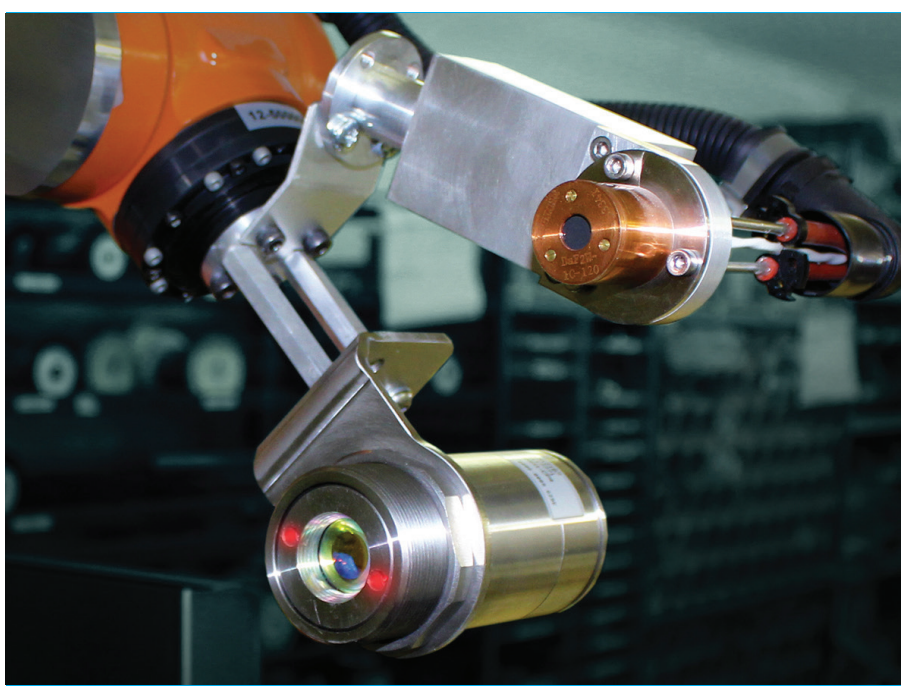
‘Bring me sunshine’: mapping the invisible IR heat spectrum – the Ceramicx/TCD story

19 MAY 2015

As part of an Innovation Partnership agreement, Ceramicx Ltd and TCD came together to sign a licensing deal and build the Herschel machine, which maps heat flux distribution and is the only one of its kind in the world, reports Tony Robinson



Author: Professor Tony Robinson, Department of Mechanical & Manufacturing Engineering at Trinity College Dublin.

Earlier this year Ceramicx Ltd and Trinity College Dublin (TCD) both signed a technology licensing agreement. The agreement represented the fruit and flowering of an Innovation Partnership (IP), part funded by Enterprise Ireland. The first such machine instrument resulting from the IP was christened the Herschel, after the 19th century discoverer of the infrared spectrum.

I led the project team and the machine build at the TCD School of Engineering. In essence, what we designed and built was a scientific tool for characterising the infrared heat flux spatial distribution in three dimensional space. The net result is an extremely sophisticated piece of machinery, the only one of its kind in the world and we at TCD are very proud of it. All the feedback from Ceramicx has been extremely positive – and that tells us that we have done our job well.

Robotic arm and infrared heat flux sensors

Signing of the licence agreement between TCD and Ceramicx. L-R: Frank Wilson and Graham McMullin

The Herschel utilises a robotic arm, linear stages, control and acquisition software and infrared heat flux sensors along with other instruments to map the heat flux distribution. The instrument is much more than the simple sum of its parts: sensors, robotics; thermocouples, state-of-the-art data acquisition and mathematical analysis software all have to work together seamlessly in order to provide something that otherwise could not be achieved; in this case the radiant heat flux distribution from any given heater system. From that base criteria the system can be tweaked to measure different IR effects, such as those on target bodies like plastics for example; effects of different heater and reflector design and the effects of different kinds of IR heat; such as short, medium and long wavelength.

