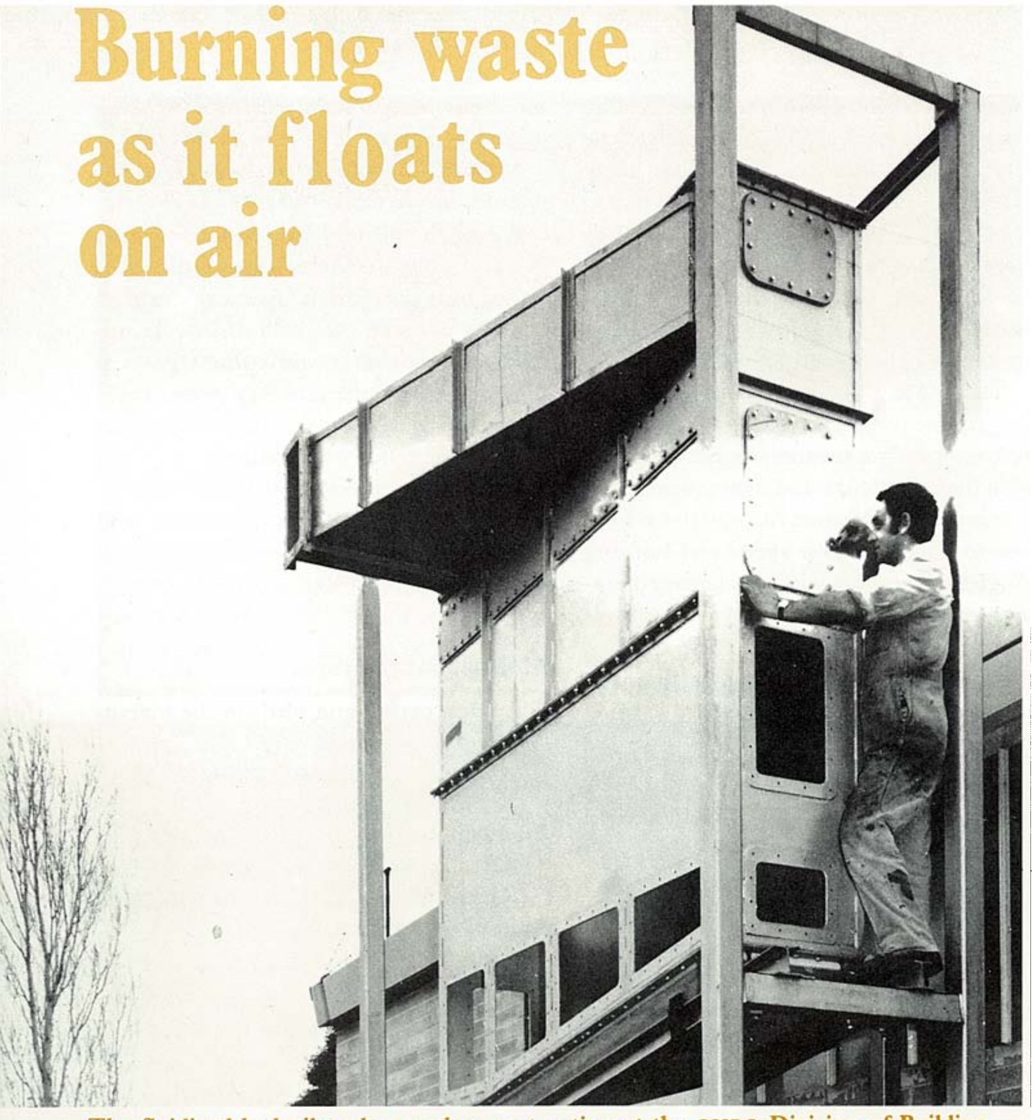
Burning waste as it floats on air



The fluidized-bed pilot plant under construction at the CSIRO Division of Building Research.

Fluidized-bed combustion is catching on rapidly as a means of dealing with troublesome wastes.

In a neat feat of pyrotechnics, upward jets of air suspend a burning bed of particles — juggled bits of fuel, ash, and sand. Engineers use the term 'fluidized' because the bed behaves as if it were a (boiling) fluid.

