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How to make the coal flow cleaner

How fluent are you in energy acronyms? Translate the following: "The CEGB wants the PWR; the AEA prefers the FBR." If you said Central Electricity Generating Board, pressurised water reactor, Atomic Energy Authority and fast breeder reactor, award yourself full marks - so far.

Now: "BFBC looks better for small units, CFBC for larger ones; PFBC may be better than either, with the right GT; but IGCC will be tough to beat." How did you do? If you looked blank, you're missing some of the most exciting action on today's international energy scene. Let's spell it out: "Bubbling fluidised-bed combustion looks better for small units, circulating fluidised-bed combustion for larger ones; pressurized fluidised-bed combustion may be better than either, with the right gas turbine; but integrated gasification combined cycles will be tough to beat."

Still confused? Let's go through it again. Fluidised-bed combustion (FBC) in its various modes is the biggest breakthrough in coal-combustion technology since the advent of pulverised fuel (PF) in the 1920s. Fifteen years ago FBC was still a technical curiosity, under investigation in laboratories here and there but of almost no interest to industries or electricity suppliers. Much of the pioneering research was done in Britain; but lack of support cost Britain its early lead in the international FBC race. Now FBC is one of the fastest-growing categories of energy technology around the world.

It can burn essentially any fuel, while minimising emissions of sulphur and nitrogen oxides; and it can markedly increase overall efficiency, producing the same energy services with much less of the troublesome "greenhouse gas" carbon dioxide. Its combination of a simple concept and apparently limitless variations has inspired designers and engineers in many countries.

Hundreds of FBC units, in sizes all the way from bench-scale to utility-scale, are now in operation, with new orders added by the month. Major plant manufacturers in Europe, North America, and Asia, including Ahlstrom, ASEA Brown Boveri, Babcock & Wilcox, Combustion Engineering, Deutsche Babcock, Foster Wheeler, Hyundai, Keeler/Dorr-Oliver, Lurgi, Mitsubishi, Northern Engineering Industries, and Thyssen are all offering versions of FBC in direct competition with traditional combustion technology, and winning customers steadily.

All FBC variants are based on the same central concept. A traditional coal combustor of whatever kind is just an empty tank in which the coal burns alone. In FBC, however, the combustor contains a layer or "bed" of fine inert particles like sand or ash. The combustion air is blown up from below through this bed, lifting the particles so that they churn and tumble like a boiling fluid: a "fluidised bed".

The bed particles are heated to incandescence, by burning gas in the fluidising air or playing an oil-flame on the bed. Once the churning bed is incandescent, any combustible material fed into it and engulfed by the glowing particies will instantly ignite and burn; the heat it releases will maintain the bed-temperature, and the start-up fuel can be shut off. Direct conduction between the tumbling particles makes heat transfer highly efficient.

The low operating temperature - about 850 degrees C - dramatically reduces formation of nitrogen oxides. If the fuel contains sulphur, a calcium mineral like limestone or dolomite can be added; the sulphur oxides react with the calcium to form solid calcium sulphate, trapping more than 90 per cent of the sulphur in the bed rather than discharging it as noxious gases. The bed acts as a heat reservoir; even cold, wet low-quality fuel will not quench the combustion. Accordingly, FBC can burn almost any material that contains enough energy to maintain the temperature - including many materials not conventionally considered fuel at all - cleanly and efficiently. FBC units now operating are burning high-ash, high-sulphur coal, petroleum coke, colliery washings, pit spoil, lignite, peat, wood and wood waste, old railroad sleepers, old tyres, industrial, agricultural and forestry wastes -- the list grows longer and longer.

In classical FBC, the fluidising velocity of the air is about two metres per second; the bed has a well-defined "upper surface" that "bubbles" (BFBC). If the velocity is increased to about eight metres per second, all the solids are carried upwards and out the top of the combustor, to be collected in an adjoining "cyclone" and reinjected at the bottom of the combustor. This "circulating" FBC (CFBC) requires a taller combustor; but the fuel remains in contact with the bed-solids as long as desired, improving fuel burnout and sulphur-trapping.

BFBC and CFBC operate at atmospheric pressure; but an FBC unit can also be placed within a pressure shell - pressurised FBC or PFBC.

The hot combustion gases from PFBC can be fed directly into a gas turbine; the high inlet temperature, 1100 degrees C compared to less than 600 for a steam turbine, boosts the efficiency of electricity generation, especially if the gas turbine exhaust is used to raise steam for a steam turbine.

This "combined cycle" of gas and steam turbines has suddenly become everyone's favorite new generating capacity. Current plans generally focus on natural gas as the fuel for conibiried cycles, but uncertainties about its long-term price and availability make the option of coal-fired combined cycles powerfully attractive. The giant engineering firm ASEA Brown Boveri (ABB) is already building PFBC combined-cycle stations in Spain, the US and Stockholm.

Nor is PFBC the only route available. In the past decade major companies including Texaco, Shell. Dow, British Gas and Lurgi have developed a "second generation" of coal gasifiers, able to convert a wide range of coals cleanly and efficiently into fuel gases. One of the most promising applications is to feed the cleaned fuel gas from a gasifier directly into a gas turbine, and to use the gas turbine exhaust and the heat from the gasifier to raise steam for a steam turbine - "integrated coal-gasification combined cycles" or IGCC.

The Cool Water IGCC demonstration plant in California, using Texaco's gasifier, has just completed an impressively successful five-year programme. Shell and Dow have IGCC plants in regular service, and British Gas and Lurgi have a joint project at Westfield, in Scotland. Several commercial lGCC orders are expected before the end of 1989.

Perhaps most exciting of all is British Coal's "topping cycle", combining gasifier with PFBC combined cycles to achieve an efficiency potentially better than 50 per cent. Only last week, Ahlstrom of Finland offered £5 million toward "topping cycle" research with British Coal at Grimethorpe, Yorkshire. Will the government provide the remaining £10 million? Or will Britain squander yet another opportunity to lead the world in energy technology?