HOW ISOTOPES BENEFIT INDUSTRY

The life of bus engines and the time taken to make beer are not at first sight connected with atomic energy. Yet the first has been considerably lengthened and the second even more considerably shortened in different countries as a result of using nuclear techniques and materials. They are only two examples; there are many others which have improved efficiency in factories, oilfields, chemical plants and other industries. They indicate not only the results of ingenuity but the rewards possible from more widespread use of the new methods.

At a symposium on radioisotope tracers in industry and geophysics organized by the Agency and held in Prague during November many reports showed not only what is possible but what is actually being accomplished in a number of industries as a matter of daily routine. The economic benefits were also demonstrated, and although the developments have been mainly in countries already highly industrialized, the potential for new industries in developing countries was clear.

Research to improve performance of motorcar, aircraft and tractor engines has been directed at establishing the causes of friction, corrosion and wear. In brewing beer it has been possible to accelerate fermentation. Pollution both of water and air can be reduced and methods of waste disposal improved. Many economies have been effected in oil production. Better quality and lower costs have resulted from work in chemical plants and processes such as glass making, metal refining, plastics and many others. Dams and railways were also mentioned among the great variety of subjects suitable for radioisotope techniques.

ENGINE WEAR AND FRICTION

One of the first relevant experiments in the USSR, as related by V.I. Postnikov, had been to render radioactive the piston rings of a new single-cylinder diesel engine in order to measure wear. This had shown that the rings were fully run in after six hours, and that rate of wear then dropped sharply and remained almost constant. Studies with tractor engines into the relation between quantities and abrasive qualities of dust and the rate of wear on piston rings had shown that dust with particles whose average diameter was 10-20 millionths of a centimeter caused most wear.

The importance of dust was also emphasized by J. Fodor (Hungary), who called mechanical contaminants the most important single wear factor. He claimed that the life of the CSEPEL engines of Budapest buses had been doubled by the introduction of filters chosen after investigations with radioactive tracers. Changes in the concentration and nature of dust in an engine could lead to variations between 1 and 10 000 in its life. Changes due to all other factors, such as the quality of fuel or lubricant did not exceed a 1 to 2 ratio. He had found that the wear was practically independent of the loading.

