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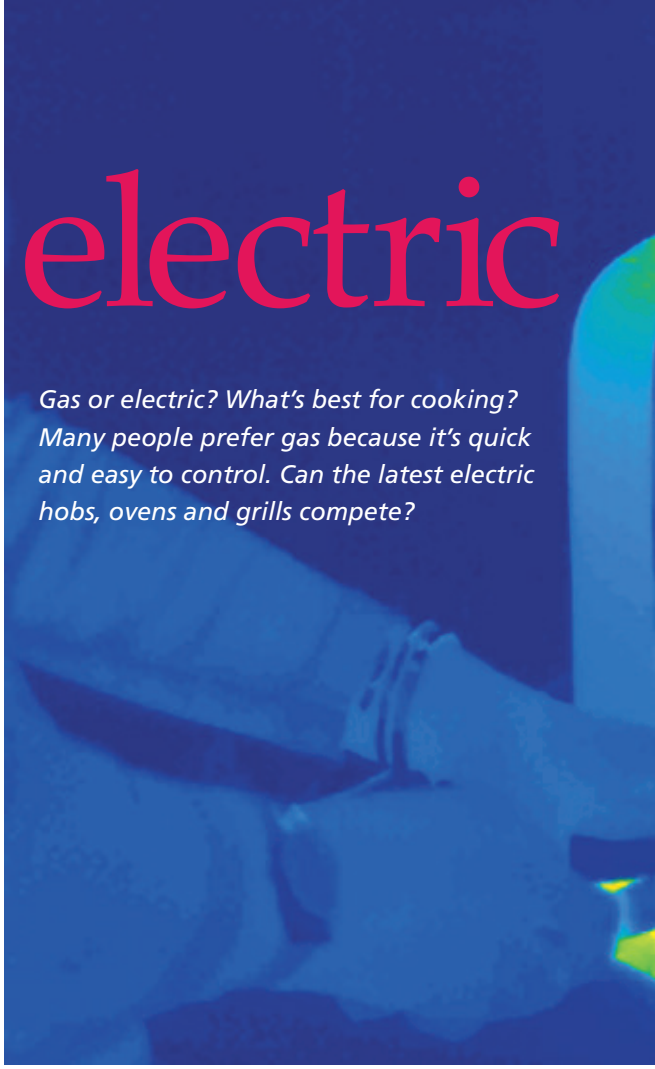
Cook electric



Gas or electric? What's best for cooking? Many people prefer gas because it's quick and easy to control. Can the latest electric hobs, ovens and grills compete?

GCSE key words
Conduction
Radiation
Efficiency
Electromagnetic induction

Cooking can be messy and time-consuming — even dangerous. So the ideal hob should have the following features:

- speed — it should heat up and cool down quickly
- controllability — it should be easy to set the desired temperature
- cleanability — it should be easy to clean up any spills
- efficiency — it should not waste energy (and money)
- safety — the user should be safe from high temperatures

Cooking requires heat energy to be transferred from a source to the food. Heat can travel by conduction, convection and radiation, and electric cookers make use of all three of these mechanisms.

INSIDE THE HOB

How does a gas hob compare with a ceramic hob in terms of cleanability?

Many new kitchens are fitted with ceramic hobs ('cooktops'). A ceramic is a hard, brittle material such as glass, and the heating elements of ceramic hobs are embedded in tough, heat-resistant glass. This means that the hob is smooth and flat, and easily wiped down.

How do the heating elements work? Three different types of element are used in modern hobs — radiant, halogen and induction — and they all work in rather different ways.

Radiant heating

In radiant hobs a metal ribbon spirals round to form the element. When the element is switched on, an electric current flows through the ribbon and, because of the metal's resistance, the ribbon heats up. Almost instantly, it starts to glow red hot and the user can see that it is functioning. Its temperature reaches about 1000°C; 97% of the energy it supplies is heat, and just 3% is light.

Electronics is having a great impact on the cooker market. Over 30% of ceramic hobs now incorporate electronic control systems.

Heat and light from the ribbon **radiate** up through the ceramic material of the hob, and are absorbed by the base of the pan. Radiation accounts for 40% of the energy supplied. The remaining 60% is heat which **conducts** upwards through the solid ceramic.

Of the energy supplied 65–70% is transferred to the pan — that's efficient. The energy conducts through the metal of the pan and into the food.

