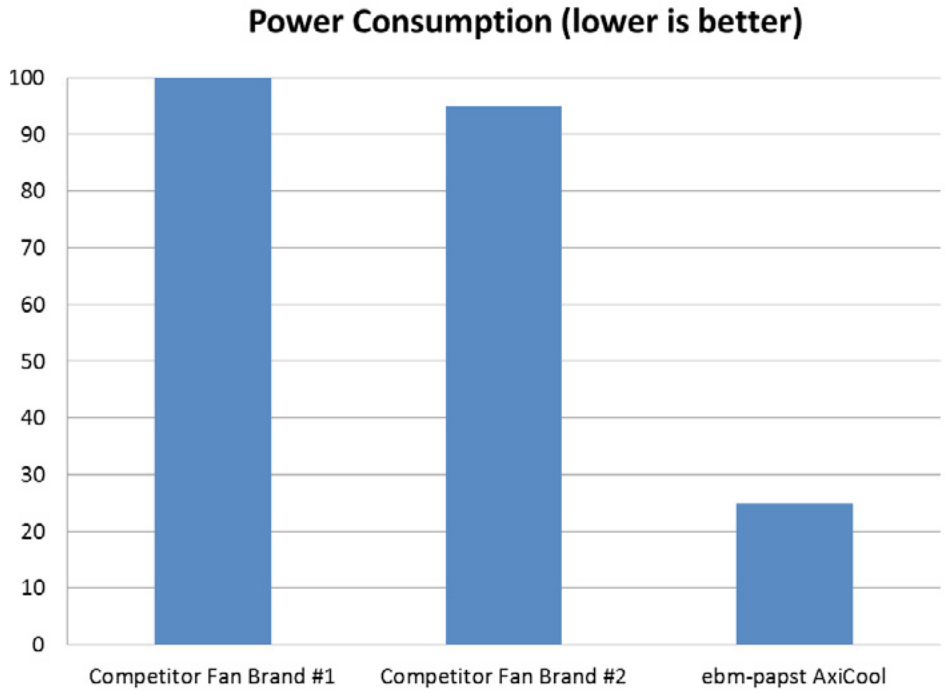
Air Distribution ***without*** Air Guiding System illustration



Air Distribution ***with*** Air Guiding System illustration



KAVA tested the new AxiCool fans alongside the European greenhouse fans onsite at Randhawa. The savings far exceeded our 50% goal. Compared to the prior fans, the AxiCool fans were consuming as little as 26% or the original power.



The AxiCool solution consumed very little compared to other industry standard fans.

