RADIATION IN INDUSTRIAL PROCESSES

APPLICATIONS REVIEWED AT WARSAW CONFERENCE

Scientists from many parts of the world met in Warsaw at a major conference organized by the International Atomic Energy Agency to discuss the application of large radiation sources in industry, particularly to industrial chemical processes. For five days, 8 - 12 September, they examined in detail all the important aspects of this rapidly growing subject. The conference provided an opportunity not only for an assessment of the techniques employed and results achieved but also for an exchange of views on new lines of development that appear promising in the light of experience gained in different countries.

By a simple classification, the uses of ionizing radiation can be divided into two broad categories. First, it can be used as a tool of investigation, measurement and testing, and secondly, it can be a direct agent in inducing chemical processes. The two types of functions can be illustrated by the well known uses of radiation in medicine and the biological sciences. For example, radiation can help in the detecting and locating of malignant tumours, and it can be employed also for the destruction of those tumours. Again, it can reveal intricate processes of plant growth and, at the same time, can initiate certain processes which result in the growth of new varieties of plants.

Similarly in industry, radiation is both a tool of detection, testing and measurement and an active agent for the initiation of useful chemical reactions. As a checking tool, it has found a variety of uses which have benefited industry to the extent of many hundreds of millions of dollars. It has, for example, served in detecting leaks in pipelines or in water, gas and electricity mains, in measuring the thickness of metal sheets and thus ensuring uniformity, in gauging the level and density of fuel, and in checking the thoroughness of mixing. Most of such applications are carried out with small radioactive sources either used externally or introduced into a substance as a tracer.

Chemical Reactions

The initiation of chemical reactions usually requires larger and more powerful sources of radiation. Such radiation can be provided by substances like cobalt 60 and caesium 137 or by machines which accelerate nuclear particles to very high energies. Cobalt 60 is a radioactive isotope of cobalt, produced by the irradiation of ordinary cobalt 59 with neutrons, while radioactive caesium or caesium 137 is found among the end products of nuclear fission in a reactor. Both emit highly penetrating gamma rays and both have fairly long half-lives, which means that their radioactivity lasts for considerable periods of time. Of the particle-accelerating machines, the most useful in this field are those which accelerate electrons to energies considerably higher than those possessed by the electrons (beta particles) emitted by radioactive substances.

These high-energy radiations produce interesting reactions both in organic life and in materials for industry. Many of such reactions can, of course, be brought about by other means; for example, by chemicals or by heat and pressure. Radiation is a supplementary but often a more effective method. It is a relatively young method and both its effectiveness and economic advantages are likely to increase with more research and practical experience.

Polymerization and Cross-linking

Some of the most important industrial uses of radiation are in the field of polymerization. Polymers - the constituents of plastics - are long chains of molecules, and the formation of these chains, which is called polymerization, is usually brought about by extremes of heat and pressure. But with the help of radiation, this process can be initiated at much lower temperatures and pressures than are normally required. For example, the well known plastic polyethylene is ordinarily manufactured by making the molecules of ethylene gas group themselves in long chains as a result of very high temperatures and pressures. If, however, the gas is irradiated, the process of chain formation or polymerization is no longer dependent on such extremes of temperature and pressure.

Another striking effect is cross-linking, by which the polymers become linked to each other at points where they cross. By this process, a large mass of plastic material can be converted into a very few molecules, with the result that the material then has a much higher temperature resistance.

Several of the papers presented at the Warsaw conference were devoted to the application of ionizing radiation to polymerization and other useful reactions in the manufacture and treatment of plastics. The polymerization of the ethylene series of hydro-carbons was discussed from various angles and the technical characteristics and requirements were described. It was pointed out by some experts that the cross-linking effect of radiation resulted in a superior product, opening the way to new applications of polyethylene. Irradiated polyethylene film has been sold for several years, and electrical wire has been made with irradiated polyethylene as the insulating jacket. Other reactions discussed included the cross-linking of poly-vinyl alcohol (PVA) and poly-vinyl chloride (PVC),

well known polymers derived from the ethylene group.

Some papers dealt with the chain oxidation and chlorination of hydro-carbons, both of which are among the most important chemical processes in industry. The effects of radiation on coal and methanation reactions were also discussed. Another subject that came up related to the possibility of improving catalysts by irradiation. It is widely realized that some of the effects produced by ionizing radiation are likely to influence catalytic properties and attempts have been made to alter the catalytic activity of solids by exposure to nuclear radiation.

Sterilization

A major field for the use of ionizing radiation is sterilization. The pharmaceutical industry, for example, has been in need of a method by which sensitive materials like proteins and enzymes could be sterilized without the application of heat or highly reactive chemicals. Ionizing radiation provides a most effective method for this purpose because it can be used successfully to destroy micro-organisms at doses which are harmless to most of these materials. And it has certain special advantages. Firstly, it can be used to sterilize the final sealed package; secondly, new, less expensive and more convenient packaging materials can be used; and thirdly, the method is easily adaptable to continuous processing.

The techniques of this method and the requirements of the radiation source were discussed by the experts at Warsaw. Another related subject discussed at the conference was sterilization of medical supplies like surgical instruments, hypodermic needles and rubber equipment. A further specific application considered in this connexion was sterilization of ampoules of distilled water with gamma rays, which can be of economic advantage in the industrial field.

The sterilizing activity of radiation is also useful in the preservation of food and there has been intensive research in several countries on devising an effective and safe method for the treatment of food with ionizing radiations. An account of this research and of the results obtained was given at the conference, and the potentialities were evaluated. The inactivation of viruses by gamma radiation, besides removing infectivity from foodstuffs or drugs, can also lead to the formation of killed vaccines which retain their antigenicity while having lost their infective property. The problem of making vaccines with the help of radiation is of great interest in view of certain disadvantages of the existing methods of inactivating viruses.

Technology and Economics

Many of the papers presented at the conference examined problems connected with the design and construction of suitable radiation sources for the varied uses in industry. Cobalt sources of different types were described in detail and their operating experience was narrated and discussed. For example, one of the papers dealt with the problems of designing a mobile irradiator for use in potato warehouses to prevent sprouting. The relative efficiency and usefulness of different radiation sources was also considered. Apart from the more penetrating radiations such as the gamma rays from radiocobalt or the artificially accelerated electrons from particle-accelerators, the potential uses of ordinary beta radiation from fission products were taken into account. Many industrial processes require surface radiation treatment rather than penetrating irradiation, and for these, fission product beta sources might be particularly useful.

Opening of the scientific conference on the application of large radiation sources in industry at the Palace Namiestnikowski, Warsaw. Left to right: Henry Seligman, Deputy Director General, IAEA, Mr. Winiewicz, Vice-Minister of Foreign Affairs, Poland, Piotr Jaroszewicz, Deputy Prime Minister, Poland, Sterling Cole, Director General IAEA, Stefan Jedrychowski, Chairman of the State Economic Planning Commission, Poland, Wilhelm Billig, High Commissioner for Nuclear Energy, Poland, and Arkadij Rylov, Deputy Director General, IAEA

Related to the problem of technological efficiency is the question of cost. The conference considered not only the relative economic advantages of various types of radiation facilities but also the larger question whether and in what fields radiation processing is economically more attractive than the convenient processing methods. Possibilities of reducing the costs of radiation processing in specific fields were examined.

Finally, the conference provided an opportunity for a general exchange of information on the radiation facilities installed in different countries and on the nature of experimental and commercial applications under way. There was an assessment of the subject as a whole, of the general state of development of the related science and technology, and of the lines of development that are likely to emerge in the near future.