EXCLUSIVE

Recent Advances Reported At International MHD Symposium

The 16th International Symposium on Engineering Aspects of MHD held in Pittsburgh May 16-18 heard reports on the most recent advances in fossil-fuel based Magnetohydrodynamics experimentaion. The most important advances in the last year included the first MHD generator running for 250 continuous hours, the successful testing of a coal-fired MHD generator with potassium seed removal of sulfur, a new record for efficient electricity conversion, and developments in the testing of electrode and channel materials for test generators.

The most exciting advance reported on at the conference, though not included in the published technical papers which went to press before the tests were concluded, was the running of the Soviet U-25 pilot plant for 250 continuous hours. One of the major problems in developing commercial MHD has been the manufacture of electrode and channel materials which could withstand temperatures of 3,000 degrees over long duration. The 250 hour continuous running was one of the criteria the U-25 had to meet to begin the third and last stage of the Soviet program, which will be the construction of a 1,000 MW commercial demonstration plant.

The remaining test for the U-25 is operation with a superconducting magnet which is being sent from the USA's Argonne National Labs next month. The magnet has just been successfully tested and is operational at its projected 5 tesla strength. It will be tested on a by-pass loop of the U-25 channel that has one tenth the mass flow of the main channel. As soon as results are generated, the Soviets will "cut metal" on the commercial demonstration plant.

Also not included in the conference papers was the testing of the University of Tennesee Space Institute's coal-fired test generator with a coal-potassium mix. The potassium is added as a "seed" to increase ionization of the coal plasma and through recent tests, also bonded

What Is Magnetohydrodynamics?

The conventional thermal method for generating electricity is to burn a fossil fuel (coal, oil, or natural gas) and use that heat to boil water to produce steam. The steam turns turbines that rotate through a magnetic field, producing an electric current. Because the fuel burns at over 23,000 degrees, but the turbine material can handle temperatures of only approximately 600 degrees, a good deal of the heat energy is dissipated and simply lost. As a result, thermal power plants operate at a rate of efficiency between 30 and 40 percent.

The development of fusion reactions and the study of the properties of plasmas (ionized gases) led scientists to postulate the following: large pulses of fusion energy could be converted — as from thermonuclear explosions — into huge quantities of electricity, that is Magnetohydrodynamics (MHD). Instead of converting heat to mechanical energy (to turn turbines) that would then interact with a magnetic field to produce a current, a hot ionized gas could be pushed directly through a magnetic field, generating current essentially with no moving parts. The plasma, or working fluid, could be produced either by fusion reactions or by burning fossil fuels at extremely high temperatures. Electricity would be produced directly by the interaction between the electrical potential of the plasma and the external field.

In fossil - fuel - based MHD, the gas produced from burning the fuel does not completely ionize, so a "seed" — a metal with a low ionization temperature, such as potassium — is introduced to increase the ionization rate and the electrical conductivity of the plasma. Most commercial MHD designs are "open cycle," where the plasma, which has dropped about 1,000 degrees after going through the MHD duct, is then put through a further steam-turbine cycle similar to a conventional thermal generator. By thus using the plasma's heat "twice," efficiency is raised to between 50 and 60 percent.

In the case of coal-based MHD, the potassium seed, in addition to enhancing the ionization rate, also chemically bonds with any sulfur in the coal, therefore providing a pollution-free combustion process. Researchers at University of Tennessee Space Institute announced recently that 95 percent of the sulfur was removed by their MHD generator, and that they had developed ways to recycle the potassium seed.

with the sulfur pollutants in the coal. The university is developing the technology to also separate the seed from the resultant slag so it can be recycled.

Avco Everett Research Labs in Massachusetts recently obtained a 15 percent enthalpy extraction rate on their Mark V Test generator. This is the highest rate obtained by any test generator. A 20-25 percent extraction rate, correspinding to a 50-plus percent efficiency for thermal power plants, is the standard set for commercial MHD power generation. Avco also reported results of studies of their Mark VI machine which were mapped to computer models they had developed, with satisfactory results.

In addition work-in-progress was discussed, including that on gaseous or plasma electrodes that Reynolds Metal Company has been developing. The second joint US-USSR electrode system test was done at the U-02 Soviet test facility with the least deterioration being exhibited by electrodes manufactured by Westinghouse and Batelle Northwest Labs. These are made of alloys containing lanthanum, iron oxides and magnesium and were tested at 2,600 degrees.