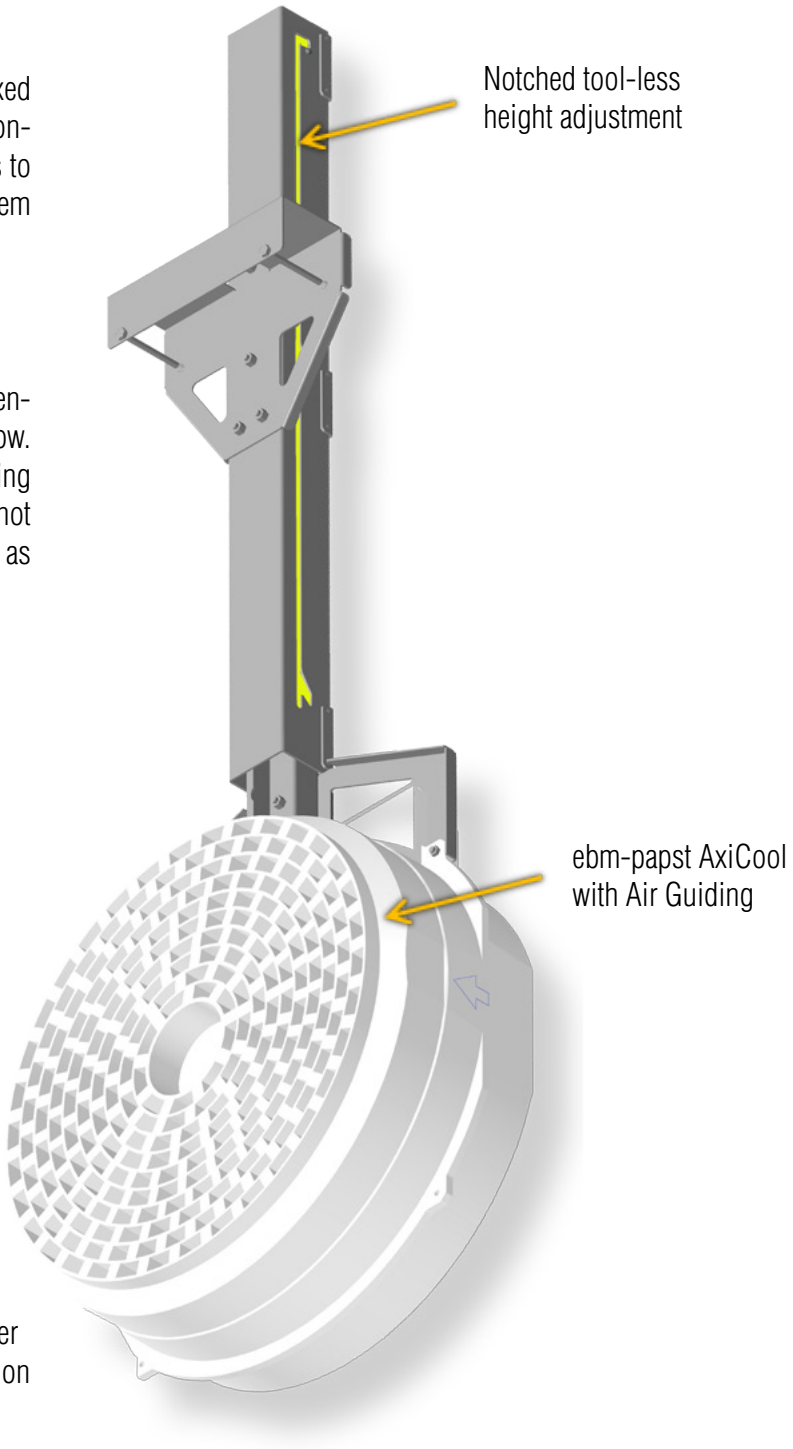
74% energy savings

6.3 Fan Mounting System

Many existing mounting systems are antiquated. A basic fixed post design seen in most applications offers little ability to control airflow height for greenhouse optimization. The task was to give the same high level of innovation to the mounting system as the fan.

Available with Height Adjustment Option:

A tool-less height adjustment is available that allows the greenhouse operator to adjust the height of the fan as the plants grow. With a notch system, it takes any of the guesswork out of setting the height from one fan to the other. This makes the process not only repeatable, but quick, lowering operational costs as well as giving consistency.



7 Greenhouse Results

By using ebm-papst fans, our goals were met and in many cases exceeded. The result can be immediately applied not only to greenhouses, but other market applications as well.

a. We could realize an immediate 74% energy savings
b. The fans provided notably better air flow distribution at the Randhawa greenhouse test facility
c. We found the installation very easy and we could move the fan housings from one area to another quickly and without incident
d. Having local control of the fan speed made set-up (calibration) and testing much quicker
e. Having local control of the fan speed also allowed immediate feedback and easy adjustments by the grower as they could see results within seconds of the installation

For more information, please contact Kava Technologies where we can assess your facility for best practices and provide operational innovations and implementation ideas and costs.

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The Stakeholders of KAVA mandated the Company to look within and determine if firstly the existing technologies meet and perform in their desired application, secondly to improve upon or fine tune such applications where possible, and thirdly to apply better technological solutions with the purpose of improving the existing applications and related production. To be effective in this process the Company has engaged the in-house resources of its stakeholders' companies as well as engaged outside technical and business minded resources that have expertise in various industries.

KAVA will explore, research, and develop solutions that improve the operational energy footprint of specific technology applications, the capital cost of installation, the operating cost of the installation, and provide back to basic systems that simplify the process overall. This equates to a reduction in complex and expensive components with off-the-shelf locally sourced parts, thereby reducing spare parts inventory, streamlining maintenance, and simplifying repairs.

KAVA is supported by ebm-papst

ebm-papst is an innovator and market leader in fans, blowers, and motors with core competencies in motor technology, aerodynamics, and electronics. With over 15,000 products, ebm-papst provides solutions to a wide range of markets including Agriculture, Air-conditioning and Ventilation, Appliance, Commercial Refrigeration, Heating, Industrial, Lighting, and more.

– **Joe Landrette,** Market Manager: Ventilation | ebm-papst Inc., Farmington, CT 06034

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