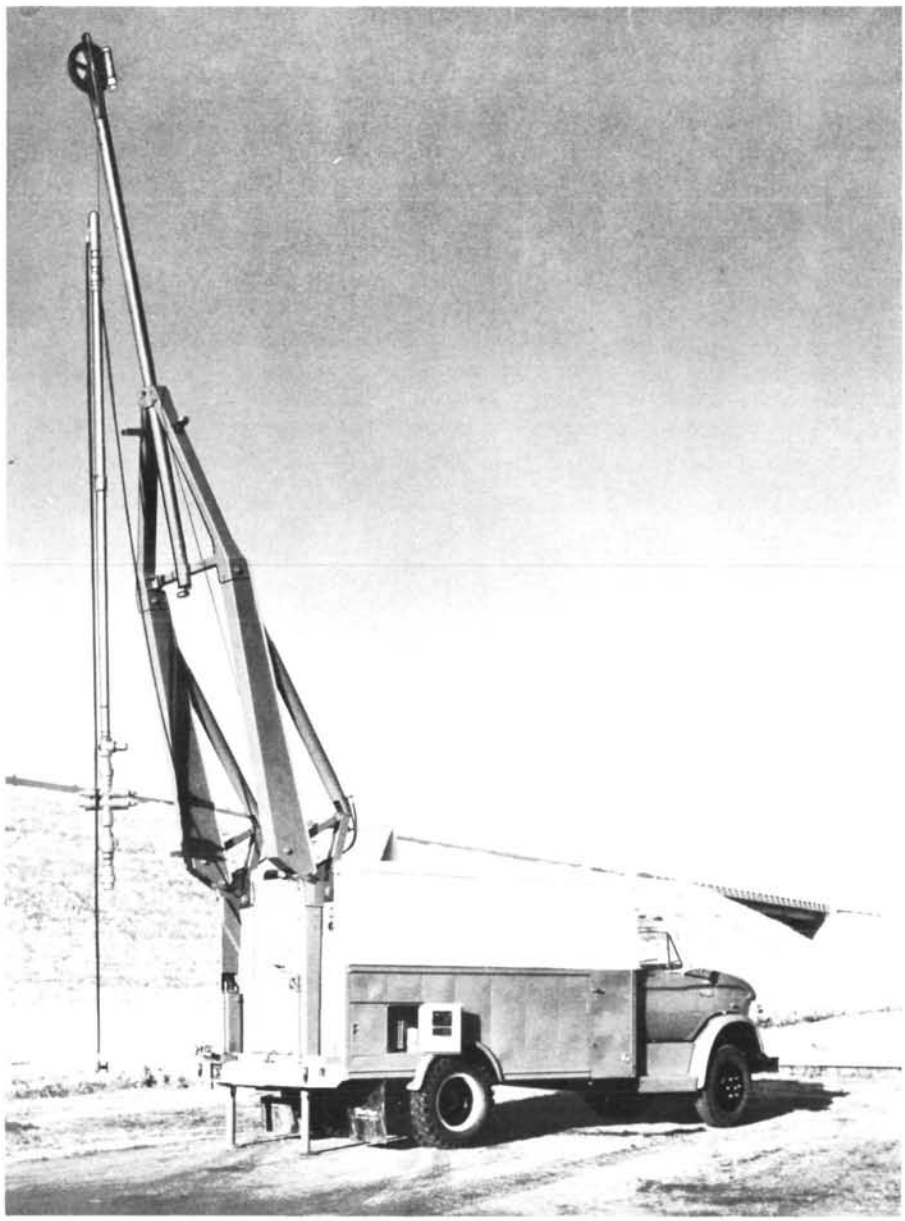
According to Postnikov, investigations carried out with a tractor at work had shown that a slight decrease in air temperature had practically no effect while the engine was being started. If, however, the temperature went down to -10° C, wear increased not only when starting but also while the engine was running. Wear on the top piston rings at -5° C was only half that at -10° C. He had also found interesting results in studies of anti-corrosion additives to fuels and lubricants for tractors. At low temperatures, corrosion of the cylinder and piston assembly could be reduced by using elements more chemically active than those used in the friction surfaces, because they neutralized the corrosive acids.

The USSR engineering industry was beginning to make considerable use of the differential radioactive tracer method, in which components are activated by bombardment with accelerated charged particles from a cyclotron, said Postnikov. Measurements are made of the decrease in activity of the surface layer caused by wear, and comparisons with samples on which wear is simulated establishes actual wear. By using this method the amount of radioactivity can be reduced by a factor of 1000 or more, making it possible to carry out investigations without having to provide radiation protection. It gave a novel technique for continuous or periodic control of wear under working conditions without stopping or dismantling the machine.

Results reported by M. Burianová and K. Hejtmánek (Czechoslovakia), who had used Skoda motorcar engines, were less clear-cut and in some respects different. They found that frequent changes in operation or of lubricating oil, filter variations or absence, all contributed to wear but that there were so many influencing factors that results of research were limited. Nevertheless they declared that in certain cases "the radiotracer technique is the only way to get some information about wear processes during engine operation".

M. Radwan, B. Rewenska-Kosituk and E. Wezranowski (Poland) had, like Fodor, used activation analysis to examine wear of bearings in agricultural machines under operating conditions. They incorporated small quantities of non-radioactive rare earth elements in machine parts, and found the amounts of abrasion products by rendering them radioactive afterwards in a nuclear reactor or accelerator. This method, which can measure quantities of labelled material of the order of a millionth of a gramme, had given results useful for production technology.

Complete mobile units designed to bring radioisotope facilities and services to oilfields are in routine use in USA. This is a unit for logging oil-well production.



A "universal tracer" was the description given by D. Chleck (USA) to the chemically inert radioactive gas ^{85}Krypton. He described its use in the form of "kryptonates" by several aircraft companies.

