ENERGY management
Journal of the Department of Energy
August 1988

Focus ON EEC & IEA ENERGY RD&D

BRITAIN CAN BENEFIT FROM INTERNATIONAL SCHEMES

Energy Management and _Focus_ have over the years given considerable emphasis to the benefits which are being derived from the Energy Efficiency Demonstration Scheme sponsored by the Department of Energy, benefits in the form of grant aid to those who host the demonstrations, benefits to the equipment suppliers and benefits to the nation and to new users when successful projects are replicated.

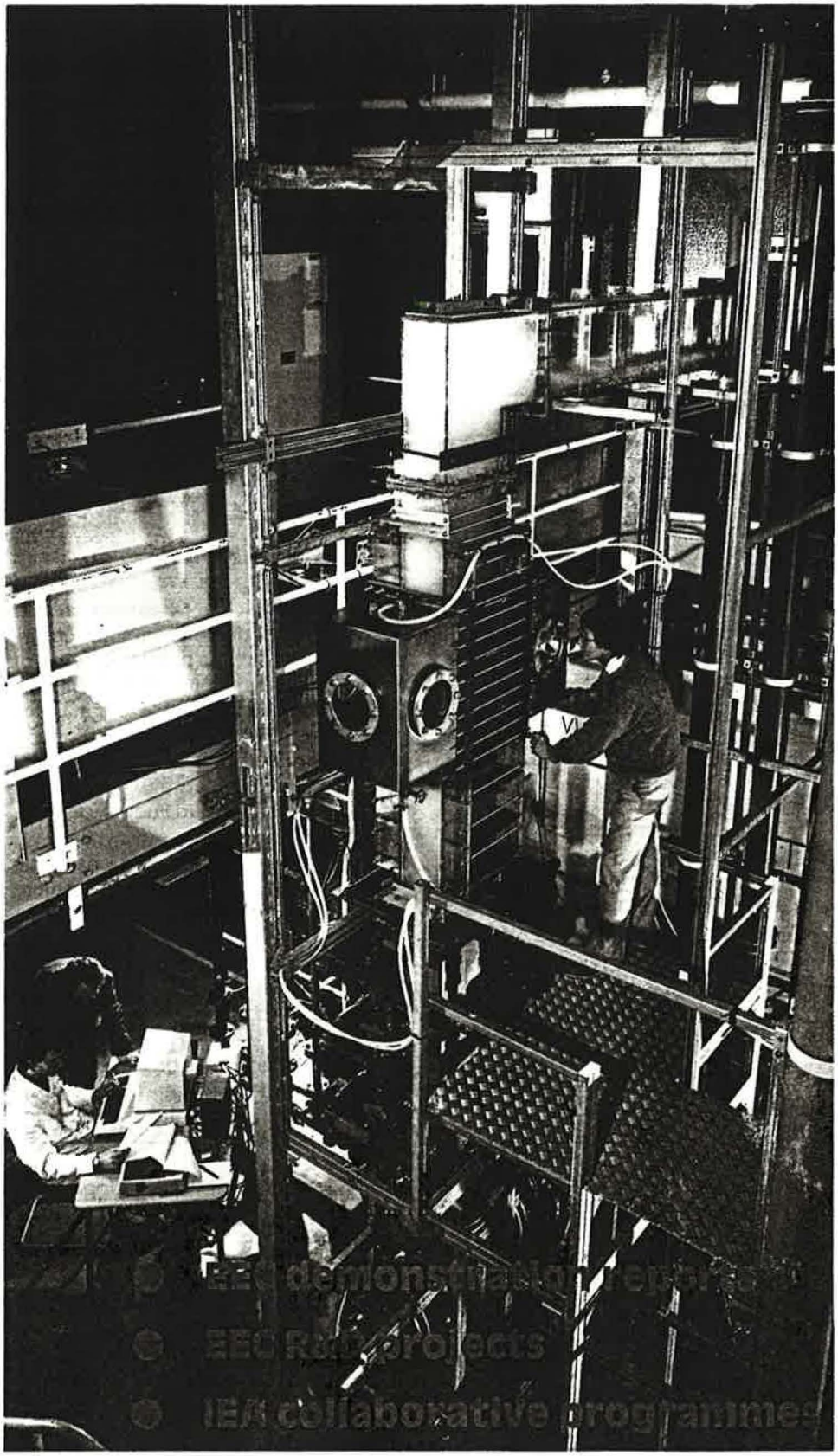
Over 350 projects have now been mounted under the Scheme and over 220 completed. These are well known and many of them have been featured in our pages.

However, the benefits which can be obtained from international programmes are less well known, benefits from the results which are available from them and benefits from the opportunities they offer for collaboration and for project support. Technology knows no national boundaries. Developed countries may differ in their access to energy sources and to some extent in their energy requirements and practices, but there are broad similarities in end use. Well over 90% of relevant RD and D is done in countries other than UK. Britain can gain from international collaboration and we have much to contribute to it.

This issue of _Focus_ concentrates on the UK participation in the RD & D programmes of the European Communities and the International Energy Agency. These major collaborative programmes, which have been running for many years, have provided much valuable information. They present considerable opportunities for future work and, in the case of the Communities programmes, for direct funding and financial support — over 750 million ECU (£500M) has already been made available for demonstration projects alone.

Many UK organisations are engaged in these programmes. Many more organisations and companies could benefit from them. This issue of _Focus_ aims to stimulate the imagination and prompt companies to give serious thought to participation in the near future.

(21)



THE ENERGY DEMONSTRATION PROGRAMME OF THE EUROPEAN COMMUNITIES

by Dr Ken Linacre, Energy Technology Support Unit

The Commission of the European Communities (CEC) has supported the demonstration of the technical and economic benefits of new technologies and new applications of technology in a series of four-year programmes which started in 1978.

These programmes have been administered by the Directorate General for Energy DGXVII. The current programme provides for funding of 360 million ECU (approximately £240M) over the period 1986-89.

There have been a number of developments in the range and scope of the programme, in its terms and conditions and in details of its administration since it began, but its broad objectives have remained the same, to help industry and other energy users to accept and take on the risk involved in adopting new and unfamiliar energy practices in the normal running of their businesses and to encourage others to take up the benefits which have been demonstrated with the help of the Commission's support.

The programme is broadly concerned with the Rational Use of Energy, and covers four main topics:

- Energy Saving
- Alternative (or Renewable) Energy Sources
- Substitution of other fuels for the use of Hydrocarbons
- Liquefaction and Gasification of Solid Fuels

In the period 1978-87 the Commission offered over 760 MECU in support to some 1,450 projects selected from approaching 5,000 proposals received.

Not all of these projects have proceeded and on some offered support in recent years contracts are still being negotiated. Over 300 projects have been completed, of which about 50% are considered to be successful, with potential for replication, 30% partially successful and 20% unsuccessful. A large number of the projects have already been successfully replicated.

While the objectives of the Commission's demonstration programme are broadly similar to those of the UK Energy Efficiency Demonstration Scheme, there are significant and important differences.

The Commission support is given, for preference, to the equipment supplier, since it is in his natural interest to seek further replication of successfully demonstrated technology in the normal pursuit of his business. Sometimes it is preferable if the user leads a project team. The Commission will give support to the user, if he is partnered by the supplier in the project, or if the user can show how replication of the use of the technology will be pursued if the project is successful.

The support offered is up to 40% of eligible costs. (Capital and monitoring). All projects must have a monitoring phase to an agreed adequate programme. However, independent monitoring is not required — but the proposer may do the monitoring himself or subcontract it.

Projects must demonstrate new equipment or technology, a new application or a new combination of established technologies. Considerable emphasis is placed on this requirement. Projects must be at full economic scale. Support is given to pilot plants in the Liquefaction and Gasification of Solid Fuels sector, but not in other sectors.

Projects must be a true demonstration with the new technique or equipment used in a real commercial application. Evidence is required from R&D studies or feasibility studies that that stage has been reached. Support will not be given to projects which are adjudged to be R&D or field trials.

Evidence is required on the economic performance expected, and the payback time must be acceptable to the sector concerned and likely to encourage replication. **We find that larger payback times than users would require in the UK are often acceptable in other Community countries.**

The project must lead to significant energy savings, energy substitution or energy generation, with evidence of good prospects for replication. However, there is no target figure which must be met nor is any "gearing ratio" used to determine the support given in relation to the expected benefits.

Projects which involve cooperation between companies or organisations in different member states are welcomed, but such cooperation is not a condition of support.

Projects which offer environmental benefits are also welcomed and considerable weight is given to this.

Proposals must establish the technical and/or economic risk which they present, which justifies their support by the Commission and without which they are unlikely to proceed.

The Commission issues a call for proposals annually. In recent years the call has been published at the end of the year, and proposals have been submitted in the following April. The proposals are evaluated and the Commission announces which it is prepared to support, generally in

	Projects Selected	Allocated Support MECU
Energy Saving	571	244
Alternative Sources	720	217
Substitution of Hydrocarbons	114	175
Liquefaction & Gasification	50	194
	1,445	764

Table 1 Distribution of support between sectors in the Demonstration Programme

SECTORS ATTRACTING SUPPORT

Energy Savings
- — in industry
- — in buildings
- — in transport
- — in agro-food industries
- — in energy industries

Biomass and Energy from Wastes

Wind Energy

Geothermal Energy

Hydroelectric Power
- — small scale systems up to 3MW

Liquefaction and Gasification of Solid Fuels
- — i.e. coal, lignite and peat

Substitution of Hydrocarbons (gas and/or oil) by:
- — use of Electricity and Heat
- — use of Solid Fuels (coal, lignite and peat)

November, though results in the solid fuels sector are usually announced earlier.

Each year the Department of Energy supports the call for proposals by issuing a booklet containing advice on making an application, together with the application form and the Commission notes for guidance. These notes and the form can also be obtained from Brussels. The detail of the areas to be supported can change from year to year so it is important always to have the right documents. Advice is available from the Department and from its support units, Energy Technology Support Unit at Harwell Laboratory and Building Research Energy Conservation Support Unit at Building Research Establishment, Watford.

For advice contact:

General Enquiries
Dr. S.E.R. Hiscocks, Department of Energy, Thames House South, Millbank, London SW1P 4QJ.
Tel: 01-211-5461
Solid Fuel Sectors
Mr. H.F. Ferguson, Department of Energy. Tel: 01-211-3772
Renewable Energy Sources
Mr. A.A. Hollis, ETSU
Tel: 0235-834621, Ext. 3561
Energy Efficiency
Electricity & Heat
Biomass & Energy from Waste
Dr. J.K. Linacre, ETSU
Tel: 0235-834621, Ext. 3502

They can help you to prepare your proposal and give you advice based on considerable experience of the programme. Applications do have to be carefully prepared, and are best prepared well in advance of the entry date, when the deadline is rigorously imposed. Applications in English now require no material in a second language. If you have a proposal in mind for 1989, discuss it now.

Each year the Commission receives about 500 proposals covering all sectors and from all countries in the Community. These are evaluated by the Commission staff, and are distributed for evaluation by experts in the member states.

They are compared in assessment meetings on each sector, where representatives of all the member states discuss their merits and any changes which may be desirable and advise the Commission on the proposals it should consider for support. The people named above are very involved in this processing of proposals and will be pleased to advise.

The number of proposals submitted by UK organisations is generally smaller than the number from other member states, in relation to our economic performance, energy demand and related factors.

Support is available for private companies, nationalised industries, local authorities, health, water and similar authorities, research organisations or private individuals. Support has been given to well established companies and to companies formed to exploit a new product.

