Heraeus

[e-book] humm3® systems

Journey to industrialisation

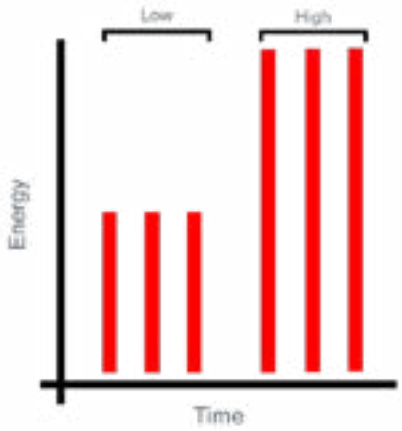
DISCOVER MORE ›

Contents

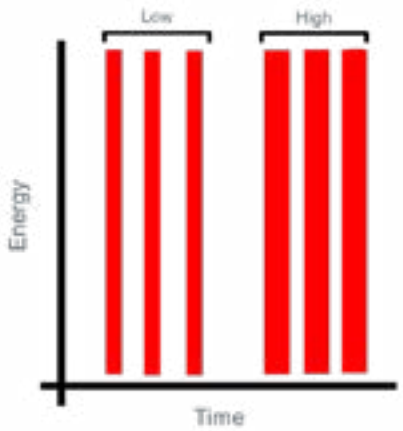
What is humm3® technology?

humm3® is a powerful pulsed broadband heat source that is designed specifically with composites in mind. It is perfect for Automated Fibre Placement (AFP), Automated Tape Layup (ATL) and filament winding. humm3® is a powerful, safe highly controllable broadband heat source.

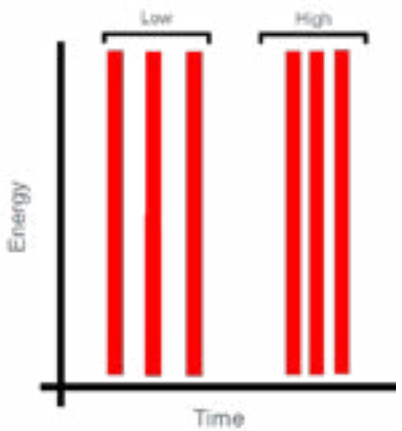
humm3® controls the heat profile using three programmable parameters: energy, duration and frequency



Pulse energy
The amount of energy put into a pulse



Pulse duration
The length of a pulse in milliseconds



Pulse frequency
How many pulses in a given amount of time, humm3® typically operates at 60hz or higher.

Did you know: The name 'humm' is derived from a hummingbird, partly as the technology shares its attributes of precision, speed and continuity of movement, and partly because the blurring of the bird's wings in flight reflects the seemingly constant light from the flash lamp (60 flashes per second), The '3' represents its 3-programmable-parameter thermal control (pulse duration, energy and frequency).

How does humm3® technology work?

To guide the pulsed energy to the correct location, a solid, transparent light guide is used, which acts like a large-scale optical fibre, collecting the energy from the flash lamp and concentrating it onto the heat zone. For AFP applications, this is typically an area near to the nip point between the roller and substrate. The end of the light guide can be shaped to optimise the energy profile, allowing a wider or tighter heat zone. This is shown in the images below.

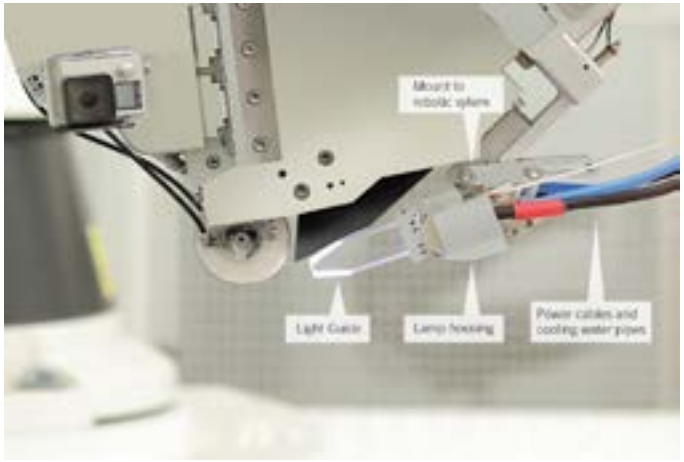


Image 1: Position of the lamp housing and light guide

Image 2: a close-up image of the technology laying up the first ply of a dry fibre panel. humm3® end effector at Coriolis

