DISTRICT HEATING

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Nuclear Heat for Industrial Purposes and District Heating

Report on an International Atomic Energy Agency Study Group Meeting in Vienna, Austria, September 1974.

Studies on the various possibilities for the application of heat from nuclear reactors in the form of district heat or process steam for industrial purposes had been made long before the present energy crisis. Although these studies have indicated technical feasibility and economical justification of such utilization, the availability of relatively cheap oil and difficulties in locating a nuclear heat source inside industrial areas did not stimulate much further development. Since the increase of oil prices, the interest in nuclear heat application is reawakened, and a number of new potential areas have been identified. It now seems generally recognized that the heat from nuclear reactors should play an important role in primary energy supply, not only for electricity production but also as direct heat.

At present, three broad areas of nuclear heat application are identified in the accompanying figure:

—Direct heat utilization in industrial processing requiring a temperature above 800 C.

—Process steam utilization in various industries, requiring a temperature mainly in the range of 200-300 C.

—Low temperature and waste heat utilization from nuclear power plants for desalination of sea water and district heating.

Such classification is mainly related to the type and characteristics of the heat source or nuclear reactor which could be used for a particular application. Modified high-temperature reactor types (HTR) are the candidates for direct heat application, while the LWR reactors can satisfy most of the demands for process steam. Production of waste heat is a characteristic of all thermal power plants, and its utilization is a major challenge in the field of power production.

In all of the identified areas of nuclear heat utilization, activities at present are mainly limited to studies aimed at demonstrating the economical advantages of conventional fuel use against production costs and fossil fuel savings. Studies are also oriented to conceptual design of heat sources such as Very High Temperature Reactors (VHTR) for the production of heat of required temperatures, and to industrial installations for particular heat application. Problems are faced when conventional heat utilization processes have to be coupled to a new heat source with different characteristics of heat transfer media and constraints imposed on their outlet temperature. Both the heat source and the transfer process must be accommodated with a specific design of interfaces to allow the transfer of heat from the reactor. The safety aspects of using nuclear heat are also of concern. To facilitate heat transfer, the heat source should be located close to the industrial installations, which are usually in densely populated areas.

Important development programmes including construction of semi-industrial prototypes exist at present in only a few countries, but their number is expanding. Process steam utilization and district heating will probably be the first steps to demonstrate nuclear heat in competition with conventional heat supply. High-temperature heat application is at least a decade away from being commercially available. In high-temperature gas-cooled reactors, helium gas is heated to more than 800 C. Produced heat can be used for endothermic chemical processes which otherwise require a considerable amount of fossil fuel.

Potential Uses

A great number of processes can potentially use the heat from nuclear reactors. Interest at present is concentrated on only a few. These are energy intensive processes, producing products enriched in chemical energy. They can be used in various industrial applications as a heat source or feed material for a new chemical

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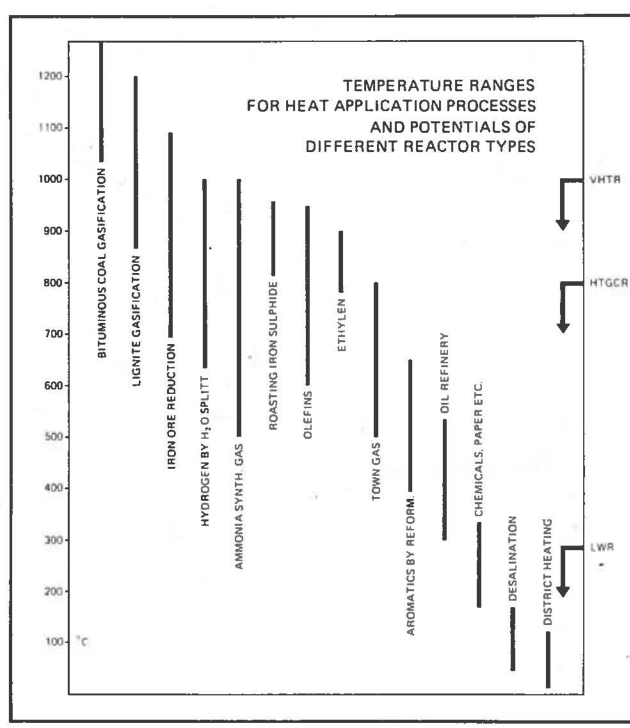

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process. The primary nuclear heat application processes being investigated are:

—Coal or lignite gasification or liquefaction with potential products in the form of fuel gases or liquids for application in metallurgy, chemical industry, etc.

—Steam reforming of hydro-carbons such as natural gas or naphtha for production of a mixture of hydrogen and carbon-monoxide in various ratios depending on their intended use. Potential applications of steam-reforming products are numerous, such as in steel-making by direct reduction of iron ores, ammonia synthesis, synthesis of methanol, synthetic liquid fuel, long distance transport of energy, etc.

—Thermo-chemical splitting of water molecules on hydrogen and oxygen, with the end use of product gases in metallurgy, the chemical industry, hydrogasification of coal, ammonia production or utilization as direct fuel.

Most of these processes require a temperature somewhat higher than present HTR are able to provide. The main efforts in a number of countries, such as the USA, Federal Republic of Germany, Japan and OECD (Dragon Project) are therefore oriented towards development of VHTR which can satisfy most of the requirements for process heat. Research work is concentrated on the development of fuel resistant to corrosion at high temperature and capable of retaining the fission products. The development of high-temperature resistant materials for heat exchangers and other installations for heat transfer from a reactor to a process is also being studied.

