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JOURNAL and Proceedings of the INSTITUTION of AGRICULTURAL ENGINEERS

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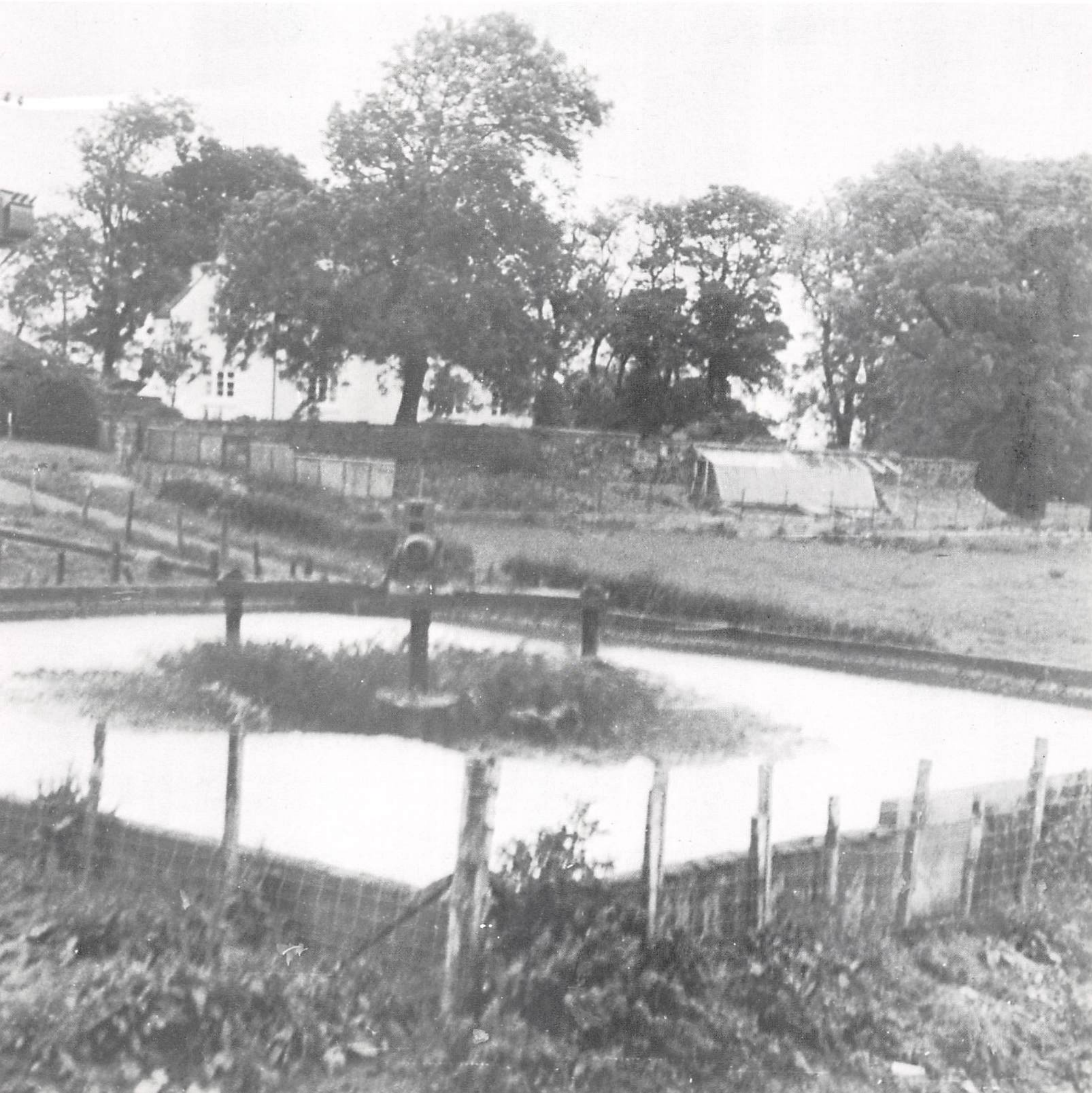

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Institution and Editorial Office:
West End Road, Silsoe, Bedford MK45 4DU
Tel: Silsoe 61096

Advertisement Manager:
LINDA PALMER

Production Manager:
NORMAN STUCKEY AIAgrE

Advertisement and Production Office:
PO Box 10, Rickmansworth, Herts. WD3 1SJ
Tel: Rickmansworth 78877

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***Cover:** Field scale aerator on a Wigtownshire farm*

The Engineers Registration Board

by John Kilgour and Colin Brutey

ONE of the most important services that the Institution can offer members is registration with the Engineers' Registration Board.

What is an engineer?

The layman's definition is not flattering since engineers do not enjoy a particularly high status in this country. There are also many types of engineers who are members of a wide variety of societies and institutions.

How is the layman to know the worth to society of this bewildering assortment?

Historically, engineers with common interests formed learned societies so that they could meet and discuss current problems with those who had similar interests. As the institutions grew, so they felt there was a need to limit membership to those with a suitable academic and practical qualifications to suit the requirements of particular group. As a result there developed an uncontrolled and unco-ordinated group of societies of varying academic levels, all trying to satisfy a particular narrow branch of engineering and not concerning themselves with any of their counterparts. In fact our own Institution started as a result of the founder members being dissatisfied with the approach of one of the larger established institutions. They developed their own set of rules and academic requirements to suit their definition of an engineer. Uniform standards within the engineering profession did not feature prominently in their deliberations.

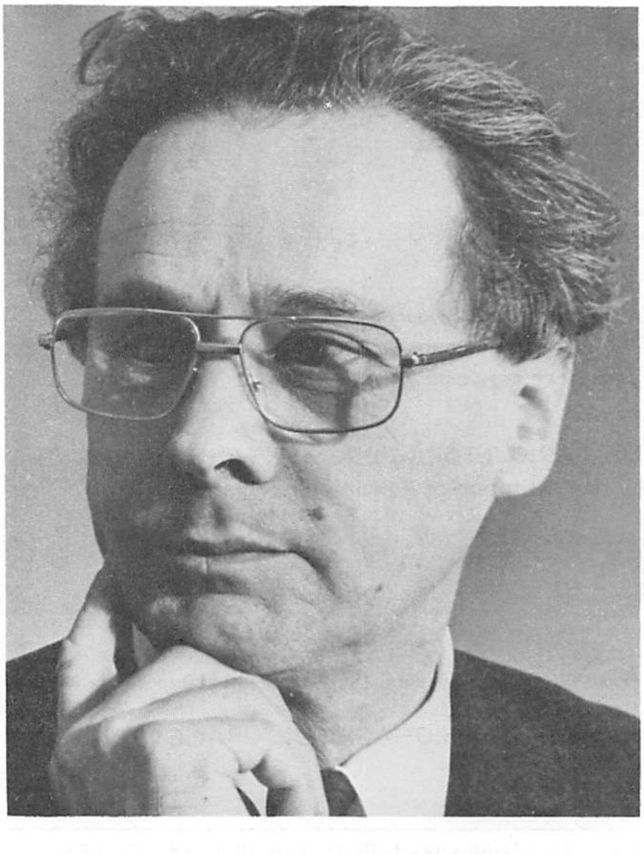
Their definitions were rather narrow and even today our Institution is predominantly concerned with power and machinery aspects of agricultural engineering and it is often suggested that if does not have a particularly active policy in other branches of agricultural engineering, as does for instance the American Society. As far as the learned society aspect of the Institution is concerned we can say we have performed this function satisfactorily as shown by the fact that the membership has grown and members take an active part in the meetings and in the presentation of technical papers. The fragmentation of the engineering profession as outlined has however meant that there is no recognisable identity and cohesion between these various types of engineers. The profession is not represented coherently to the public, or to the government. At the same time the growing complexity of engineering and growing interdependence of what have traditionally been regarded as discreet technologies have shown the limitations of the narrow institutions set up.

An inter-disciplinary approach is often necessary to solve modern day problems. Many spring to mind. For instance, to produce a certain product for a particular market there needs to be raw materials; where and how do these come from in sufficient quantities; what effect do the waste products have on the environment; can this process be combined with others to enable the limited resources to be used more effectively?

Where does the Engineers' Registration Board fit in with the above comments and observations? The policy of the Engineers' Registration Board is to bring together the existing wide-ranging engineering institutions and societies in order to find a common basis which can be used to define an engineer, any engineer. It also aims to specify minimum academic and formal training requirements, which all engineers should possess. Various institutions will of course have additional requirements related to their particular field. By adopting this approach it is hoped to present an easily definable level of engineer which can be universally understood by all. This should enable the employers in both the public

John Kilgour

Colin Brutey



and private sectors to have a readily identifiable product, the professional engineer, with known abilities and responsibilities.

There are three levels of engineers specified and each institution is investigated and the membership grades are assessed in respect of the academic and formal training content. These grades are then given an appropriate level according to the criteria used by ERB. Our Institution has for the present been classified into two levels — technician engineer and engineering technician, corresponding broadly to membership grades, Member and Fellow, and Technician Associate, respectively. The definitions of these Engineer Registration Board levels, Technician Engineer and Technician, have been described in previous articles in this Journal as have the requirements of our various grades, so an individual who is selected into a particular grade by the Membership Panel of the Council automatically meets the various requirements of the Engineers' Registration Board grade and is eligible to apply for registration. The small fee charged is to cover the cost of administration needed to maintain the central register.

The requirements of the Engineers' Registration Board are by no means completely formalised yet. The Joint Qualifications Committee of the Technician Engineer Board is discussing at the moment the question of training requirements for technician engineers and how this can be defined and formally documented. Other matters being discussed are concerned with the articles of association of the institutions so that they can eventually be brought into line with each other, in order that, for instance, a mature candidate, a man with no formal academic qualifications, has to meet similar minimum requirements before being accepted by any of the member institutions. All these changes and new rules are not made by some faceless body with no regard to the individual members. Each institution is represented on the various boards by one of its members. Ideas are discussed and these are then reported back, in our case, to the Membership Panel and to Council. Council then decide on what action is necessary, taking into account the wishes of members and the overall policy. The representative then puts this point of view to the Engineers' Registration Board where a decision is taken that will affect all the member institutions.

At the moment, registration carries no legal implications, but it may well be that in the future an engineer will have to be registered in order to practice his profession. This should ensure that the quality of work is acceptable and the public will have a guarantee that the contractor has employed a competent man. As a result the engineer will be seen for what he is, and so his status should improve in the eyes of the world.

A further implication of registration can be seen in relation to other countries' engineers. In an age when an engineer can be expected to work in a country other than the one in which he qualified, the new country must have some guarantee of the ability of the man to perform at a satisfactory level of competence. The eventual target is that a registered UK engineer can be directly compared with his overseas counterpart and will be able to practice at that level in any country without the possibility of having to become re-qualified or having difficulty in getting his abilities recognised.

As a member of this Institution you should register with the Engineers' Registration Board in the appropriate grade and as a prospective employer you should only ask for applications from registered engineers. All parties concerned will then know what they mean by an "engineer". As already explained, being a registered engineer will have far reaching implications for this Institution and for you in the future. Many changes are inevitable, so it is up to you to make your views known so that the future policy of this Institution can reflect the needs and aspirations of the individuals it represents.

Institution members on the Engineers Registration Board are:— J Kilgour, M Clough (Technician Engineer Board); C Brutey, R Fryett (Engineering Technician Board).

IMechE Conference on Off Highway Vehicles, Tractors and Equipment

The Institution is associated with the organisation of this conference to be held at IMechE HQ, Birdcage Walk, on 28 & 29 October.

Research and development at University College, Dublin

Grass–cutting

THE objective of this project[2, 3] was to investigate the fundamental mechanical properties of grass crops, and to establish criteria for use in the scientific design of grass-cutting machines.

Laboratory tests

Tests on the low-speed ($1.25 \times 10^{-5} - 7.5 \times 10^{-5}$ m/s) mechanical properties of grass established the minimum or ideal shearing energy requirement (average = 30.1J/kg/m) for the cutting of grass stems in double-shear. Compared to this as a standard the high-speed (10 – 60 m/s) impact laboratory cutting rig revealed an average efficiency of only 23%. Clean impact cutting was produced at speeds greater than 25 m/s.

The high speed impact cutting process is inherently inefficient as unnecessary damage to the crop and unnecessary friction consume a considerable amount of energy, as does the transfer of momentum to the stems. Compared to the same standard the experimental mowing machine was later found to be only 7% efficient. The difference between the mowing machine efficiency and that of the high-speed laboratory cutter is due mainly to the greater power consumed in conveying the crop through the machine.