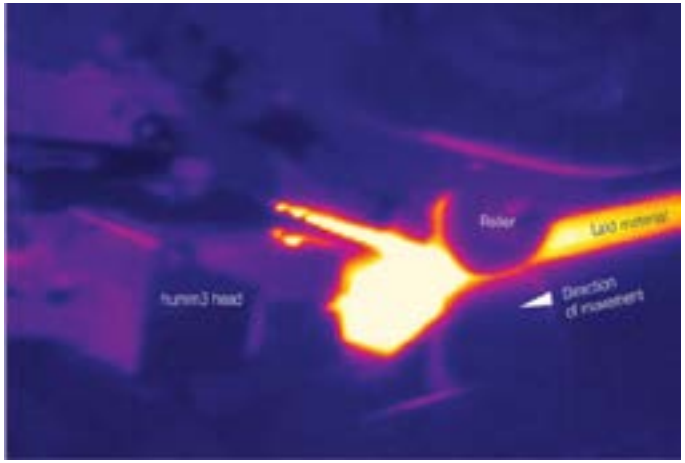


Image 3: a thermal image of the same geometry, showing the energy concentrated at the nip point

The challenge and need for change

In 2012, the National Composites Centre (NCC) UK was looking for a powerful, controllable heat source that could be safely used by industry for materials that require higher energy - such as thermoplastics and dry fibre.

One of the most important considerations for the NCC was that the heat source must be safe for use within industrial settings. Laser is often used for these materials and it performs well, but comes with a high safety burden. Reducing this burden was a driving force that prompted the NCC to look for an alternative heat source.

This coincided with Heraeus Noblelight's own aspirations. The team in Cambridge that produces xenon flash lamps were researching different ways of using their products and were actively searching for new applications. Composite processing was high on their list.

humm3® was developed. It has fast temperature ramp up and cool down rates required for composites heating. It is a safe, broadband emitter that doesn't require a class 4 laser enclosure. The agile head is compact and allows for complex tooling and shapes. It has a high energy and temperature output and is scalable in width. The largest heated widths in the field are 300mm currently and could go wider.

Why use xenon flash heating?

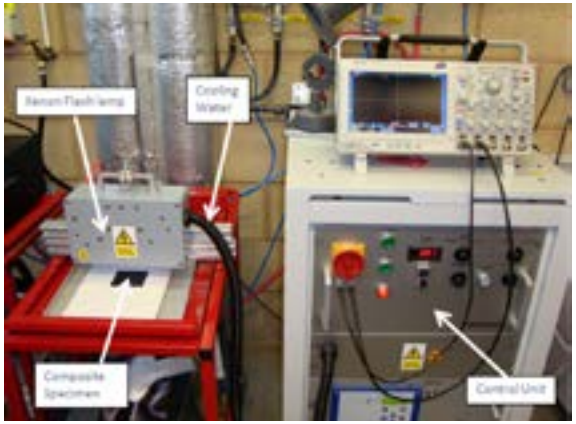
At the time, there was a gap in technology:

- **Lasers -** are incredibly quick to heat and cool and offer high temperatures. The large volume of laser optics causes issues with complex forms. There is a high safety burden using class 4 lasers as they cannot be used without an interlocked enclosure. Finally, they can be expensive, especially when you take into account the cost of safety enclosures and the additional management of maintaining a safe working environment.

- **Infrared emitters** - are inexpensive and small in volume however, the relative ramp up and cool down rates are slow in comparison to laser and xenon. IR emitters are unable to provide the precise control or hit the temperatures required for dry fibre and thermoplastic materials.