Various industrial processes and installations using heat from VHTR are at the stage of theoretical and experimental studies. In the Federal Republic of Germany, a large development programme, supported by the Government by (the equivalent of) US $20 x 10^{6} up to 1975, is being undertaken. Efforts are concentrated on coal gasification and steam reforming processes. A coal gasification experimental unit with a capacity of 5 kg c/h is in operation and a semi-industrial one of 200 kg/h is near completion. Plans for construction of a coal gasification demonstration plant using nuclear heat, for which an investment of US $450 x 10^{6} is foreseen, is scheduled for completion in 1983. A hydro-coal-gasification semi-industrial plant of 100 kg c/h is also under construction; development work on helium heated steam reformers is well advanced; a full size test section (EVA Einzelrohr-Versuchsanlage) of a steam-methane reformer is in operation, and a complete unit is under design. The immediate interest is in the production of hydrogen and CO mixture for use in direct reduction of iron ore, synthetic gas, hydro-coal gasification and long-distance transport of latent chemical energy.

Japan is another country with an important research programme. Several high-temperature helium loops are in operation and the conceptual design of an experimental VHTR of 50 MWt is completed. A direct reduction steel-making pilot plant will be connected to this reactor. A programme of development for the design, construction and operation of this pilot plant is supported by a budget of US $25 x 10^{6} over the next six years.

The joint efforts of several countries involved in the OECD Dragon Project are concentrated on investigation of the characteristics and potentials of the VHTR for process heat application, with a significant programme of development of fuel for such reactors.

At Ispra, research work initiated by EURATOM on thermo-decomposition of water for hydrogen production is in progress. A four-year programme was initiated in 1973 with funds of approximately US $10 x 10^{6}.

Process Steam

Although the possibilities of utilization of process steam from a nuclear reactor have been studied for a long time, no major project of this kind has yet been completed. At present only a few power plants are producing steam for industrial application, such as Douglas Point in Canada, which supplies a heavy water production plant with steam, or Halden Reactor in Norway, which for more than ten years has delivered steam to a local paper factory. Firm projects for steam electricity are planned for the Midland Nuclear Power Plant in the USA, now in the construction phase, for the production of 492 MW(e) and additional steam, and the BASF project in the Federal Republic of Germany, still in the planning stage for the production of 369 MW(e) and 1650 t steam/h. There seem to be no technical obstacles for process steam application in various industries such as the petroleum, chemical, paper pulp and food.

The possible competition of nuclear process steam with steam produced by fossil-fired boilers has stimulated an increasing interest in research into small single or dual purpose plants of a simple design, to supply steam to local industries and possibly for district heating. Studies made in France and Finland indicate the economical justification and probable advantages in comparison to conventional boilers.

Interest in process steam utilization is extended to new production areas where application of nuclear steam may be of great importance in the future. This is particularly so with the use of low-grade steam for sea water desalination. The demand for fresh water is rapidly growing, and the production unit capacities needed are approaching the stage where the utilization of the commercially available nuclear power plant would be economically justified.

It seems that process steam from nuclear reactors will be the first readily available application of nuclear heat in industrial processes which can compete with the conventional steam supply at present fuel prices.

District Heating

The use of low-temperature heat and waste heat from power plants can represent a major contribution to the improvement in the efficiency of the utilization of energy

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resources. The relatively low temperature at which the waste heat is delivered from power plants restricts its application to a few areas, among which residential heating is the most important one. The concept of utilization of large heat sources, such as nuclear power plants, for heating purposes, foresees a district heating scheme with an extended distribution network.

Consequently, a major interest in nuclear district heating is shown in those countries where such schemes are already in existence, and where energy consumption for heating represents a considerable item in the total primary energy demand. Studies on district heating are, therefore, particularly advanced in Scandinavian countries where up to half of all primary energy consumption is used for this purpose. Major programmes are reported from Sweden and Finland, where the nuclear power plants at present under construction or being planned are foreseen as sources for heating large residential areas.

The main problems to be solved in connection with nuclear district heating are the selection of optimal heating schemes, which includes a choice of temperature for heat transmission media. The heating scheme will influence the reduction in electricity production of the plant. Temperature can be the same as in conventional schemes, around 110 C or higher, requiring a high reduction in plant electricity production, somewhat lower with modification of radiators at the consumer end, or quite low with a heat pump at the receiving end. Heat transmission, storage and distribution, the appropriate selection of materials for a heat transmission network, prevention of heat losses and assurance of a reliable supply of heat, are additional problems to be solved.

Although a number of technical, administrative and legal problems remain, it is certain that district heating can bring considerable economical benefits, and a great reduction in total fuel requirements. ✱

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Charles F. Luce, Chairman of the Board and Chief Executive Officer of Consolidated Edison Company of New York, has been appointed by the Savings Bond Division of the U.S. Department of the Treasury, to head its 1977 public utility savings bond drive.

In announcing Mr. Luce's selection, William Simon, Secretary of the Treasury, said that Mr. Luce will be spearheading a national effort to solicit savings bond subscriptions from more than 374,000 utility employees in America.

Francis E. Drake, Jr., Chairman of the Board and Chief Executive Officer of Rochester (N.Y.) Gas and Electric Corporation, was elected Chairman of the Board of Directors of Associated Industries of New York State Inc. at its 62nd Annual Meeting in Lake Placid.