Kryptonates are solids into which krypton had been incorporated without undergoing chemical reactions. Any process, chemical or mechanical, which disturbes their surface causes a proportional loss of krypton and consequently of its radioactivity. Another property is that, when heated to a given temperature up to melting point, a kryptonate loses a given fraction of its initial activity. A typical example was the measurement of the temperature to which turbine blades are exposed in jet engines. After three hours running and then cooling, the blades are removed and, after measurement of radioactivity, put into an oven and heated. No loss in activity is then observed until the highest temperature to which the section had been subjected during running was exceeded.

IN THE OILFIELDS

The fact that radioisotope tracer techniques had been for ten years well established in the petroleum industry was agreed by William E. Mott (USA) and D.M. Srebrodolsky (USSR). They reviewed the ways in which methods had been extended and refined during the last ten years. All major oilfield operations were affected — drilling, well completion and secondary recovery (a technique of bringing oil to the surface by creating pressure artificially with the help of water or gases). Mott dealt with the extent to which the techniques are used, some of the practical limitations and alternative methods. He gave some recent uses in wells where there was simultaneous production from several layers. The growing acceptance of tracer services in USA was due principally to increased confidence in the reliability of the data, bringing a change in mood. For the first time there was a real appreciation of the conditions which must be satisfied to obtain maximum value from a tracer survey. Several service companies had developed complete mobile units especially designed for the purpose and to provide supporting services.

Srebrodolsky reported that very large savings had been made in USSR drilling and operation of oil and gas deposits. He estimated them at tens of millions of roubles a year. Tritium had been found to be particularly valuable for tracking underground water movement and for studying hydrodynamic relations between oil-bearing geological formations. It had been possible to make substantial corrections in plans for the development of deposits and to reduce considerably the number of wells needed. To give an idea of the use made of tracers in USSR, he stated that 220 oil wells had been investigated in the Romaslinsky area of the Tatar Autonomous SSR and 132 wells in the oil deposits of Western Turkmenistan during 1965.

Methods involving simultaneous use of different tracers to ascertain the movement of oil, gas or water between a number of wells were described by P. Sandru (Rumania), who used radioactive iodine, zinc and heavy water, and

by M. Gondouin (France). The latter carried out his experiments at the Hassi Messoud wells in Algeria, using gases in which hydrogen had been replaced by tritium.

AVOIDING DAM ACCIDENTS

By using radioactive sulphur and phosphorus P. Lévêque (France) had been able to discover small fissures in rock, aiding civil engineering projects to avoid such accidents as dam breakages. The isotopes seeped into micro-fissures of rock samples, showing them clearly on photographic film after three to six days. R. Jirkowski (Czechoslovakia) had used the radioactive gas radon, found naturally in the soil in certain areas of his country, to establish whether there were any potentially dangerous faults or fissures in places where dams were to be built.

POLLUTION

To keep the constantly increasing pollution of seas and water within tolerable limits it is necessary to determine their capacity to dilute and disintegrate. In Denmark, according to P. Hårremöes, radioisotope tracers had been used for this purpose since 1959 and had become a routine before selection of sites for sewage disposal. Studies made last year in the Sound between Denmark and Sweden will decide the design of sewage disposal for the town of Hålsingborg. Establishment of sewage fields in the sea at a certain depth might enable them to dispense with secondary treatment and still keep pollution of coastal waters within permissible limits. Tracings so far made will be reviewed under an IAEA research contract placed within the Danish Isotope Centre. The aim is to develop a method readily applicable to more intricate problems of effluent dispersal.

J. Guizerix (France) dealt with the various type of polluting materials and their behaviour following experiments in a river and on the Mediterranean coast. Under French legislation pollution from radioactive effluents was, thanks to most careful studies and the establishment of severe standards, the least dangerous of all.

R.M. Chatters (USA) described a nethod for attaining a better understanding and reduction of the sources of stream pollution in the pulp and paper industry. Wood fibres added to the effluent were previously treated with a salt of lanthanum which was rendered radioactive by neutron bombardement of samples subsequently taken from the river.

Air pollution having become a serious problem in industrial areas, it might become necessary to trace gas effluent from a particular stack in order to find its proportionate share. M. Kato (Japan) stated that by injecting cobalt sulphate into the stack of a power station, taking air samples and making their cobalt radioactive by neutron bombardment, gas diffusion over a large area

could be established. Cobalt could be detected by this method in amounts as low as five hundred millionths of a gramme.