What we did

‘Wet Horace’

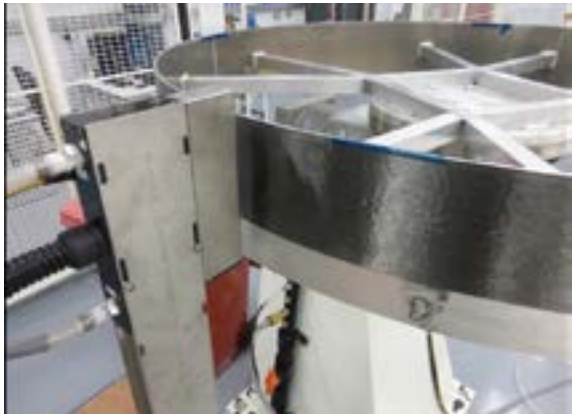


‘Wet Horace - was the ‘pet name’ for a water-cooled prototype xenon heating system. The initial experiments began with ‘Wet Horace’, which comprised of xenon flash lamp, housing, power, control and an oscilloscope to monitor output. The team learned that they could heat a piece of composites material from room temperature to 220°C in a single flash in milliseconds.

Prototype version

Prototype version. ‘Wet Horace’ was replaced by a newer, more innovative design. It was more compact, robust and safer. For the first time it allowed for greater levels of integration on an AFP robotic system. This version did not feature the light guide many associate with the humm3® system - the team had not yet discovered the benefits of this approach.

First dynamic trials test rig

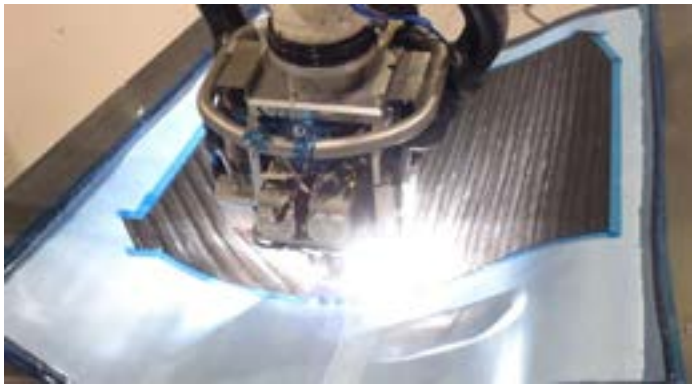


First dynamic trials test rig. These dynamic trials featured a static flash lamp and a large drum that rotated on a horizontal plane at speeds of 18rpm (1.5 m/s). The flash lamp heated the dry fibre that was attached to the outer circumference of the drum. The rig enabled full control over speed, offset, pulse energy, duration and frequency.

humm3® in action

Click here to see the humm3® in action at Compositadour

Click here to see the humm3® in action at Coriolis



This system is located at **Compositadour** in France and is shown laying up eight 1/4 inch tows of Hexcel high tape dry fibre.
The image shows the control as the process starts, as the flashing commences the humm3® system approaches the concave section, it then slows, before accelerating away at a metre per second all the time maintaining optimal temperature.

This image shows a demonstrator spar being produced on a **Coriolis** system in France. The robot starts the process from zero velocity, it accelerates before slowing down to navigate the corner and then is seen accelerating away. This demonstrates precise levels of control required to maintain the optimal process temperature.

Government funded projects

Image 4: Demonstrator day at the National Composites Centre, UK in 2016

Both images were taken at a demonstrator day at the **NCC** in 2016. This day denoted a transition between two projects. Heraeus Noblelight were successful in winning **NATEP** funding which enabled significant development. Later, a funded project with **Innovate UK** which enabled the construction of a larger 32kW research and development system that allowed us to explore the potential of humm3® with more power.

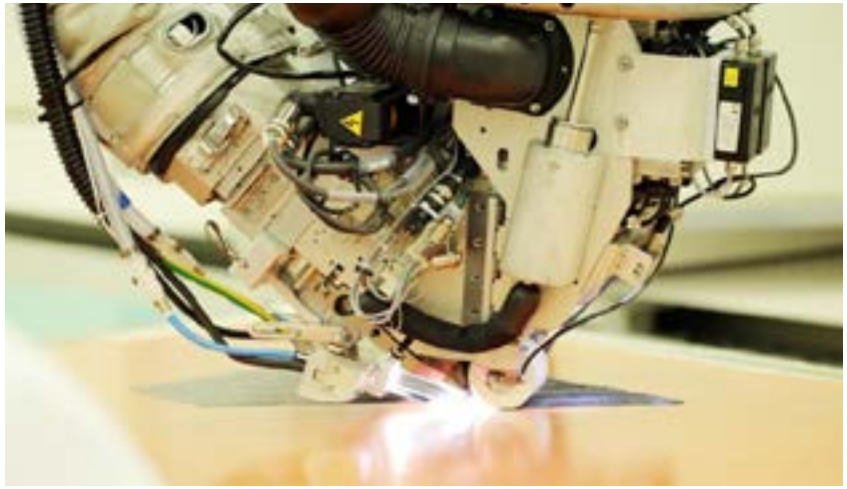


Image 5 Close up of humm3® at the demonstrator day at the National Composites Centre, UK in 2016

