Solar Hydrogen Project at Neunburg vorm Wald, Germany

SWB
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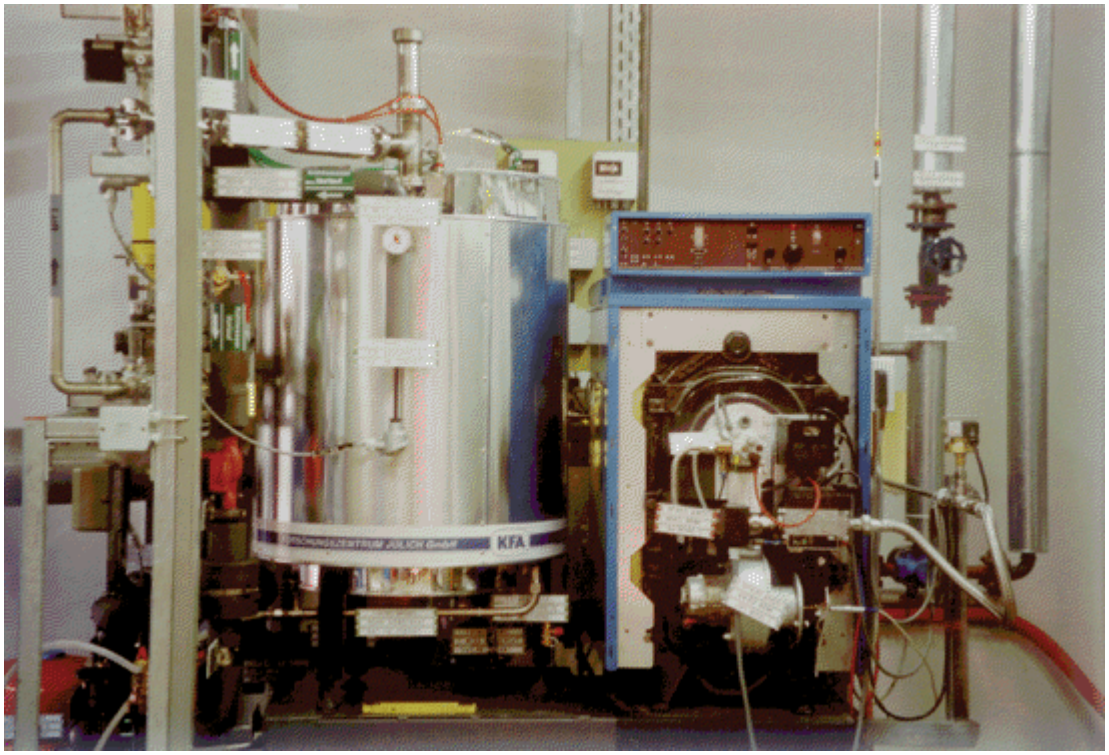
Modified conventional heaters are suitable for heating with hydrogen

Emission levels good, in particular with catalytic burners



Mixtures of natural gas and hydrogen are usable successfully for space heating and cooling service at normal levels of requirements. Systematic testing of heating units and an absorption-type refrigeration unit at the SWB solar hydrogen project at Neunburg vorm Wald, Germany, have furnished appropriate confirmation. Two modified conventional calorific-value

heating boilers were found to work reliably at as good as any percentage ratio of the two gases. Minor elevation of nitrogen oxide emissions can be controlled by increasing the excess air, however entailing a drop in efficiency.
These emissions are appreciably lower with so-called catalytic burners, in which reaction temperatures stay below 900 degrees Celsius. High efficiency was recorded for all the heaters investigated.

Looking into a solar hydrogen energy scheme

The objective set by SWB in its Neunburg vorm Wald project is to integrate the production of electricity from sunlight into a solar hydrogen energy system. Hydrogen gas is employed as an energy storage medium, because sunlight is an intermittent phenomenon. Sunny periods are exploited for photovoltaic generation of electricity, which is used to decompose water into hydrogen and oxygen by electrolysis. The gases are stored in suitable vessels pending final distribution to supply the energy required to drive heaters, car engines, fuel cells plants or the like.

Over 92 percent of the energy consumed in German homes is used for heating purposes. The application of hydrogen would contribute greatly to reducing the carbon dioxide emissions associated with this energy consumption.

Heating with hydrogen

Part of the work undertaken within the SWB project was accordingly directed to exploring the suitability of hydrogen as a heating fuel. Since it is unlikely that any conversion to hydrogen as an energy medium would be total and all at once, tests were run to study the effects of gradual additions of hydrogen to natural gas. (Gas mixtures of about 50 percent by volume of hydrogen and 20 to 30 percent methane were incidentally common earlier in town gas supply.) Attention was also placed on appropriate duty of the heating boilers for domestic requirements. Two prototypes included in the test program had a heating duty of 20 kilowatts, suitable for a single-family house. As so-called calorific-value boilers, the heaters exhibited very high efficiency. Water vapor forming during combustion is partially condensed so as to recover further energy additional to the heat of combustion. Both boilers are modified conventional models with a top-mounted combustion chamber. Below this is the ancillary heating surface and at the bottom a pan to collect the condensed water. The boilers can be fired with mixtures of natural gas and hydrogen ranging between 5 and 95 percent by volume and both gases on their own.

Catalytic combustion of hydrogen

At the end of 1992, work also commenced on a so-called catalytic heater at Neunburg vorm Wald. Use of a palladium catalyst in this heater promotes the combustion of natural gas and hydrogen, resulting in the temperatures at which this takes place being appreciably lower than with "normal" combustion.

By contrast with conventional combustion, the reactions in catalytic combustion proceed on solid surfaces coated with catalytically activated material. As a result, "combustion" can be achieved at as low as 900 degrees Celsius. At these temperatures, the release of nitrogen oxides is very small.

Industry has devoted considerable effort to developing catalytic systems in recent years. The unit used for testing at Neunburg vorm Wald has a maximum boiler duty of 10 kilowatts and can be fired with either natural gas or mixtures of natural gas and hydrogen, the latter forming between 10 and 50 percent by volume of the mixture. Calorific-value boiler design was adopted for this catalytic heater as well to increase efficiency.

Catalytic combustion of hydrogen has technical advantages in absorption-type refrigeration units, because the low reaction temperatures result in less thermal stress on the desorber section. An absorption-type refrigeration unit with a duty of about 17 kilowatts was adapted for hydrogen operation in 1994 by modifying a conventional air conditioning unit and was successfully employed by SWB to support refrigeration requirements at the facility.

Altogether successful results

By and large, work with two of the three heaters tested and the absorption-type refrigeration

unit has been successful after completing necessary improvements. The main advantage lies in a significant reduction of emissions. The problem of nitrogen oxide emissions, which requires attention on conventional burners owing to their high combustion temperature - hydrogen burns at about 2,050 degrees Celsius, methane (here natural gas) at about 1,880 degrees - did not occur with the catalytic burners due to their lower temperatures.

The experience reported holds good promise above all with a view to stepwise transition from the contemporary fossil fuel natural gas to the prospective future fuel hydrogen, having demonstrated that mixtures of natural gas and hydrogen are well suited for heating and cooling applications.