The terms of support are generous and the application procedures, though they require some detailed attention, are not onerous in relation to the support which can be obtained. A number of companies have benefited from Commission support for innovative ventures. Why not you? the Department of Energy will be pleased to advise you if your project is likely to qualify for support and to help you in preparing a proposal.

Advice on Community Energy RD&D funding is available from the Department of Energy. Pictured above (left to right) are advisers: Dr Ken Linacre; Dr Steve Hiscocks; Arthur Hollis; and Fraser Ferguson.

(22)

Where to get more information

Information on the projects in the Commission's demonstration programme is available in three stages.

When a contract is placed on a project, it is entered on the SESAME database. This entry is updated as the work proceeds. SESAME gives a single sheet description of the project, with title, contractor, location, objectives and present "state of play". It is equivalent in content to the EEDS Project Profile, but of course is not illustrated.

The Commission publishes "sectoral catalogues" of SESAME entries, which also contain an analysis of the projects by technology, application etc., and updates these from time to time.

Catalogues are available in the following sectors:

Energy Savings in Industry
Energy Savings in the Agro-Food Industries
Biomass and Energy from Wastes
Wind Energy
Geothermal Energy

Information on SESAME is now available via a publicly accessible service, DATACENTRALEN. Those wishing to make regular use of SESAME should contact:

Mr. Friis,
DATACENTRALEN, Host Centre,
Retortvej 6-8. DK-2500 – Valby,
Copenhagen, Denmark.
Tel: 010-451-758122
The connect hour charge is DKr 600.

Completed and successful projects which are judged to have potential for replication are publicised by means of a "flag brochure", an illustrated, full-colour, four-page sheet, similar to EEDS Expanded Project Profiles. Flag brochures give details of the project with the technical and economic results.

Final reports are also available in the Commission's EUR series.

The Commission also holds workshops, usually at the site of successful projects, to publicise the results to a selected group of people who are most likely to be interested in its replication.

It has recently been agreed that ETSU will act as a "focal point" in the UK for information on the Commission's demonstration programme. ETSU plan to provide up-to-date information on what is available through its normal channels of communication, such as events, Energy Management, Review etc. BRECSU will handle information in the buildings sector. However, ETSU will not handle supplies of the Commission's publications.

For further information you may wish to write to:

Commission of the European Communities,
Directorate General for Energy – DGXVII, rue de la Loi 200, B-1049 Brussels.

contacting:

Theo Van Rossum	(Workshops)
Hugh Finlay	(Workshops)
Viviane Deveen	(Publications)
Martine Lecomte	(Publications)
Linda Van Malderghem	(SESAME)

(23)

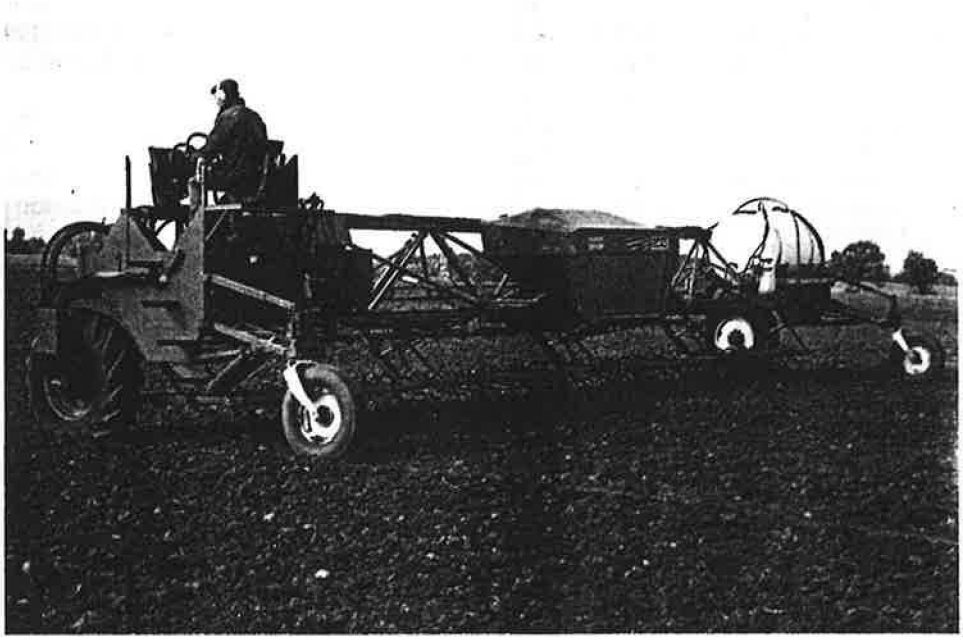
British invention saves energy in agriculture

Producing crops on a field "bed system" offers many advantages. The ground is worked only to the minimum extent necessary for crop cultivation. By avoiding travelling over the actual seed bed or growing crop with heavy machinery, the soil structure is maintained. Further, the energy required for crop cultivation is much reduced.

In order to achieve these advantages, Mr David Dowler invented and developed the prototype Gantry System, which he has used successfully over several seasons at Stamford Hall Farm, in Warwickshire, where he grows some 100 hectares of cereals. This has shown fuel and oil savings of at least 50 per cent over conventional cultivation or equivalent to 7.16 tonnes of oil/year per 100 hectare.

Although there has been wide interest in this concept, equipment was not available. Dowler Gantry Systems Ltd has been formed to manufacture and market the gantry and the EEC supported demonstration project mounted to allow other farmers to confirm the energy savings and other benefits in cultivation of arable and vegetable crops. AFRC Institute of Engineering Research, Silsoe, will continue its interest in the equipment by carrying out the monitoring programme.

This development could be a milestone in agricultural mechanisation with one energy saving machine/system able to cultivate, sow, fertilise and spray arable and vegetable crops – an economically attractive prospect.



The prototype of the Dowler Gantry System in use. The demonstration/production machine will be restyled and will contain several refinements. Enquirers should contact Dowler Gantry Systems Ltd, Stamford Hall Farm, Pillerton Priors, Warwick.

SYSTEM

The Dowler Gantry System consists of a steel triangular cross section truss 12 metres long, which has a steerable driven and an undriven castor wheel at each end. The drive wheel can be rotated 120 degrees around a vertical axis, to allow travel and steering in a lengthwise mode and the castor wheels can be brought closer to the space frame to reduce the travelling width to under three metres.

The driver's cab is located above and at one end of the frame. The 65 kW Diesel engine is located within the frame at the cab end, together with associated hydrostatic and hydraulic pumps and an oil reservoir to provide hydraulic service for steering, fertilizer and spray motors. A spray tank is mounted at the opposite end. Facility for mounting a pneumatic fertilizer spreader is provided as are link-ages beneath the frame for attaching the cultivation equipment.

Braking on the move is provided solely by control of the hydrostatic circuit, but at rest, a park brake can be released onto each drive wheel.

Output from the variable-displacement pumps to the wheel motors is controlled by a steering wheel/joystick in the cab. In the field mode the drive wheels are effectively locked at right angles to the lateral axis of the frame and steering of the vehicle is achieved by differential speed of the wheel motors. One wheel is held stationery — the other driven at speed to begin a new bed. Alternatively, both wheels can be turned to "shuttle" along the headland.

In the transport mode the driven wheels can be pivoted independently and their rotational speed, either forward or reverse, controlled independently, thereby making it extremely manoeuvrable, easily turning within its own length.

Its unladen weight is approximately three tonnes.

The hydraulically linked cultivator attachment arms enable the cultivator to follow variation in ground contour whilst maintaining precise depth control.

DEMONSTRATION PROJECT

As the central mechanical component in a total system of cultivation, the Dowler Gantry can be used for tillage operations, seed-sowing, fertiliser spreading and spray operations.

In contrast to the seed bed, the actual wheelways in the field become compacted permanent paths and enable the Gantry to move easily and at speed even in what would be considered as "wet" conventional field conditions.

This factor enhances the energy saving features of the system and the combination of reduced tillage requirement and improved work rate have led to fuel and oil savings of at least 50 per cent over conventional systems. The ease and speed of work also contributes to the scope for indirect energy savings in fertiliser and chemicals.

In the demonstration a more detailed assessment of energy saving will be made with a wider range of crops and under differing soil conditions.

Two of the demonstration machines will be located on farms in Kent and Lincolnshire for the whole of the "Field-use" stage. This will enable their use to be measured during a complete cropping season. It is likely that the crops involved will be a mix of cereals, sugar beet, potatoes and field vegetables.

The third demonstration machine, which will be sited at Stamford Hall Farm, in Warwickshire, will undergo measurements for work carried out at this site. It will also be used for temporary placing at perhaps two or three locations during the period for additional demonstration work.

Independent testing and services will be provided by the AFRC Institute of Engineering Research.

(24)

New energy efficient cupola proved

Stanton PLC, replaced three existing iron melting cupolas at its central melting plant with one new energy efficient cupola incorporating a joint application of German and U.K. technology. With the introduction of a new hot blast cupola at the central melting plant at the Stanton Iron Works, the company has demonstrated its determination to reduce process costs and remain comptitive in a fierce international market.

The project is to some extent a Community project in that equipment and know-how has come from a number of EEC countries including: Luxembourg; Belgium; West Germany; and the U.K.

The rapid change of technology is such that the new cupola has replaced three cupola's which less than 20 years ago were considered to be in the forefront of technology. Two major innovations are combined in the development. Subtuyere oxygen injection which was jointly developed by Stanton and British Cast Iron Research Association, and the long campaign lined cupola with dirty gas recuperation which was developed by Dr. Kuettner & Co. GmbH.

PROCESS

At Stanton, scrap metal, coke, ferrosilicon and limestone are fed into the top of the cupola through an above gas take off charging chamber where they are heated countercurrent with ascending hot combustion gases. After reaction, hot metal is drawn from the base of the vessel to serve three pipe plants. To improve the energy efficiency of holding metal at high temperatures and throughput, the melting zone is lined with special high temperature refractories and oxygen is injected below the main tuyeres where the preheated air enters the cupola.

A further feature is the high shaft which improves heat exchange between the burden and the hot gases. Unlike the earlier cold blast cupolas the new one is designed to operate for up to three weeks continuous operation without the need to repair the refractory lining. With oxygen injection and the resiting of the waste gas offtake below the charge door the waste gases leaving the cupola now contain 15 per cent carbon monoxide. This is burned in a combustion chamber into which additional air is blown and the hot gases at 800° are fed into a new hot dirty gas recuperator which preheats the air to the tuyeres.

Not only is the potential heat in this now recovered, but the carbon monoxide (CO) content is reduced to the levels recommended in the latest EEC directive relating to CO emission. Special attention is also given to cleaning the exhaust waste gases before discharge to the atmosphere.

This oxygen injection gives additional benefits of rapid start up and temperature recovery after a stoppage.

An outline of the operation of the cupola is shown in Figure 1.