The humm3® team are currently working on the **CLEAN SKY 2 FRAMES** initiative which has the purpose of making a thermoplastic tail section for aircraft. Heraeus' role is to take the lead in producing an optical thermal stimulation tool which speeds up the process of getting these parts made. We are really pleased to be partnering DLR and Compositadour on this initiative.

Anatomy of a humm3® system

Control panel - uses digital signal for heat on/off, an analogue signal, start/stop and 4-20 milliamp signal which varies the output power relative to process

Chiller unit - This unit takes the heat from the heat exchanger and removes the excess heat from the process area.

Water - Acts as a coolant.

Head - Xenon flash delivery.

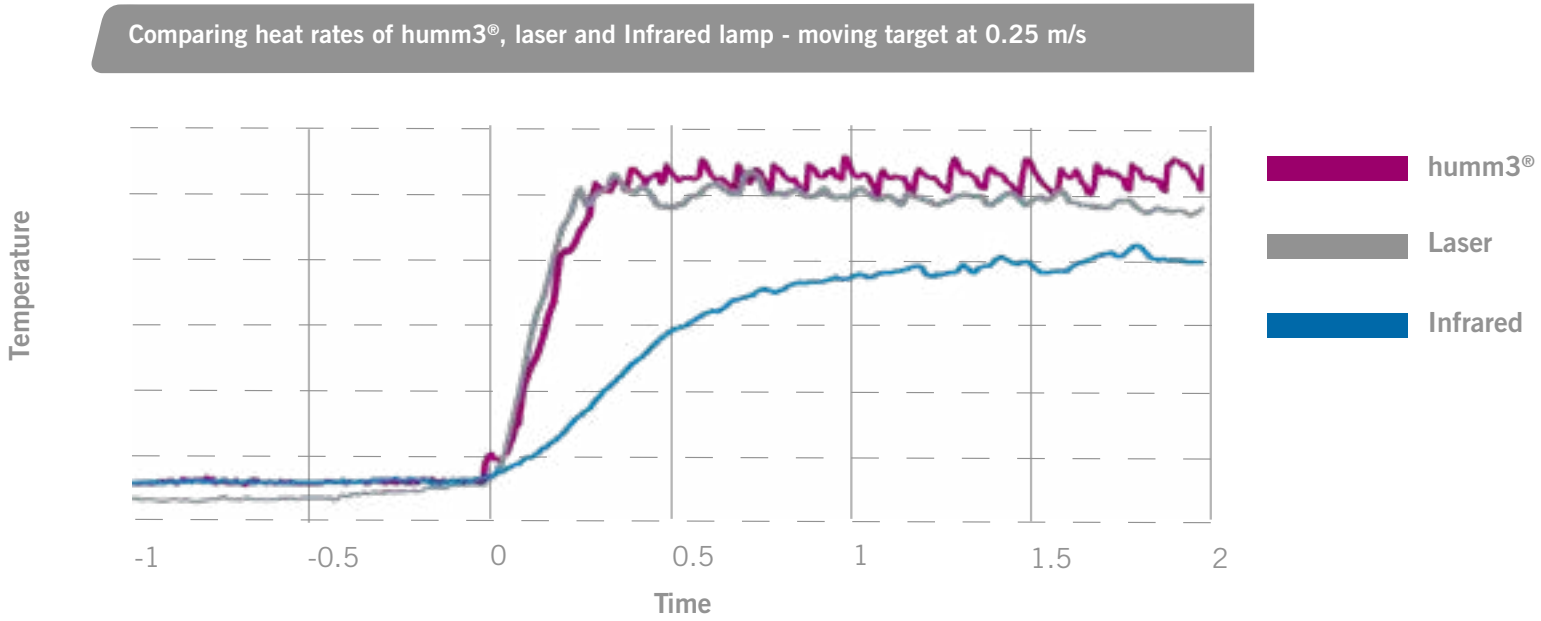
Light guide - This uses internal reflection to deliver energy precisely into the process.