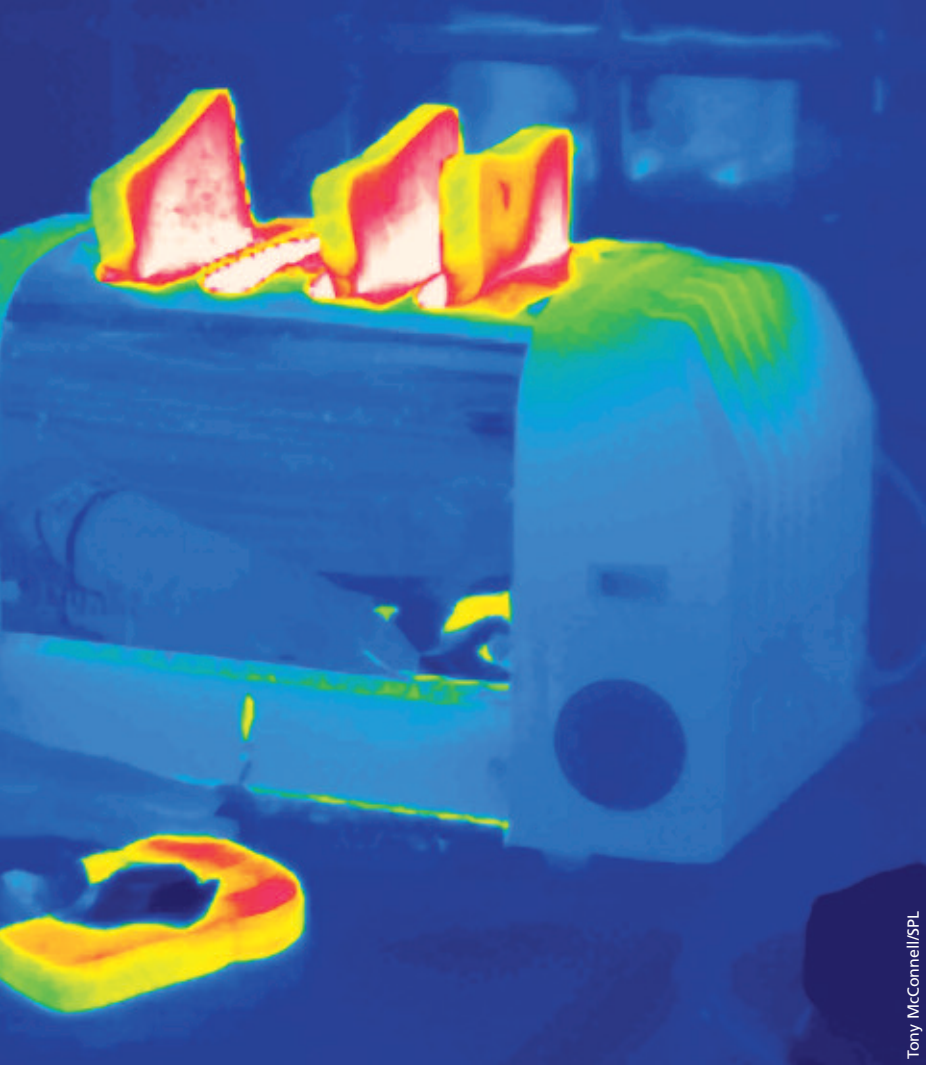
There's a lot involved in the design of a good radiant heating element:

- The ribbon is arranged to supply more heat around the edges than near the middle. This is known as 'edge-weighting', and gives a more uniform temperature across the base of the pan. The result is faster boiling times and more evenly-cooked pancakes.
- The ribbon is mounted in an insulating moulding. This prevents energy from escaping downwards or sideways, and reflects radiation up towards the pan.
- A modern element is fitted with an electronic sensor which detects excessive temperatures and switches off the current. Older elements used a cruder, less sturdy electromechanical control system.

Halogen heating

Halogen hobs use tungsten filament lamps to supply energy. The lamp is in the form of a ring, so that the glowing filament matches the shape of the base of the pan. A halogen lamp is designed to have a much longer life than a standard light bulb. The filament is closely surrounded by a quartz envelope capable of withstanding high temperatures. The envelope is filled with a halogen gas; if tungsten atoms evaporate from the filament, they combine with the halogen atoms and are deposited back on the filament when it cools down. This can give a lifetime of 10 000 hours, compared with 1000 for a conventional light bulb.