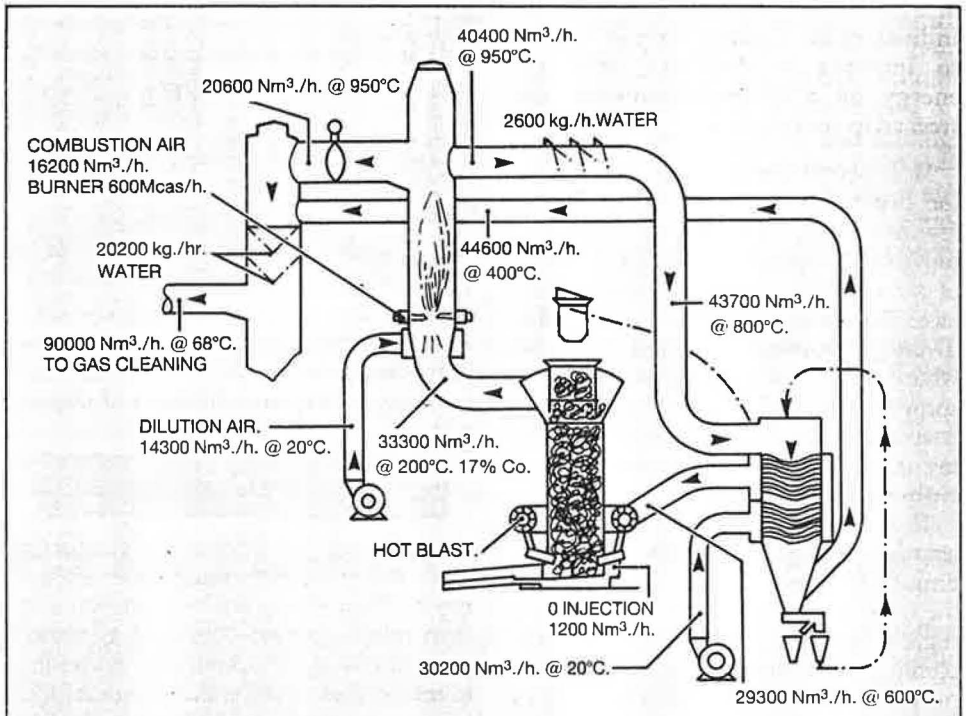


Figure 1. PROCESS FLOW RATES APPLY TO 65tph MELTING RATE.

BENEFITS

The design and operation of the new cupola produces a number of benefits apart from energy saving some of which are more difficult to quantify, but in total they will significantly improve the overall payback time. One of the characteristics of the new cupola is higher tapping temperatures of the liquid iron. These high temperatures increase carbon pick up which may lead to usage of cheaper metallic charge materials and additives.

Other important features include:-

- The refractory lining in the cupola melting zone greatly reduces the heat loss to the shell.
- Higher metal tapping temperatures reduces post tapping treatments such as superheating and recarburising thus saving on electricity costs.
- More flexibility in melting rates to match downstream requirements.
- Silicon losses are reduced.

ECONOMICS

The capital costs of the project were calculated to give a payback in simple terms of 3.2 years. Looking at the figures from the accountants point of view using DCF techniques and carrying out a sensitivity evaluation the following applies.

Assuming a 15 year life for the plant the Internal Rate of Return excluding EEC aid was 29.05 per cent and this fell to 4.57 per cent if the project was not successful. If one takes into account the EEC grant the figures become respectively 37.84 per cent and 8.39 per cent, the improvement in the latter figure making the technical risks more acceptable.

(25)

The cost savings accrue from:	%
Cupola coke	38.8
Carbon benefits	
Recarburisers	4.2
Hotter metal*	5.6
Reduction in silicon losses	11.1
Oxygen	29.8
Electrical power	7.2
Gas	–3.5
Refractories	6.8
	100.0

* Electricity savings

Steel floats on air in new coating line

The principle of the Hovercraft is used in a new oven developed by Spooner Industries for Coated Strip of Walsall to improve productivity and save energy on a 60 metres/minute new steel strip coating line.

Most people are aware of the air cushion principle as used in Hovercraft but few are aware of its use in industry to move heavy loads or to provide cushions of air to prevent contact between surfaces. This project extends this technique to the production of coated steel strip where the surface of the steel can be sprayed top and bottom with a suitable coating and during the coating and drying stages the strip is suspended on a cushion of air.

The process is carried out in what are termed catenary ovens whereby a continuous web of material passes through the oven supported by air jets spaced at regular intervals to prevent the material coming into contact with the floor of the oven and thus spoiling the coating. Prior to this development this technique has only been applied to paper, textiles and lithographic printing.

DEMONSTRATION

Coated Strip Ltd of Walsall, specialists in the coating of metal strip, teamed up with Spooner Industries of Ilkley, a market leader in web processing technology and Integrated Energy Systems Ltd, Preston, to submit to the EEC a proposal for an Energy Demonstration Project grant in respect of a process line incorporating an air flotation oven with heat recovery. The system can handle double sided coated webs of all weights and avoids the problem of sag between rollers and underside sweating which were features of earlier systems.

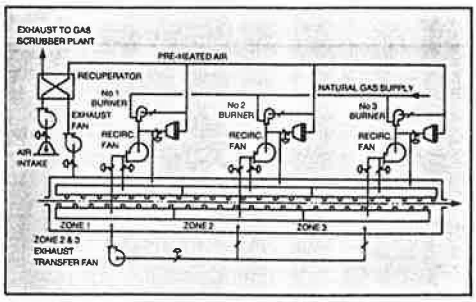


Figure 1. Flow diagram.

OVEN DESIGN

The oven, see Figure 1, consists of three independent heating zones each 6 metres long where solvent removal and strip heating occurs. The zoning system gives flexibility for optimising conditions in terms of air velocity and temperature. In conventional catenary ovens the air gap is 400mm to cater for the catenary sag between rollers but with the air cushion the gap is maintained at 75mm as there is no sag. This is achieved using a design of two parallel air injection slots which prevents flutter and instability and not only enables the product to float but increases the heat transfer rate considerably.

One problem to be overcome was better control of the air flow, the fitting of air nozzles at 750mm pitch has enabled the oven to be fitted with a heat recovery recuperator in the exhaust outlet for preheating the ventilation air.

The opportunity was taken with the introduction of the new air cushion technique and zone firing to incorporate a recuperator in the exhaust duct to the scrubber plant and thus improve the energy efficiency of the oven.

Figure 2 shows a Sankey diagram of the energy flows and projects a design thermal efficiency of 39 per cent, a major improvement as compared with the 13 per cent obtained on the old catenary oven. In practice a figure of 31.9 per cent was obtained, the shortfall arising from over ventilation of the oven. Steps are being taken to reduce over ventilation and reach the design figure.

At the design efficiency of 39 per cent the total energy savings will be 324 tonnes oil equivalent (TOE) per annum of which gas savings will be 360 TOE some of which will be partly offset by increased electricity usage which after taking into account of losses in generation will amount to 36 TOE.

The annual savings in energy costs will be £43,128 which gives a payback on the total costs of the scheme of 5.9 years. If the EEC grant is taken into account the payback becomes 3.5 years.

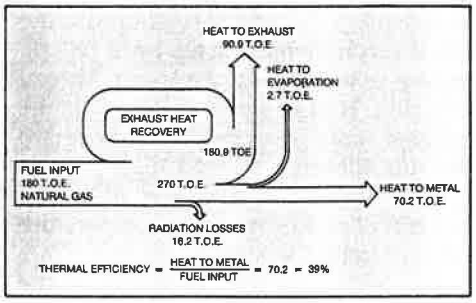


Figure 2. Air flotation oven with heat recovery — heat balance.

(26)

Tumble dryer controls improved

Leicestershire Health Authority is carrying out trials on improving the control of laundry tumble dryers which could lead to reduced energy and subsequent proccessing costs. In the NHS laundries alone, the potential savings through better control is estimated at £600,000 p.a.

Standard batch tumble dryers are operated to remove a specific amount of water so that the fabric is in a suitable condition for the next activity, usually ironing. The machines are batch loaded and the drying time controlled with simple timer controls. The tendency is to set the timer to ensure all fabrics are dry irrespective of their initial water content or type of fabric. This can lead to overdrying and a waste of energy.

Until recently it has not been possible to monitor moisture removal with sufficient accuracy and dynamic response to achieve the optimum conditions.

Three parameters control the drying process, these are:

- Relative humidity
- Flow of air
- Temperature

The rate of change of these parameters during the drying cycle is shown in Figure 1.

PROJECT

Leicestershire Health Authority in conjunction with the GEC Engineering Research Centre at Whetstone obtained an EEC Energy Demonstration Project grant for investigating the improvement of the tumble dryer.

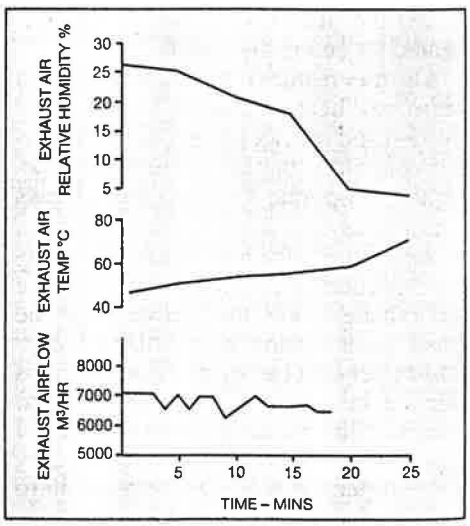


Figure 1. Variation of exhaust duct parameters Ortex 741S1 batch dryer.

The objectives of the project were:

- To incorporate moisture extraction measurement rates in a range of three representative types of laundry batch tumble dryers.
- To carry out a detailed monitoring exercise on each dryer, to establish the effectiveness of the moisture extraction control system in achieving energy saving over a period of at least six months.
- Following the monitoring study, to assess and report on the cost effectiveness and reliability of the system.
- To demonstrate the possibility of obtaining energy savings of 24 per cent as compared with a conventional control system.

The technical features included in the proposal included an advanced humidity sensor, true averaging of flows across the dryer duct, auto purging and fault monitoring. A microcomputer/logger is used to ensure flexibility of the operation and to record data.

Different fabrics have differing moisture retention levels and the project covered at least three types of fabric, namely light and heavy cottons and synthetics such as polyester.

COST BENEFITS

The economic evaluation was divided into two parts, the first relating to the demonstration project itself and the second to replication. The latter is a most important element in obtaining EEC support and in the case of this project, the results could be applied to laundries throughout the EEC.

Taking the project first, the demonstration phase was expected to cost £9500 whilst the saving in energy attributable to the improved control was £750 p.a., however a further saving of £1000 p.a. would be gained through the reduced cost of calendering, towel folding and folding because the moisture content of the dried fabrics would be the optimum for these operations. Thus savings of £1700 would be achieved for a cost of £9500 representing a payback of 5.4 years.

However on replication the cost falls sharply to £1300 and the payback on energy alone would be 21 months. If one includes the other savings the payback becomes only nine months.

(27)

Motor vehicles to run on landfill gas

New membrane techniques developed by Monsanto, are planned to be used in an Enercol Energy Systems Ltd scheme to purify landfill gas for use in Lancashire County Council motor vehicles.

Developments in the management of landfill sites has seen a growing realisation of the potential of domestic waste as a source of combustible gas. There are a number of places in the U.K. where exploitation and development of landfill sites is proceeding to produce combustible gas which is either being burned in boilers or used in a gas turbine for power generation. For combustion, the gas does not require much purification but if it were to be used on a commercial scale in petrol or diesel engines the gas would have to be purified to exacting standards if problems with combustion within the engine were to be avoided.

MOTOR VEHICLES

Enercol Energy Systems Ltd, a company jointly owned by Lancashire County Council's Lancashire Enterprises Ltd, Amercoeur Energy Plc and John Harwood applied to the EEC for an Energy Demonstration Project Grant in respect of a purification system for landfill gas which would enable the purified landfill gas to be used in petrol and diesel engined vehicles. Landfill gas consists primarily of 40-50 per cent carbon dioxide (CO_2) and 50-60 per cent methane (CH_4) on a dry basis which burns quite well in boilers and burners but for vehicle engines the proportion of methane must be raised to 90 per cent or better or the inert components will reduce both the power and the efficiency of the engine.