STEEL AND BEER

A number of examples of economic gains to be obtained were given by Postnikov. Comparing tracer with micrometric measurement on steel cutting tools at different speeds had proved the tracer method to be about 66 times more economic in metal consumption and 50 times better in terms of time. This was without taking into account savings in labour costs and power consumption. The USSR food industry had also made successful fuse of the techniques. The brewing industry was introducing an improved production process; by finding the lifetime of labelled latic acid bacteria it had been possible to reduce the fermentation process to one or one and a half days from the previous five or six days. The quality of the beer was also being improved.

Radioactive gold had been used by D. Donhoffer and E. Duftschmid (Austria) in tests aimed at prolonging the life of railway wheels and tracks used by fast trains. It enabled them to select an oil film only a millionth of a millimetre thick, spread automatically from a moving engine on to wheels and rails. They considered it a method which could be adapted to many other railroad investigations.

PLANT KINETICS

While the papers on geophysical applications, wear and friction studies and dispersal of effluents illustrated the great variety of tracer techniques, the dominating topic was plant kinetics — the movement of fluids, gases or solids through industrial plants. In a review paper K.J. Ljunggren (Sweden) pointed out that radioactive isotopes were particularly useful compared with other substances such as salt and dyes. Great sensitivity permitted the use of such small amounts that no interference with the process was possible, and gamma-ray nuclides made it possible to take direct measurements from the outside of vessels and pipes.

Twenty-six out of a total of 47 papers dealt with this subject. They referred to such diverse industries as cement, paper and pulp making, cellulose bleaching, superphosphate, carbon black and glass production, refining aluminium, magnesium and nickel, oil refining, polymerization of organic substances, control of impurities in blast furnaces and galvanic coating.

In discussing techniques, G. Robin (France) stressed the advantages of activation analysis because no radiation protection was needed in factories and analysis could be carried out separately.

J.B. Dahl (Norway) had made studies to find the efficiency of turbines in hydro-electric plants to establish as exactly as possible the water flow through

turbines. He found that the blasting of a container, carrying radioactive iodine incorporated in penicillin, in the water stream by means of explosives had proved most efficient.

For measurement of large flow and for calibration of permanently installed flow meters at lower rates, radioisotope methods had been superior to others, declared C.G. Clayton (UK). They were precise and could be operated with negligible hazard. They had been accepted in UK in civil engineering for acceptance tests on large flow systems such as water cooling facilities at power stations, and were being considered for turbines in hydro-electric power plants. They could also be used on a large scale to collect data in town gas mains and generally to measure gas flow.

MAKING ISOTOPES ON THE SPOT

One reason why the methods are not more used has been the difficulty of obtaining the very short-lived radioisotopes at the places where they have to be used. An easily transportable antimony-beryllium source described by T.R. Churchill (Canada) should remedy this situation, since with it the isotopes can be produced economically on the spot.

To find why radioisotope tracers are not more generally used for large-scale studies of industrial plants, the Agency asked Member States to provide information on the present stage of routine uses. Replies from 13 countries were summarized by C.K. Beswick (IAEA), who came to the conclusion that the reasons for limited use, though varied, are generally either lack of technical information or lack of engineers with the proper training, experience and enthusiasm. Nevertheless a number of industries, particularly chemical engineering, oil refining and iron and steel now exploited them as a matter of routine. Their potential usefulness as a tool for finding bottle-necks and for process efficiency studies was becoming better known, thanks to the persistent efforts of a relatively small group of specialists. In almost every country their use in industry had been fostered by Government-controlled organizations, many of whom still provided an experimental service. Refinements to some of the rather crude methods first used and the development of special equipment and reliable measuring instruments had helped to convince many industrialists.

TECHNOLOGY MATURED

In the view of K.J. Ljunggren, who was Chairman of the last session, the most remarkable fact that had emerged from the symposium was the way in which tracer technology had been combined with other techniques in many industries. There was clear evidence that isotope technology had matured. Industrial plants no longer served as playgrounds for the scientific isotope specialist; instead engineers were waiting impatiently for immediate answers to important questions. They were getting what they needed. They were using radioactive tracers as an excellent tool.