One of the most interesting experimental areas is the use of CO_2, helium and cesium to produce a carbon dioxide laser in the MHD channel itself. CO_2 lasers can be used for isotope separation and, if powerful enough, to trigger thermonuclear reactions. L.M. Biberman and others at the High Temperature Institute in Moscow have been working on this idea for the last seven years and reported at the symposium that an MHD laser had been produced at the Institute with an experimental output of 10MW of laser radiation. In this experimental design, the laser and energy source (the MHD electric power generation) are joined together in a single device.

How The Soviets Sputniked The U.S. In MHD

In 1962, at the First International Conference on MHD in England, two prominent Soviet scientists announced that the USSR had embarked on a program to develop commerical MHD. A.E. Sheindlin, the head of the Soviet Institute of High Temperatures, outlined a four-phase program which would bring the Soviets to commercial demonstration by the early 1980s. Academician E.P. Velikhov, the deputy director of the Kurchatov Institute of Atomic Energy and one of the most renowned plasma physicists in the Soviet Union, presented some fundamental analysis of the thermodynamic and electromagnetic instabilities which could be expected under certain conditions in MHD plasmas. Both presentations have since been dramatically realized.

Soviet scientists' initial interest in MHD was for direct conversion of fusion energy to electricity, and the MHD work at the Kurchatov Institute has continued to focus on thermonuclear energy as the source of heat for an MHD generator. The Institute of High Temperature's MHD program has had the parallel goal of demonstrating commerical feasibility of MHD using fossil fuel as the heat source. This latter program, now nearing the successful completion of its third phase, will bring a 1,000 megawatt commercial demonstration plant on line by 1982. It will be the only such plant in the world.

It should not be surprising to U.S. scientists and military intelligence personnel that the Soviets may also have developed an MHD generator fueled by pulsed fusion explosions, nor will such persons be unaware of the possible military implications. The operation of an anti-ballistic-missile particle beam would require a tremendous source of pulsed energy, invulnerable to attack and independent from commercial power grids. Since only thermonuclear explosions could satisfy those requirements and still provide the magnitude of energy needed, it would be necessary to develop a controlled way of converting that energy to electricity. It appears that the Soviets have effectively solved that problem.

In the case of fusion-based MHD, the Soviet Union had undoubtedly pursued both military and commercial applications simultaneously. Likewise, the unique success of the Soviets' fossil-fuel-based program demonstrates their commitment to carry through a 20-year scientific and technical perspective. Furthermore, it should be crystal clear — especially since it has been said directly by Velikhov and others — that it is the Soviets' theoretical understanding of plasma behavior that is the basis on which all of their MHD work, both nuclear and fossil fuel, has been done. This is incomprehensible to many scientists in the United States only because U.S. work on MHD has never been done on such a rigorous scientific basis.

Originally the West was actually ahead of the Soviets in MHD. The U.S. MHD fossil fuel program was initiated by a handful of corporations, as early as prior to World War II. Researchers at Westinghouse, General Electric, and Avco Corporation began by experimenting with small generators, but by the mid-1960s only a government-supported program could have scaled up the experiments and solved the problems associated with a commercial program. The U.S. government chose to fund MHD research only in military and space applications, and the commercial generating designs were scrapped. These noncommerical applications, aiming for a short burst of energy for space propulsion or weapons and radar pulses, did not pose the problems involved in generating electricity for long durations that would have to be solved for utility use of MHD. As a result, when the Soviet Union announced in 1971 that their phase three pilot plant, the U-25, was now running, the United States was left on the short end of the technology gap.

This is a very promising area of work which the Soviets have pursued with the idea of an integrated fusion-MHD machine.

Future plans for the U.S. coal-based MHD program include the completion of the MHD Component and Integration Facility in Butte, Montana which began construction in May 1976. The facility will test components in the 40MW range and is the first engineering test phase of the program. By 1985 the Energy Research and Development Administration expects to complete an Engineering Test Facility which will demonstrate the integrated performance of key component and subsystems in the 250MW range, and finally by 1990 the last test phase will center on the Commercial Demonstration Plant which will be a direct coal-fired open cycle MHD plant ready for commercial application.

The U.S. program, based on the use of coal, still has many engineering problems to solve. It is at least five years behind the Soviet natural-gas based system due to a lack of governmental interest and support throughout the 1960s. After the announcement of the operation of the U-25 in 1971, the U.S. was embarassed into starting a fairly serious program. In 1973 the joint U.S.-USSR MHD program was initiated and there has been an open exchange of technology since then, but an insufficient commitment from the U.S. federal government to fund a crash program.

As industry representatives have recently remarked when briefed on the recent advances in MHD technology and the possibility of natural-gas based MHD for commercial use by the mid-1980s, it seems that money could be more wisely spent on developing MHD for a 50 percent increase in fuel efficiency, rather than forcing industries to go through a costly and waseful forced conversion to coal.