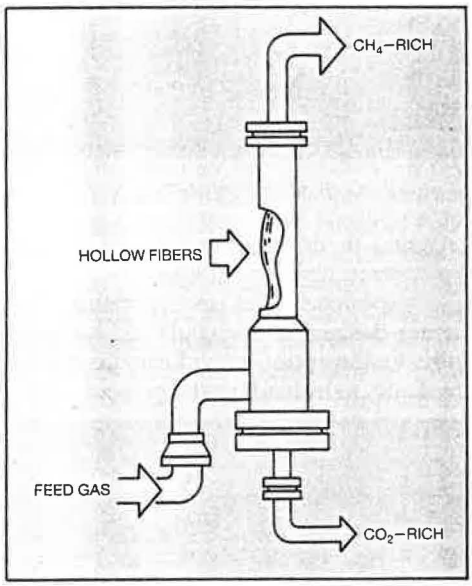


Figure 1. PRISM® separator

The key to the purification system is the use of recently developed hollow fibres which are permeable to carbon dioxide and impermeable to methane. Using this technique the incombustible CO_2 is removed from the gas and the calorific value raised.

PRISM

PRISM is the trade name of the hollow fibre gas separator developed by Monsanto and is shown schematically in Figure 1. The landfill gas under a pressure of 25kg/cm^2 is passed through a bundle of hollow fibres installed into a vessel with special end seals. The fibres which are akin to molecular sieves are more permeable to CO_2 than CH_4 which hence diffuses through the fibres leaving the landfill gas richer in methane. By using multistage and recycle techniques it is possible to raise the methane content of the gas to better than 90 per cent thus making it suitable for internal combustion engines.

ECONOMICS

The overall scheme for using the landfill gas includes provision for the gas to be piped 10 km. from the landfill site to the point of use on the Riverway Industrial Estate on Preston Docks. The original scheme for which an application to the EEC for grant aid was made included a gas fired CHP plant and compressed natural gas (CNG) vehicle fuelling station at a total estimated cost of £2.8 million.

The economic evaluation of the vehicle fuelling scheme is based on extracting 500,000 therms (52,750 GJ) of landfill gas which will be upgraded sufficiently for running vehicles. This is equivalent to 1,362,000 litres of petrol in thermal value.

Diesel engines can be converted to run on a mixture of natural gas/diesel fuel but maximum economy is only obtained at high engine speed/high torque conditions such as motorway driving. At the present time dedicated gas or dual gas/petrol engines are the most economic for general duties.

The overall cost of the upgraded gas is calculated to be 18.6 p/litre which compared with the cost of petrol at 37.4 p/litre gives a saving of 18.8 p/litre. This will give a total annual saving of £263,411. The annual operating and maintenance cost are estimated to be £65,000. For the demonstration plant the estimated payback time is 5.3 years. It is expected, however, that the payback will reduce to approximately three years for replicated plants.

(28)

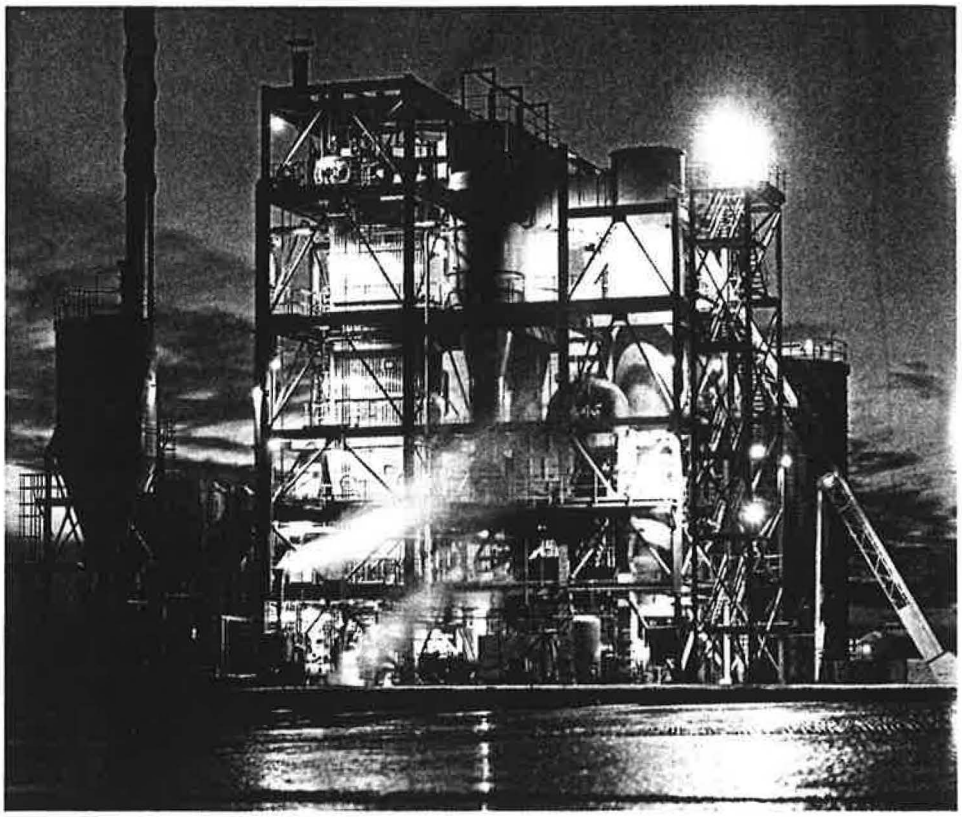
Fluidised bed boiler technology extended

Circulating fluidised bed (CFB) technology has become very important due to the need for power stations to abate the emissions of sulphur and nitrogen oxide pollutants. Multisolid fluidised bed technology (MSFB) however, brings the additional benefits of extremely wide fuel flexibility, ease of control and wide load turndown range to CFB technology.

For these reasons Foster Wheeler Power Products believes that economic application of MSFB technology can be achieved for unit sizes with steam outputs of less than 40te/h to serve a variety of process and manufacturing industries, enabling solid fuels to be utilised efficiently and economically in place of oil and gas fuels.

In a joint project, which is receiving EEC support, with ICI, Foster Wheeler has installed such a boiler designed to produce 40000kg/h of superheated steam at 45.0 barg and at 430°C, with a steam turndown to 5000kg/h or a superheat temperature of 430°C at 6500kg/h. The thermal input is designed to be 38MW when firing low quality coal with a boiler efficiency of 90 per cent on a net CV basis. The design level of emissions will meet the provisions of the U.K. Clean Air Act over a wide range of fuel types.

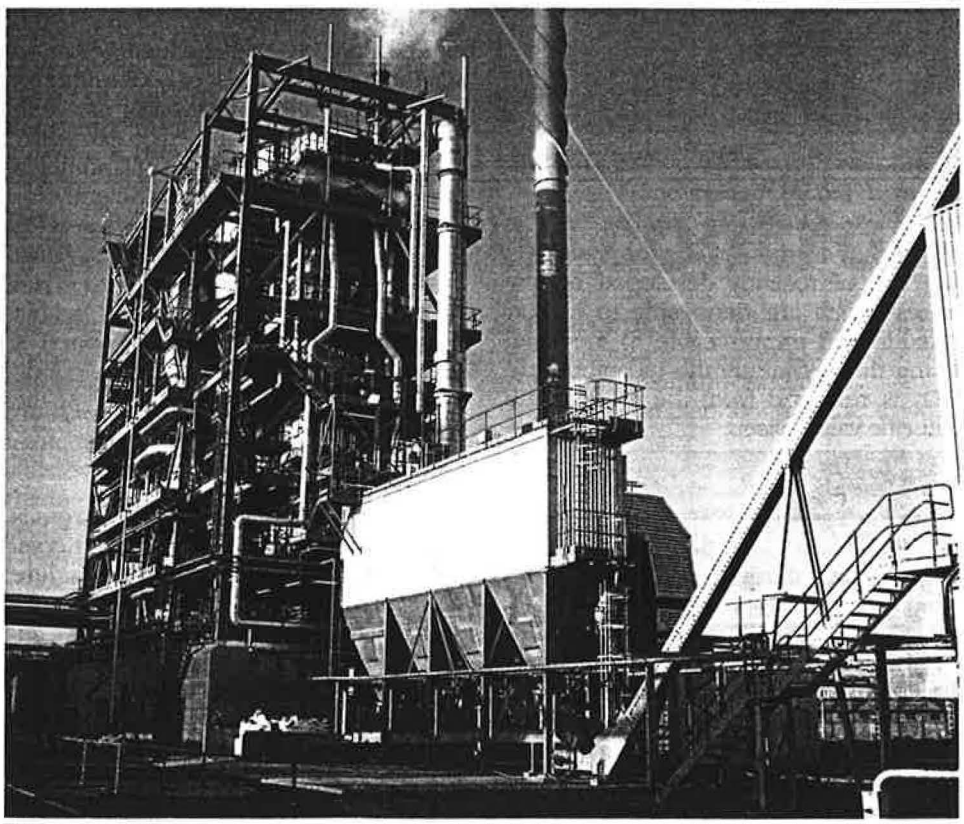
The basic Circulating Fluid Bed Technology is licensed by Foster Wheeler Power Products Ltd from the Batelle Institute of the USA and FWPPL is engaged in developing this technology for commercial applications.



View of 50t/h Multi Solid Fluidised Bed boiler plant at Listowel, Republic of Ireland.

A prototype plant incorporating the Batelle design has been built and successfully demonstrated at the Kerry Cooperative Dairy in Ireland but the present proposal incorporates significant changes in design with the objective of reducing the capital cost and improving the efficiency.

Innovatory features include, an insulated high intensity two-stage combustor, a redesigned air distribution system and an external heat exchanger, which is integrated with the boiler circulating water system. Additionally, techniques for feeding low grade fuel have been improved and a special de-ashing system incorporated. The use of an external heat exchanger avoids many of the problems associated with in-bed tube erosion by the fluidised bed particles.



The Foster Wheeler Power Products Multi-Solid Fluidised Bed boiler plant for ICI, Dumfries.

Combustion

Combustion is carried out in two stages in the combustor, with reducing conditions in the dense fluid bed in the lower half of the combustor reducing the amount of nitrogen oxides. It is anticipated that NOx emissions will be less than 120 ppm when burning fuel containing less than 1 per cent nitrogen. Secondary air above this bed induces turbulence within the gas steam and circulating material and ensures complete combustion. The external heat exchanger and boiler are designed to operate in series incorporating a second bed of inert material fluidised by air. Flue gas recycle is incorporated to provide operational flexibility. The combustor is refractory lined and temperature control is effected by controlling the mass flow solids from the external heat exchanger.

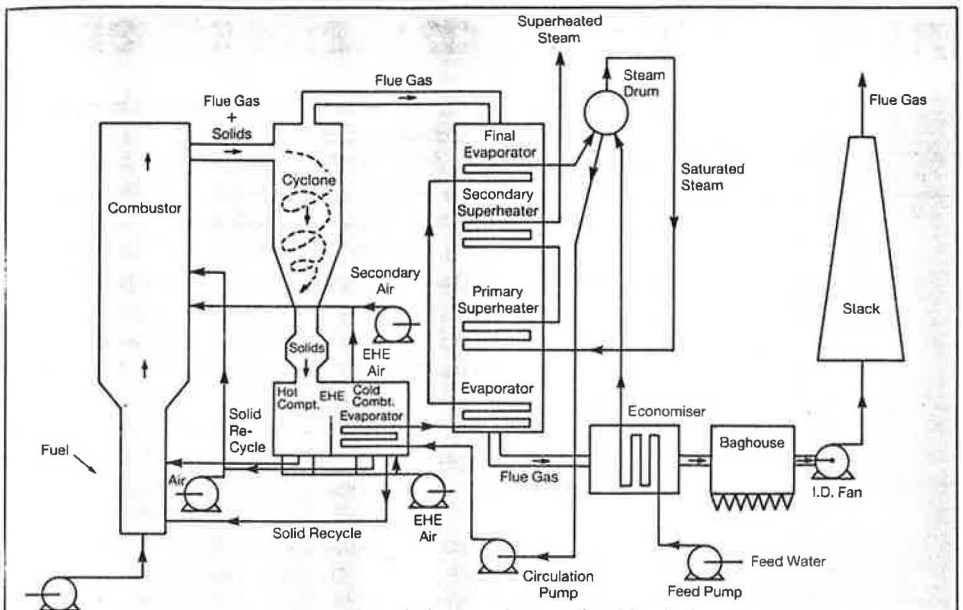


Figure 1 Multisolids circulating fluid bed demonstration project. Typical flow chart – thermal output 31.5MW.

