Science & Technology

Fusion torch can create resources

by Marsha Freeman

In the next 20 years the need for new technologies will be more in raw materials extraction and processing than in the production of energy. The economy of the 21st century will depend upon the development of these technologies to redefine the resource base of the globe and open up new horizons for producing and using raw materials.

Fusion energy and plasma techniques coupled to fusion power reactors have a vital role to play in materials and chemical processes. Traditionally the energy, mainly heat, from the combustion of fossil fuels has been the method of raw materials extraction, reduction and processing. In 1968 a proposal was put forward by two scientists, William C. Gough and Bernard J. Eastlund, to use the unique properties of fusion to meet the tremendous energy, materials and fuel needs of the next millennium.

In a report prepared for the U.S. Atomic Energy Commission in 1969, Gough and Eastlund state that their concepts "evolved from strong belief on the part of the authors that controlled fusion should not be viewed solely as another means of providing heat to generate electricity via the conventional steam turbine cycle. Rather, controlled fusion should be investigated as a new *prime energy source* with potential inherent advantages uniquely suited for direct conversion of energy into forms useful for society."

Gough and Eastlund's concept, termed the fusion torch, outlines two major uses for the unique properties of the fusion plasma.

First, the ultra-high-temperature plasma produced in the fusion reaction can be used to reduce *any* material into its basic elements. Second, the energy in this ultra-high-temperature plasma can be used to produce a full field of electromagnetic radiation to permit chemical processing to take place in the body of a working fluid.

The basic concept of the fusion torch is the transfer of plasma from the region where it is generated in the fusion reactor through a connecting region which isolates it from the plasma source to an interaction region. There the high temperature plasma is ready for torch applications. Any solid material, including scooped-up sections of the earth's crust, oxidized ores already mined, or solid urban waste, can be fed into the interaction region.

The high thermal conductivity and large energy flux of the torch plasma produces a shock vaporization, from the propagation of shock waves in the plasma, which ionizes the solid. Lower-temperature plasmas created by shock tubes or electric arcs cannot produce the shock waves, and the solid material merely cools the plasma.

Separation techniques

In the fusion torch, when the solid material has been ionized and broken down into its constituent elements, a separation technique must be used to recover the elements. A number of such separation techniques have been proposed and tried experimentally. They include electromagnetic separation, which first separates the electrons in the plasma from the plasma itself, and then separates the ions of differing mass.

Quenching, or quick cooling of the plasma will produce the simplest molecules and prevent different atoms from recombining, such as in the reduction of ferrous oxide into iron and oxygen. Quenching can be done by injecting a cooler gas, flowing the plasma over a cold surface or expanding the plasma flow.

If the temperature and density of the plasma are held constant in a set of conditions favorable to the recombination of a desired species of material, this selective recombination will allow the accumulation of the desired materials on the walls of the torch.

Other methods of separation, including charge exchange, plasma centrifuges, plasma accelerators and curved magnetic fields, have also been investigated.

Gough and Eastlund estimate that by the year 2000, an all-electric city of 10 million people would need an electrical capacity of about 140 gigawatts. If 10 GW of this total were used in the fusion torch, the municipal solid waste alone could generate 27,000 tons of materials which could be recycled for use.

Low-grade ore which is not economically exploitable by conventional methods would become attractive, and eventually, with fusion power commercial and widely available, whole sections of the earth's crust could be processed to extract important raw materials.

Without developing this direct plasma application to solid raw materials processing, there is no possible way to meet the economic development requirements of either the advanced countries or the developing countries in the next century. On the other hand, if we do carry through fusion torch R&D, the very notion of "raw materials" will be transformed in the most expansive way.