The Herschel instrument fits right into the guiding philosophy of Ceramicx founder and director Frank Wilson, who often uses the expression “to measure is to manage”. Frank’s aim from the outset was to commission a machine tool/scientific instrument that could measure IR heat flux and thus help manage the IR heat spectrum and all the heat work within it. In essence, Frank wanted to bring science into the realm of applied engineering and design and leverage it to make his company’s IR products and systems the best in the world.

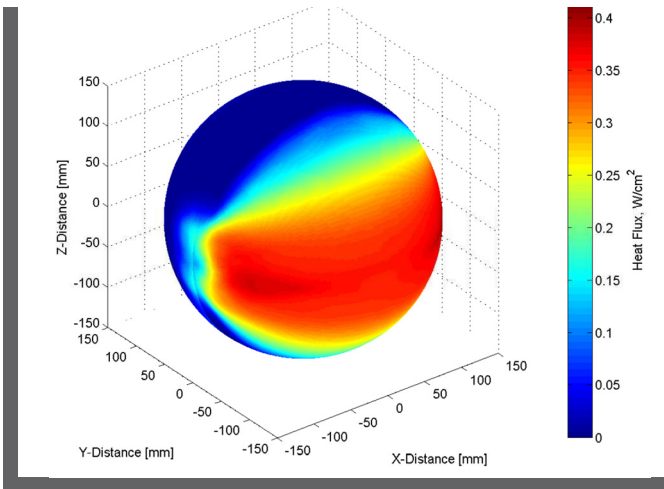
In the early days of the project, Frank noted to me that infrared (IR) radiation was sometimes described as “sunshine without light”. Many IR heat practitioners and users in industry were used to treating IR heating as something of a ‘black art’, where only rule of thumb, proprietary experience and knowhow held sway.

Continued next page

IR heat design in 3D space

The new Herschel has now changed that state of affairs at a stroke. It has effectively illuminated what was previously invisible and therefore laid bare much of the empirical data and guess work involved in IR heat design. The instrument now provides an open and transparent method of precisely measuring and mapping that distribution of infrared energy in 3D space.

The Herschel can therefore enable all stakeholders in the IR heating business to make design decisions based on what has been measured and quantified. We not only know how IR heaters and heater systems work, we now know how to design them to work better. From an end-user standpoint the repercussions are quite striking and far-reaching; everything from massive energy savings to increased production cycle times for high volume manufacturing industries. More than that, the Herschel is now helping Ceramicx in all its IR heater design work, providing great 3D specificity on the actual performance of new designs of heaters and heating systems as well as positioning Ceramicx products against their international competitors using precise scientific data.



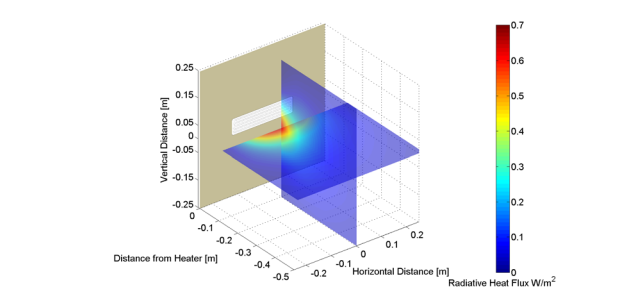
Measured heat flux distribution around an infrared heating element

Combining the state-of-the-art IR sensing technology with state-of-the-art robotics is the true innovation of the Herschel. A specialised grip was manufactured that fixes the heat flux sensor to the wrist of a six-axis robot. Software programs were then written to position the heat flux sensor anywhere and in any position in front of heaters and heater assemblies

IR heat distribution and thermoforming

The small size of the sensor and accurate positioning of the robot allows excellent resolution when it comes to heat flux mapping of industrial scale equipment and facilitates the measurement of everything from the energy efficiency of heaters to the amount of energy that would reach a target in real application. There was simply no way to do this in the past. This is why the Herschel has given Ceramicx such a competitive advantage over other companies in the IR heating industry; it is using science and has left the days of rule-of-thumb behind.