Users of halogen hobs like the way the element glows brightly, and can be seen to change instantly as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Above left: *Kitchen appliances are designed to help the user avoid getting burnt. They are checked using thermal imaging, in which infrared radiation is detected by a camera to create a 'thermogram'. This thermogram of a toaster shows that its sides (blue) are cold even though the heating filaments and the toast are hot (red, white). You can see that the butter is cold, and there is an image of the hot toast, reflected in the side of the toaster.* ***Above right:*** *Radiant heating elements on hobs*

they alter the controls. Modern halogen elements incorporate ribbon heating as well, to give the best of both worlds.

Induction heating

Induction heating is different. The element is a coil of wire that carries an alternating current, with frequency 25–50 kHz. That means that the current flows back and forth up to 50 000 times each second. The coil acts as an electromagnet. Because the current flows back and forth, the magnetic field through the coil keeps reversing. The changing field penetrates the metal of the pan and causes an alternating current to flow in it. Because the pan itself has resistance, it gets heated by the current.

If you know about transformers, you will find this easier to understand. In a transformer, an alternating current flows in the primary coil. This produces a varying magnetic field which induces a current in the secondary coil. In induction heating, the pan takes the place of the secondary coil. Pans must be made of steel (because steel is mostly iron, a magnetic material).

Induction heating transfers almost all of the electrical energy supplied to heat the pan. This makes it highly efficient, and it is fast, too — more than 50% faster than gas or other electrical methods. It is highly controllable, so the user can cook sauces gently, or melt chocolate without burning it. And the surface of the hob does not heat up, so spills don't stick and the whole thing is much safer.

RESEARCH AND DEVELOPMENT

Is there anything new to be achieved in designing hobs and ovens? Ceramaspeed is a leading British

● Find out where else halogen lamps are used, and why.

BOX 1

Electric cookers usually have their own cable running direct from the fuse box. This is because a large current — up to 40 A — flows when they are fully in use.

They operate from the 230 V mains, so their maximum power is:

$230\ V \times 40\ A = 9200\ W$

or about 9 kW. Each ring might have a power rating of 2 kW, so the current flowing through it would be:

$2000\ W / 230\ V = 8.7\ A$

Some electric toothbrushes are recharged by electromagnetic induction.

Halogens are elements of group 7 in the periodic table, including fluorine, chlorine, bromine and iodine.

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Above: *The research laboratory at Ceramaspeed*

Top right: *An engineer at work in Ceramaspeed's design office*

Right: *The temperature of a ribbon heating element being measured with a pyrometer*

company in this field, based in Kidderminster, Worcestershire. It manufactures radiant, halogen and induction heating elements, and has sold over 80 million in the last 25 years.

Peter Wilkins is Director of Research and Development at Ceramaspeed. Here, he describes his department's work.

Our development activity is generally split into two areas. We are continually developing new versions of our **core product** — principally new radiant heater designs for hobs and oven grills. Typically we launch 15 major new products per year — some for specific customers, some with wider applications.

The other area is **advanced system development**: the main thrust here is our intelligent cooking systems programme. This makes use of advanced high temperature sensors combined with sophisticated control techniques. We are developing complex control algorithms which are taken up by our electronic controls partners to incorporate into software. Typical features we have developed through sensor/controls integration are automatic boil-dry detection (to be launched with a major European manufacturer later this year), and highly accurate and sensitive temperature control for consistent pre-set frying and simmering cooking cycles.

We are working on a pan-sensing system for conventional radiant heaters. This uses the induction principle — a sensor loop is mounted on the heater top surface, under the glass, with a small alternating current flowing through it. When any metallic cookware is placed on top, the current changes and this is easily detected.

We have a total R&D team of around 25 people in the UK and five at our North American operation. The disciplines are varied: a team of seven mechanical engineers and a design manager support new product development; there's a mix of materials scientists and physicists for advanced technology programmes; the lab team is mainly physics orientated; and we now have electronics skills for controls systems and interfaces.

Project management skills are also important because it is imperative to deliver new products to meet timescale, cost and quality targets.

Computer design techniques are vital. We use a computer-aided design and manufacturing (3D CAD/CAM) system called Solidworks for product design, rapid prototyping and internal tooling requirements. Twelve people can work with this at any one time.

We also have simulation and modelling tools which we have developed ourselves. We use a database combined with Excel spreadsheets to design heating elements and to model the way heat flows from the heating elements.

An algorithm is a set of rules which is carried out in sequence to solve a problem. Computers make use of algorithms for calculations and to control systems.

David Sang *writes textbooks and is an editor of* CATALYST. *He is grateful to Peter Wilkins and colleagues at Ceramaspeed for help in writing this article.*