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Coal comfort in fluidised beds

Spare a moment of sympathy for the electricity planner. Forecasts are forecasts, demand is demand, and never, it seems, the twain shall meet. For new plant construction schedules and costs, think of a number and double it. For fuel costs quadruple it, and keep fingers crossed. It is of course permissible to include stacks on generating plant, but it would be better if nothing went up them but air, preferably not too hot.

Such are some of the enervating ground rules for the electricity planner's game. And now, as if to heap further ashes - if not sackcloth - on his head, he is being told that he will likely have to learn again to love his old tormentor, coal.

Nevertheless there are a few hopeful signs on the horizon. No one would try to persuade the electricity supply industry that a return to coal is good news. But it is by no means as bad as might be thought. Coal utilisation technology, after a long hiatus, is on the move again. Indeed coal gasification and liquefaction are already routine catchphrases in the energy community, partly because they have until recently received most of the attention. However, another approach is now making a yet more rapid advance: the direct combustion of coal in a fluidised bed.

Fluidised bed combustion has not yet become an energy catchphrase. On the contrary, many of those who might be most interested have not even heard of it. Such potential users are the major target of a report entitled *Fluidized Bed Energy Technology: Coming To A Boil*, by Walter C. Patterson and Richard Griffin, newly published in New York, Washington and London, by Inform under a contract with the US Department of Energy, with additional financial support from the Rockefeller Brothers Fund.

In conjunction with publication of the report, seminars were held in New York and Washington, with speakers including senior representatives from the US DOE and Environmental Protection Agency, major engineering and design groups involved in fluidised bed developments, and corporate customers for fluidised bed systems.

The response to the seminars was enthusiastic, eliciting many inquiries from Chicago, the US west coast and eastern Canada. Inform and the US DOE are now discussing the possibility of a series of further similar seminars later this year.

Probably the most striking realisation attendant on preparation of the report was the actual amount of activity now underway in fluidised bed energy technology, the scope of individual projects and the speed of developments.

The Inform report concludes that atmospheric fluidised bed systems for industrial applications are already available on a straightforward commercial basis with the usual warranties; that pressurised fluidised bed systems will probably be available on a similar basis by the mid-1980s; and that large-scale systems for major electricity-supply applications will be of importance from the 1990s onwards. The speed of development of the fluidised bed is undoubtedly related to the essential simplicity of the fluidised bed concept itself.

If air is blown up through a bed of fine inert solid particles like sand or ash, the rising air lifts and stirs the particles so that the bed appears to boil; it is "fluidised", exhibiting properties both of a solid and of a fluid.

If a fluidised bed is heated to a suitable ignition temperature, usually between 700 and 900 degrees C, virtually any combustible material fed into the bed will burn.

The turbulence of the bed maintains a uniform temperature throughout, and the thermal capacity of the solid particles keeps this temperature stable. It is accordingly possible to burn a variety of fuels in the same fluidised bed combustor, including fuels which contain a high proportion of non-combustible material like ash or water.

An appropriate design of fuel feed system makes it possible to change over rapidly from one fuel to another, or even to feed a mixture of quite different fuels simultaneously.

A fluidised bed combustor is thus ideally suited for the combustion of waste material like urban or industrial refuse.

The solid bed material mediates heat transfer from the bed to boiler tubes or walls, increasing the rate by a factor of four or more, and making it possible to produce the same output from a unit which is physically smaller and less expensive. The enhanced heat transfer also allows the production of high-quality steam from a bed operating at a temperature much lower than that in a conventional firebox, minimising the production of nitrogen oxides. If high-sulphur fuel like US Appalachian coal is mixed with a suitable proportion of ground limestone or dolomite, the sulphur in the fuel combines in the bed with the stone, to form solid calcium sulphate.

In this way it is possible to remove well over 90 per cent of the sulphur in high-sulphur coal, producing a dry solid waste which can be disposed of with the coal ash.

Atmospheric pressure

The two main lines of development involve operating the fluidised bed either at atmospheric pressure or at a pressure of several atmospheres.

Atmospheric fluidised bed systems are farther advanced in development than pressurised systems, in part because atmospheric systems are based directly on those which have been employed for decades for non-energy applications in the chemical and metallurgical industries, for catalysis and heat treatment.

The largest atmospheric fluidised bed unit now in operation is at the Rivesville power station of the Monongahela Power Company in West Virginia. The Rivesville plant is a 30MW (electric) demonstration unit, ordered in 1972 with support from the then US Office of Coal Research (now part of the US DOE). It was constructed on an existing site, and had to employ existing buildings and facilities, a circumstance which led to some early difficulties, especially with coal feeding. However, a new coal feed system has now been installed, and the plant is in final stages of commissioning, operating at its design output in extended test runs.

Pope, Evans and Robbins, design consultants responsible for the project, are confident that it will prove itself in regular service, burning local West Virginia coal, meeting sulphur and other emission control standards without difficulty, and offering no special problems for disposal of solid waste.