Hot gas cyclones remove over 99 per cent of particulate matter from the flue gases, the solids are returned to the inlet of the external heat exchanger. A schematic of the plant is shown in Figure 1.

The unit is designed to feed a wide range of solid fuels, including coals, peat and factory refuse. Fuel oil can also be used if solid fuel supplies are interrupted. The system's ability to fire "opportunity", low-cost fuels, provides satisfactory pay-back times for commercially oriented steam users, although with the recent falls in oil prices pay-back periods are being extended. The fall in oil prices requires the fuel flexibility attributes of the MSFB system to be fully exploited and Foster Wheeler Power Products considers this technology is a viable and commercial option for steam raising, even at today's oil prices.

(29)

Atomic station to test new coal boiler

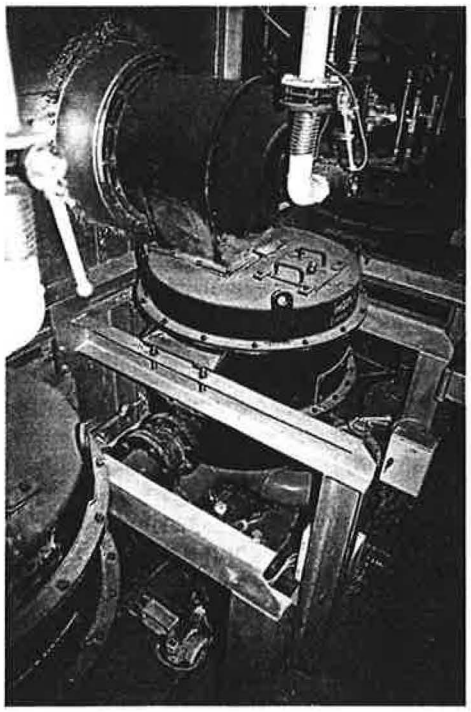
A new design of twin fluidised bed combustor, developed by British Coal in collaboration with Senior Green, of Wakefield is to be used to fire a water tube boiler at the United Kingdom Atomic Energy Authority's Culham Laboratory.

The boiler is to provide hot water for site heating at a pressure of 16 bar and a temperature of 185°C. Thermal efficiency is expected to be in excess of 82 per cent on a gross C.V. basis.

The outstanding features of the new design are, high combustion intensity – leading to a compact boiler unit of low cost potential; the ability to provide fully automatic unattended operation with a high level of control flexibility; high overall efficiency without the need for any form of in-bed heat transfer surface; and, importantly, the capability of providing low emissions of atmospheric pollutants.

This combustion system was developed by British Coal with European grant aid and has previously been demonstrated at the Coal Research Establishment, at Stoke Orchard in Gloucestershire. Based on design information provided by British Coal, Senior Green (a British coal licensee for this technology) have now developed and built this first commercial plant in association with EMS Thermplant as the consultants/managing agents acting on behalf of Culham Laboratories. In recognition of the possible risk in scaling up in size from the pilot plant (3MW) to the commercial unit (8.2MW), assistance with the development costs has been obtained through an EEC Energy Demonstration grant.

The Senior Green twin bed boiler uses the atmospheric shallow fluidised bed principle, the fuel being burned in two stages to increase flexibility and combustion efficiency for a wide range of solid fuels. The furnace section of the boiler consists of two adjacent beds, the first pyrolysing the fuel under reducing conditions with limited air whilst the second bed acts as a char combustor burning with excess air. Transfer of char from the first pyrolysis stage to the second char combustion stage is by ports located near the base of the common dividing wall. The arrangement of the two beds is shown diagramatically in Figure 1). The hot combustible gases from the first stage are then burnt with the oxygen rich gases from the char combustor in a combustion chamber, generating a temperature of 1500°C. The flue gases then pass through a convection section and economiser. A high proportion of the coal ash will pass through the boiler and is removed from the flue gases by a bag filter. Any oversize ash accumulating in the fluidised bed is removed by an air classifier system and conveyed pneumatically to an ash hopper. The combustion system generates low levels of nitrogen oxides (about half of that from conventional fluidised bed combustion) and sulphur emission can readily be controlled, if required, by the addition of limestone to the bed.



2.8MW Senior Green combustor/pyroliser boiler.

As this project is the first commercial scale boiler employing the technology, there are both technical and economic risks and it is not easy to divorce one from the other. However, British Coal feel confident concerning the scale up of the design and have tried to ensure that any risks are minimised.

What is clear however, is that project success will help towards the goal of reducing emissions of pollutants, particularly those that contribute towards acid rain, and will assure a continued future market for coal.

The total cost of the investment at Culham, including the test and demonstration programme is about £1.25M, with equipment and installation costs accounting for £850k.

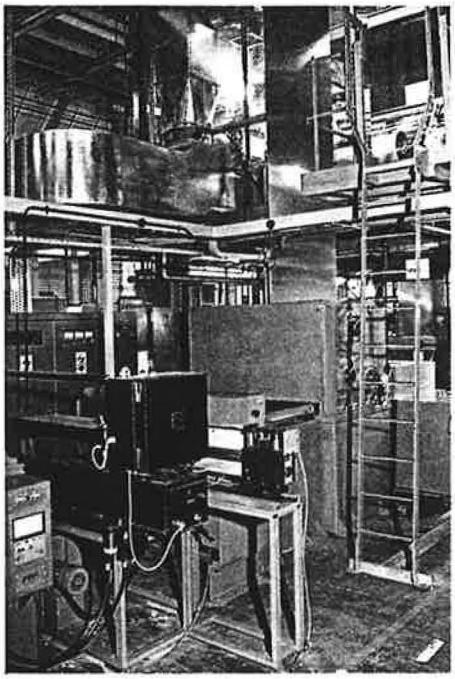
(30)

Thermoplastic polymer for coating of metal sheet

Traditional techniques of coating steel strip for can making involve lacquering the surface using gas fired heaters to set and dry the lacquer. Although electricity is a secondary form of energy and substantial energy losses can occur in its generation from a primary energy source there are a number of process applications where this loss of efficiency in generation is more than offset by improved productivity and high utilisation efficiency.

In this project, development work by Metal Box Research and Development Division at Wantage will lead to the building of a Metpolam lamination facility at the company's Neath, South Wales factory with production commencing by June 1989. The laminated steel will be used for producing standard non easy-open can ends for food cans, easy open ends for beverages and foods, drawn 2-piece food can bodies and components for aerosol cans.

Factors attracting support under the Communities' Energy Efficiency Demonstration Project included novelty of application, collaboration with Oxford University (Department of Metallurgy and Science) in the development of ultrasonic evaluation techniques and participation in the commercial evaluation of Metpolam laminate for packaging by Carnaud of France.



General view of the Metpolam semi-production line at Metal Box, Wantage.

Metpolam is a new product in which a protective polymer film is bonded to sheet metal to enhance the performance of the metal substrate used in making drawn cans, ends and can components.

Steel feedstock of thickness 0.1mm to 0.35mm will be coil coated with a preformed thermoplastic film in the range 12 to 200 microns.

The lamination plant will have an output of 10 million square metres p.a. and will include:

steel coil handling equipment; coil shearing and joining; tracking; fault detection; induction heating; lamination and quench.

The induction heating equipment is specialised and novel and enables close control of temperature across the 950mm width of steel and the process if fully computer controlled; overall efficiency is typically 75 to 80 per cent.

Temperature uniformity is critical and a specification of ± 2 per cent temperature variation has been determined for the most demanding end uses.

(31)

Induction technology replicated worldwide

A new breed of electric induction heater, based on a multi-layer coil (MLC) design concept, was demonstrated under two EEC Energy Demonstration Projects in 1979, and has already begun to contribute to British exports, with ten installations going abroad so far. The first export order went to Veltanda, Sweden, followed by others in Denmark, Norway, Indonesia, West Berlin, South Africa, Zimbabwe and recently two units have been shipped to China.

The novel induction coil was first demonstrated at Delta (Manganese Bronze), Ipswich, to heat billets of various copper alloys, and at British Alcan (British Aluminium), Banbury, to heat aluminium billets. Replication in the UK followed at Century Aluminium who have now replaced conventional single-layer coil (SLC) induction heaters at their two plants, at Sanquar, Dumfriesshire and at Birtley, Tyne and Wear. Heaters have also been installed at McKechnie Metals Ltd at Aldridge, and at British Alcan Tubes Ltd, Redditch. Another MLC is soon to be installed at another UK aluminium extrusion plant.

MLC was developed by the Electricity Council and licensed to Inductoheat Banyard Limited after a 1 MW prototype heater was successfully demonstrated at Capenhurst. The prototype demonstrated the potential for significant energy savings by reducing copper losses (I^2R) in the induction winding compared with conventional single-layer induction heaters. It also demonstrated that the range of sections which can be heated efficiently at mains frequency can be extended, and that more rapid heating can be achieved.

Both EEC energy demonstration projects at Ipswich and Banbury, respectively showed considerable energy savings for a range of alloys and billet lengths, compared with equivalent figures on conventional single-layer coil heaters. They were between 26 per cent to 33 per cent for the aluminium preheater, and 25 per cent to 36 per cent for the copper preheater. These figures represent savings of 59-76 kWh/tonne for aluminium and 55-127 kWh/tonne for the copper alloys.

The first commercially manufactured coil was sold to SAPA of Sweden, who converted an existing SLC heater to MLC operation, making use of most of the existing ancillary electrical equipment. SAPA had already uprated the throughput of their extrusion presses and the change to MLC produced a 25-30 per cent increase in the number of billets heated per hour, without increasing the electrical rating of the heater.

The installation in West Berlin, is a continuous feed aluminium log heater working with a hot shear facility. Here Banyard supplied a complete package, including log handling, heating and shearing equipment.

Meanwhile, Century Aluminium Limited, a member of the Hydro and Aluminium Group, installed their first MLC at Birtley, in August 1986. It replaced a single layer coil induction heater, rated at 700 kW. The new coil is rated at 572 kW, and led to energy savings of 22 per cent in the first year of operation.

The MLC was part of an overall programme of cost reduction which introduced a programmable logic controller, to integrate control of the heater and press. Combined savings from the new installation, including energy and increased throughput, gave a payback of less than 7 months on a total capital investment of about £75,000.

Following this success, Century Aluminium have installed two further MLC systems at their Sanquar plant.

(32)

THE R&D PROGRAMME OF THE EUROPEAN COMMUNITIES

In addition to the Energy Demonstration Programme operated by the Directorate General for Energy – DGXVII, the Commission of the European Communities has a Research and Development Programme in Non-Nuclear Energy, operated by the Directorate General for Science, Research and Development – DGXII.

This has been conducted through a series of four-year programmes, the first covering 1975-79, the second 1979-83 and the third, which is reaching its close, 1985-88. The third programme had a budget of 175 MECU, and supported pre-competitive R&D in companies, research institutions and universities.

