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To bed betimes

The advantages of fluidised-bed combustion in energy-conversion systems have become appreciated comparatively recently. A new report on the subject appeared last month

What is a fluidised bed? And why is the concept now arousing so much interest? Suppose you have a boxful of sand or ash, in the form of fine solid particles. If the floor of the box is porous, or has suitable holes in it, you can blow air up through the floor, and through the bed of solid particles. If the air is rising fast enough, it will begin to lift the particles, stirring them into turbulent motion, like a boiling fluid. The boxful of "boiling" sand is a "fluidised bed". It combines the properties of a solid and a fluid, in a way which is proving to have an impressive variety of applications.

Fluidised beds are not in themselves novel. The concept was first developed in the 1920s, and has been in common use for decades in the chemical and metallurgical industries, for catalysis and for heat treatment processes. But the use of fluidised beds in energy-supply technologies is of much more recent vintage. Even those with specific responsibilities for decision-making about energy remain far from adequately briefed about the potential of fluidised-bed systems.

Two years ago there appeared a major study entitled *Energy Futures*, by Stewart Herman and James Cannon, published by INFORM, a non-profit research and educational organisation based in New York. *Energy Futures* devoted 17 chapters to an in-depth description of the status of new energy technologies, and of the organisations involved, from solar energy to fast breeder reactors. It at once became a standard work of reference. However, even *Energy Futures* gave only passing mention to fluidised-bed energy systems. When the omission was pointed out, INFORM decided to prepare and publish a special supplement to *Energy Futures*, devoted specifically to fluidised-bed energy technology. As the scope of relevant activities became apparent, the supplement grew into a book-length report, entitled *Fluidized Bed Energy Technology: Coming To A Boil*, including commentary on some 70 organisations in the field. The INFORM report was published at the end of June, in conjunction with seminars in New York and Washington DC, arranged with the cooperation of the US Department of Energy. Seminar speakers included Dr Steven Freedman of the Fossil Fuels Division, US DOE; Frank Princiotta, director of the Energy Processes Division of the US Environmental Protection Agency; Michael Pope, chief executive of Pope, Evans and Robbins, Inc; Dr Carl Lyons of Battelle Memorial Institute; and senior officials from the Union Carbide Corporation. Each seminar was attended by some 70 people, drawn from industry and various levels of government.

The seminars started from the same premise as the introduction to the report: "INFORM's survey of companies active in this field suggests that fluidised bed combustion is on the threshold of becoming a major energy technology ... Very few people outside the specialist field, however, have even heard of fluidised bed combustion. The present report is an attempt ... to describe the basic principles of fluidised bed applications ... the economic, environmental and institutional implications, and the present prognosis for future development."

Fluidised-bed combustion, as its name indicates, is the burning of fuel in a hot fluidised bed. If a fluidised bed is heated to an appropriate temperature, usually between 700 degrees C and 900 degrees C, it assumes the appearance of a basin of boiling lava. Virtually any combustible material fed into the hot bed will burn - even wet sewage sludge. The turbulence of the bed maintains a uniform temperature throughout, and the thermal capacity of the hot bed particles keeps this temperature stable. Heat is transferred to boiler tubes or walls not only by convection and radiation, as in conventional fireboxes and boilers, but also by conduction, through the continual impacts of the incandescent bed particles on surfaces in the bed. The rate of heat transfer is thus increased by a factor of four or more, suggesting the possibility of a more compact and less expensive unit for the same output. It is also possible to produce high-quality steam while maintaining a bed temperature much lower than that in a conventional firebox. The lower combustion temperature decreases materials problems, and makes it possible to minimise the formation of nitrogen oxides. Furthermore, if the fuel to be burnt contains a significant amount of sulphur - as for instance does the Appalachian coal of the US - a fluidised bed offers an ingeniously direct way to control the emission of noxious sulphur dioxide and trioxide. A suitable proportion of pulverised limestone or dolomite is fed into the bed. At the operating temperature of the bed the sulphur in the fuel combines not only with oxygen but also with the calcium in the pulverised stone, to form dry solid calcium sulphate. The sulphated stone is drained off the bed with the fuel-ash. Well over 90 per cent of the sulphur in high-sulphur fuel can be removed before it reaches the flue.

While petroleum and natural gas were reliably and cheaply available the various virtues of fluidised-bed combustion remained largely academic, since there seemed little need to burn low-quality or high-sulphur fuel. However, as the INFORM report makes clear, that state of affairs has lately undergone a dramatic change. Since 1973 the interest in fluidised-bed energy systems has burgeoned.