The role of the sand — or similar inert material — is to act as a heat reservoir, making the bed behave more uniformly. A surfeit of air and numerous encounters with hot and burning particles encourage even the most reluctantly oxidized material to burn — hence the technique's advantages.

Scientists at the CSIRO Division of Process Technology have found fluidized-bed combustion ideal for incinerating coal-washery waste — the material that is left when the mined coal is washed free of shale and dirt. The clean coal is mostly exported to Japan where it is needed for making coke, but the waste stays behind in Australia, where it is becoming something of a problem.

More than 60 million tonnes of coal were cleaned last year in New South Wales and Queensland, and in the process 58 washeries discarded about 20 million tonnes of waste. The proportion of reject material has risen steadily from 12% in 1956 to 28% today, largely as a result of less selective mining techniques.

Coarse lumps of coal-bearing shale make up most of the waste, and this material is usually dumped in heaps or as land fill in gullies. The remainder of the waste, the tailings stream, is a slurry of fine coal and dirt that is usually disposed of by pumping into settling ponds constructed from coarse rejects. Over the decades of coal mining, it is estimated that more than 100 million tonnes of colliery waste have accumulated.

Even if carried out properly, these disposal methods aren't ideal environmentally. The heaps and ponds are unsightly and take up large tracts of land, often near population centres or scenic areas.

Sometimes more serious effects can be produced accidentally. Wind can create a dust nuisance or carry smoke and fumes from smouldering heaps set alight by bushfires or spontaneous combustion. Other problems include slippages in unstable heaps and leaching of acidic components into local waterways.

More stringent environmental regulations now in force demand that new dumps should be landscaped and made environmentally acceptable. These will lead to increased disposal costs, in excess of $5 a tonne.

The pilot plant has shown that colliery waste is a valuable asset because of its energy content.

In this light, burning the waste becomes an attractive notion. Raw washery refuse is essentially coal-bearing shale — about one-third of it coal-like material. It is a very low-grade fuel. Burning produces a light-coloured fine aggregate more inert and resistant to weathering than the raw shale. In this form, disposal should be environmentally cleaner, and cheaper. Moreover, the burnt shale has potential value as a construction material for roads, and for brick and cement manufacture.

As the CSIRO scientists have shown, fluidized-bed combustion can readily burn the waste. In *Ecos* I, we reported how a test rig at the Division had successfully burnt coarse refuse containing up to 80% ash and slurries with as much as 60% water. This remarkable performance is beyond the capabilities of any conventional incinerator.

Science on the scene

Since that time, a 2-tonne-per-hour pilot plant has been constructed and operated at the Glenlee coal washery near Camden, N.S.W. Its cost was met by the Joint Coal Board, with the site and services provided by the colliery owners, Clutha Development Pty Ltd. CSIRO provided the staff and met operating costs. The pilot plant has substantiated the early promise shown by the test rig. According to the scientists now working on the plant, Dr Robert La Nauze and Dr Greg Duffy, it has also shown that colliery waste is a valuable asset because of its energy content, an asset that should be put to use.

The total energy contained in the wastes produced from Australian coal washeries represents about one-sixth of the energy in the mined coal. Going on 1978 figures, that is equivalent to 6 million tonnes of good-quality steaming coal, the scientists calculate. A small washery — treating 400 000 tonnes a year — could put out 35 MW of heat. This could be used to supply power and heat to the adjacent mine, or for coal drying.

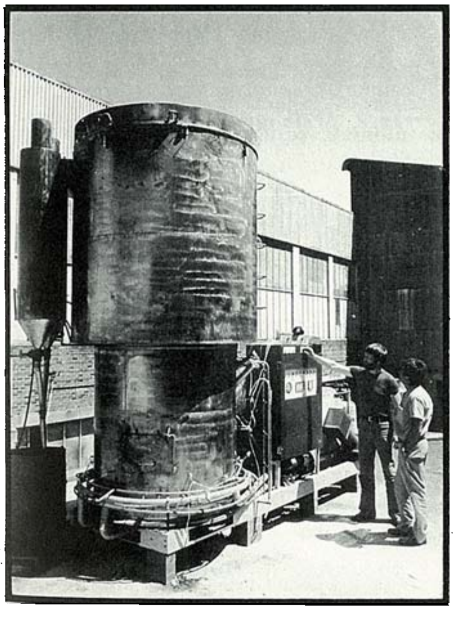
A larger washery processing 4 million tonnes a year (like one proposed for the Hunter Valley, N.S.W.) could recover 350 MW of heat or generate 120 MW of electricity. This is more than half the power supplied by Newcastle's Shortland County Council.