A fourth programme, with a budget of 122 MECU over four years will begin on 1 January 1988. Detailed contents are still being discussed but are likely to be broadly similar to those of the previous programmes.

The Commission encourages collaboration between organisations in different member states, either by direct collaboration in projects or by organisation of contractors meetings covering specific areas of the programme at intervals during its course. The third programme contained two main areas,

- Development of Renewable Sources of Energy, and
- Rational Use of Energy

Sub-sectors of these areas are shown in Table 1.

Table 1 CEC 3RD R&D PROGRAMME PROGRAMME SECTORS

RATIONAL USE OF ENERGY

- Energy Conservation
  - a) Buildings
  - b) Industry
  - c) Transport
  - d) Energy storage
- Utilisation of Solid Fuels
  - a) Heat and power production
  - b) Transportation of solid fuels
  - c) Solid fuels science
- Production and utilisation of new energy vectors
  - a) Production of synthetic fuels from coal
  - b) Production of synthetic fuels from biomass
  - c) Studies on systems and materials relating to a) and b)
  - d) Generation of hydrogen for synthetic fuel production
  - e) Fuel cells
- Optimisation of the production and utilisation of hydrocarbons
  - a) Improvements in the knowledge of hydrocarbon deposits
  - b) Use of natural gas
  - c) Use of heavy petroleum fractions
  - d) Fuel/engine matching
- Energy systems and modelling
  - a) Maintenance and utilisation of existing models
  - b) Development of new models
  - c) Application of models and consolidation of the associated infrastructure

DEVELOPMENT OF RENEWABLE ENERGY SOURCES

- Solar Energy
  - a) Solar energy applications in buildings
  - b) Thermomechanical solar power plants
  - c) Photovoltaic power generation
  - d) Solar radiation data
  - e) Solar energy applications in agriculture and related industries
- Energy from Biomass
  - a) Development and recovery of biomass for energy purposes
  - b) Biomass conversion techniques
  - c) Utilisation of biomass as a source of energy
  - d) Photochemical and photobiological processes
- Wind Energy
  - a) Assessment of resources in Europe
  - b) Wind generator experiences
  - c) Development of technologies and prototypes
- Geothermal Energy
  - a) Exploration and assessment of resources
  - b) Performance of geothermal reservoirs
  - c) Production and management of reservoirs
  - d) Utilisation and conservation of resources
  - e) Hot dry rocks
  - f) Training and education

DIFFERENCE

While the demonstration programme operates on an annual call for proposals, and the individual projects may take various times to complete, the R&D programme supports fixed term research projects which are co-ordinated into an overall programme to meet the Commission's requirements. Hence the tendency is to have a large call for proposals at the start of the programme and to allocate the funds available for the whole period. Limited calls for proposals, covering very defined topics to fill gaps, were issued during the first half of the third programme.

ENERGY CONSERVATION

The energy conservation sector of the third programme has a budget of 26.5 MECU.

In the buildings area, emphasis has been placed on heat pumps, with particular stress on improving the performance and reducing the cost of existing compressor and absorption heat pump types and on developing new types. For industrial applications, work is directed to the development of high temperature heat pumps. 23 heat pump projects are receiving 3.3 MECU.

A large section of the programme is devoted to the industrial sector which accounts for 41 per cent of energy use in the Community. 3 MECU is allocated to development of new industrial processes covering topics such as crystallisers, evaporators, dryers, ovens, reactors, etc. Heat exchanger development is aimed at better performance and reduced costs, ceramic heat exchangers for high temperature heat recovery, fouling and corrosion problems and development of an "expert system" for heat exchanger selection.

Combustion projects receive funding of 8 MECUs. Some 90 per cent of the energy used in the Community, in industry and in transport, is derived from combustion. This multi-disciplinary programme involves some forty laboratories, in universities, research and industrial laboratories, including those of major car manufacturers. It covers research in advanced diagnostic techniques, investigations of laminar, turbulent and spray combustion, ignition, reaction kinetics, generation of pollutants and modelling in furnaces and engines. There is also work on engine design and operation.

Work on fuel cells was introduced to help stimulate interest in this area in the Community and fifteen laboratories are engaged on projects on molten carbonate, direct methanol and solid oxide fuel cells at a cost of 3 MECU. Advanced batteries had received considerable support in the earlier programmes and notable in this was the work on solid lithium batteries offering high energy and power densities and room temperature operation. 2.5 MECU has been allocated to their further development in the present programme.

UK laboratories and companies are making major contributions to the Commission's R&D programme in individual research projects and in project co-ordination.

Continued on page 20

Table 2
CEC ENERGY R&D PROGRAMME
Brochures on The Energy Conservation Sub-Programme

- Heat Exchangers for Industry
- Heat Pumps
- Rankine Cycle Engines
- Combustion
- Energy In Industry – Technologies & Applications

The Brochures are available from:
Mr. G. Hoyaux,
DGXII-E-5,
CEC,
200 rue de la Loi,
B-1049 BRUSSELS.

RESULTS

The content of the programme is described in detail in brochures which are available from the Commission: those in the energy conservation sector are listed in Table 2.

Results of the programme are published in several ways. The proceedings of contractors meetings, held at the midpoint or at some other interval during the programme, are published. These contain useful summaries of the relevant programme areas. However, such conference proceedings take some time to prepare. Proceedings in the current programme will be available shortly. The Commission also publishes booklets giving a one-page description of each project, and again those on the third programme will be available shortly. At the end of each programme the Commission organises a conference at which all the contractors present the results of their research. Later, reports on the individual contracts are published in the EUR series.

The summary reports and contractors meeting reports from earlier programmes are listed in Table 3.

The Commission is presently planning a fourth R&D programme. Details of this and a call for proposals are expected later this year or early next.

Table 3 Reports on the 1st & 2nd R&D Programmes

Programme Summary Booklets:
THE COMMUNITY'S FIRST ENERGY R&D PROGRAMME – ENERGY CONSERVATION
Survey of results and Compilation of New Projects – Second Edition. 1982
EUR 7389 EN

THE COMMUNITY'S SECOND ENERGY R&D PROGRAMME – ENERGY CONSERVATION
Survey of Results. 1983
EUR 8661 EN

Contractual Meeting Reports:
ADVANCED BATTERIES AND FUEL CELLS
Proceedings of the second contractors meeting Kelkheim April 1982.
EUR 8078 EN

ADVANCED BATTERIES AND FUEL CELLS
Proceedings of the third contractors meeting Bordeaux 1983.
EUR 8660 EN

HEAT PUMPS
Proceedings of the contractors meetings Brussels April and May 1982.
EUR 8077 EN

ENERGY CONSERVATION IN INDUSTRY COMBUSTION, HEAT RECOVERY AND RANKINE CYCLE MACHINES
Proceedings of the contractors meetings Brussels June, and October 1982.
EUR 8434

ENERGY CONSERVATION IN INDUSTRY APPLICATIONS AND TECHNIQUES
Proceedings of the contractors meetings Brussels on May, June and October 1982.
EUR 8436

FLUIDIZED BED SYSTEMS
Proceedings of the contractors meetings Brussels, October 1982.
EUR 8562

ENERGY CONSERVATION IN TRANSPORT NEW ENGINES AND FLYWHEELS
Proceedings of the contractors meetings Brussels October 1982.
EUR 8435

ENERGY CONSERVATION IN BUILDINGS HEATING, VENTILATION AND INSULATION
Proceedings of the contractors meetings Brussels December 1981, May, September and October 1982.
EUR 8463

Conference on the 2nd R&D Programme

Proceedings of the International Seminar Düsseldorf, Germany, February 1984.
EUR 9236
Volume 1: Combustion and Heat Recovery
Volume 2: Engines and Batteries
Volume 3: Applications and Technologies

Edited by: A. Strub and H. Ehringer VDI Verlag, 1984
ISBN 3-18-419095-1

Other publications made in the framework of or dealing with this programme are:

ACHIEVEMENTS OF THE EUROPEAN COMMUNITY'S FIRST ENERGY R&D PROGRAMME
J.C. McMullan and A.S. Strub (1983)
ISBN, 90-247-2511 g.

ACHIEVEMENTS OF THE EUROPEAN COMMUNITY'S SECOND ENERGY R&D PROGRAMME
J.C. McMullan and A.S. Strub (1984)
ISBN, 92-825-4276-9

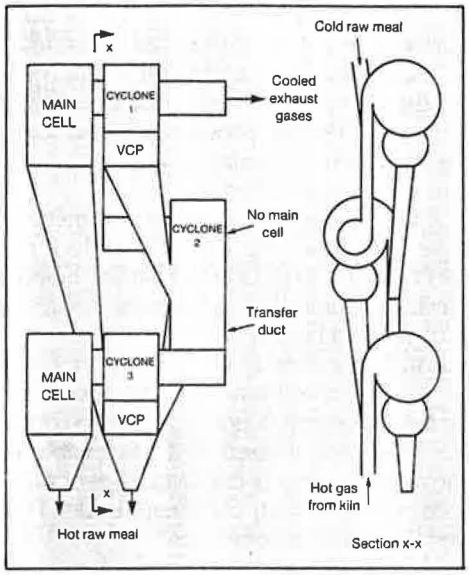
(33)

Cyclone heat exchanger aims to cut waste at cement works

Research into a new type of cyclone heat exchanger by University College, Cardiff in conjunction with Blue Circle Cement and British Coal could lead to much smaller, compact cyclone preheater towers for cement works and save up to 20 per cent in energy consumption. Applications to other industries are envisaged.

Waste heat and dust removal recovery from the waste gases of cement kilns are vital if energy costs are to be contained and atmospheric pollution minimised. Currently this is achieved by passing the hot gases leaving the kiln (typically at up to 1000°C) through a series of interconnected cyclone separators (typically four or five) in countercurrent with the cold raw cement meal. The system thus acts as a countercurrent direct contact gas to solid heat exchanger.

A complete system is extremely costly, being typically 50-70 m in height. Significant pressure drops develop and fan power requirements are high. The energy costs associated with the bucket elevator to convey raw cement meal to the top of the system are also very high.



Cardiff cyclone preheater tower

The project aims to integrate recently developed cyclone dust separator technology with the heat exchanger requirements of the rotary kiln. In the new cyclone separators material is removed by the use of a novel system termed the vortex collector pocket (V.C.P.). The V.C.P. is a circular chamber attached to the side of and slightly overlapping the main cyclone chamber. Material is collected whilst there is no net gas flow into the V.C.P. These new cyclone dust separators are about half the size of conventional units and can be orientated vertically or horizontally. Horizontal orientation is preferred owing to the saving in space and especially height. Very considerable savings in capital cost are expected, as well as at least 20 per cent in energy.

The work programme will be carried out at University College, Cardiff in three stages. The first will examine the operation of a vertically mounted system of 250 mm exhaust diameter in relation to heat exchange and particle retention whilst the second stage will concentrate on the development of a horizontally orientated device, which will then be incorporated in a pilot cyclone preheater tower with three stages. (34)

Regenerative burners to operate on low calorific value gas

In a research project supported by the CEC, British Steel has demonstrated the operative reliability of a novel regenerative burner system utilising low calorific value fuel gas and capable of high temperature performance at high efficiency.