Mathematical analyses and models

The cutting process employed in rotary mowers and the movement of the crop during and after cutting is complex and was investigated as follows:

This article briefly reviews the results of two recently completed projects which were funded by the Irish National Science Council. The overall research and development programme has previously been described by the present author[1].

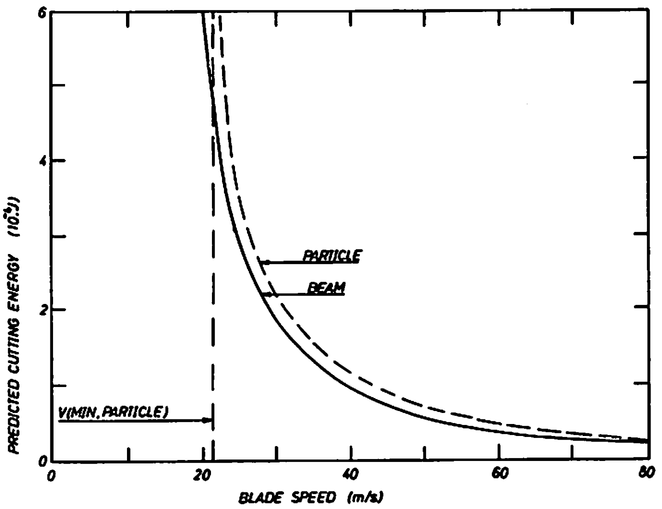
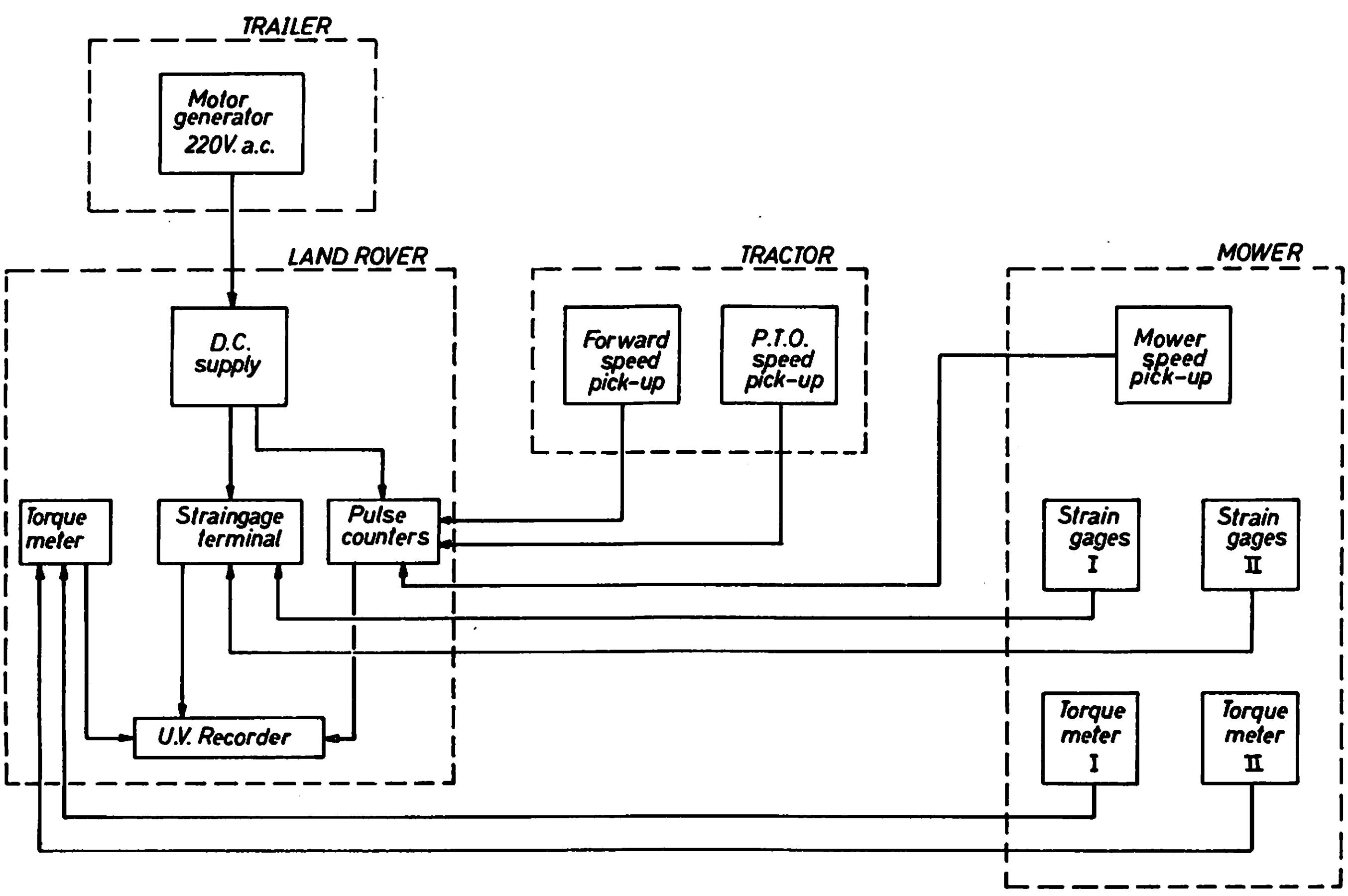


Fig 1 Mathematical modelling of the impact single-shear cutting process: (a) Grass as a beam of length 0.25 m and linear density 7.5×10^{-4} kg/m. (b) Grass as a particle of mass equivalent to a beam length of 8.55×10^{-3} m ie 6.41×10^{-6} kg.

(a) Model of the grass stem as a beam in the cutting process.
(b) Model of the grass stem as a particle in the cutting process.
(c) Relationship between mower geometry and cutting ability.
(d) Motion of the cutting blades relative to a mower rotor being driven at constant velocity or constant torque.
(e) Movement of the grass particles on a mower rotor.
(f) Movement of grass particles around a mower rotor.

Fig 2 Layout of instruments in field test rig



The usefulness of the mathematical approach was demonstrated by the close agreement between the minimum predicted cutting velocity, 21.6 m/s (in the case of the grass stem particle model, Fig. 1) and that found experimentally in the laboratory, 25 m/s.

Field tests

A two-drum rotary mower was used in a series of field mowing tests in which the effect of crop type and the machine operating characteristics on power consumption were measured (fig. 2). The power consumed was reported as a function of forward speed (1.4 – 10 m/s, 5 – 36 km/h), drum rotational speed (100 – 260 rad/s, 950 – 2480 rev/min) and type of blade used. The power consumed, P (kW) was found to be related to the forward speed, V (m/s) by the following approximate relationship:

$$P = 2.68 + 0.1225V + 0.0385V^2 \qquad (1)$$

The work per unit cut area, W(J/m^2), was obtained by differentiating equation (1) and dividing by the mower cutting width, 1.65 m:

$$W = 74.2 + 46.7V \qquad (2)$$

Equations (1) and (2) apply only to (a) values of V in the range 1.4 – 10 m/s (b) the standard rotor speed of 1788 rev/min (c) a mower inclination from the horizontal of -1.6^{o} ie mower "bites down" into work. The best mower performance was achieved at a forward speed of approx 2.7 m/s (9.7 km/h) and a blade speed of approximately 90 m/s. Additional factors tested were mower inclination from the horizontal (+ 1.6 to – 3.2^{o}) and rotor inertia (using a commercial rotor of 30 kg mass and 1.39 kg m^2 inertia, and a special light weight rotor of 17.1 kg mass and 0.792 kg m^2 inertia).

A statistical analysis revealed that the crop density (0.9 – 5 kg/m^2) was by far the most important crop characteristic accounting for 46% of the variation in power consumption. The stem shearing strengths (7 – 133 kN/kg/m) and number of stems per unit area (900 – 5400/m^2) accounted for 14% each. Other factors such as crop height (0.42 – 0.95 m), crop dry matter content (17 – 34% W/W), crop type (perennial rye grass, Sceempter hay, tetraploid hay), and crop age (May–August cutting season) had lesser effects.

Design of rotary mowers

The appearance of the mass of crop per unit area as the greatest influence on cutting energy in the field was important. It suggested that designers should concentrate not on the actual cutting of the grass, but on the transfer of momentum to the cut material and the conveying of it over the rotors. In the type of machine used in the field trials considerable power could be saved by driving the blades at a different speed to the rotors. The blades could then move at the high speed required for cutting while the rotors moved at a speed just sufficient to convey the cut crop away. The power consumed in friction between rotor and crop and the transfer of momentum would be greatly reduced. The outer edge of the rotor could also be used to help hold the crop as it is being cut and so reduce the transfer of energy even further.

A suggested design procedure for both disc and drum rotary mowers was developed. The design procedure includes both the geometric or purely mathematical aspects as well as the engineering requirements of satisfactory field performance and economy of power. The factors considered were the mower working width, the blade speed, the forward speed, the blade number and length, the rotor spacing, the rotor inertia and the power required. The type and details of the rotor driving mechanism were not considered. Although the design guide was developed for grass crops grown in the Republic of Ireland, it is also valid for grasses grown elsewhere and for different forage crops.

The grass-cutting research project has stimulated the design and construction of a patented 1.68 m rotary mower in our department[4]. Initial field testing of the prototype revealed highly satisfactory performance. We now hope that the machine will be produced commercially.

Reverse osmosis

THE process of reverse osmosis has been shown to be a promising dewatering technique in the field of agricultural processing. Most membranes are based on cellulose acetate and our study[5, 6, 7] has investigated the effects of the fabrication and formulation variables on their performance during skim milk concentration.

Membrane test cells

Figure 3 shows a diaphragm pump feeding the test cell through an accumulator and a pressure relief valve set at 20 MN/m^2. The test cell consists of three 25 mm thick plates each 250 mm in diameter with membranes sandwiched between them. The middle or high pressure plate has small channels cut on each of its faces. The high pressure feed flows through these channels while in contact with the membrane. Channel size and flow rates ensure constant turbulent flow. Stainless steel plates, perforated with 1.5 mm holes support the low pressure side of the membranes and permit removal of permeate. A back pressure valve gives the desired system operating pressure. Transducers enable continuous pressure monitoring.

In conjunction with this cell, a laboratory module of the DDS type *(De Danske Sukkerfabriker)* was used. This unit had the advantage of simplicity of use and accommodation for larger membrane areas – (0.36 m^2 compared with 0.02 m^2 for the laboratory fabricated unit). A disadvantage was its variable flow channel size with consequent variation in Reynolds Number. Performance was, however, identical for both units.

Results

The optimum membrane appears to be one with a low degree of cross linking, the larger pores of which are blocked by a small water insoluble molecule such as silver nitrate. Also successful are the conventional formamide modified membranes and the more recently developed 'thin film' type membranes. Flux and rejection data are shown in table 1 for the range of membranes utilised. Mass transfer models were also tested and it was found that optimum results were obtained using modified models from capillary diffusion theory. A brief study of membrane structure using scanning electromicroscopy did not fully support this theory.

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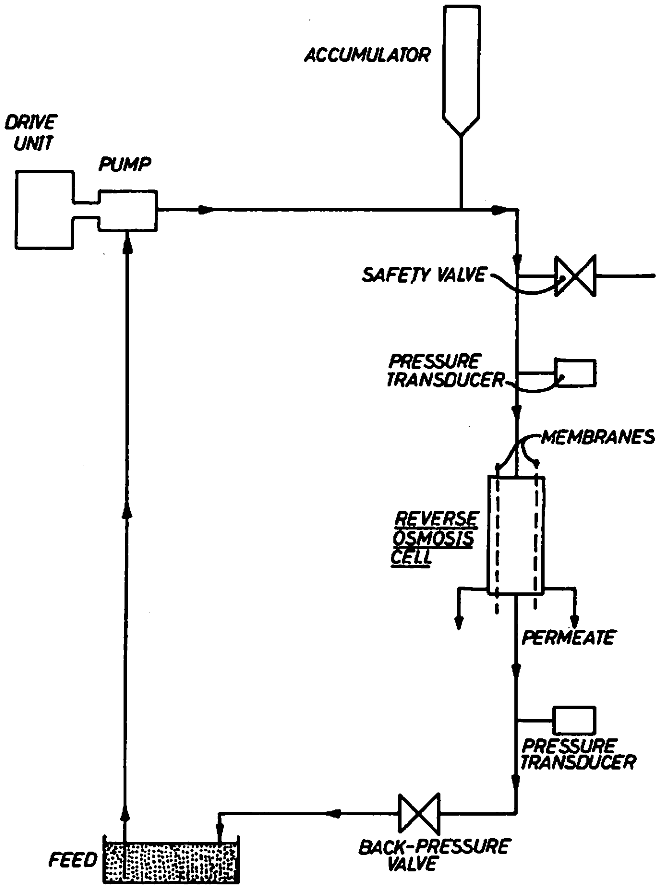

Fig 3 Diagram of continuous-flow laboratory test unit.

