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A melting pot of old and new technologies: General Electric is producing an advanced version of one of the most complicated machines ever built, writes Peter Marsh.

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Gas turbinescontain well-tested technologies as well as ones that are novel and exotic. Indeed, some observers say the gas turbine industry has not been adventurous enough in trying out new ideas.

"The industry is extremely conservative, and the basic principles behind gas turbines have not changed for decades," says Carl Deeley, a manufacturing expert at TBM, a US consultancy.

Even so, an impressive list of technologies have to be mastered in a gas turbine. They include computer-aided design, novel gas-flow techniques and new materials and coatings.

Gas turbines "are among the most complicated systems that anyone has made", says Dan Jones, chairman of Lean Enterprise Academy, a UK manufacturing research group.

In a gas turbine designed for power generation, natural gas is compressed and then burned to release hot combustion products.

By pressing against the sides of turbine blades fitted to a revolving drum - the turbine part of the system - the hot gases drive a generator to create electricity. In a further refinement, waste gases from the turbine are normally used to drive a separate steam turbine, so maximising the energy output of the system.

Gas turbines for creating electricity have evolved in the past 50 years, in work linked to the development of engines for aircraft.

Inside a power turbine, gases pass through the system at about the speed of sound. Small aerofoils fixed to

the sides of the compressor and turbine force the gas molecules to change direction about 20 times a milli-second. That causes "swirl" effects that maximise the transfer of energy to the machine's rotating parts.

Engineers use advanced computer-aided design techniques, plus strong and light materials, to ensure the right type and quantity of these swirl effects. A gas turbine produces stresses equivalent to spinning a bus at the end of a 3m pole at 3,000 revolutions a minute. Great care must therefore be taken to ensure the machine does not break up.

The temperature of the gases inside the turbine must be kept as high as possible to maximise their energy content. At such temperature - about 1,400Degrees C - most metals melt.

Another challenge is that inside the combustion chamber, immediately in front of the turbine, the temperature at which combustion of natural gas and air takes place must be kept as low as possible. That reduces the creation of nitrogen oxides that are a by-product of combustion and damage people's health.

In the H-system, GE's engineers created a new type of cooling system - using steam rather than air - to draw heat away from the metal parts. They also used novel materials and coatings to ensure the metal components can withstand ultra-high temperatures.

In this way, the temperature of the gases inside the turbine can be kept extremely high - up to 1,430Degrees C, or 120Degrees C higher than in GE's previous generations of turbines - without increasing the combustion temperature of about 1,470Degrees C that features in previous GE systems. The high temperature inside the turbine leads directly to the high efficiency that is a feature of the H-system.

GE has worked on novel materials alongside the two largest makers of the blades and aerofoils used in gas turbines: US-based Precision Castparts and Howmet, part of the Alcoa aluminium group. Few details of these companies' technologies are ever released to the public.

For all the exotic nature of such work, it takes place in a measured way. Technological advances take years to come through. Supporting Mr Deeley's views about the innate conservatism of the industry, GE's designers have gone to some lengths to minimise the risk of the H-system not working properly.

For instance, the machine's combustion unit is based on technology seen in previous turbines because GE was worried about the consequences of trying out anything too new.

Art Smalley, a US manufacturing consultant, thinks the mixture of new and old ideas in the H-turbine can be justified.

He says that more novel concepts tend to be tried out in car engines than in gas turbines. "Millions of car engines are built every year, and so car designers have a lot of opportunity to try out something new. The number of new gas turbines is a lot smaller and the consequences of something going wrong (in a gas turbine design) are immense."