06 Creating the **world's smartest iron**

The brief
LAURASTAR, the world leader in high-end domestic ironing systems, first contacted Cambridge Consultants just before Christmas 2003. The Swiss company already made the most advanced ironing systems in the world but they wanted to improve them still further and make an 'intuitive' iron using automatic motion detection.

A brief history lesson
For hundreds of years man has essentially done the same thing – heated up a lump of flat metal and rubbed it over clothing until reasonably crease-free. However, clothes are good insulators and are therefore difficult to heat up. If you press the iron onto the cloth you can heat the fibres through conduction, but that is hard work and you eventually polish the material to leave it shiny. Steam irons were introduced because the steam passes through the fibres, heating them more efficiently. But restrictions in the amount of water you can store in an iron without making it unwieldy have limited the effectiveness of these devices.

LAURASTAR has invested considerable engineering into their products. They have developed a separate steam boiler, capable of heating the water to 160°C and 3.5 bar pressure, which delivers steam via a mono-tube to the iron. The iron then reheats the steam, so as it is released it is completely dry. In addition, users are trained to apply steam on the forward stroke (to heat the cloth) using a button, then to release the button to flatten the cloth on the return stroke and 'set' the fabric. The whole time a fan is running within the ironing board, which cools the cloth. The system typically halves the ironing time taken with a more traditional iron.

The challenge
The only problem with LAURASTAR's ironing technology was the need to push a button to release the steam. Users found this a little tiresome and occasionally left the button depressed more than they should, using more steam and water, thereby leading to a less efficient process. LAURASTAR initially developed a mechanical prototype which showed the principal functionality: automatically giving steam only when travelling forward and automatically running the fan only when the iron is in the hand of the user.

LAURASTAR tasked Cambridge Consultants to come up with a way to realise this functionality, assuring high accuracy, high quality, long lifetime and robustness. This had to be achieved whilst also making it easy to produce and not sensitive to temperature changes and ageing.

We were given a month to come up with a working model of our preferred solution and the rationale behind our decision. Time was short because LAURASTAR wanted the iron in production in 2005 – its 25-year anniversary.

Candidate technologies
Initial brainstorming revealed 23 ways, albeit some quite far-fetched, for the iron to detect motion.

Using a requirement specification to guide our decisions, we took just over a month to whittle the concepts down to a favoured three, although one solution stood head and shoulders above the rest. The two ideas that did not quite make it involved using an optical correlator (as used in an optical computer mouse) and accelerometers. Both solutions had limitations. Optical correlation needed serious processing power and was limited to an unworkable 50°C. Accelerometers were an obvious solution but they would always be subject to delay in steam delivery as they had to confirm that the iron was in place on the board before the steam could be released.

The favourite solution was to use strain gauges, which are small electrical elements applied to a sliver of stainless steel. When they are bent, the resistance of the element changes slightly and this can be detected and related back to accurately measure the strain. They are common in industry and are used in the home in electronic bathroom scales. A half-bridge strain gauge, correctly placed on the handle, was able to detect the user applying the force required to make the iron move. This led to an instantaneous response (steam turned on within a millisecond) that no other technology could match. A second half-bridge gauge was used to determine when the iron was being picked up; once in-hand, the iron was prevented from automatically producing steam – an important safety requirement.

The strain gauges were also used in tandem to automatically turn on the ironing board fan should either gauge receive a signal – yet another intuitive feature incorporated into the system.

A successful demonstration of our model iron, and explanation of our rationale, was enough for LAURASTAR to give Cambridge Consultants the go-ahead on the main development programme. However, they did have one bit of bad news for us.

Data modulation

The mono-tube, used to bring steam and electrical power to the iron, was already as stiff as LAURASTAR was prepared to accept. Fine wires would be broken as soon as the mono-tube was flexed, so we had to engineer another way of communicating all of the signal information back to the main ironing board.

The answer to the communication problem was a data modulation technique. Sophisticated electronics overlaid a modulated 'fingerprint' on the electrical power being drawn from the ironing board power supply. A second bespoke piece of electronics sited in the ironing board then 'decoded' the modulated signal and instructed the necessary valve or fan to operate in the prescribed manner. Although technically more complex than individual wires, the modulation technique offered a very robust method of co-ordinating the multiple control signals.

Calibration and drift

Strain gauges are excellent at detecting even the smallest strains, such as when a piece of plastic experiences thermal expansion. It was clear from the start that we had to develop a way of both avoiding the impact of thermal expansion and developing a system that did not need to be calibrated (a process far too costly for a high-volume product of this nature).

To solve this problem we utilised two half-bridge strain gauges (each half-bridge consisting of two strain gauge elements). The first strain gauge pair was used to detect forward motion and the second to detect lift. The use of half-bridges meant that we could effectively subtract the signal of one element from that of the other and so eliminate uniform strains that they were both being subjected to - for example thermal effects.

The long-term drift of the strain gauge signals was tackled by incorporating an algorithm that regularly zeroed the relative signals from the two gauges when the iron was not being touched.

The net result was an iron that did not require any factory calibration, was resistant to short-term heating effects and immune to long-term performance drift. The solid state electronics also promised a long trouble-free lifetime.

Packaging and mechanical assembly

There was a considerable amount of electronics to fit into the iron in order to apply the algorithms to the strain gauge signals and then to 'code' and communicate the on/off messages. Measurements taken under the rear cover of the iron revealed that temperatures regularly exceeded 100°C – not a great environment for a printed circuit board (PCB).

The decision was taken to house the PCB within the handle itself – by definition this could not be excessively hot as the user had to be able to pick up the iron! Careful PCB design meant that everything could be housed in the space available whilst meeting the clearances necessary from a legislative point of view. The PCB ran at low voltage and, for additional longevity, it was given a compliant coating to reduce the risk of any long-term degradation from what was still a steamy environment.

Handover to manufacture

For a new product concept to be introduced successfully it is vital that the handover to the manufacturer is considered from the beginning of the project. Cambridge Consultants' engineers had worked with LAURASTAR's preferred industrial designer, electronics sub-contractor, moulder and assembly plant as the project progressed to ensure there would be a minimum of surprises on production ramp-up.

Years of designing products on other people's behalf have taught us some important lessons – not least that you have to be there to ensure a successful handover. This meant that Cambridge Consultants' engineers were present at LAURASTAR's manufacturing plant over 12 successive weeks as the production rate increased.

Results

The net result of all this work was a completed iron, launched into Europe in the summer of 2005 and in time for LAURASTAR's 25th anniversary celebrations. It is a job that we and our client are very proud of.

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"To accentuate the 25th anniversary of LAURASTAR, both product ranges (ironing systems and ironing steam stations) were replaced and harmonised with the new corporate identity. Besides many other new features, for example the intuitive folding of our systems and the integrated water filter, the intuitive iron was the 'jewel in the crown'. Based on our market surveys and inside market knowledge, we estimated that ca. 30% of our products sold would be with the intuitive iron. In reality we note that in the last 12 months almost every second product sold has been the intuitive iron."

Jan Beekman, LAURASTAR's chief operating officer