Table 1

Performance of membranes using skim milk as feed and a feed pressure of 10 MN/m^2 (100% rejection of protein in all cases).

Membrane type	Additive	Permeate flux $m^3/m^2/day$	% Rejection Lactose	Cation K	Ca
Quaternary:—	$Mg(ClO_4)_2$ – Loeb (a)	0.748	99.6	89.5	99.6
Cellulose acetate	H_2O_2	0.058	97.9	83.0	97.8
Acetone, water + additive	Glyoxal	0.170	56.2	63.0	94.1
Ternary:—	Formamide	0.850	99.6	91.0	99.9
Cellulose acetate	triethylphosphate	0.223	99.9	97.0	99.9
acetone,	Acetic acid	0.250	98.2	96.0	99.6
additive	Dimenthyl sulfoxide	0.218	53.6	62.0	93.0
	Dimethyl formamide	0.032	95.0	95.0	99.0
Binary:—	Acetic acid	0.353	97.9	81.0	99.5
Cellulose acetate	triethylphosphate	0.402	92.7	64.0	98.0
+ additive	Dimethylformamide	0.400	96.8	60.0	99.0
Blocked membranes	Silver chloride	1.25	95.0	91.0	86.0
Thin film type (b)	Polyacrylic acid	0.600	90.0	80.0	85.0

a. Loeb & Sourirajan, Dept of Eng, Univ of California, Los Angeles Report 59-28, 1959.

b. Lonsdale, Office of Saline Water, US Dept Int Report PR577, 1970.

Conclusion

The main conclusion of the project was that the problems to be overcome in concentrating milk by reverse osmosis at reasonable costs are those connected with elimination of the protein deposit on the membrane surface rather than membrane development. Research in this direction is under way.

Examples of other uses for reverse osmosis in agricultural processing include fractionation of glucose syrups[8] and waste water treatment[9].

For further information on these projects contact P B Mc Nulty.

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Research and development at National College of Agricultural Engineering

Straw utilisation: A technico-economic study of straw collection, storage and transportation from farm to processing factory

Background to the problem

IN the NFU Working Party Report on Straw Disposal, 1973, it was estimated that 38% of the total straw produced in Britain in 1972 was surplus to the requirements of the farming industry for feeding, bedding etc and that of this approximately 93% was burnt and the remainder ploughed in. In weight terms the amount of straw burnt was estimated to be approximately 3.5 million tonnes. As a somewhat conservative straw yield/hectare figure (2900 kg) was assumed in the report, the actual tonnage of straw burnt in Britain in 1972 could well have been much higher.

A number of possible uses for this apparently wasted raw material are currently being investigated. Many of them involve a factory-scale industrial process, which if commercially exploited, would require straw to be packaged, stored for some period (either on- or off-farm) and then transported to factories. These uses include straw pulp for paper making (wheat straw preferred), conversion of barley straw to a high energy animal feedstuff by alkali treatment, furfural production and fibre board manufacture.

The Wolfson Foundation supported straw project at NCAE (start-date September 1974) forms part of a loosely co-ordinated national programme in a number of technological fields designed to promote more efficient utilisation of that straw now burnt.

Project objectives

The study is concerned with the logistics problem of year-round supply of straw of specified quality from farms to processing factories which, of course, do not exist at this time apart from pilot scale plant. In broad terms, the purpose is to determine a comprehensive model of the system of costs involved in obtaining a satisfactory year-round flow of straw from farms to factories using both existing and new packaging technologies. Further, to explore the wider issues of these costs on the desirable location and viable throughput of processing factories and the price of straw which might have to be paid to farmers to induce them to conserve their surplus straw for industrial processing in preference to burning.

Thus, the NCAE study should contribute towards determining whether or not an economic case can be made for any or all of the industrial processes under consideration ie the case for the establishment of a national network of factories of perhaps different kinds and throughput. Whilst it is not the purpose of the project to investigate the technological aspects per se of the straw conversion processes referred to earlier, some knowledge of them is essential in as much that they will relate in a two-way manner to the following:—

(i) the supply of straw, its quality etc
(ii) straw packaging, handling, storage and transportation (physical systems and costs) and
(iii) the number, size and location of factories.

In detail the project objectives are listed below:—

(a) to ascertain the costs to the farmer for straw collection from the field and storage on the farm taking into account the diversity in bale handling systems design and the influence of scale,
(b) to establish the cost per ton mile of transporting currently available bales from the farm to the processing factories and to determine any potential savings obtainable by increasing bale density.
(c) to determine the costs associated with centralised storage of straw for comparison with on-farm storage costs,
(d) to establish the role of farmer co-operatives, contractors and/or other intermediate trading organisations in supplying straw on a year round basis to processing factories and the influence these agencies would have on costs.
(e) to find optimal locations for processing factories of given throughputs where the factories are processing (a) all cereal straw and (b) barley straw alone.
(f) to establish the costs and benefits associated with straw burning in situations where all recommended precautions are adhered to by the farmer.

Progress to date

A straw allocation — factory location model is being developed using the infinite set approach. Initially, a single factory model with sources defined at the county-by-county level is being constructed but as confidence is gained in the modelling procedure so various additions will be incorporated eg multi-factory solution, step-wise linear transport costs, specification of factories with different straw type requirements, and in the final event, analysis in much greater depth, where the sources are defined on a 10 km^2 grid basis.

The data required for the model include the number of potential sources of straw, their location and the amount of straw available at each location, the transportation cost per ton mile and the factory operating costs. Sources of information already approached include ADAS, straw merchants, haulage contractors, farmers and industrial organisations. One of the vital relationships to be determined is that between the price paid to farmers for straw and the quantity (and quality) which will be forthcoming to processors. This will necessitate a thorough investigation of the positive benefits which farmers ascribe to burning.

For further information on this project contact D H Noble, R W Radley and D L O Smith.

Low cost primary cultivation - A report on the progress with the Snail

Principle of operation

THE Snail device was evolved in an attempt to enable a small farmer in a developing country to cultivate his land during the dry season so that planting could be carried out at the beginning of the rains. Early planting is normally considered to be a prime requirement in achieving a significant increase in crop yield.

The principle of the Snail is based on that of a winch operation which is used to achieve a high pull from a light weight machine, resulting in effective use being made of the power developed by a small engine. A detailed description of the early development of the concept has been published by Muckle, Crossley & Kilgour (1973a[1]), (1973b[2]) and a description of a short-term test in Malawi during 1973 is given by Crossley & Kilgour (1974[3]).

Design of the current machines

THE design of the cultivation equipment is based on a modified ox implement fitted with a short skid to resist downward movement normally taken by the oxen. It is relatively simple, and different types of tool such as ridging bodies or weeding blades may be fitted.

The tractive unit must provide sufficient traction for forward motion at a suitable speed, adequate torque to drive the winch drum and be easily controllable. Many variations are possible but the current Mark 4 prototype makes use of a petrol or diesel engine (both types are to be tested) of 3 kW with an output speed, via a reduction gearbox, of 500 rev/min. Multiple vee-belt drive, incorporating a combined clutch/tensioner, transmits power to the winch shaft which is mounted transversely behind the engine, the winch speed being 130 rev/min. With a cable drum diameter of

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150 mm, this provides a pull of 2.5 kN at 1 m/s for weeding operations. However, by means of a pulley mounted on the implement, with the end of the cable attached to the tractive unit, the pull may be doubled to 5 kN for primary cultivation. Usable cable length is 100 m and 50 m respectively.

Drive to the single, centrally mounted, traction tyre is achieved by means of an enclosed chain, the alternative drive mode (winch drive or ground drive) being selected by a dog clutch. This configuration enables good ground clearance to be provided for use with ridging and stability is achieved by an adjustable chassis cross member incorporating wheels or skids.

For the transportation made, the chassis cross member can be quickly removed and a suitable trailer based on an ox cart "plugged" into a built-in pivot on the tractor unit.
This enables the operator to sit on the trailer and steer the articulated three-wheel unit so formed by means of handlebars. A road speed of 8 km/h is attainable and a brake is also incorporated.

Future developments in field testing

FUNDS for an extensive test scheme have been generously provided by the Ministry of Overseas Development, and the author will be supervising the testing of two, later four, prototypes in Malawi for 15 months from March 1975. Performance details will be obtained from the machines when used in various conditions within the country and the feasibility of local production will be explored. In addition to providing as assessment of the technical viability of the device it is anticipated that an economic evaluation will be made, enabling the commercial possibilities of the system to be defined.

If the first series of tests in Malawi are successful, there is provision, within the programme, for a further year of testing using a larger number of prototypes. These tests may be in India, with the possibility of local manufacture being actively investigated.

For any machine to be successful, it must be possible for the owner to produce more profit from using the device than it costs to own it. With a relatively small simple machine such as Snail, it would appear that the possibilities for commercial success are more promising than they would be with a larger device which would require group ownership with all the problems which this entails. No general solution to the problem or mechanisation of small farms in developing countries has yet been found, although various alternatives, ranging from human and animal power through to small and standard sized tractors, have applications in certain conditions.

It is felt that the Snail principle offers the possibility of an answer to at least some of the problems associated with this increasingly important area of world agriculture, but to what extent it represents an answer will become better known when the current test programme has been completed.

Considerable effort has been made to prevent escalation of cost and complexity and it is felt that the current prototypes represent the simplest sound design which can reliably carry out the required tasks in the conditions encountered. It must be explained, however, that the project is still in the prototype stage and, until extensive tests have been carried out on a number of prototypes over a period of two to three years, there is no intention to release the design for production.

For further information on this project contact C P Crossley

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Research and development at University of Reading

A driverless tractor

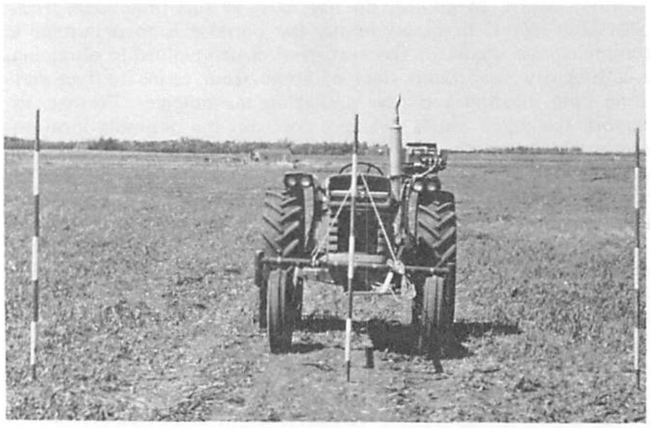
A DRIVERLESS tractor should be able to perform a variety of work patterns with implement widths ranging from less than a metre to as much as ten metres and produce a quality of work at least as good as can be achieved by an operator working continuously. The main factor affecting quality is accuracy and to ensure there are no gaps in the work whilst avoiding excessive overlap, the total error on any pass needs to be of the order of not worse than 0.1 m. A system which provides such accuracy at reasonable equipment cost is leader cable guidance, and it can be shown that the cost of laying the wires becomes economic if the spacing is of the order of 50 m.

At such wide spacings the magnetic field between a pair of cables is substantially vertical, and a guidance signal can be obtained by comparing the magnetic field strength at either side of the tractor. If the two sensors are about 1.5 m to 2 m apart ie no wider than the tractor, the ratio of the two field strengths changes by about 0.006 for each metre of lateral motion. A very precise and stable detector is therefore required, and a suitable circuit[1] has been developed and tested satisfactorily.

In this circuit, the sensor coils are connected in the feed back loop of their own head amplifiers which gives very high stability. By feeding back a further signal aided and the other opposed. The output signals can be made to be equal at some point between the wires the tractor can be made to follow a predetermined track down the field. Since all the factors controlling this position depend upon ratios, excellent stability can be obtained.
track down the field. Since all the factors controlling this position depend upon ratios, excellent stability can be obtained.

The necessary feed back ratios are precomputed and stored in a programmer. This contains a memory for the current position, and each time the tractor reaches the headland the implement width is added in, thus causing the control system to move the tractor across the field.

The programmer was built using a microprocessor which is greatly superior to a hard wired controller. Not only is it potentially cheaper but modifications both at development and in use can be made by simply changing a few instructions in the programme, and very comprehensive self checking features, which are essential for safety, are simple to incorporate.



A driverless tractor on test at University of Saskatchewan, during IFAC Conference, June 1974. Tractor is back on the centre line after completing a circuit.

There is now a great deal of knowledge on tractor guidance available, and full automation or driver aids are commercially quite feasible. What is now required is for a few farmers to try them out in practice.

