**Design Team**

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Faculty Mentor: Dr. Douglas Byrd
Industry Mentors: Jeff Buter, Colin Mullins, Randy Palm, Hany Roman, Faisal Siddiqui

**Background**

Allied Air Enterprises is an HVAC company under Lennox International that brings together six brands — Armstrong Air®, AirEase®, Concord®, Ducane®, Allied Commercial™ and Magic-Pak® - to give distributors and dealers the ultimate source for heating and cooling solutions.

**Objectives**

The Single Packaged Vertical Unit (SPVU) Efficiency Enhancement Team’s mission is to evaluate and utilize alternate technology and methods to improve the Energy Efficiency Ratio (EER) of the MagicPak, 2.5 ton, V-Series Unit.

**Needs and Specifications**

- **Critical to Quality Needs**
  - Improved EER - When creating HVAC systems, energy efficiency is an important need set by the consumer to keep power costs low.
  - Improved Cubic Feet per Minute (CFM) to Meet Industry Standard - An increase in CFM allows the system to cool or heat a building faster.
  - Fit Within Space Constraints of V Series - When buildings are designed, the dimensions of the HVAC system is accounted for. To avoid building remodeling the space constraints have to remain constant.
  - Easy to Maintain - The ability to easily maintain a HVAC system allows minimal downtime when the system breaks and is being repaired.

**Product Specifications**

<table>
<thead>
<tr>
<th>Needs</th>
<th>Metrics</th>
<th>Units</th>
<th>Target Specification</th>
<th>Fallback Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Within Space Constraints of Previous Model</td>
<td>Same Footprint as Previous Model</td>
<td>Cubic Feet</td>
<td>20.51</td>
</tr>
<tr>
<td>2</td>
<td>Improved Cubic Feet per Minute (CFM)</td>
<td>Volume Flow on Outdoor</td>
<td>Cubic Feet Per Minute</td>
<td>2.32 x 3.60</td>
</tr>
<tr>
<td>3</td>
<td>Improved Energy Efficiency (EER)</td>
<td>Cooling capacity per power input</td>
<td>Units per Watt-Hour</td>
<td>&gt; 11</td>
</tr>
<tr>
<td>4</td>
<td>Easy to Maintain</td>
<td>Time to Replace Failed Device</td>
<td>Minutes</td>
<td>&lt;20</td>
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</tbody>
</table>

**Concept Selection**

<table>
<thead>
<tr>
<th>Design</th>
<th>Condenser Airflow Device</th>
<th>Blade Modification</th>
<th>Hardware Rearrangement</th>
<th>Change in Aerodynamics Flow</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Axial Fan</td>
<td>none</td>
<td>Addition of Low Pressure Drop Exhaust System</td>
<td>Reduction of Airflow Contact Area</td>
</tr>
<tr>
<td>2</td>
<td>Two Axial Fans</td>
<td>none</td>
<td>Addition of Second Axial Fan</td>
<td>Reduction of Airflow Contact Area</td>
</tr>
<tr>
<td>3</td>
<td>Axial Fan</td>
<td>none</td>
<td>Turning Vanes</td>
<td>Reduction of Airflow Contact Area</td>
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<tr>
<td>4</td>
<td>Improved Axial Fan</td>
<td>yes</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>5</td>
<td>Axial Fan with Conduction Condensate Spray</td>
<td>none</td>
<td>none</td>
<td>none</td>
</tr>
</tbody>
</table>

A combination of Design 3 and 4 were selected. Shown below is the Schematic Diagram.

**Engineering Analysis**

**Air Flow Functionality**

- Current flow rate and cross sectional area used to obtain bulk inlet flow velocity
- Cross section of unit was modeled in ANSYS Fluent using calculated bulk velocity
- Vortices and areas of recirculation were discovered in top left corner near exit and in middle left lip where the flow must make a large angle turn
- Modifying exhaust compartment geometry reduces vortices and shows lower back pressure

**Thermodynamic Efficiency**

- Modeled thermodynamic cycle as ideal vapor compression cycle
- Current EER of 9.2 gives Coefficient of Performance (COP) of ~2.7
- To obtain 11 EER a COP of ~3.2 is needed which can be accomplished by:
  - Reducing work of the compressor
  - Increasing the heat removed by the condenser
  - By increasing the air flow more heat is removed by the condenser allowing the compressor to consume less power
- To be beneficial, the added power consumption from fan creating the increased air flow must be smaller than the decrease in power consumed by the compressor

**Intermediate Test Data**

<table>
<thead>
<tr>
<th>Spec</th>
<th>Baseline</th>
<th>Modified</th>
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</thead>
<tbody>
<tr>
<td>Noise (dB)</td>
<td>72.00</td>
<td>70.50</td>
</tr>
<tr>
<td>Air Flow (CFM)</td>
<td>680.47</td>
<td>780.70</td>
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<tr>
<td>RPM</td>
<td>1410</td>
<td>2020</td>
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</table>

**Summary**

- Current prototype has a 15% increase in CFM
- Preliminary test results show the current prototype did not reach the desired 11 EER
- The prototype is not in the optimal design configuration, but has created a foundation in which the target specifications and customer needs can be achieved
- Compared to the baseline unit, the current prototype has a 4 inch increase in diameter, an insert that reduces surface area and removes a sharp turn in the exhaust compartment, and a motion system that allows the larger fan to be installed

**Future Direction**

The next steps in the development of this design product is optimization of components. The structure has been set in place with the development of a patentable motion system and its allowance to fit a 22 inch diameter blade in the system while continuing to be easily maintained.

**Acknowledgements**

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**References**