Power supply - A 6kW standalone power supply.

Image 6: An NFS2001 which is designed for laboratory settings

Comparison of humm3® heat up and cool down rates

The table opposite shows a measured area comparing the three heating devices. humm3® and the laser ramp up and cool down almost instantly whereas with IR the ramp up and cool down is significantly slower. The latent heat is removed from the head of the humm3® with chilled water. The removal of latent heat aids precise temperature control.



Experiments on moving targets have shown the heating rate of humm3® is equivalent to laser, and much faster than Infrared lamps. This is also true for cooling - humm3® has no residual heat.

Figure 1: Table comparing heating rates of humm3®, laser and IR lamp - moving target at 0.25 m/s

Thermal imaging of a thermoplastic lay-up

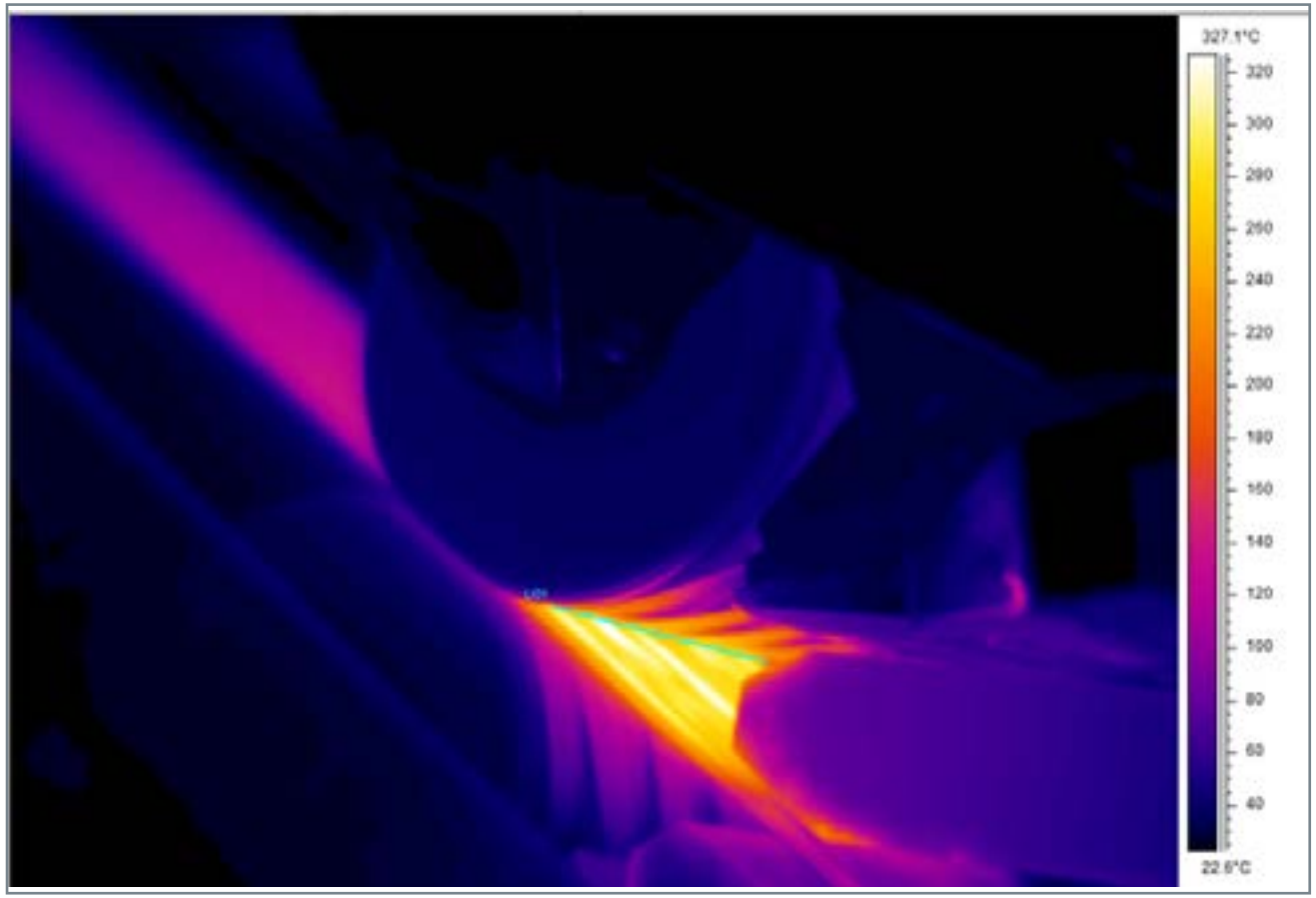


Image 7: Thermal image of a thermoplastic lay up

This is a thermal image of thermoplastic lay up. The light guide can be seen to the right and remains relatively cool. There is an even, homogeneous heat profile across the process which reached temperatures up to 320°C.

There is some evidence that crystallinity and porosity is improved by the way that humm3® heats in comparison to other heat sources. It is still early days, but it seems that the fact that heating and cooling takes places over a relatively larger area may improve the quality of the finished part.

Power law