Present work on automatic tractors is concentrated on safety[2], vehicle dynamics and economics.

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→*page 33*

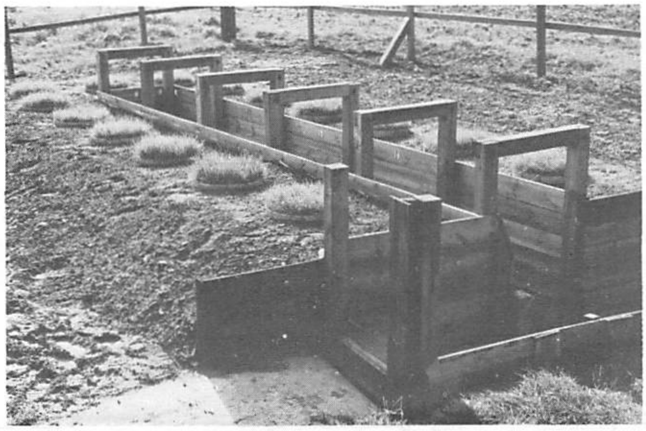
An evaluation of aerobically treated cow slurry compared with untreated cow slurry when applied to grassland

THE objectives of the study are to evaluate the extent of the benefits to agricultural production and environmental quality which aerobic treatment of cow slurry may provide and to compare this with the organic irrigation of untreated cow slurry, when applied to grassland.

The following parameters are being measured:—

1. The extent of nitrogen utilisation: This is measured by monitoring the grass yields and composition from a series of lysimeter plots to which treated and untreated cow slurry have been applied at nitrogen rates varying from 100 kg/ha to 600 kg/ha annually.
2. The extent of loss by leaching of nitrogen compounds when applied at monthly intervals throughout the year.
3. The response by grassland to applications of nitrate nitrogen (during the summer) from treated cow slurry when compared with organic nitrogen in untreated slurry.
4. The extent that the soil is able to retain BOD_5 and COD from treated slurry compared with untreated by an examination of the drainage water from the lysimeters.
5. The levels of coliform organisms present in the drainage water from the plots.
6. The loss in the drainage water of nitrogen, phosphorus, potassium, magnesium, calcium, sodium and iron from the plots compared with a series of controls.
7. The build up in the top 150 mm of the soil of the above named minerals due to the applications of slurry.

The study consists of 15 lysimeters of which three are controls, and six receive the treated cow slurry and six the untreated. Each lysimeter consists of an undisturbed soil core one metre deep and 508 mm wide, removed intact from the field and contained by a spun fibre glass cylinder. The soil consists of a light acid, free draining sandy loam from the flood plain of the Thames at Sonning.



The 15 lysimeters installed at the University Farm, Sonning, for studies on aerobically treated cow slurry.

The cores were removed to the treatment site and 80 mm of the base soil was removed and replaced by a coarse washed gravel to aid drainage. The bases were sealed by a layer of sheet fibre glass to which a central drainage sump consisting of 35 mm plastics waste water-pipe was fitted. The completed cylinders were then hoisted on to a concrete platform surrounding a central monitoring passage. The passage sides were boarded up and the cylinders buried to ground level leaving 50 mm projecting above the surface. The plots were sown with Lolium Multiflorum (Italian ryegrass RVP) on 1 July 1974. Monitoring of the rainfall and drainage from the lysimeters started in September 1974.

Running parallel with the study is an investigation into the changes in the soil microflora caused by the applications of slurry on the lysimeter plots, carried out by the Department of Microbiology at the University of Reading.

Ventilation of livestock buildings

OVER the last three years a number of systems have been designed and installed in pig and calf houses. The main purpose of the work has been to evaluate the performance of these systems under practical conditions and to demonstrate how good ventilation might be achieved. The physical conditions resulting in the houses, the power consumption, mode of operation and the problems arising during continuous operation of these systems is being monitored.

a. Extraction system — pig fattening house

Fig 1 illustrates a ventilation system that has been installed in a pig fattening house. Its main features are:

1. Air extraction from beneath the slats of the house.
2. Fan speed controlled by means of a solid-state temperature-based controller.
3. An automatic inlet control to maintain correct air velocity through the inlets at all fan speeds.
4. A fail-safe system to operate in the event of power failure.

This system has been in operation for a period of three years and proved extremely satisfactory. House temperatures are maintained to within 2°C of the desired house temperature. Control of the desired condition is only lost when the pigs in the house provide insufficient heat to meet the structural and minimum ventilation heat losses or when the outside ambient temperature exceeds the desired temperature level. The use of a solid state controller with a temperature sensor of low thermal mass ensures a quick response by the system to changes of the house temperature. The automatically controlled inlets are set to provide an inlet velocity of 3-4 m/s and direct the inlet air along the ceiling of the house. The inlet speed is maintained at all fan speeds, which ensures a constant pattern of airflow within the

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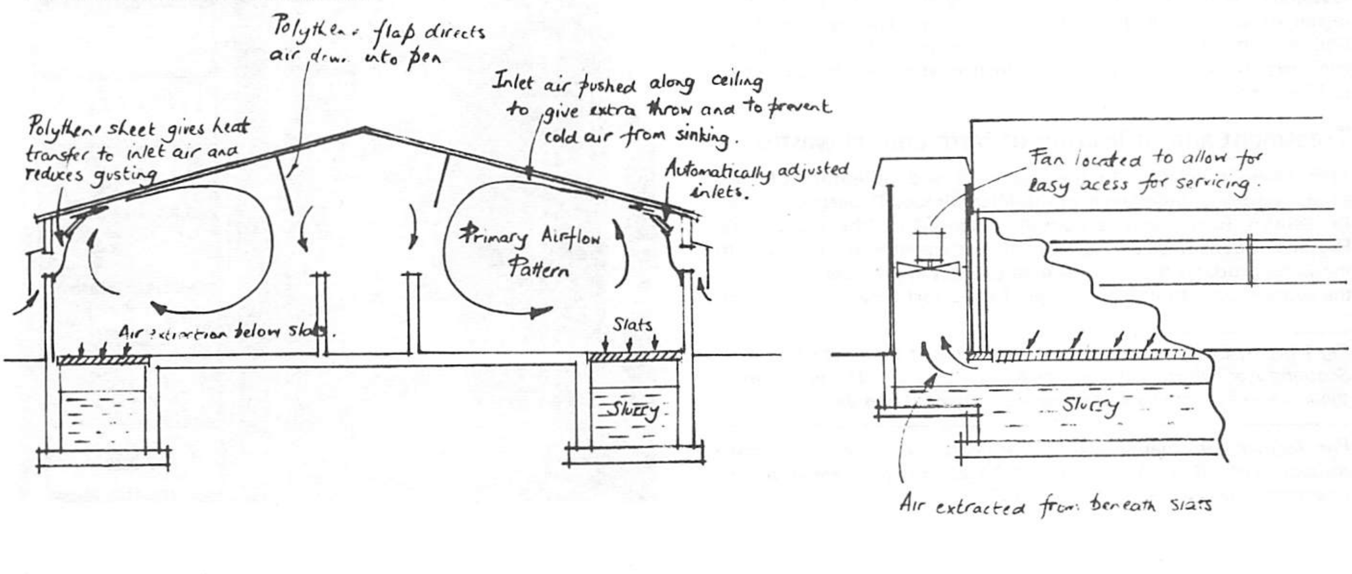
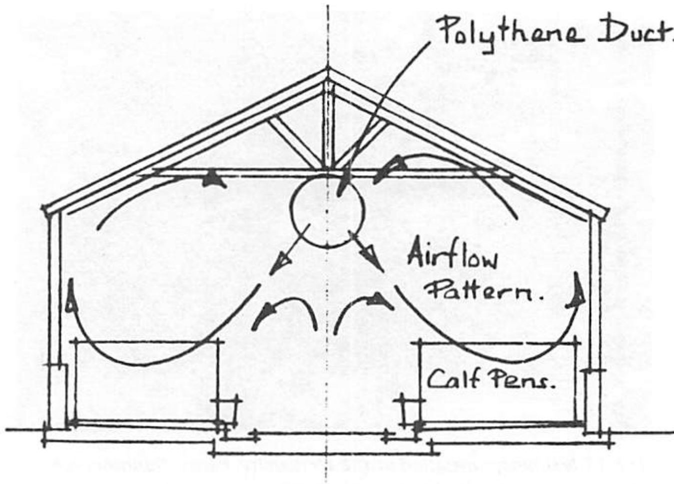
Fig 1 Extraction system for pig house.





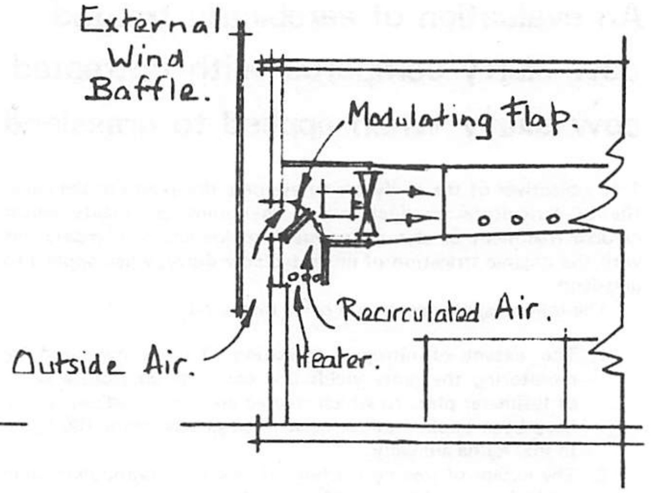


Fig 2 Recirculation system for calf houses.

house. The use of this constant velocity inlet together with the effect of the polythene sheet (between the inlet opening in the wall and the inlet flap) appears to reduce considerably the effects of wind and overventilation in winter.

When the system is switched off there is a very quick rise in house temperature, and it was decided to install a fail-safe system to open the doors in the event of power failure. This simple arrangement has proved to be quite adequate when such failures have occurred.

b. Recirculation system – calf house

Fig 2 illustrates a ventilation system that has been installed in two calf houses. The main features of this system are:

1. Ventilation control is by a recirculation system up to half the maximum ventilation rate. On/off control is used between half and full ventilation rate.
2. The system is used in conjunction with polythene ducts, which are designed to provide the same pattern of air movement at all ventilation rates.
3. A heater is also used to prevent high relative humidity and low temperatures both occurring at the same time.

This system has been in operation for two years and has proved quite satisfactory. The airflow pattern can be maintained at all ventilation rates and is unaffected by outside air temperature or wind effects.

The temperature requirements in the calf house are easily met since temperatures between 5°C and 20°C are acceptable. However, it is important to avoid high air velocities over the livestock at the lower temperatures and this is successfully achieved, by the system running at half speed during colder weather.

When the system runs at full speed the air velocity over the stock increases but since this only occurs at higher temperatures it is not detrimental to the livestock.

For further information on these projects contact J A C Gibb

Research and development work at the West of Scotland Agricultural College

FOR many years the work of the West of Scotland Agricultural College was split between Glasgow and Auchincruive near Ayr but with the opening in 1974 of the new teaching and biology buildings by the Secretary of State for Scotland, Mr William Ross, the move to Auchincruive was completed. The provision of enlarged facilities at the one centre has improved all aspects of the service to farmers in the West of Scotland and not least in the field of research and development work.

The R and D interests of the College cover a wide field and include work in agriculture, horticulture with emphasis on protected cropping, and food technology related to milk and milk products. Livestock farming is the major agricultural activity in the west region of Scotland and in this field there are two aspects of the College's effort which are of particular interest to agricultural engineers, namely, the work on animal wastes and the project on calf housing.

Treatment and utilisation of farm animal wastes

THE work in relation to the treatment and utilisation of farm animal wastes is undertaken in the Microbiology Department under Dr Selwyn Baines and is partially financed by the Agricultural Research Council. Much work in the treatment and utilisation of the waste products from animal enterprises is in progress throughout the western world but a great deal of the effort is based on trial and

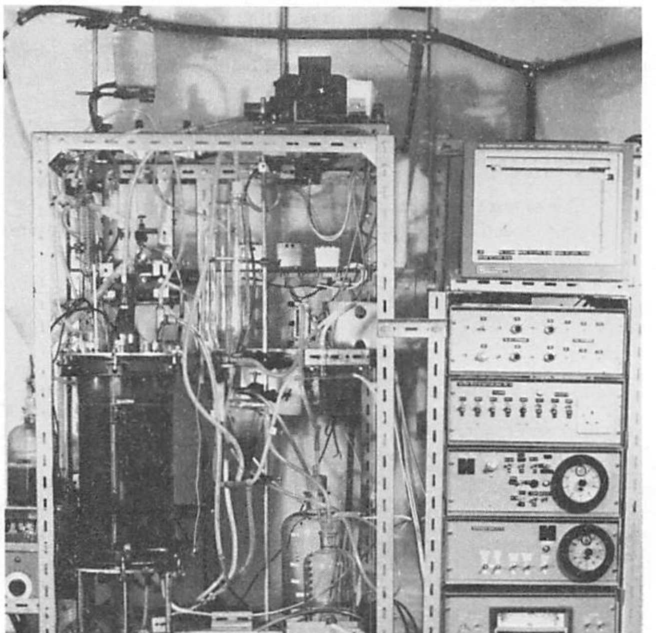


Fig 1 (right) Laboratory fermenter for slurry at the West of Scotland Agricultural College: the fermenter is the glass vessel on the left and has associated control equipment alongside.