Even though Herschel began as somewhat of an abstract concept, we have subsequently learned that it is immensely helpful to designers of industrial IR processes and systems. For example, there was no reliable way of knowing the IR heat distribution from arrays of heaters for industrial process, such as heat treatment and thermoforming, since you could not 'see' the heat. Now, we can see the IR heat and how it spreads in 3D space and this has opened up a whole new world in terms of our understanding of IR heating systems and how to properly design them for specific targets, which can range from plastic bottles to automobile brake discs.



Three-dimensional heat flux map in front of an IR heater element

The machine build was quite a challenge, especially because Frank wanted the system to be portable. The system required the co-ordination of robotics, controls, sensing and measurement and theoretical heat transfer analysis.

Herschel design for K show

From the outset, it was clear that Ceramicx needed us to design and construct the Herschel at a very aggressive pace so it was ready for the world's largest and most sophisticated plastics exhibition, the triennial Kunststoffe show in Dusseldorf, Germany.

Continued next page

That was a tough order. We worked tirelessly for a little less than a year in TCD and against all odds we delivered the Herschel on time, if not a few days early. The Herschel was shipped to Ceramicx with plenty of time to 'kick-the-tyres' on it before its international debut at the K Show, in October 2013. In the event the exhibition drew some 219,000 visitors through the gates over the course of a week

The K 2013 show was quite extraordinary. It was like nothing I have ever experienced before: overwhelming in fact. Being a mechanical engineer it was like a technology playground: robots, massive machines, scientific equipment…everything you could think of was on display and for sale. And when I reached the Ceramicx stand I was naturally put to work immediately. Our Herschel innovation was perfectly located on the corner of the booth – and quite an attention-getter. It seemed like there was always somebody gawking at it, trying to figure out how it did what it did.

The Herschel in action at the K Show in Dusseldorf, 2013

This is where we would step in and explain the Herschel. The K 2013 show was a perfect venue to really show how academic research can be very relevant to industry, which I think is something that needs to be expressed more in Ireland these days. If you get the right team together and you give us the right project, we can and will deliver something that has a direct line of sight towards creating value and making profit for Irish companies.

Following the K 2013 exhibition and further experiences a groundswell of interest and support from the international manufacturing community encouraged both TCD and Ceramicx to plan the sales and marketing of further machines for an international user base. Our new joint licensing agreement formalises these plans and fires the starting pistol for a programme of international marketing and sales.

The new deal carries far-reaching implications for international manufacturing and for industry. The applied science of IR heating is still in a relative infancy. IR heating is commonly misunderstood and often misapplied in manufacturing. The new Herschel can help remedy many of these situations and dispel a lot of IR heating myths.

New revenue stream for Ceramicx

We are very happy with our joint agreement and with the shape of the future. Ceramicx Ltd has been perfecting and honing its IR heat work trade for the past 25 years and The Herschel will not only sharpen this to a point, but will provide a new revenue stream to the Ceramicx global sales network. The company has distributors in all continents and currently exports 98 per cent of its IR heating production to more than 62 countries.

As we at TCD help design and build more Herschel's with Ceramicx and help the technology evolve, it will create ever more resources for IR heating stakeholders, provide more transparency in a very competitive and fast-paced market and deliver efficient IR products and services to the worldwide industry and domestic heating industries.

Professor Tony Robinson heads up a team of researchers in the Fluids and Heat Transfer Laboratory in the Department of Mechanical & Manufacturing Engineering at Trinity College Dublin. He is also the co-founder and director of Confluent Research Ltd, a leading consultancy in the realm of heat transfer and fluid mechanics for various sectors of industry. In addition, and thanks to Irish Aid, Tony's humanitarian work takes him to African countries, working on energy access technologies for the developing world.