VPI Hydronic Oven

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Introduction

After VPI (vacuum-pressure impregnation) of resin into the stator, the resin then needs to be cured in a controlled environment. This is normally done in a large, purpose-built convection oven (either electrically heated or gas fired) as the resin needs to be cured at a high temperature for a set period.

However, curing by simply baking the stator can lead to unevenly cured resin and longer cure times.

Since we have a patented and highly efficient cooling system in our motors, we can take a different approach to the curing process. With our hydronic oven, we can use our motor's cooling system, to heat the stator instead. Just like heating a home with radiant floor heating versus forced air. This changes how the stator cures eliminating the issue of unevenly cured resin and making the curing process better overall.

1a. Hydronic Oven Model

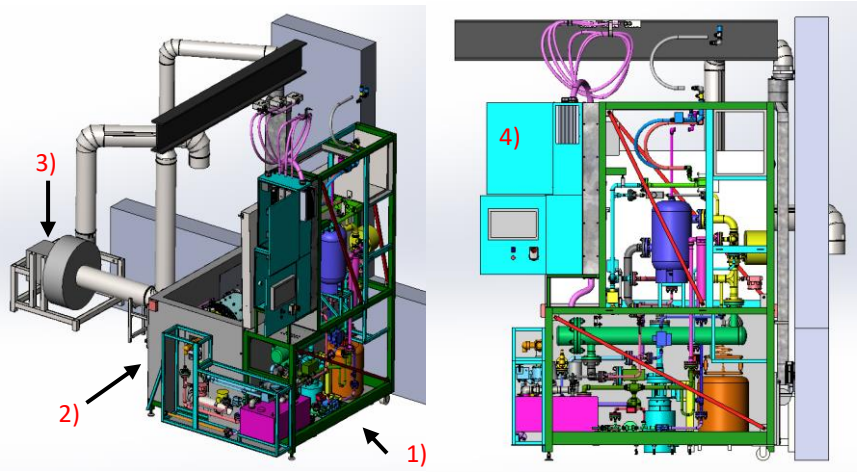

Figure 1a: CAD Model

1. Piping System
2. Class A Oven, with explosion relief and rotisserie system
3. Blower system - fume evacuation
4. Electrical Enclosure

Key Components:

- 72kW Accutherm Immersion Heater
- High Temp Oil Pump
- Rotary Union – Rotating Fluid Passageway
- SWEP Brazed plate liquid heat exchanger (allows cooldown in ~15 minutes vs liquid-air heat exchanger which took ~1.5 hours)

1b. Mechanical Build/Revisions (w/ Side Panels Removed)

Control System Revisions

Before

After

Key Components:

1. Siemens Equipment: S7-1200 & ET-200 PLC, Contactors, Temp. transmitters
2. DMM Tech Servo System
3. ABB Variable Freq. Drives
4. OnLogic Industrial PC

Control System:

- This fixture strictly follows NFPA 70 and 79 regulations and guidelines. Each component is supplied with adequate power and protection and all conductors/cabling are appropriately sized.
- The Siemens PLC, programmed via Siemens' Simatic Step 7 Software, utilizes appropriate safety modules monitors inputs and outputs of the system from numerous sensors. The heater is PID controlled by the PLC via PWM, using air-cooled solid-state relays and a 90A Siemens contactor. The PWM controls the duty cycle of the immersion heater, controlling the energy input to the system which heats the fluid. All wires are specifically labeled for future diagnostics and clarity.
- OnLogic PC communicates with the PLC, allowing for an operating to check system status via an HMI (Human-Machine Interface)
- VFD's allow for precise control over system flow rate, rotisserie speed, motor protection and error monitoring.

How It Works

Curing:

- Overview: A stator is connected, system fill begins, air is evacuated during a low speed/flow cycle, pump speed increases and the heating begins to bring the fluid to operating temp. The system will hold the stator at 200C for 6 hours. During which, a few things are occurring: The control system is monitoring for any faults/irregularities, the stator is rotating on a rotisserie rack to avoid resin pooling at the lowest points, promoting an even cure, and the blower system is evacuating vapors from the oven chamber. After the cure cycle finishes, the system purges the stator of fluid, and the process completes.

Integrated Safety Systems:

Below are examples of when the PLC is programmed to pause the cure cycle if any of the following occur:

- Low fluid level (monitored via load cells on an expansion tank)
- Lack of airflow through oven chamber
- Loss of pressure/flow in fluid system
- Cure temp too high (and the system cannot correct it)

The control system also has functions built in for operator safety, such as the oven lid not being able to open when the stator temperature is above the threshold for safe handling, or whilst the system is in operation.

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Thank you to Alex Roux also, for his mechanical design work with revising the rotisserie system.

Conclusion

Why Do We Use This Method?

Efficiency and quality. With an efficient cooling system used as a heating system, the amount of time and energy required decreases, as heat transfer is better in the stator and more of that heat goes to curing just the stator itself. As opposed to convection heating the stator, but also the environment the stator is in. With conventional methods, you can run into an issue of the outside resin being cured perfectly, but the resin inside remains tacky. This is not optimal as the inside curing properly is most important and it increases cure times overall. With the hydronic approach, the stator is cured from the inside out, eliminating issues with unevenly cured resin and a need for extended cures.

So, overall, we can utilize an already existing system for another purpose, along with a purpose-built machine, and consistently have better results in the end.