For further information on the projects mentioned here make contact with G C Mouat BSc NDAgrE FIAgrE, Head of the Engineering Department, Auchincruive.

error methods. Some of the laboratory work at Auchincruive is designed to provide basic data on which scientific approaches to full scale treatment plants can be based and experiments are proceeding to determine the parameters which affect the biotransformation and degradation of waste materials. The work is carried out in small scale fermenters which are fully automated so as to provide controls for loading rate, total suspended solids concentration, dissolved oxygen concentration, pH and temperature. The results show the effect of varying the loading rate and dissolved oxygen concentration in the aerated mixed liquor on the oxygen consumption and the products of the treatment system. For example, high rate, short-time aerobic treatment of slurry is sufficient for odour removal and the elimination of soluble compounds which may give rise to water pollution, whereas more prolonged treatment can result in up to 40% reduction in solid material and the production of a relatively stable product which can safely be applied to the land.

Many experimental systems of slurry treatment are based on dividing waste products into different types of material such that solid particles can be treated separately from the colloidal material and so on. The Auchincruive work enables predictions to be made on the treatment necessary for different fractions of slurry so as to produce acceptable products. Experiments on the four major components of pig and hen excreta (coarse and fine solid particles, colloids and solutes) have determined their chemical composition and biodegradability. Such information is essential in determining the economical justification for separating slurry into fractions before beginning treatment. Information has been obtained on the rate of microbial growth in the aerobic treatment systems and experiments have shown that there is in some instances a net increase in the total solids in a slurry due to the growth of micro-organisms during periods of aeration.

Laboratory results are being followed up in field scale experiments. On a farm in Wigtownshire a permanent installation is being constructed following successful preliminary trials using a 10 kW floating aerator in an existing 300 m^3 slurry tank to treat slurry from 5000-6000 whey fed fattening pigs prior to land application. In the new plant slurry from the piggeries will drain into a 400 m^3 tank fitted with three 5 kW fixed aerators, mixed liquor from this tank will flow into the original 300 m^3 tank with its 10 kW floating aerator and after further treatment there will be applied to the land via rainguns. Continuous monitoring will be carried out on the effluent flow from the piggeries and of the oxygen concentration, pH and temperature of the mixed liquors. Additionally there will be routine soil analysis and land drainage studies on the ground receiving the treated materials.

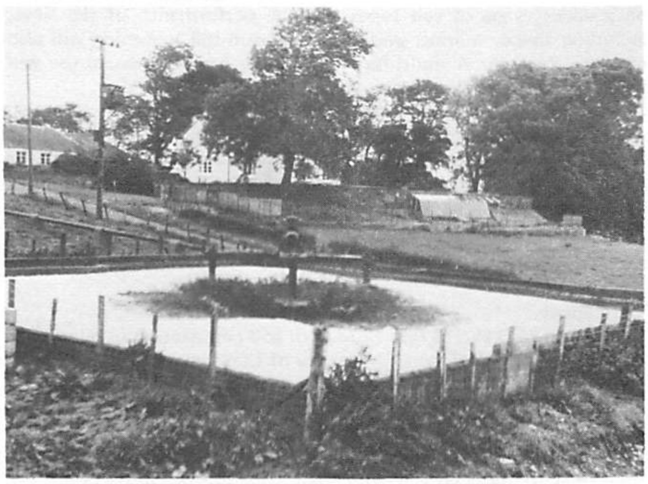


Fig 2 Field scale aerator on a Wigtownshire farm which is monitored by the staff of Microbiology Department, Auchincruive.

The design of experiments and the operation of pilot scale plants at other centres, such as those at the Scottish Farm Buildings Investigation Unit, Aberdeen, and the National Institution of Agricultural Engineering, Silsoe, are now being modified to take account of the results from the WSAC. The data from the experiments is also used in the development and confirmation of mathematical models of farm waste treatment systems in association with the University of Newcastle. Clearly in this brief report it is only possible to touch at one or two facets of the work on animal wastes. Further investigations include those concerned with the production from pig slurry of single cell protein for use as an animal feed supplement. The major objectives of the WSAC work can be summarised as the provision of detailed biological and biochemical data which are necessary for the design of treatment systems. Efficient treatment systems are those which produce an innocuous and preferably, a valuable by-product such as an animal feed supplement or a more suitable fertiliser than untreated slurry.

Calf Housing Project

THE losses of young calves are at an unsatisfactory high level throughout the United Kingdom and are higher as one travels to the north and west of the country. It is therefore appropriate that the West of Scotland College should study the effects of different calf house environments and levels of feeding on the performance and health of calves. The first experiments are concerned with the period from birth to weaning as this is the period when calves are most susceptible to climatic and nutritional influences.

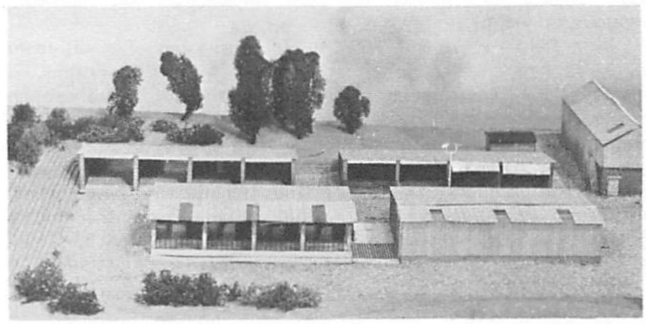


Fig 3 Model of part of the project site of the Animal Husbandry Department at Auchincruive showing the four experimental calf houses.

The project leader is Norman Day of the Department of Animal Husbandry who had the help of the Farm Buildings Department of the College in the design of four experimental calf houses which have provision for environmental control. A major contribution to the project was made by Dr J McLean of the Hannah Research Institute in the design and installation of automated recording equipment for environmental data. Thermocouples are utilised to measure ambient temperature and a black ball thermocouple measures radiant temperature. Air movements within the houses are determined by hot wire anemometers whilst a dewcell is employed to measure the relative humidity. Provision is also made for sampling the air within the houses by means of a small pump working on an intermittent cycle. The conditions outside the calf houses are monitored using similar recording equipment in conjunction with a thermocouple inside a Stevenson Screen, a solarimeter measuring solar radiation and wind speed and direction indicating equipment.

Signals from the instruments are taken to a separate room containing a digital voltmeter and data transfer unit linked to a teleprinter; it is in this way that information is directly recorded onto tape for computer analysis. A typed copy of the data is also immediately available for rapid visual examination and checking.

The experimental husbandry unit also accommodates older cattle fed on a variety of diets. Control of feeding arrangements is facilitated by the use of Calan Broadbent doors used in conjunction with a tombstone feeding arrangement. The system requires that each animal carries on a neck chain a plastic key containing an electronic circuit turned to one of twelve frequencies. When the appropriate key is brought near to a door an oscillator circuit in the door, which is tuned to the same frequency, is used to withdraw a solenoid bolt. The animal carrying the key, and only that animal, is then able to push the door open and gain access to its ration. The system operates on 18 volt direct current and standby power is provided by a bank of batteries charged from the units own power source. Experience has shown that normally it takes two days for cattle to accustom themselves to the use of the doors. So far mechanical and electrical defects with the system have been few and usually due to simple faults such as broken neck chains.

Work on the project commenced in the early part of 1974 and only preliminary results requiring further confirmation are available at the present time.

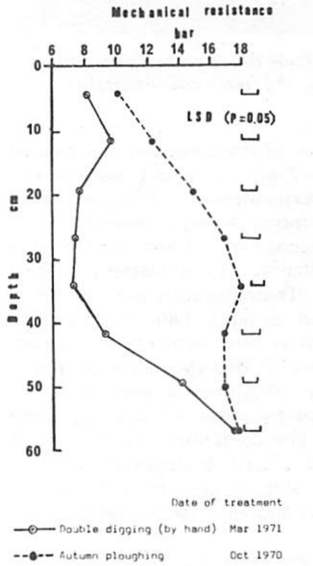
In addition to these two major projects the College has in progress a number of other projects of significant interest to engineers. These include a milk production systems investigation, a study of rotary milking parlours, work on intensive crop production under plastics covered structures and the development and evaluation of low cost drainage systems.

Research and development at Wye College

A double digging machine

THE merits of double-digging have long been recognised by gardeners who use hand tools to prepare the ground before sowing or planting. This technique, however, has not been applied to field crops because of the absence of machinery suitable for agricultural use. The incidence of compaction is believed to be widespread in mechanised agriculture (Soane, 1970). Investigations by Gooderham and Fisher (1972), Fisher *et al* (1975) and by El Karouri (1974) at Wye College have shown that soil compaction can markedly reduce crop yield.

In a field experiment at Wye, double-digging of a silt loam by hand had a dramatic effect on soil physical conditions, as indicated by penetrometer measurements (fig 1). This thorough loosening of the soil gave a 14% increase in barley yield in 1971 and a 15% increase in the yield of a two-year ley of Italian rye-grass in another experiment in 1972/73 on silt loam, but no such increase was obtained on a clay soil. These results were, nevertheless, sufficiently encouraging for a prototype double-digging machine to be built in 1973, where the aim was to reproduce the loosening effect previously achieved by hand digging.



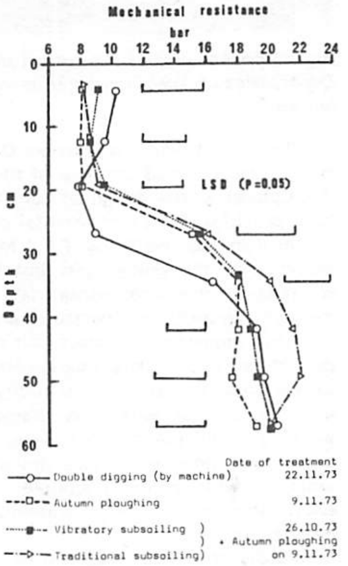


Fig 1 (left) Means of penetrometer measurements taken on 29 April, 18 May, 7 June, 28 June, 19 July, 26 August 1971.

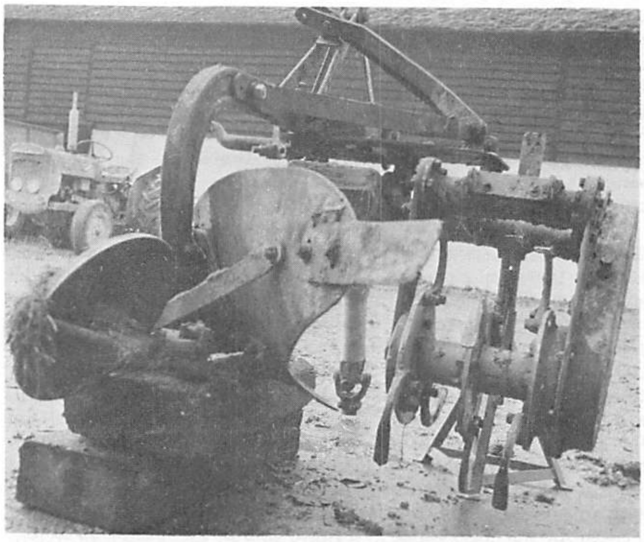
Fig 2 (right) Penetrometer measurements taken on 25 April 1974.

In developing the machine the requirements were:—

1 to break up very thoroughly the sub-soil;
2 to retain the top-soil and sub-soil in separate layers, and to avoid soil inversion;
3 to mount the machine on a standard 3-point tractor linkage so that tractor power take off could be used.

Possible designs included (a) a double depth mouldboard machine, (b) two rotor assemblies one above the other, (c) mouldboard plus fixed tines and (d) mouldboard plus rotary tines. Designs (a) and (c) were rejected because of the difficulty of achieving thorough loosening of the sub-soil. Design (b) presented the major problem of providing a mechanical drive. The eventual design was therefore based on (d), a single furrow mouldboard plough with a rotor to follow behind the tractor wheel in the furrow bottom preceding furrow inversion (see photograph).