The second largest atmospheric unit is a 25MW (thermal) boiler supplying the district heating grid of the town of Enköping, near Stockholm, in Sweden. The Enköping unit, supplied by Mustad and Son of Norway, was ordered to provide rapid and wide-ranging flexibility of fuel supply, burning heavy residual oil, coal, wood chips or peat, interchangeably. Several smaller units are now in service, and a much larger number under construction for industrial and commercial electricity and steam supply in several countries.

The Tennessee Valley Authority has commissioned three design studies for a full-scale 200MW (electric) station using atmosphere fluidised beds, from Combustion Engineering, Babcock & Wilcox (US) and Foster Wheeler. Babcock & Wilcox Ltd of the UK, in cooperation with the National Coal Board, have since August 1975 been operating an atmospheric fluidised bed boiler at their Renfrew factory in Scotland, producing 40,000 lb/h of steam.

Experience on the Renfrew unit, arguably the most successful in the world to date, has helped B&W Ltd to win three orders for fluidised bed units for the State of Ohio, which is eager to encourage the technology, to improve markets for high-sulphur Ohio coal. In late June B&W Ltd were dealing with over 40 enquiries from 14 countries about their fluidised bed systems; B&W Ltd say they expect at least 20 of these to lead to firm orders within a year to 18 months.

Pressurised

Five of the B&W Ltd enquiries, however, relate not to atmospheric but to pressurised systems, for electrical supply. The first of these was a feasibility study undertaken in late 1976, for the American Electric Power Company, one of the world's largest coal-burning electrical utilities.

B&W Ltd would supply the pressurised fluidised bed combustor, and Stal-Laval, the major Swedish turbine manufacturers, the turbines, for an innovative combined cycle electricity generating unit of a type now attracting increasing attention.

Hot gases from the pressurised fluidised bed combustor would be fed directly into a gas turbine; its exhaust gases would then be used to raise steam for a steam turbine, in the usual combined cycle arrangement.

The critical engineering question posed by such a design relates to clean-up of the hot combustion gases between the fluidised bed and the gas turbine. Particulates from coal combustion have been notoriously deleterious to turbine blades, and have always previously thwarted attempts to develop coal-fired gas turbines.

However, Stal-Laval is confident that it will be able to cope with the problem. B&W Ltd hopes that an agreement will be forthcoming within a matter of weeks to proceed with detailed engineering design of the AEP plant. A similar unit is also under discussion with British Columbia Hydro. B&W Ltd says it has also had an inquiry from Italy, and one other which it still considers confidential.

In the meantime, pressurised fluidised bed hardware is taking shape on a demonstration scale both in the US and in the UK. Curtiss-Wright, under a contract with the US DOE, is installing a pressurised unit to power an existing 7MW (electric) C-W gas turbine at the company's headquarters in Wood Ridge, New Jersey. The unit will also feed a heat-recovery system to supply process steam.

At Grimethorpe colliery in Yorkshire work is well underway on construction of what will be the world's largest pressurised fluidised bed test rig, an 80MW (thermal) unit being built under the auspices of the International Energy Agency.

Both the Curtiss-Wright and the Grimethorpe units are expected to be in service next year, to carry out extensive test programmes burning different fuels, evaluating emission control and hot gas clean-up, and providing design data for larger facilities.

To date virtually the entire data base for pressurised fluidised bed units larger than bench-scale has come from the Leatherhead rig of the UK's Coal Research Establishment, an 8MW (thermal) unit which has been in service since 1969. Only the dedication of its small research team kept it from being shut down at the end of the 1960s; now fluidised bed designers are queuing up to use it.

UK power station?

In the UK a top-level working party drawn from the coal industry, its trade unions and the government early this summer recommended the construction of an 80MW (electric) demonstration pressurised fluidised bed power station, to cost an estimated £50m to demonstrate the technology to prospective overseas customers for British fluidised bed technology.

The UK Department of Energy has not yet formally endorsed the proposal, but the Central Electricity Generating Board, in a notable shift of stance, has declared itself prepared to "play host" to such a power station, and to provide a site. The CEGB's previous lack of interest in fluidised bed technology has been a stumbling block impeding UK development of the concept for almost a decade. Its change of heart cannot but be welcome to Britain's growing band of fluidised bed advocates.

However, as even such advocates are forced to concede, the utility market for fluidised bed systems of whatever kind faces a variety of problems which relate not only to fluidised bed technology itself but also to the present circumstances of the prospective customers.

It is, to be sure, true, as the Inform report points out, that uncertainties remain as to the cost and reliability of fluidised bed units, and their compliance with increasingly stringent standards for sulphur oxide and particulate emissions.

All things considered, it is heartening to be able to report that the hapless electricity planner does, after all, have something cheering to look forward to.