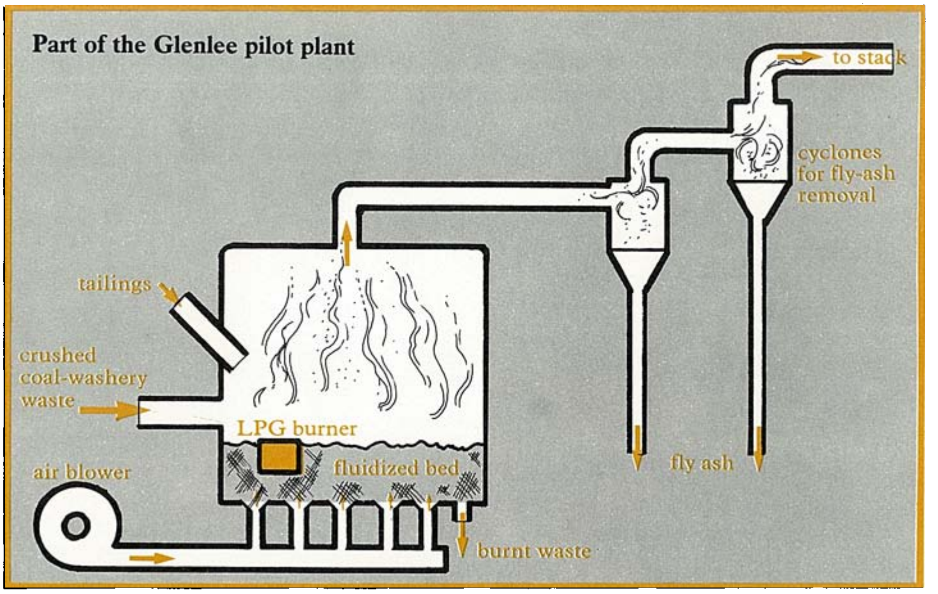
Dr La Nauze envisages that a power station run on coal-washery waste could serve a large aluminium refinery. Even the small pilot plant has a rating of 4·5 MW of heat. This is with the tailings thickened to 35% solids and burnt with small additions to the coarse fraction. The tailings, normally a soup containing about 95% water, need to be thickened to at least 12% solids in order to get some heat output from burning the coarse rejects and the tailings in the proportion (85:15) produced by a coal washery.

Recent work with the pilot plant has shown other pleasing results. Because of the low combustion temperature (around 850°C), the plant releases very little of the harmful oxides of nitrogen and could, with the addition of limestone, be used to burn wastes that have high sulphur contents. Other undesirable by-products of coal burning, such as alkalis, are also at a low level.

The National Energy Research, Development and Demonstration Council has given high priority to work on the

A 1-square-metre Pyrecon combuster.





The LPG burner provides heat during start-up. After the normal operating temperature is reached, combustion in the fluidized bed is self-sustaining.

substitution of coal for oil in industrial furnaces and boilers. This strengthens the scientists' conviction that with fluidized-bed combustion they are on the right track.

The next step is to install heat exchangers in the pilot plant to quantify in detail the amount of recoverable energy. Tests on wastes from other washeries are also planned.

Burning other wastes

If lumps and slurries of coal waste can burn, then many other sorts of waste can too. In 1978, Flameless Incineration Pty Ltd installed a test fluidized-bed plant at the Brisbane abattoirs. It has demonstrated an ability to burn a wide range of abattoir wastes and supply good quantities of steam.

Another company, Pyrecon Pty Ltd, is marketing fluidized-bed combustors embodying novel features developed and patented by the Division of Process Technology team. Two of the company's 'pyrofluidized waste converters', as it calls them, are now in service.