In the first prototype, reverse rotation was used because of the simple drive possible with an existing gear box and the theoretical reduction of 20% in rotational energy input (Hendrick and Gill, 1971). However, the rotor of the current prototype has forward



The double-digger.

rotation which improves the force characteristics, throws less soil forward, and gives some push advantage to counteract plough draught.

To test the machine's effectiveness, a field experiment comparing double-digging with conventional subsoiling, vibrating subsoiling, and ploughing is being carried out on two soils, a silt loam and a clay, using test crops of sugar beet and Navy beans.

Although investigations are incomplete, penetrometer readings (fig 2) taken five months after treatment show that double-digging reduced mechanical resistance at 20-30 cm depth, whereas the two subsoiling treatments did not achieve this loosening effect. Furthermore, in 1975 the machine has operated successfully at its working depth of 35-40 cm. Further field trials will be carried out on a wider range of soil types and the performance of the tines, including shape, number and speed, for sub-soil loosening will also receive attention. A multi-furrow machine for commercial use will involve further developmental work.

Apart from the advantage of giving a more thoroughly loosened sub-soil, the machine is expected to operate successfully over a wider range of soil moisture conditions than those required for traditional subsoiling. Furthermore, the machine, with suitable modifications, could be adapted for mixing fertiliser into the sub-soil, or on marginal shallow soils for controlled mixing of top and sub-soils as when marling.

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Hendrick J G and Gill W R, (1971). Rotary-tiller design parameters, Pt 1. Direction of rotation Trans ASAE 669–674.

Soane B D, (1970). The effects of traffic and implements on soil compaction. *J Inst Agr Eng* 25,3, 115–126.

For further information on these projects contact I B Warboys, P T Gooderham, J M Wilkes, and S M Wilkins, Wye College (University of London), Ashford, Kent.

Note this date: 14 October 1975

THE FUTURE FOR OPERATOR EFFICIENCY & SAFETY IN THE AGRICULTURAL INDUSTRY

VENUE: National Agricultural Centre, Stoneleigh

These conferences organised by the Institution of Agricultural Engineers in support of National Farm Safety Year will seek to deal with this important subject in an every day and practical manner, and particularly to interpret and highlight the effect of the 1974 Health and Safety at Work etc Act on the responsibilities of machinery and equipment designers and manufacturers.

The chairman will be J H Wilder OBE BA FRAgS HonFIAgrE Past President of the Institution, who is well known throughout the agricultural industry for his support of sound design principles in relation to operators safety.

PROGRAMME

10 30	–	"The Health and Safety at Work etc Act: Its effect on designers, manufacturers, suppliers and installers of agricultural machinery." John Weeks: Director of Farm Safety MAFF
11 00	–	"The Guarding of Mowing Machines, with some notes on the work of ISO in this sphere." Wilfred Klinner: NIAE
11 20	–	"Research into the Stone-throwing Problem with Small Rotary Machines". J M Anstey: Production Director Wolseley-Webb
11 45	–	"The Problems of Ventilation and Dust in Farm Buildings, with particular regard to barn machinery". W H Dempsey: ADAS Newcastle
12 10	–	Questions/Discussion
12 30	–	Lunch
14 00	–	"The Ventilation of Farm Buildings to Mitigate the Dust Problem". E Prosser: Electricity Council
14 25	–	"Ergonomics of Tractor Design with particular regard to environment in the safety cab". John Matthews: NIAE
14 50	–	"Psychological Aspects of Agricultural Ergonomics". Ron Easterby: University of Aston in Birmingham
15 15	–	"The Relationship of Livestock to Human Beings and Machines on the Farm". M Seabrook: University of Nottingham
15 45	–	Questions/Discussion
16 30	–	Tea and Disperse

Registration forms will be mailed to UK members of the Institution. Overseas members wishing to register for the Conference, and anyone requiring further information should write to the Secretary, The Institution of Agricultural Engineers, West End Road, Silsoe, Bedford MK45 4DU, tel: Silsoe (0525) 61096.

Industrial straw usage

by Dr D Slight

Introduction

THE problem of straw disposal, even neglecting the wastage of natural resources, is sufficient to generate greater interest in potential industrial applications for the surplus straw. In the United Kingdom, the production of wheat, barley and oats yield some 10 million tonnes of straw annually. Straw yields vary greatly for a number of reasons. They are very dependent upon the nitrogen level in the soil, they are influenced by the type of growing season and also, to a large extent, straw yield depends upon the particular grain varieties which are in fashion. Barley is undoubtedly the most important when discussing straw disposal but from an industrial point of view the important one is wheat.

In the context of straw production, there are basically two types of farm. On the one hand, there are the mixed farms with a balance of stock and crop. In general, these farms do not have a straw disposal problem. On the other hand, the specialist cereal farms and the farms which operate a rotation of crops without a major livestock enterprise are those where a problem often can and does exist. Where these farms are located in the centre or towards the west of the UK, straw will usually find a ready market with local livestock farmers who require it for bedding or feeding cattle; but where farms with high straw production are located near the East Coast from the Lothians to the South of England, transport costs to the livestock areas in the West are high and usually prohibitive. Even if transport costs were reduced, it is doubtful whether the sheer quantity of straw produced in the intensive cereal areas could be utilised in livestock production.

Of the three species, oat straw seldom if ever incurs a disposal problem. Oats tend to be grown only on livestock farms and the straw is valuable as a feed for cattle. The larger quantities of wheat and barley straw, on the other hand, do not find such a ready market. The traditional uses of wheat straw on farms as a thatch for stacks or root clamps have long disappeared, and there is virtually no requirement for barley straw on cropping farms.

It is relatively easy for farmers in the dry cereal areas to burn the surplus straw and there may be some technical advantages in doing this — for example, returning the minerals to the soil and destroying disease spores. The practice, however, is becoming unacceptable to the non-agricultural population, mainly because of the way in which burning is carried out. Farmers avoid setting fire to a field when neighbouring fields contain unharvested grain and burning is usually left until the end of harvest when the weather is often not quite so good and the swaths of straw are perhaps wet. Consequently, the whole countryside is set ablaze on the first dry day after harvest. In East Lothian, with a light westerly breeze, life in Dunbar must be decidedly unpleasant.

Fortunately, there is the alternative of fitting combine harvesters with choppers and ploughing in the residue but this, too, is not without problems. Wind can blow the chopped straw onto neighbouring land and roads or pile it up like snow drifts against hedges. Ploughing is difficult when the spread is not even. There is also the biological problem of "nitrogen locking" which necessitates higher fertiliser rates the following year. After a few years, this nitrogen is slowly released and fertiliser levels can be reduced once again.

It has been estimated that some 3-4 million tonnes of straw are burned annually in the UK. By curtailing this practice, even assuming that some farmers will change over to chopping, an industrial outlet is required for approximately 3 million tonnes annually. As an industrial raw material, straw has four main properties. First it is a source of fibre, second it is a low density insulating filler, third it is combustible and has been used as a fuel although to a very limited extent and fourth it can be used as a nutrient material for biological decomposition by micro-organisms.

Straw for papermaking

AT the present time, the only property which is being exploited commercially is the fibre source for paper and board making. There are several sources of fibre available to the paper making industry, the main ones being wood pulp and esparto grass. Both of these are in short supply and, in fact, there is a world shortage of fibre. It would seem that the surplus straw should find a ready market for papermaking but this is not the case. Straw is not a preferred material. The pulping process is more difficult and it produces a pulp which is inferior to that from other sources.

The lack of success, over half a century, in making conventional recovery of chemicals from chemical pulping liquor work satisfactorily, is a major problem and particularly now that control of pollution has become strict. The production of one tonne of pulp produces about 75 000 litres of effluent. Unless toxic materials can be either recovered from it or neutralised by chemical treatment, the disposal of the effluent is virtually impossible. The second difficulty arises as a result of the slow draining properties of straw pulp as compared with pulp made from wood fibre and the necessity to provide more extensive holding plant for this to take place. A third point is that usually a higher degree of bleaching is required when using straw as against wood pulp. There are several other chemical and technical disadvantages with straw which all tend towards the necessity for a more complex pulping plant with higher capital outlay and running costs. But a fourth problem of direct relevance to agriculturists is assocated with the very seasonal nature of the farm production process. In a cereal area, the annual straw production takes place in a matter of a few weeks at most. With the widespread use of combine harvesters, the straw is often broken up into short lengths and is mixed with chaff. In paper making, it is the actual stem of the plant — the true straw which is best for the process; the residue of the heads and chaff are high in silica and degrade the final paper product. Furthermore, the tendency by plant breeders to produce short strawed varieties together with the seasonal variation in straw length, which incidentally is accentuated by the subtraction of a constant factor of about 10 centimetres for the stubble, is a further reason for rejecting straw as a pulping raw material.

The short production season and the intensive effort which takes place on cereal farms at harvest time to secure the grain in good condition usually means that straw must take second place. Collection and handling does not begin until all the fields have been harvested. From the paper-makers point of view, straw must be collected almost immediately after combining and certainly within two or three days if the pulping quality is to be maintained. This presents most farmers with a labour problem and it is unlikely that present methods could be employed.

A typical pulping mill might have an output of 500 tonnes/day and this figure has been generally accepted as the lower limit for viability in the industry[1]. Also, for a pulping mill to be viable, it must be operated throughout the year. As it requires about 2½ tonnes of straw to produce a tonne of pulp, a mill requires 300 000 tonnes of straw per year. The important point, however, is not this total figure but that the straw is required at the rate of about 1 000 tonnes each working day throughout the year. If farm production takes place in about a month, then storage must be found for around a ¼ million tonnes of straw for each pulp mill. The straw must be kept in good condition and, with the low density of baled straw, 250 000 tonnes occupies an enormous volume. A number of problems arise such as the cost involved in paying industrial rates for suitable premises, the fire risk and the cost of precautions, the maintenance of the building not to mention the handling which would undoubtedly involve a large labour force and the difficulties and perhaps hazards of continuous dusty work.

Compared with straw, wood pulp can be supplied on a continuous flow basis. Timber felling can take place all the year round and it seems unlikely that straw would be considered were it not for the current world shortage of wood pulp, its rising price and the lack of foreign exchange in the UK to pay for imports. There are, however, certain circumstances in which straw has definite advantages in the making of paper.

In pulping wood for chemical pulp, that is to say wood reduced by chemical as opposed to mechanical agents, the de-barked trunk is normally the only part of the tree which is used. Wheat straw on the other hand may comprise about 46% internodes, 4% nodes, 17% heads and 33% leaves.[2] Physically, it is about as heterogenous for pulping as a whole tree including the bark and the leaves.

Straws have a high content of silica which is almost absent in most timbers and this chemical difference has had an important influence on the history of straw pulping. The higher content of

Paper presented at the annual conference, "Profit from Straw", organised by the Institution of Agricultural Engineers, Scottish Branch, and held at Dunblane Hydro Hotel on 26 February 1975.

pentosans and lower content of lignin in straw also influence pulping and pulp quality. Bleached straw pulp differs physically from wood pulp, particularly in having an exceedingly high content of fine non-fibrous cellulose material mainly split and broken up parenchyma cells. The pentosan content of straw pulp is about 25%, nearly five times higher than that of wood pulp. The differences between straw and wood, both in pulping and in the finished pulps, stem mainly from these features. It is nevertheless true, however, that the high proportion of fines and the high pentosan content confer on bleached straw pulp a certain advantage. By filling in the voids in the paper sheet, the fines help to produce papers of particularly uniform formation and the pentosans help to give straw pulp useful strength and body which wood pulp lacks. It is, therefore, advantageous to substitute some part of the wood pulp with straw pulp to achieve a more uniform sheet in the manufacture of writing and printing papers. To take advantage of these characteristics, it is usually necessary to treat straw pulp and wood pulp separately in the preparation section of a paper mill. Where there is only a single line of preparation machinery and the straw and wood pulps have to be treated together, it has proved difficult to take advantage of these desirable properties of straw pulp although the texture may be improved. There is, however, a disadvantage in the colour of the finished paper. Paper containing straw tends to lack the brightness and whiteness of paper made entirely with wood pulp and this might be unacceptable in certain specialised uses. Straw pulp can be used effectively and with some advantage, however, in the production of corrugated packing paper. The straw tends to impart a rigidity which restrains the corrugations from collapsing when the board is compressed — indeed, corrugated board made entirely from straw is sometimes too stiff and waste paper may require to be added to make it slightly softer.