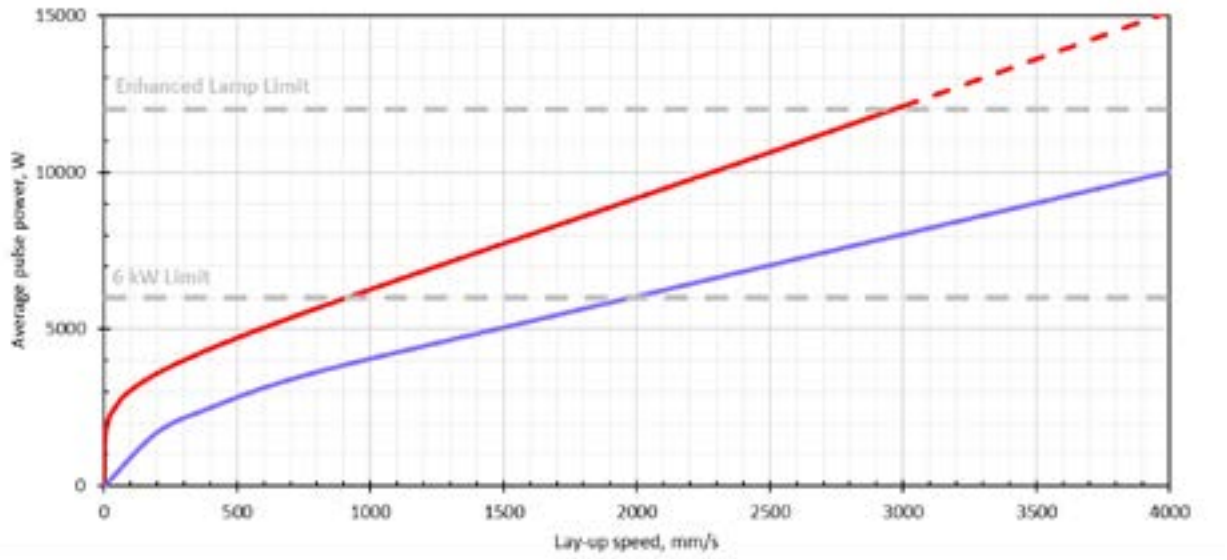


Figure 2: 2" heated width – speed vs. power law for dry fibre at 210°C nip point temperature (red) and thermoset material at 50°C nip point temperature (blue). Note graphs are estimated above 1000mm/s using power law equation.

Click here to read more: Power control of a flash lamp-based heating solution for automated dry fibre placement by Monnot, P., Williams, D. P. & Di Francesco, M.,

This model was generated via our trials with Innovate UK using a large system to exercise a broader parameter range of humm3® technology. The lines on the graph represent process temperatures and are referred to as 'power laws'. Earlier, we mentioned humm3®'s control capability and here we see how that is useful in maintaining precise temperatures in dynamic processes.

The model shows the temperature (along the red line) at 220ºC and represents Hexcel® high tape material processes.

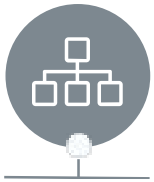
The blue line represents thermoset materials. We can see that this can be laid up really quickly however, it is key to note that when using humm3® the heat can be applied and removed straight away so that there is no wastage or difference in adhesion at the start or end of the process. Precise control and rapid ramp up and cool down enables 'power law'. The instantaneous ramp up and cool down response times of humm3® enable fast deposition rates with constant temperature control at variable speeds.