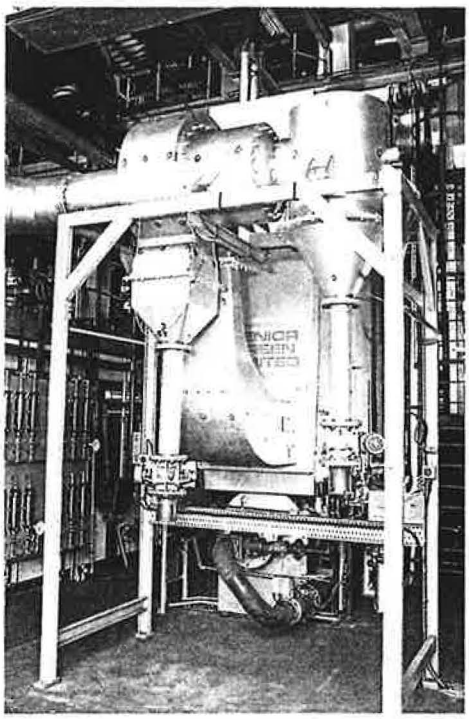
The system is based upon the extension of the application of the self-regenerative principle, developed jointly by British Gas and Hotwork Development Ltd, to both combustion air and fuel gas supplies.

Two burners operate in tandem, one of which fires while the other regenerates both the fuel gas and air pre-heat beds using a very short time cycle, typically 120 seconds.

Blast furnace gas with a calorific value of approximately 2.9 MJ/m^3 was utilised as the fuel source.

The aim of the trials was to complete 1500 hours of operation with the objective of verifying the versatility and long-term reliability of the "double" regenerative system.

Specifically investigated during the trials were: the effect of varying the thermal input, the effect of varying the excess air, the effect of varying the heat extraction load, the waste gas analysis and stack loss, and the regenerator bed temperature profiles.



Regenerative burner system, of the type installed by British Steel to run on blast furnaces.

The 1500 hours of operative trials were carried out on schedule, only minor difficulties involving the system hardware were experienced. During the duration of the trials, all investigations were completed as planned and the results successfully indicate the ability of the system to achieve high temperature performance at high thermal efficiency. Efficiencies in the order of 85-90 per cent were typical of the results achieved.

The system is capable of using blast furnace gas in applications where previously only premium fuels could be used.

The research programme carried out has demonstrated the double regenerative burner principle. A provisional patent application has been lodged. Discussions regarding the commercial exploitation and licencing agreements for sales of the system have started.

Four major areas have been identified from the initial work as requiring additional development to optimise the system. These are; the use of enriched gas and gases containing hydrocarbons, pulse firing, regenerator bed sizing and NOx emissions. (35)

Johnson Matthey investigates catalysts for fuel cells

Johnson Matthey is currently involved in developing internal reforming catalysts for use in molten carbonate fuel cells. These catalysts will enable the efficient conversion of methane/steam mixtures to hydrogen and carbon monoxide at temperatures within the range 575-650°C.

Molten carbonate fuel cell systems operating at 650°C are ideally suited for the direct use of carbonaceous fuels such as methane to produce electricity. The fuel cell is tolerant of carbon monoxide and carbon dioxide and the high grade heat produced by the fuel cell can be used efficiently to drive the endothermic reforming reaction.

Extensive literature searches revealed that there are two basic problems encountered with internal reforming. Firstly the catalysts are subject to corrosion by the molten carbonate electrolyte, and secondly, even if the catalyst is not corroded it can be smothered or wetted by the carbonate. Initial work at Johnson Matthey has concentrated on an extensive corrosion testing programme and the measurement of contact angles of carbonate on various materials.

A wide variety of ceramics and metals have been tested for 100 hour periods at 650°C under $H_2/CO_2/H_2O$ whilst being partially submerged in carbonate (62:38 mol per cent $Li_2CO_3 : K_2CO_3$). These conditions were aimed to simulate as closely as possible conditions near the anode in an actual fuel cell. A hot stage microscope has been constructed and has enabled the measurement of contact angles of various materials with carbonate under H_2 and CO_2 gas environments.

This extensive test programme is enabling the selection of materials suitable as catalysts or catalyst supports. Initial studies have resulted in the identification of catalysts and support materials which show low wettability combined with corrosion resistance. The promotion of nickel-based catalysts with precious metals has been confirmed. Potential reforming catalysts are undergoing activity testing 'in house' and promising systems will be tested in a molten carbonate fuel cell at the laboratories of CNR-TAE, Messina, Sicily, joint collaborators in the EEC supported research project.

Dr. B. Harrison, Manager, Catalyst and Chemical Technology, Johnson Matthey emphasises: 'The problems posed for catalysts in the molten carbonate fuel cell environment are daunting and impose significant limitations on catalyst design. However, our results to date are promising in terms of catalytic activity, together with the potential for durability. The real test will come when catalysts are run in an actual fuel cell environment in Messina.'

(36)

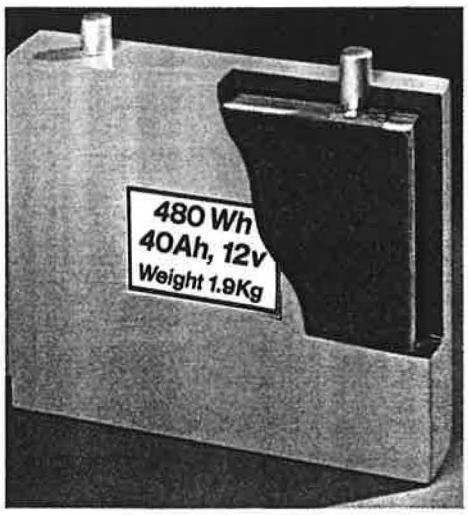
Solid-state lithium advanced battery project

Large, high energy density, batteries for electric vehicle traction applications are the objective of one Harwell team in EEC-sponsored work on solid-state rechargeable lithium batteries.

One of the major obstacles to the extensive use of electrically driven vehicles has been the limited practical energy storage capability of currently available batteries. This has restricted the range of such vehicles to about 50 miles. High energy density lithium batteries offer a solution to this problem and staff of the Applied Electrochemistry Centre at Harwell, working in conjunction with a U.K. company, are looking at the use of an all-solid-state system based on a polymeric electrolyte. A flexible thin film, large area, design concept utilizes a lithium metal foil anode and a vanadium oxide-based cathode. In addition to offering a high energy density and a long cycle life, the system will also be mechanically rugged and safe. The use of automated fabrication techniques already available in a number of industrial sectors will provide for straightforward scale-up and low production costs.

Previous laboratory work in collaboration with U.K. universities and research laboratories in Denmark (The Anglo-Danish Project), partly supported also by the Department of Trade and Industry, had validated the concept in small cells and the overall aim of the present project is the demonstration of the scale-up of the technology, towards eventual commercial exploitation. Cell construction materials are those already well characterized in laboratory-scale experiments and performance is initially being assessed in the temperature range of 90°C to 140°C.

To date, cells of up to a few ampere-hours capacity have been fabricated and evaluated at 120°C. Initial discharge capacities at rates consistent with vehicle traction applications, are reproducible and in excess of 90 per cent of the theoretical cathode capacity. Extended cycling leads to a decline in capacity but retentions of >60 per cent have been achieved over 50 to 100 deep galvanostatic cycles. This performance is similar to that achieved with small cells and represents a scale-up factor of over one thousand. Non-optimised, encapsulated, cells have practical energy densities of 85Wh/Kg and 200Wh/litre. Thermal modelling studies of a 20KWh battery operating under a standard urban driving cycle suggest that the thermal management of a practical unit will be achievable using readily available materials' technology. Preliminary results from cells incorporating improved polymer electrolytes developed within a separate programme at Harwell, indicate that similar performance can be achieved at room temperature.



A model of a proposed electric vehicle battery module. A real battery, of bipolar design, would have a gravimetric energy density at least five times higher than it's Pb-acid equivalent.

Proposed future work will include a wider assessment of cell performance in respect of capacity as a function of rate, depth of discharge, duty cycle, temperature and cycle life together with studies related to cell abuse and safety. This will include overcharge/overdischarge and short-circuit behaviour, as well as non-electrical abuse. Further scale-up may also be addressed.

In the words of the Harwell team: "The exciting potential of the, all-solid-state, polymer electrolyte-based, rechargeable lithium battery concept has been confirmed through a further step towards it's eventual exploitation. With continued commitment and further extensive R and D, it's use for electric vehicle traction remains an excellent possibility."

(37)

Diesel engines to run on residual fuel oil

A programme of combustion research at Harwell aims to extend the range of fuel oils which can be burned in large diesel engines.

The Harwell Combustion Centre is carrying out a number of related projects in conjunction with U.K. and overseas research laboratories. One such EEC funded R&D project relates to the use of residual fuel oil in large diesel engines and could lead to economic advantages and extend the range of fuels used in such engines. However the nature of this type of oil which represents the dregs of the oil barrel can give rise to severe operating difficulties which could lead to excessive pollution and heavy maintenance charges.

This Harwell project is being carried out under the sponsorship of members of the European diesel industry including Lloyds Register of Shipping. The work concentrates on investigating the correlation between the chemical composition of the residual fuel oil and the ignition, combustion and soot forming properties under realistic engine conditions, with particular reference to low load conditions.

The work programme is divided into four areas, the first concentrating on studying the combustion of selected residual fuels and some possible future fuels, which include highly cracked and highly aromatic residues. A large high temperature cell capable of operating at 800°C and 120 bar pressure is the focal point of this stage. Of particular importance are studies of the fuel vapour around the pulsed spray since this determines the quality of ignition and hence potential soot formation, and the initial rate of heat release. Many specialist techniques are used including high speed photography, optical spectroscopy, and Schlieren techniques.

An understanding of the very complex compositions of residual fuel oils is needed to understand the combustion phenomena and in the second area of work a wide range of analytical techniques is used including nuclear magnetic resonance, gas chromatography, and infra red analysis.

The third area of work considers the combustion of selected chemical types such as branched-chain alkanes and aromatics in a small high temperature combustion cell together with the effect of fuel pyrolysis prior to combustion.

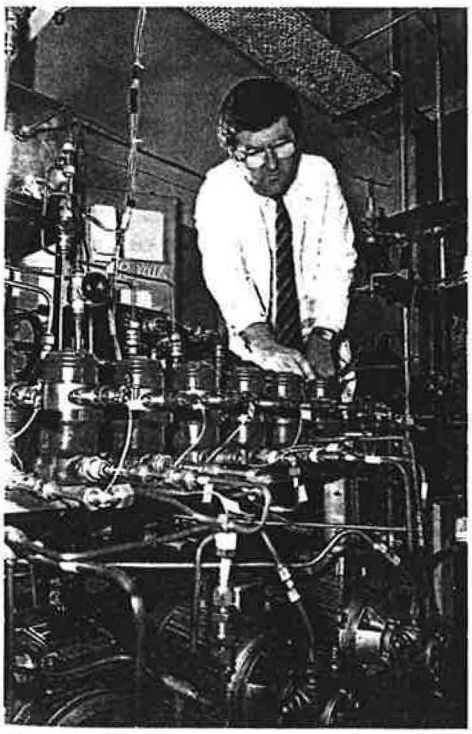
Lastly a theoretical combustion model is being developed around specific parameters such as the rates of chemical attack at key sites in the aromatic molecule and the rate of vaporisation from a binary fuel.

In addition to this project, Harwell is playing a central role in coordinating combustion research in the field of turbulent combustion and diagnostics. A large number of U.K and EEC universities are cooperating in this field, and one particular project 'The Strained Flame Library' involves calculations of the properties of strained flames from fundamental kinetic and transport data for a range of fuels. The strained flame date will be used in turbulent combustion models.

(38)

Ulster University seeks improved performance of heat pumps

As part of its continuing work in the field of heat pump research the University of Ulster in cooperation with the heat pump division of Leroy Somer of Angouleme, France is carrying out studies of the potential of the Granryd cycle in effecting a significant improvement of the Coefficient of Performance (COP) of vapour compression heat pumps.