The larger, a unit with a bed area of 4 sq m, can consume 2 tonnes of rice hulls an hour. It is operating at one of the rice mills of the Ricegrowers Cooperative Mills Ltd at Leeton, N.S.W. This company produces 130 000 tonnes of rice hulls a year, and their disposal by dumping and burning is a costly exercise. Rice hulls are so very light that a large truckload weighs but 7 tonnes.

If this first unit performs as expected, the company plans to buy more to cope with its waste production. It hopes to recover the heat generated — 7 MW from each unit — for drying and heating.

A smaller unit, with a bed 1 sq m in area, is burning petrochemical residues at the Seven Hills works of Drum Reconditioners (N.S.W.) Pty Ltd. It can consume 900 litres of liquid waste, or 0·5 tonne of solids, each hour.

The dregs from 200-litre drums — some 3000 a day come in for cleaning and refurbishing before going back into service — are tipped into settling tanks. The oils that float to the top are pumped to a conventional boiler to produce steam used to heat wash and rinse liquors. The material at the bottom is incinerated in the new fluidized-bed combustor.

A Melbourne company has another 4-sq-m unit on order for the disposal of paint wastes. Again, the company is in the business of refurbishing 200-litre drums, but its aim is to accommodate the needs of paint-manufacturers for disposing of their waste. It estimates that Melbourne at the moment holds some 10 000 200-litre drums full of such waste, waiting around for someone to take them away.

With its fluidized-bed combustor the company hopes to get rid of the waste — and get hold of more drums. It calculates that a single combustor should be able to burn all the paint waste generated in Melbourne. As a bonus, it plans to use heat from the combustor to produce steam.

Pyrecon has a pilot-plant combustor at its factory in Sydney, with which it has demonstrated that feedstocks as diverse as gellified resins, spent coffee grounds, waste rubber and plastics, sewage sludge, caustics, and orange peel can be satisfactorily incinerated. (Actually, fresh orange peel will not allow sustained combustion; it needs to be pre-dried.) The company says the automatic controls built into its units will allow such 'fuels' to be burnt without further attention after start-up.

Wood waste to charcoal

Charcoal is probably best known as a barbecue fuel, although older people will remember its use in gas-producers on vehicles when petrol was in short supply during World War II. But it is also a high-grade smokeless fuel suitable for industrial purposes. Dr Paul Fung of the CSIRO Division of Building Research is investigating the possibilities of using fluidized-bed combustion to turn sawmill residues into this commodity. Heat available from such an operation could also be put to good use.

Of the saw logs removed from forests, only 40–50% ends up as timber. That means that more than 5 million tonnes of off-cuts, bark, and sawdust are produced annually. Unlike the softwood mills, which integrate their operations with industries that make paper or particle board, mills working with hardwood generally incinerate or dump their residues.

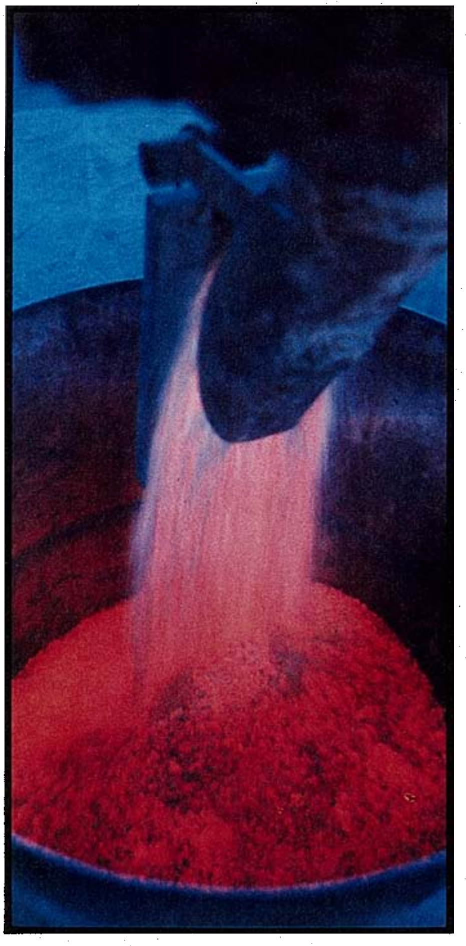
It shows good promise of allowing timber mills to dispose of their waste, supply energy for their operations, and provide a saleable product.