Straw boards

ALTHOUGH paper production would appear to be the main industrial use for straw, particularly wheat straw, there is an increasing straw requirement for the production of boards for the building and furniture trades. Wood chip board is a well known product and it might seem unlikely that straw could be used for this purpose instead of wood, straw being a much softer and altogether more fragile material than timber. But straw is, in fact, very strong and tough; it is built to carry leaves and grain which can be heavier than the straw itself. Chip boards made with straw are strong and their breaking point is considerably greater than that of similar boards of wood. This is partly because the individual straws are thin in comparison to their length and this relationship determines the bend-break strength. Straw also has the characteristic of relatively even thickness which gives a more homogenous surface and also an edge that is denser than those of wood chip boards. Straw has an outer waxy layer, called the cuticle, which protects the plant from disease and water loss and this gives straw boards a very special surface finish which can be used for decorative purposes. Many different types of straw board can be made,[3] the quality ranging from very light boards with an open decorative structure and high insulating capacity to very heavy strong boards with considerable mechanical strength. The boards can be given the same surface treatments as wood chip boards, lacquer, veneer, lamination etc. They are claimed to be waterproof and could presumably be made weather resistant. The material is also suitable for pressure casting to make disposable pallets, chair seats, etc.

Wheat straw is used for straw board production at a commercial plant in the South of England. At a Danish research institute near Kolding, there were samples of board made from barley, oats and rye with apparentl', similar properties. In a television programme on the UK production, great emphasis was laid on the quality of the straw. Moisture contents were carefully checked and limits of acceptability were enforced, the preferred moisture content being in the region of 16%. The straw was also carefully examined for purity and texture. Contamination by weeds, such as couch grass, and straw which had been severely threshed and physically degraded into short lengths were causes for rejection of the load. Board making can be a useful outlet for straw but the quality must be correct.

Another interesting product under investigation in Denmark is compressed straw.[4] Instead of using normal baling pressures, straw is subjected to extremely high pressure in a tapered screw press which expells all the air and perhaps some of the residual moisture in the nodes. No binding agent is required. The process is continuous and the straw emerges as a cylinder about 10 cm in diameter which can be cut into suitable lengths. The sample of the material looks exactly like a log of wood. It feels as hard as timber, and has approximately the same density as timber. It can be sawn like timber, produces sawdust and only a close examination reveals that it is in fact made from straw. Whilst this material has not been commercially exploited, it has been used like logs as a fuel for domestic use in enclosed stoves and it burns just like wood producing slightly more ash presumably because of the higher silica content.

The production of this type of material on the farm economically by a machine similar to a pick-up baler or even fitted to a combine in place of a straw chopper has a potential for solving certain problems. The density is much higher than baled straw, it is free from dust and it is self-binding. It would presumably be produced in standard sized lumps and would lend itself to normal bulk handling techniques — a front loading bucket, for example — and transport and storage costs would be much reduced using tipper wagons and bulk bins. The real question, of course, is whether such a material would be acceptable in industry. Such a technique, which degrades the straw length, is unacceptable for board production but it is unlikely to affect straw for pulping which is one of the big outlets.

Processed straw for animal feed

STRAW pulping for paper is based almost entirely on wheat straw and the production of boards in the UK also uses wheat exclusively as a raw material but the major disposal problem is with barley. The main research effort is directed towards using surplus barley straw effectively and economically as an animal feeding-stuff. Straw fed directly to ruminants has limited digestibility and is often used more as a means of increasing the bulk of a ration high in concentrates rather than as a nutrient.

It has been known for many years that a treatment process with caustic soda solution is capable of increasing the digestibility of straw by as much as 40-50%[5] and straw then becomes not merely a source of bulk in the diet but a useful source of energy and a valuable nutrient material. Straw, treated in this way and combined with materials such as soya, urea and minerals, has been used to produce a balanced feed for cattle without the inclusion of cereal grains. The process is not cheap and could not easily be carried out on the farm unless it was a very large enterprise capable of supporting industrial facilities. The fact that one feed compounding company has set up a large scale straw treatment plant demonstrates the commercial interest in this outlet for straw.

Other uses for straw

THERE are some other properties of straw which could be exploited commercially but which are unlikely to lead to substantial outlets for the farming industry. Straw has been, and still is, used to a limited extent as a packing material. There is an obvious fire risk and a decline in use is likely as other products and means of packaging, such as moulded plastics, are developed.

Straw has also been mixed with concrete to produce an insulated lightweight block which can be used in the building and construction industry. The quantity of straw involved is small and substitute blocks in the form of concrete which has been expanded by a foam are a more useful and more standardised product.

Although brief mention has been made of straw as a fuel, it is relevant to refer to the work at Nottingham University where straw from a crop is used to provide the heat to dry the grain. This is unlikely to find wide acceptance and the economics are questionable because the costs of collecting, transporting and feeding the straw into the furnace. In any case, in Scotland, when the grain is very wet and requires a lot of drying, it may be necessary to dry the straw before it would burn — to dry the grain!

As a nutrient material for the growth of micro-organisms, straw has undoubted possibilities but, this is not being exploited commercially, probably because there are other materials which can be used for the purpose. It has been suggested that straw could be used to produce methane gas but even with the high cost of oil this is not a viable proposition.

A further limited use for straw in the form of bales is in plant culture for tomatoes, cucumbers and so on. Keen gardeners who have used bale culture claim excellent results but, again, the market is small.

Conclusion

'PROFIT from Straw', the title of this conference is more likely to occur in the short term through better straw usage within our own industry. There is a big future for barley straw in animal feed production and there are obvious advantages in keeping the whole straw operation within the farming industry so that the benefits accrue to agriculture. Profit from straw sold to industry for use outside agriculture is a longer term venture. Further development

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The efficient use of slurry

by L·E Osborne

Introduction

A PAPER[1] presented to the 1973 Annual Conference of the Institution of Agricultural Engineers contained the following prophetic statement. "In as much as one tonne of inorganic fertiliser requires six tonnes of coal equivalent in its manufacture, the price of this large item of farm expenditure is very closely linked to the price of energy. The expected rise in the cost of the latter in the near future could make the re-use of organic fertiliser on the farm a more attractive economic proposition".

Now that energy prices have risen, and still are rising more quickly than the most pessimistic could have predicted, the use of organic fertilisers available on the farm is becoming an economic necessity. The amounts of plant nutrients included in fertiliser delivered to farms[2] are shown in fig 1. The dramatic decrease in deliveries since 1971/72 may reflect the increase in the cost of manufactured fertiliser or perhaps a growing awareness that increase in application does not necessarily result in an increase in crop yield and may cause water pollution by leaching of nutrients.

It has been estimated[3] that the manure production from housed animals in UK, 1971 contained 372 000 t of N, 75 000 t of P and 241 000 t of K. These figures are likely to have been slightly higher in 1972/73 because of an increase in the total numbers of cattle. Comparing them with the values from fig 1 it can be seen that in 1972/73, animal manure already on farms contained the equivalent of at least 54, 19 and 70% of the N, P and K respectively which were delivered as manufactured fertiliser.

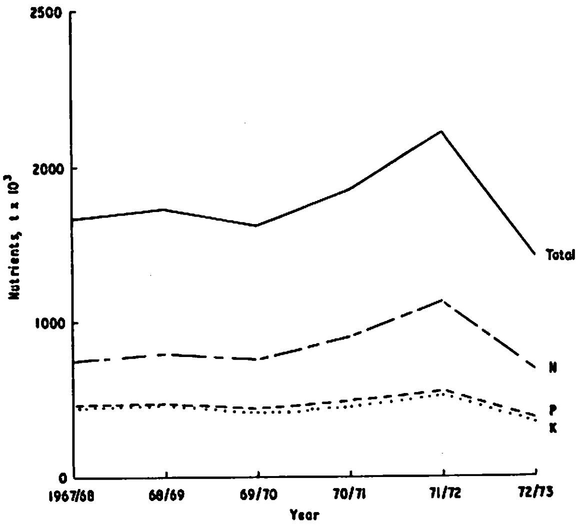

Fig 1 Deliveries of Plant Nutrients to Farms

It is impossible to estimate the overall efficiency of utilisation of animal manures. Ignoring the availability of the plant nutrient once the slurry is applied to the ground — and there are differing views on the speed at which nitrogen for example becomes available for plant use — the efficiency of application of slurries to land leaves much to be desired, dosing at rates providing too much N,P and/or K for the following crop being common place.

If manufactured fertiliser prices continue to rise the amount used will almost certainly decline and the on-farm nutrients will form a larger part of the total available. This paper considers various methods of dealing with slurry to optimise the use of the plant nutrients they contain.

Land spreading

This is obviously the cheapest form of slurry disposal, with disposal being the operative word in many cases. Costs of spreading vary widely but a typical figure for pig slurry is about £0.80/a per pig place. Thus for a 500 pig unit the cost of slurry disposal close to the unit will be about £400/a and for every mile further away will cost an extra £250 or so. To this sum must be added the value of plant nutrients "wasted" because the slurry has not been applied to a crop at the right time and in the quantities that the plants required, about £1/a per pig place — so the total cost is now £1150. If a sacrifice area is used as a slurry dump one must also add on the loss of income from this area, on which perhaps another 500 pigs could have been kept, or alternatively a crop grown. So the total cost of disposal is obviously likely to be well above £2.00/a pig per place.

In order to optimise the use of plant nutrients some form of storage must be provided. An above ground 100 000 gallon concrete tank with pumps and motors for a 500 pig unit will cost about £3800 after grant aid (or £380/a) and a 200-day capacity. This will allow most of the spreading to take place during the crop growing season but because of the need to have adequate storage for the winter period up to 45% of the slurry will have to be spread in autumn. This will lead to the leaching of most of the nitrogen and the consequent loss in fertiliser value of the autumn-applied slurry. The loss in value and the storage costs combined can eliminate the saving in plant nutrient costs due to slurry storage over winter. So it can be seen that if manufactured fertilisers continue to increase in price quicker than other products such as pumps and storage tanks it will be more economical to store slurry and use it to avoid laying in fertilisers. Similar hypotheses can be applied to cattle slurry but the problem of sacrifice areas does not normally arise because beef or dairy units are usually associated with large areas of land used to produce forage.

The foregoing may suggest that land spreading is the answer but theoretical studies[1] have pointed out a number of constraints on this method and lead to the conclusion that land spreading is satisfactory provided that precautions are taken to avoid:—

1. Dilution and contamination.
2. Spreading on sloping or saturated land.
3. Spreading on unstable soil.
4. Spreading odourous slurry wherever smell nuisance can arise.
5. Spreading out of the growing season when plants do not require the nutrients.
6. Spreading at rates so high that a solid mat accumulates on the surface, all the available nutrients are not used in the season of application, or pollution of surface or sub-surface water occurs.

Clearly some of these restrictions will apply to a large number of farms and research work is in progress at various centres to enable slurry to be applied to land safely and economically. Some of the processes developed are discussed below.

Separation

For the dairy unit, separation of the solid and liquid fractions of slurry can prove a valuable aid to management and a variety of machines for the purpose have been previously described[4]. A common method of handling cattle slurry has been to use lagoons, often taking the form of an excavation surrounded by an earth bank formed from the spoil. This may have to be lined by an impermeable membrane under some soil conditions. Lagoon emptying is usually an annual operation where sufficient free land is available. On many farms this is just after harvest and may involve the use of heavy duty shovels or drag-lines. Because of the tendency of the solids either to settle into a dense sludge or to float and form a thick crust, emptying by vacuum tanker or pump is often impossible. Moreover sampling to determine plant nutrient contents is extremely difficult and the tendency is to empty the lagoon onto the nearest convenient fields, leading to the wastage of nutrients and possible pollution problems.

The use of a separator results in a stackable, easily handled solid and a liquid which, whilst settling a little does not crust. Both fractions can be easily sampled for nutrient content. The solid at 18-20% dry matter can be handled in the same way as farmyard manure, will compost and can be applied to arable land in the spring before planting, for example, a forage maize crop. The liquid which can be held in a lagoon can be easily pumped through small bore pipes and sprinklers or removed by tanker and can thus be used on grazing land during the summer. Because of the low dry matter content compared to unseparated slurry (some 3-6%) smothering of the crop with solids is less likely.