Industrialisation - what we learned

That power is a good thing.
Our customers required high average power, and this led to us making power supplies in a modular format. Our largest power supply in the field is over 40kW.

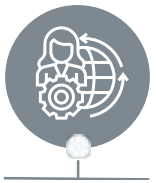
Off robot - on robot.
It became desirable to put the higher energy modules closer to the process - the power supply was split into ‘off robot’ and ‘on robot’ modules.
The on robot module is designed to be in a dynamic setting. All cabling is suitable for dynamic integration.

Interchangeable heads.
Industrial applications required a ‘plug and play’ head connectivity so that head modules can be replaced quickly with minimum down time to suit process requirements or for maintenance.



Fieldbus communications.
We use Profinet / Modbus PLC machine control with intuitive user interface for ease of machine integration.

Artificial Optical Radiation (AOR).
humm3® is very different to lasers with a reduced safety burden. Our team has become leaders in this area and are able to provide quantitative information and help customers manage AOR.



Service models.
Heraeus is a global company with service engineers on every continent.

At the NCC we work with innovators to use composites technology to solve some of the most complex engineering challenges of our time. We're especially proud of our relationship with Heraeus Noblelight, whose humm3® technology allows companies to fully exploit the benefits of Automated Fibre Placement, and helps us to accelerate the development and uptake of composites across a wide range of industries. This technology began its journey from a brilliant idea to a product that is used worldwide here at the National Composites Centre.

- ENRIQUE GARCIA
Chief Technology Officer,
National Composites Centre.

humm3® in the field - National Composites Centre, UK.

The humm3® has been installed on the NCC's **AFP-ATL** cell. This system has multiple process widths, heads can start at 102mm (4") for Automated Fiber Placement (AFP) and from 75mm to 300mm wide for Automated Tape Layup (ATL).

This is the **Ultra High Rate Deposition Cell**, this was built to progress the rapid production of composite wings - particularly for the Wing of Tomorrow programme. This industrialised humm3® system has 6 x 1.5" heads that abut to provide a continuous 9" heated width with individually compliant and tuneable 1.5" sections.

humm3® in the field - Grofi Cell, Deutsches Zentrum für Luft und Raumfahrt (DLR), Stade

In the Grofi cell at the DLR the cell is set up as a tracked system with the robots moving from maintenance bays to various different work stations where they lay up on large tools. The system on this site is fully integrated with 4” (102mm) heated width head module and can be ported from one robot to another - the on robot power supply can be lifted from one robot to another depending on process requirements.

Conclusion

humm3® technology is a flexible, controllable heat solution for Automated Fiber Placement (AFP), Automated Tape Layup, filament winding and other composites applications. It is a sophisticated, pulsed light solution using three pulse parameters to hit target temperatures in a fraction of a second.

Benefits of humm3®:

- **Rapid heat/cool** with no residual lamp heat – ideal for required high temperature composites heating of dry fibre and thermoplastics
- **Enhanced safety** – humm3® is a safe, broadband emitter that doesn't require a class 4 laser enclosure or the associated safety management burden
- **Option for wide heated** width, resulting in a rapid deposition
- **Small agile head**, ideal for complex curvatures
- **'plug and play' head connectivity** - head modules can be replaced quickly to suit your process requirements and for maintenance
- **Precise dynamic** temperature control.

Click here to request access to our accompanying webinar: 'humm3® - our journey to industrialisation'.

To discover more about humm3® or to discuss how we can help you choose the right heating source for your composite materials or process, please contact our representative.

Heraeus

For help choosing the right technology for your composite heating needs please contact:

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Heraeus Noblelight with its headquarters in Hanau and with subsidiaries in the USA, Great Britain, France and China is one of the technology and market-leaders in the production of specialty light sources and systems. The organisation develops, manufactures and markets infrared and ultraviolet emitters, systems and solutions for applications in industrial manufacture, environmental protection, medicine and cosmetics, research, development and analytical measurement techniques.

Our site in Cambridge, UK is the centre of excellence for flash lamp technology and the home of the humm3® system. We were proud to win the Queen's Award for Innovation in 2015 for Automated Flash Lamp production.

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