exotic power

Electro-mechanical electrical generating equipment is based on a principle established by Faraday more than 100 years ago: that a current is induced in a conductor which is moved through a magnetic field. In a magnetohydrodynamic generator the solid conductor of such "conventional" equipment is replaced by a stream of high-temperature working fluid — gas in the form of plasma, or liquid metal. Electrodes placed in this stream may be used to "pick off" the current induced in it.

Magnetohydrodynamics (MHD), a study which began as a laboratory curiosity, may now be on the threshold of use as a supplementary source of electric power. This article contains a summary of the results presented and conclusions drawn at the Fifth International Conference on Magnetohydrodynamic Electrical Power Generation, organized jointly by the European Nuclear Energy Agency (ENEA) and the IAEA, in collaboration with the Federal German Ministry for Education and Science and the Max Planck Institute for Plasma Physics, Garching, held at Munich from 19 to 23 April.

Progress and prospects

Open cycle systems for MHD electrical power generation can now be considered as having reached the prototype stage, while very substantial progress has also been made in closed cycle gas plasma systems and liquid metal systems —both of particular interest in connection with advanced nuclear reactors which could be used to heat the working fluid to a suitable temperature. These were the overall conclusions of the Munich conference, which was attended by more than 250 participants from 25 countries and three international organizations. The conference was worthy of particular note in that it brought together experts concerned with all the major MHD development programmes worldwide, notably those of the USSR, United States, the Federal Republic of Germany and Japan.

Since the fourth international symposium on MHD electrical power generation, held in Warsaw in 1968, there has been steady progress in acquiring understanding of the processes involved in extracting electrical power from the high velocity stream of conductive working fluid which is the basis of MHD processes. Several large-scale experiments have demonstrated the possibility of producing electrical power by MHD processes (open cycle, closed cycle plasma, and closed cycle liquid metal systems).

Open cycle MHD systems capable of efficiencies between 48 and 53 per cent are now being developed in several countries, particularly in the USSR, which has a very important programme in this field. During the past five years an experimental 2 kW installation in Moscow known as U-02 has been operated successfully for extended periods and has provided data from which the first plant on an industrial scale, U-25, has been built. This installation provides 25 MW of electricity by MHD conversion and an additional 50 MW by using residual heat in the working fluid to operate a conventional steam cycle. Completed only recently, this is the first plant of its kind to enter operational service.

Within the USSR programme, it is now envisaged that the U-25 and U-02 installations, together with a third which was completed recently at Kiev, will be used in operational tests to demonstrate the feasibility of running an MHD generator continuously for periods of up to 5000 hours. Plans are also being made for the design of a 1500 MWe MHD/steam power station having an overall efficiency of 50 per cent, based on the technology now being proven in the U-25 installation.

At the Munich conference the capital cost for this large power station was quoted as 140 roubles per kilowatt electrical output; electricity generating costs some 15 per cent lower than those of any other system in the USSR were foreseen. Development work is also going on in that country on MHD stations for peak load operation, expected to be in use for about 500 hours a year; it was stated that these would be competitive with other systems in the USSR.

Among other important MHD programmes described and discussed at the Munich conference was that of the USA, where considerable work in the past with large capacity open cycle installations has now led to a revival of interest, mainly in association with coal-burning systems. A new long-range development programme is being prepared.

Considerable work was reported from Germany. The Institut für Plasmaphysik at Garching (Munich) and the industrial group M.A.N. Werk built recently a one megawatt pulsed facility for the study of a 10 MW peak load power station: this facility was operated for the first time during the conference. At Jülich and Essen, design teams are working on a 30 MW facility (Vegas II) which will use coking gas as its heat source.

In Japan, the design and construction of an MHD pilot plant has reached an advanced stage, and the plant is expected to begin operation in 1972. From Poland, where a substantial MHD development programme has been under way for many years, successful tests of various components over long periods of continuous operation were reported.

Economic studies on large-scale open cycle MHD stations for continuous operation on base load were reported to the conference. These indicated that stations using MHD in conjunction with conventional generating systems could be made economically attractive, particularly if account were taken of the requirement for minimising air pollution by oxides of sulphur. It was clear, however, that the economic usefulness of open cycle MHD systems, whether for base- or peak-load operation, must differ from one country to another because of considerable variations in costs of fossil fuels and the "nuclear" alternative.

Closed cycle plasma MHD systems

During the past three years significant progress has been achieved in the development of closed cycle MHD systems for electrical power generation. Experimental results obtained in Germany and in Italy have shown that the predicted performances can be achieved in practice in small-scale experiments. Although some physical and technical problems remain to be solved, it is now possible to estimate with reasonable accuracy the characteristics and performances of multi-megawatt MHD generators. These predictions have been substantiated by investigations performed in the United States, USSR, the Netherlands, Sweden and Switzerland. The high power densities inherent in MHD nuclear generators, coupled with the high efficiencies obtainable, should result in both lower electricity costs and a reduction in all kinds of pollution associated with power generation. However, it remains to be seen whether suitable high-temperature reactors can be developed for use in this work.

Liquid metal closed cycle systems

It was announced at the Munich conference that a generator using potassium at 900°C had been brought into operation in the USSR, one kilowatt of electricity being produced with an injector-type cycle having an efficiency of 3 per cent. A new generator of a similar type, with an electrical power of 1 kW, was also reported to be in operation in the US; this used a mixture of sodium-potassium alloy and nitrogen and a separator-type cycle.

These examples show that liquid metal MHD is now a proven concept. In addition, there exists still a great potential for developments in two phase or emulsion type liquid metal generators, though experts believe that there are still a large number of technical problems to be solved. Liquid metal MHD generators seem particularly promising since they require temperatures obtainable in high temperature nuclear reactors.

A general conclusion of the Munich conference is that all three types of MHD generator system can be developed to achieve electrical power generation with very high efficiency. In a rapidly growing electricity market, reductions in fuel consumption, air pollution and waste heat discharge are important factors in favour of use of MHD power generators. Having achieved technical success, MHD now has to demonstrate that it can succeed economically.

This article is based on a technical summary prepared by the Scientific Secretariat of the conference and issued by ENEA.