EUROPEAN COMMUNITIES

Information R+D

SERIES: RESEARCH AND DEVELOPMENT
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HYDROGEN R&D IN THE COMMUNITY

1.- Prospects for Hydrogen

Non-conventional primary energies, such as nuclear energy and solar energy, now under consideration for reducing the Community's dependence on oil and natural gas are normally available as heat. There is a great deal of benefit to be derived from converting this heat, not only into electricity, but also into synthetic fuels, which are easily stored and economically transportable and capable of satisfying a large number of energy needs which cannot conveniently be met by electricity.

Hydrogen seems to be the most promising candidate for adoption as a manufactured fuel used as such or transformed into other hydrogen-rich chemical compounds (synthetic natural gas, methanol, ammonia, etc.).

Some of the interesting characteristics of hydrogen as a possible energy carrier are the following:

- it can be produced from water and reverts to water when being used;
- pollution levels at the user's end are low;
- it can be stored in large quantities - possibly underground;
- it can be convoyed by pipeline systems, in the same way as natural gas.

2.- Hydrogen R&D programmes in the Commission of the European Communities

All technologies have a long lead-time for extensive application; for this reason the "Hydrogen System" cannot be more then a long term prospect. The related technologies must be available on time. This applies especially true to the production technology. Since hydrogen is not an energy source but an energy carrier like electricity, energy is needed to produce it.

The most likely non-fossil options to be used for centralized hydrogen production are nuclear and solar; other sources can be considered in the future, such as wind or wave energy-or in some cases hydroelectric power when available in large quantities and cheap. These energy sources could produce electricity, which in turn could be used to split water into hydrogen and oxygen in electrolytic plants. Although electrolysis of water is a well-known technique, considerable development will be required for large-scale, economic application. A new route towards water splitting is the so-called "thermochemical" process. Conceptually, heat from a high-temperature source, such as a nuclear reactor of the HTGR type, is used in a process consisting of various chemical reactions with the overall result that water is split into its constituents, hydrogen and oxygen; all intervening chemicals remain within the process cycle. This technique, which has recently been demonstrated on laboratory scale, requires a great deal more development.
The long lead-times for these complex technologies, which will have to be technically and economically proven before hydrocarbon fuels crash to be available, necessitate intensive long-term efforts. Realizing this, the Council of Ministers has approved multiannual R&D programmes on hydrogen, both in "direct action" and in "indirect action".

2.1. Direct action

The direct-action programme on hydrogen is part of the overall multiannual programme being conducted by the Joint Research Centre of the European Communities. The activities of the JRC in the field of hydrogen are focused on the evaluation of the potential of thermochemical decomposition of water as a production technique for hydrogen. This work, started in 1970 and continued in the 1977-1980 multiannual programme at a cost of 15.33 mEUA(x), is centred on the identification of chemical cycles and the definition of criteria on which to select the most suitable of these cycles. This means, for instance, that not only are the basic data of a possible cycle investigated but also the chemical engineering aspects, environmental aspects and production costs are taken into account. To evaluate the thermochemical processes and to estimate the possible hydrogen production costs, an extensive computer program, OPTIMO, embodying economic as well as other data, has been developed. To put the thermochemical cycles in their proper perspective, they are being evaluated by comparison with their competitor : present-day and advanced electrolysis, which has the same basic principle, i.e., to decompose water using only energy, in this case electricity, instead of heat. Over the past four years many possible cycles have been identified and investigated, after which most of them have been rejected on the grounds of the criteria of selection which have been developed. The choice has been narrowed to three "sulphur cycles".

(x) Million European Units of Account.

These cycles have in common the fact, that the high-temperature stage, where the heat from the external high-temperature heat source is absorbed, results in the thermal decomposition of sulphuric acid. The two most promising of these cycles are the Mark 11 and the Mark 13, both of which are "hybrid", which means that both cycles include an electrochemical stage.

After extensive testing of all reactions involved, a complete laboratory circuit has been built for the Mark 13 cycle. This circuit, designed for a production of 100 litres of hydrogen per hour, was completed in May 1978 and has already been operated successfully for many hours. Although this is only at laboratory level and although a great deal of effort has still to be created in order to attain technical and economic competitivness for a large industrial plant, the operation of the Mark 13 circuit in the JRC is an important milestone, since it is believed to be the first demonstration in the world of the feasibility of a complete thermochemical cycle. This is not the cycle that has been definitively selected; it is only an example of the feasibility of this method, which was the object of the present research phase to demonstrate.

2.2. Indirect action

The indirect-action programme within the Energy R&D Programme of the Directorate General for Research, Science and Education is performed by means of research contracts on a cost-sharing basis (normally 50/50) between the Community and national laboratories, industry and universities. The main objective of the first programme (mid-1975, cost 13.24 mEUA) is to speed up the technical progress needed for the economic production of hydrogen, to evaluate its potential uses and to assess its possibilities as an energy carrier in the future energy market.

This programme comprises three main areas:

A. Thermochemical production of hydrogen

This project is designed to back up and supplement the activities carried out in the direct-action programme, which were described in section 2.1.

B. Electrolytic production of hydrogen

The results of activities carried out in this field are very promising. Using various approaches, the electrolytic production techniques have clearly been improved at laboratory level. Confirmation of the results in small-scale electrolysers (5-10 kW) and in medium-scale electrolyzers (100 kW) is currently being sought. The laboratory results show that the energy consumption for the production of hydrogen from water has been decreased from the initial value of about 5 kWh/m^3 to 3.6 kWh/m^3 for a current density of 5-10 kA/m^2. These new technologies have now to be fully developed for application to large industrial plants, in order to be able to replace the present methane steam-reforming process.

C. Use

The objective of this project is to collect experimental or bibliographical data on hydrogen safety and on the prospects for the use of hydrogen as an energy carrier. Studies have been made of alternative storage methods and of the behaviour of materials in hydrogen and their optimization for this use. The information obtained is to prepare the way for the extensive use of hydrogen -to be considered as an energy carrier only-in the long term.

The interest shown by laboratories throughout the European Community and the encouraging results obtained thus far are providing useful guidelines for the mapping-out of a second programme on hydrogen technologies.

3.- International activities

The hydrogen R&D activities in the Community are in line with those in the rest of the world. The International Energy Agency has created as one of the Implementing Agreements for Cooperative actions a "Programme of Research and Development on the Production of Hydrogen from Water"; this agreement was signed in October 1977 by Belgium, Canada, the Federal Republic of Germany, Italy, Japan, the Netherlands, Sweden, Switzerland, the USA and the European Community. Three activities have already been started under this cooperative scheme, namely:
- thermochemical production
- the coupling of a thermochemical production plant and a high-temperature reactor,
- asessments of the future market for hydrogen.

The fact that the Commission has the chairmanship of the Executive Committee of the Agreement and that the Joint Research Centre acts as "Operating Agent" in the first and third of those activities illustrates the leading role being played by the Community in hydrogen research.