Test rig for examining properties of oil refrigerant mixtures at the University of Ulster.

The key element of the Granryd cycle is that the refrigerant which normally flashes on entry into the evaporator in a conventional cycle, is removed prior to this point in the cycle and work is extracted from it by expanding it into the compressor cylinder. The nature of this cycle requires that the expansion valve of the reversed Rankine cycle is replaced by a specially designed 'pump down vessel' in which this expansion can be carried out, and also that the cycle is no longer continuous, but must take place in a number of stages. As part of the cycle the compressor is subjected to large and rapid variations in suction pressure and the effect of this on compressor reliability is one of the main areas of interest in the research. Additional research will be carried out to determine the optimum design for the 'pump-down vessel'. Using a rolling piston compressor in place of either a reciprocating or screw compressor should also lead to further efficiency improvements.

The initial design of the Granryd cycle test rig has now been completed and construction of the hardware is complete except for the final connection of the instrumentation to the data loggers. The real time data logging program is at present undergoing extensive testing to ensure its reliability and preliminary testing of the cycle should begin any day now.

Dr John McMullan, University of Ulster reports:

"While the design and construction of the Granryd cycle was being undertaken our existing test rig, designed to investigate the interaction of lubricating oil with refrigerant, has been collecting further data, so that we now have a large base of information on the problems of oil-refrigerant mixing in heat pump systems.

For the future use of this test rig, we are poised to undertake an investigation of the properties of the new refrigerants which are now starting to appear in response to the United Nations' embargo on the production of halocarbon refrigerants."

The opportunity is also being taken in this research programme to look at methods of improving the regulation of the evaporator superheat by using microcomputer control techniques.

Dr John McMullan, enthuses: "This work is very exciting, and the combined effects of the new cycle and the improvements in control which come from our better understanding of oil-refrigerant interactions, can lead to improvements of up to 25 per cent over the performance of existing refrigeration systems."

(39)

Sheffield examines alternatives to lead in petrol

With the increasing emphasis within the EEC on reducing lead pollution from motor vehicles, Sheffield University, supported by an EEC grant, has initiated a systematic programme of research into the influence of structure and other characteristics of substitute fuel components in petrol in relation to engine efficiency and pollution. Parallel work is being carried out using an SI engine operating at standard ASTM and realistic conditions to evaluate the performance efficiency and to investigate pollution emissions.

Historically lead has been used to raise the octane number of motor fuels to prevent knock in engines but because of its toxic properties there is now pressure to reduce and eventually eliminate it from petrol. The precise mechanism of knock in engines is not yet fully understood, though most evidence indicates a two stage ignition process with a cool flame preceding autoignition of the cylinder end gas.Critical in the knock process would seem to be branching agent radical concentrations. The requirements of the anti-knock additive is to be thermally stable and relatively reactive toward free radicle reactions, with the production of relatively inert free radicals. The approach of this research is to investigate various families of compounds slightly altering the basic molecule of the additive to enhance its anti-knock properties.

In doing so it is expected to achieve:

1) a greater insight into the influence of additive molecular structure on the mechanism of knock, and
2) the identification of a small group of economically viable petrol additives which improve fuel characteristics and engine performance, whilst producing acceptably low levels of pollution emissions such as nitrogen oxides and unburnt hydrocarbons.

Additives tested include both commercial and specifically engineered molecules. Included are alcohols and the equivalent amines, novel ethers, furans, phenols and formamides. Tests are done using model base fuels of repeatable composition and the fuel characteristics are studied using a single cylinder, variable compression ratio engine. Fuel economy, power output and emissions are determined on a fully instrumented four stroke spark ignition engine with a hydraulic dynamoter.

RESULTS TO DATE

Screening tests with over fifty potential additives have shown that amines are more effective anti-knock additives than the equivalent alcohols. The presence of tertiary nitrogen atoms imparts a strong pro-knock effect. Five membered rings lead to a better performance than six membered ones.

Further work is currently under way in the four stroke engine test rig, completing tests with promising additives in the previous base fuel. A new base fuel has been provided recently by BP Sunbury which simulates commercial unleaded petrol. This will be used with the most promising additives, enabling further structural interactions to be examined. Based on results to date further compounds are to be synthesised and tested. The results obtained will be correlated with autoignition models.

40

INTERNATIONAL ENERGY AGENCY PROGRAMMES

The International Energy Agency (IEA) is an autonomous body which was established in 1974 within the framework of the Organisation for Economic Cooperation and Development (OECD) to implement an International Energy Programme. It carries out a comprehensive programme of energy cooperation among twenty-one of the OECD's twenty-four member countries (France, Iceland and Finland are not members of IEA). One of the main aims of the IEA is to further cooperation among participating countries to reduce excessive dependence on oil through efficiency of energy end use, development of renewable energy sources and energy research and development.

The IEA cooperative R&D programme covers four areas:

- end use technology (i.e. energy efficiency & conservation)
- renewable energy
- fossil fuels
- nuclear fusion

Each of these areas is guided by a Working Party on which all member countries are represented. They report to a senior committee which has oversight of the whole programme and it in turn reports to the Governing Board comprising the Energy Ministers of the IEA countries.

Within these broad programmes, detailed collaborative work programmes are covered by Implementing Agreements. These are agreed, signed and managed by those who wish to participate in them: the management is in the hands of an Executive Committee with the agreed programme organised, progressed and reported by an Operating Agent, usually one of the participants.

ORGANISATION

Work in IAs is frequently subdivided into smaller packages defined in Annexes and these work programmes are organised in the same way under Steering Committees. Several organisations from any one country can participate in an IA, but each country has only one vote at the Executive Committee. Each Implementing Agreement reports annually to the appropriate Working Party and the IEA Secretariat, who comment on the work, but the participants have the management of their own programme. The work in IAs is frequently part of government supported and national programmes, but that is not essential, and IEA is encouraging and wishes to foster increased participation by industrial organisations and companies.

It should be emphasised that IEA is not a funding body and all work is funded by participants at levels agreed by them. There are two recognised patterns of collaboration.

FUNDING

In joint funded programmes the participants put an agreed amount of money into a common pool to finance work to be carried out by one of them.

In task sharing programmes, participants undertake to do part of a joint programme, organised so as to avoid unnecessary overlap and agree to exchange results: frequently participants can contribute projects to which they are already committed in national or company programmes.

An organisation participating at its own expense is under no obligation to make detailed information available outside the programme and the extent to which results are released in either type of collaborative programme is up to the participants. They may prepare non-sensitive reports for the IEA and non-participating countries, but in some programmes, the participants have conducted all the work in confidence.

There are at present 10 active Implementing Agreements within the end use technology area.

Building and Community Systems*
Heat Pump Systems
Combustion Processes*
Heat Transfer and Heat Exchange*
Energy Storage
High Temperature Materials for Automotive Engines
Pulp and Paper Industry*
District Heating
Alcohol and Alcohol Blends as Motor Fuels*
CADDET*

UK organisations participate in 5 agreements, marked with an asterisk, though not necessarily in all annexes when there are several of them.

Dr. Hiscocks of Department of Energy is the Chairman of the End Use Technology Working Party and Dr. Linacre of ETSU is the UK delegate. If you want further information on any of the existing Implementing Agreements and the work which they cover, please contact them (addresses on page 11). If you have an interest in any other area and think that your work would benefit from internal collaboration and that the IEA procedures, or something similar, might provide a suitable framework, they would be pleased to discuss your ideas for a possible new initiative. (41)

New centre to disseminate demonstrated technology

The CADDET project is the latest collaborative programme to be established under IEA auspices. CADDET is the Centre for the Analysis and Dissemination of Demonstrated Energy Technology. Under this programme the participants will share information on demonstrated technology in the end use or energy efficiency areas and the centre will publish selected information in a standard format and conduct and publish analyses on selected sectors or technologies.

The Implementing Agreement was signed in March '88. The participating countries to date are Denmark, Finland, Italy, Netherlands, Norway, Sweden, Switzerland, USA and UK, but it is hoped that more will join shortly and several send observers to the executive committee meetings. The Operating Agent is NOVEM and CADDET is sited at its offices at SITTARD near MAASTRICHT in Netherlands: NOVEM is an organisation similar to the Energy Technology Support Unit here. Some of the analysis work will be done at the CADDET ANALYSIS SUPPORT UNIT which the Swedish government has established at Chalmers University, Gothenburg, as part of its contribution to the project.

ETSU is the UK representative in CADDET. Information has been made available from the Energy Efficiency Demonstration Scheme in the form of project profiles and expanded project profiles, and British Gas PLC and the Electricity Council have contributed their published case studies, many of which arise from the GEM and PEP award programmes. ETSU, BRECSU, British Gas and the Electricity Council all have promotional programmes through which CADDET output can be made available to the appropriate end users. CADDET sets great store by the national teams which will collect the required input and handle its output; we are fortunate in that appropriate material and structures are in place. The working language of CADDET is English.

The first CADDET bulletins, similar to our profiles, have now been published, and the output will increase. CADDET will also publish a newsletter and will maintain a register of demonstration projects which have been notified which will also be able to provide useful information. We plan to keep you informed of progress through Energy Management and other channels. (42)

Energy technology data exchange

Those wanting information on energy technologies can now access a large data base of bibliographic information from this country. Entries consist of title, author, abstract and index information. The data base was established via an IEA Implementing Agreement on Energy Technology Data Exchange, signed in January '87, under which data on reports and articles arising in each participating country are exchanged. Twelve IEA member countries are participating, others are expecting to join and France is also participating in the agreement. National teams provide an input of data from literature searches covering all energy fields, including nuclear.

The Information Office at Harwell Laboratory leads and coordinates the UK input for the Department of Energy, the other UK contributors being British Gas, CEGB, Electricity Council, Institute of Petroleum, Department of Energy and ETSU, each covering the fields of direct interest to them. The UK input approaches 10,000 publications per year.

Information on coal technology is obtained through the IEA Coal Technology Information Service. The information is stored at the Oak Ridge National Laboratory where it is added to the Energy Data Base established by US Department of Energy in 1974, which may also be accessed directly in the same search.

Access may be obtained in UK via two commercial on line services. Those wishing to become regular users should contact.

DIALOG Information Services,
P.O. Box 188,
Oxford. OX1 5AX

or

STN,
Fachinformationszentrum,
D-7514 Eggenstein – Leopoldshafen 2,
Karlsruhe,
Germany.

DIALOG may be able to suggest a suitable contractor for those who require to make a casual or infrequent search. (43)

Research aims to cut energy use in buildings by 80%

Research into energy use in buildings is a vital part of U.K. contribution to IEA research programmes.

The past fifteen years have seen major changes in attitudes to saving energy in buildings through the introduction of improved standards of insulation and a better understanding of the basic parameters affecting energy use coupled with the introduction of controls and building energy management systems (BEMS). At the same time, as techniques such as cavity wall insulation, better draughtproofing and double glazing have been introduced they have in turn given rise to problems associated with ventilation rates and condensation.

Because of these kinds of interactions it has become increasingly clear that a fundamental examination of the factors relating to the efficient use of energy in buildings will be required if further advances in energy efficiency are to be achieved without introducing unacceptable environmental conditions. It is predicted that in the USA the application of new energy conservation technology in such areas as new window types, gas heat pumps, light sources and building materials could decrease energy consumption in buildings by 80 per cent.

It is against this background that eighteen countries who subscribe to the International Energy Agency participate in the 'Energy Conservation in Buildings & Community Systems' Programme.

National representatives identify areas of potential collaborative research from which to date twenty projects have been initiated ranging from the way people behave with regard to ventilation, energy auditing, condensation and the widespread introduction of BEMS. Of these,

Continued on page 26