Two types of fluidised bed

The two major categories of fluidised-bed systems are those in which the fluidised bed operates at atmospheric pressure, and those in which the bed operates at pressures up to 10 atmospheres or higher. Atmospheric fluidised-bed boilers in industrial sizes up to 500 000 pounds of steam per hour are already available from seven different manufacturers, in the UK, the US and Norway, on a straight-forward commercial basis with a warranty. Babcock & Wilcox Ltd. in cooperation with the National Coal Board, have been operating an atmospheric fluidised-bed boiler with a 3 m X 3 m bed at their Renfrew works since August 1975, supplying 40 000 pounds of steam per hour, and demonstrating the removal of more than 99 per cent of the sulphur from high-sulplhur coal. In late June B&W Ltd were dealing with. more than 40 inquiries from 14 countries, of which they expect at least 20 to be converted into firm orders within the next 18 months. The Energy Equipment Co Ltd of Olney, Bucks, in 1977 adapted a 30 000 pound-per-hour boiler at the Bournville factory of Cadbury Ltd with a fluidised-bed combustor. Energy. Equipment say that the unit, which has been in routine coal-fired operation since early 1978, is the first fluidised-bed system sold on an ordinary commercial basis with no special considerations of any kind, financial or otherwise Stone-Platt Fluidfire Ltd, of Birmingham, have alreadv delivered a 10000 pound-per-hour unit to Virginia Polytechnic Institute in the US, and another similar unit has been sold to General Motors for delivery by early 1979. The National Coal Board and its offshoot, Combustion Systems Ltd, have carried out several adaptions, of which the largest is a fluidised-bed combustor in an 80-MWt boiler at the River Don plant of British Steel, which is expected on stream later this year.

In the town of Enkoping, near Stockholm, Sweden, a 25-MWt fluidised-bed boiler has been supplying the town's district heating system since November 1977. The boiler, supplied by Mustad and Son, of Norway, is designed to burn any available fuel, including heavy oil, coal, wood chips and peat, interchangeably. In the US, an even larger fluidised-bed boiler, with an output of 30 MWe is now being commissioned at the Rivesville power station of the Monogahela

Power Co in West Virginia. After early teething troubles the coal feed system of the Rivesville plant has been completely revamped. Michael Pope, of Pope, Evans and Robbins, designers of Rivesville, told the New York seminar on 26 June that the Rivesville plant is now operating up to design specifications while working on extended test runs.

Work on pressurised systems, while not so advanced, is progressing rapidly. Curtiss-Wright is installing a 13 MWe pressurised system at its main plant in Wood Ridge, New Jersey. A much larger unit, 80 MWt, is under construction at the National Coal Board's Grimethorpe colliery in Yorkshire, under the auspices of the International Energy Agency. Both the Curtiss-Wright and the Grimethorpe rigs are expected in service in 1979, to provide a growing data base for the still larger units desired by electricity supply systems. At least three electricity supply systems - American Electric Power, British Columbia Hydro, and the Tennessee Valley Authority - are already involved in detailed feasibility studies of various types of fluidised-bed generating stations. In Britain, the recent Department of Energy report *Coal Technology* proposed the "design, construction and operation of an 80-MWe (200-MWt) full-scale reference-commercial, demonstration plant for the pressurised fluidised-bed combustion of coal for use in combined cycle (gas/steam turbine) power generation, capable of operating with wide, variable grades of coal and capable of absorbing sulphur oxides in crush limestone added to the bed - total project cost £50 million."

A precarious lead

The proposal in the *Coal Technology* report is for a unit intended unambiguously as a "demonstration" plant, to display to overseas customers the lead in fluidised-bed energy technology which Britain still, albeit precariously, holds. But Michael Virr, managing director of Stone-Platt Fluidfire, is concerned lest emphasis on demonstration of central electricity units be coupled with failure to seize the opportunities now opening up for export of industrial-scale fluidised-bed units. Virr quotes a recent US study, which estimates that in 1980 the market for industrial fluidised-bed boilers in the US alone will be worth $31.5 million in 1977 dollars: in 1985, $945 million; and in 1990 $2765 million. The INFORM report concurs that the industrial market for fluidised-bed systems is already open, and likely to expand with rapidity even within five years.

As the INFORM report discusses, uncertainties remain - about reliability, emission-control performance, disposal of sulphated stone, and comparative economics. However, recalling the proverbial stricture about a watched pot, the very obscurity of fluidised-bed development may hitherto have helped avoid many of the embarrassments of premature enthusiasm. Be that as it may. it seems likely that no amount of watching henceforth will keep fluidised-beds from coming to the boil.

Fluidized Bed Energy Technology: Coming to a Boil, by Walter C. Patterson and Richard Griffin, is available direct from INFORM, 25 Broad St, New York 10004, USA ($45), or through Friends of the Earth Ltd, 9 Poland St, London W1 (£25).

(NB: this footnote on the INFORM report, included here for completeness, is now three decades old and no longer valid.)