Exceptions exist where a woodchip export outlet is close by or local demand for firewood is significant, but by far the major portion of the residues is disposed of. It costs too much to transport the waste any distance.

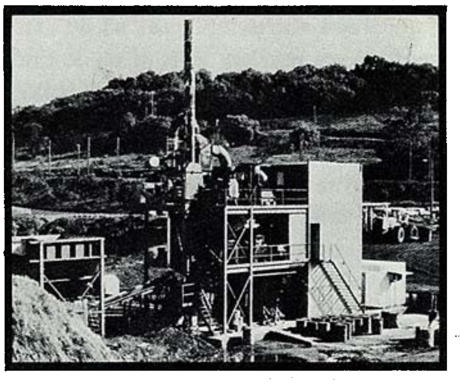
Dr Fung considers that fluidized-bed combustion shows good promise of allowing mills to dispose of their waste, supply energy for their operations, and provide a saleable product.

If all the nation's timber mill residues for a year were utilized in this way, they could produce 910 000 tonnes of charcoal, 940 million kilowatt-hours of electricity, and 8000 million megajoules of process heat. Some 13% of the total energy used by mills comes from petrol and diesel fuel, and charcoal could possibly be used as a substitute.

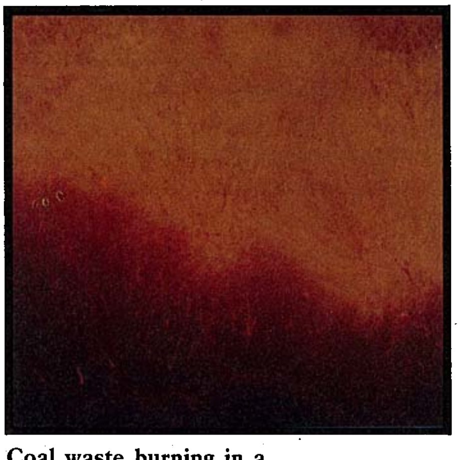
A typical hardwood mill, which cuts 22 000 cubic metres of logs a year, produces 72 tonnes of waste daily. Some 12 tonnes of charcoal could be recovered from this waste, as well as some 287 000 MJ of heat — more than enough to season all its timber and generate its total electricity needs.



Burnt-out ash flowing from a fluidized bed.



The pilot plant for burning washery waste at Glenlee.



Coal waste burning in a fluidized bed.

Within the timber industry, wood-fired fluidized-bed furnaces have already become commercially available for steam-raising. The potential exists to significantly increase their usefulness. Dr Fung has experimented with a laboratory-scale rig (15-cm-diameter bed) and is at present in the process of building a pilot plant designed to handle 0·5 tonne of wood waste an hour.

He found that the technique shines in its ability to handle varied types of residues with moisture contents up to more than 100% for green wood. (The moisture content is derived by comparing the weight of the moist wood with its weight in an oven-dry state.) Operating temperatures of around 500°C are most suitable, he found, giving a good self-sustaining burn without losing too much charcoal.

The yield of charcoal at this temperature is theoretically about 30% of the dry wood, but the actual figure will depend on how long the particles remain in the bed. This in turn will depend on the size of the wood particles fed in — the finer the better (to a limit), as small pieces will promptly be swept up the flue and recovered.

Sawdust is ideal, but chips can be handled if a method of continuously sieving off lump charcoal from the bed is introduced. Dr Fung will be instituting such a system in his pilot plant, and he expects he can recover 80% of the charcoal this way.

Andrew Bell

More about the topic

Burn before burying: an assessment of the utilisation of coal wastes to produce power. R.D. La Nauze, G.J. Duffy, and R. Sanderson. *Proceedings, Eighth National Chemical Engineering Conference, Melbourne, August 1980* (in press).

Carbonization of timber industry waste and heat recovery in a fluidized bed. P.Y.H. Fung. *Proceedings, Seventh Australian Conference on Chemical Engineering, August 1979*, 1979, 130–4.

Cleaning up coal wastes. *Ecos* No. 1, 1974, 11–14.

Fluidised-bed combustion: a state-of-the-art review. R. La Nauze. *Chemical Engineering in Australia*, 1979, 4(4), 20–30. (This issue is devoted to the topic of fluidized-bed combustion.)