Theoretically it is possible to produce about 40% solid and 60% liquid from the separation of cattle slurry but in practice the proportions are nearer 25% and 75% because of the unavoidable dilution by rain and washing water. Separator efficiency calculated from the input slurry dry matter and the output solids dry matter is affected by several factors. These are the slurry dry matter, screen hole size and the pressure applied to the mat of fibrous solids which forms on the screen and consequently the separated solids dry matter. Rotary screens with press rollers and combined brushed screens and roller presses have similar efficiencies of about 50%, changing slightly with slurry dry matter. The relationship between pig slurry dry matter and separator efficiency is shown in fig 2 when producing a solid fraction with 18% dry matter. A larger screen hole size permits a higher throughput but reduces efficiency. When separating a 7% dry matter pig slurry an increase in efficiency from about 50% to 53% would be expected if the screen hole diameter was changed from 3.2 mm to 1.6 mm. Apart from this the hole diameter has little relevance within practical limits because the actual filtration occurs through the mat of fibre which is pressed onto the screen. With a 3.2 mm screen, 90% of the dry matter particles in the liquid fraction from separated pig slurries at both 3.7 and 6.0% dry matter were found to be under 200 μm in diameter. A reduction in the pressure applied results in an increase in efficiency of separation when calculated on the basis given above but will give a wetter solid fraction. In practice the quality of the output solids will govern the pressure which has to be applied. Although marginal differences in separator efficiency may be obtained with machines different from those considered above, large improvements will almost certainly need other techniques such as chemical flocculation prior to separation and their use may be difficult to justify.

Because of the difficulty of pumping cattle slurry at fairly low rates, feeding a separator can be a problem. The use of a chopper should be avoided if possible because of the high rate of wear caused by grit and concrete dust which cannot be kept out of cattle slurry. One type of separator developed by NIAE can be gravity fed from a channel thus obviating the need for a pump with all the resulting operational problems.

Those who are sceptical of the merits of separation claim that a drawback is that the process involves the use of two handling systems — one for solids and one for liquids. Practical experience suggests that this is not a great disadvantage and the degree of control which management has over the whole process from cow to crop is a very real advantage indeed.

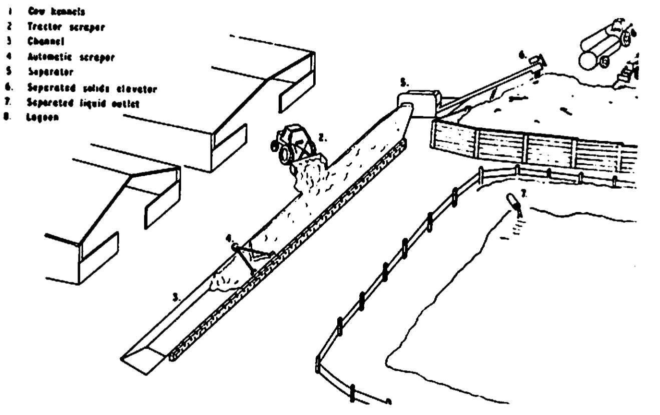

Fig 3 Schematic diagram of separator installation for dairy unit.

The process of separation can therefore make it possible to remove the constraints on land spreading detailed above with the exception of that of smell when spreading the liquid. The solids, both from cattle and pig slurry, have practically no smell at all and the separated liquid from cattle does not have an objectionable odour even after nine months storage. The separated liquid from pig slurry however, smells after a period of anaerobic storage and less of the total can be removed as a solid than with cattle slurry. Thus the advantages of separation are not so great with pig slurry as for cattle slurry. Pig slurry tends to settle and not crust, does not contain long pieces of straw, hay or silage and is more easily pumped although pump wear rates can be high.

The costs of a separator and ancilliary equipment, ie feed mechanism, solids elevator and store for liquid are difficult to specify at present because of the lack of farm experience. On-farm trials being conducted by NIAE are providing information on the type of equipment which is required and it will be possible in the near future to specify, for example, the best methods of conveying the separated solids away from the separator. It seems likely that for a 300 cow dairy unit, a channel and scraper feed to the separator, with a solids elevator, all complete with switchgear for fully automatic operation, as shown in fig 3, will cost about £4500-£5000. The power required is 2-3 kW so running costs will be low. Against this must be offset the ease of emptying and the reduction in size of the lagoon required to contain the separated liquid instead of the unseparated slurry and the possibility of more effective use of the plant nutrients in the slurry. These are in theory worth at least £3600 from 300 cows housed for five months. There are also the inquantifiable benefits of easier management and peace of mind.

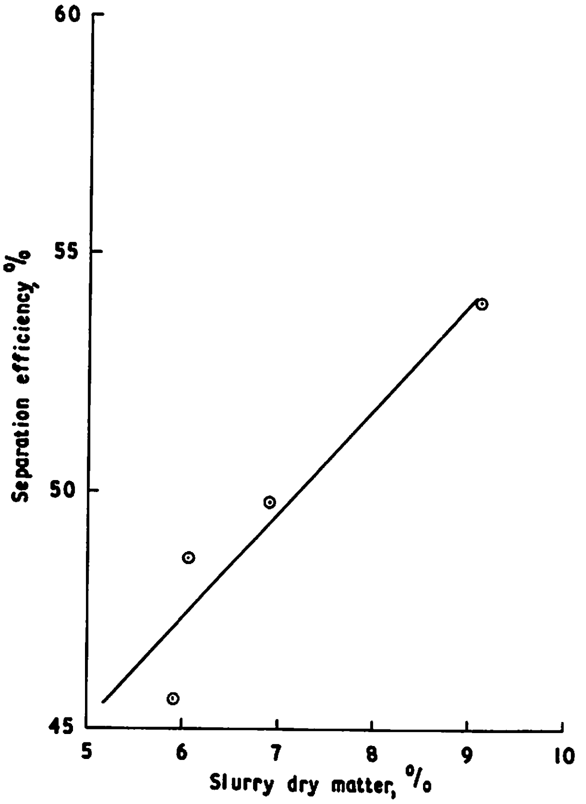

Fig 2 Effect of Slurry Dry Matter Content on Separator Efficiency

Smell removal

The measurement of smell is a difficult and complex subject. Work in Holland[5] has shown that about 20 different substances were responsible for smell from piggeries and that six of these substances were always present with unpleasant smells.

As stated earlier, separation produces an almost odourless solid but the liquid, in particular from pig slurry, will smell when removed from store as will un-separated slurry. The smell, caused by anaerobic bacteria can be considerably reduced if not eliminated by some form of aeration to promote the growth of aerobic bacteria. Oxygen can be introduced into the slurry by various means including surface aerators, coarse bubble aeration from sub-surface equipment supplied by a compressor, entrainment by a jet of the liquid which is pumped onto the surface or by a trickling (high rate) filter. The amount of aeration required will depend on the biochemical oxygen demand (BOD) of the waste and whether it is desired to reduce smell at the site of the store or on the field.

If smell when spreading needs to be reduced but strong smells for a short period can be tolerated at the store, aeration prior to removal from store may suffice. Aeration can be started some three or four weeks before removing the slurry or separated liquid and will result in the immediate liberation of the odorous gases

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produced by anaerobic bacteria. But most of the smell will have gone when spreading starts.

Continuous aeration is required to avoid smell both at the store and when spreading, and will also give a reduction in BOD. Little work on this aspect has been conducted in the UK but numerous experiments have been carried out in Holland, resulting in a "standard" procedure for handling pig slurry[6]. A typical installation consists of a concrete stave storage tank with a surface aerator which runs continually. Mixed liquor from the tank is pumped to the piggery channels to flush out fresh slurry which is returned to the storage tank. In the summer flushing is carried out daily using about 7500 litres of mixed liquor, in the winter twice weekly flushing is said to be sufficient. An advantage of frequent removal of slurry from the house is that the channel depth under the slats needs to be only about 375mm, thus reducing construction costs. The average capital cost for the tank, aerator and flushing system was, in 1973/74, £3.70/pig place with running costs of £0.48/pig fattened.

Sub-surface injection, which can eliminate the smell problem when applying slurry to land has been investigated in USA and Europe. The obvious advantages, apart from the smell aspect, are that run-off is eliminated, the plant nutrients are placed in the soil and damage to the soil structure by surface matting or ponding at high application rates is avoided. However, the power requirement is high and the use of separated slurry or the provision of an effective stirrer and chopper on the machine is essential to avoid blockages. Also it seems that, in UK conditions, the logical place for cattle slurry application is on to grassland. This poses the problems of damage by tines and the suitability of many permanent pastures because of slopes, wet or heavy soil conditions or stone content. However, if in the future, limits are set on the amount of slurry which can be applied on the surface, injection may provide a solution to odour problems in certain circumstances.

Treatment

In the context of this paper, treatment is defined as an operation which alters the characteristics of slurry, thus facilitating the handling and subsequent utilisation of the products of the operation. Obviously treatment can only benefit those who have particular problems of waste handling. These may be insufficient, or indeed, no land on which slurry can be spread, a location in or close to an urban development leading to complaints about smell or run-off and leaching of nutrients resulting in water pollution. The aeration systems, mentioned briefly in the preceeding section treat slurry to a limited extent when used on their own in that the reduced BOD of the mixed liquor can help to avoid pollution of drainage water. If used in conjunction with a separation, settlement or perhaps a chemical flocculation process, they come fully into the category of treatment systems. Early work on the treatment of farm wastes was aimed at producing an effluent to Royal Commission recommendations for discharge into a water course. The strict requirements for a Royal Commission effluent, less than 20 mg/l BOD and 30 mg/l suspended solids, are very difficult to achieve with farm wastes and although some experimental plants have been successful, they are complicated and difficult to control. If a suitable effluent can be produced it will represent a small proportion of the total output of the treatment plant. With each pig producing about 32 kg of slurry per week, it is likely[7] that the solids which need to be removed weekly from an oxidation ditch, for example, will be 8 kg/pig of fibrous solids (20% dry matter) and 17.5 kg/pig of small solids as de-watered sludge at 10% dry matter. Thus over 80% of the input may re-appear as solids or sludge after treatment and must be applied to land. The remaining oxidation ditch effluent will then require further treatment to permit discharge to a water course eg settlement or chemical flocculation, which will result in even more sludge. The above example whilst relating to an oxidation ditch can be applied to any aerobic process and illustrates the problems of concentrating on producing a clean effluent. These facts were recognised by NIAE and reported in 1971[8] and since then work has been directed at finding methods of maximizing the solid output from treatment plants.

Pilot scale experiments[9] have shown that a treatment system (fig 4) consisting of separation, high rate filtration and sludge de-watering (using chemical flocculants) can convert into solids up to 70% of the slurry produced daily by 400 pigs. The solids are smell free and can be handled like farmyard manure. Thus they can be stacked and spread when required and can be easily transported to neighbouring farms if no land is available. Neighbours are much more likely to accept relatively homogenous smell-free solids than smelly liquids of varying and often indeterminate

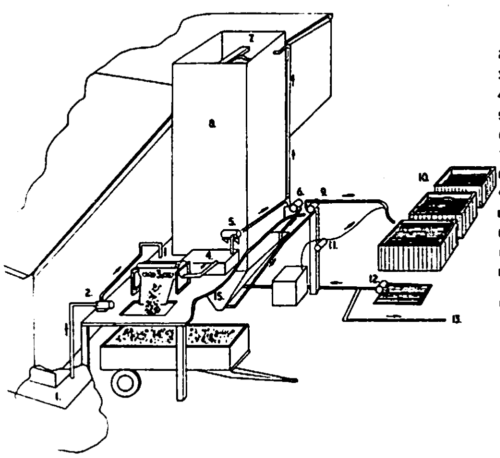

Fig 4 Schematic diagram of pig slurry treatment system.

fertilizer value. The solid products may also perhaps be saleable: one or two farms are already selling the solids from separated slurry to amateur gardeners and horticulturalists. The liquid effluent from the NIAE treatment system has little smell but is at present far too polluting to be put into a water course, having a BOD of up to 10 000 mg/l. It is low in suspended solids, is easily pumped and stored and can obviously be applied to land at much higher rates than raw slurry. Proposals for further development of this process on a farm scale should result in the evaporation of more of the liquid and calculations[10] suggest that under summer conditions the system could have a completely solid output.

The loading rate, 9.8 kg/m^3 of medium/day, of the high rate filter used in this system is about ten times that of filters used in domestic sewage treatment and with a retention time of 2.5 days results in little reduction in total BOD. Sufficient soluble BOD, about 30%, is removed to produce a relatively smell free sludge and filtrate when the sludge is de-watered. This approach leads to an efficient plant in terms of capital cost, only 5.5 m^3 of plastics medium being required to deal with the slurry from 400 pigs.

Sludge de-watering has hitherto been difficult but a simple process has now been developed. Flocculant is metered into the sludge outlet which leads to either a compound made of a single thickness of straw bales or slatted wooden pallet-based boxes lined with hessian. These boxes permit mechanical handling of sludge which will de-water from about 4.0 to 10.0% dry matter in four or five days. Straw bale compounds holding up to 40 t are effective for de-watering to a solid which can be handled by tractor front loader after draining for three or four weeks. Some of the filtrate from sludge de-watering is returned to the filter tower circuit and provides control over the circulating liquid dry matter content. The complete system is automatic and has been designed for operation by farm labour with no special skills. So far all trials have been carried out on slurry brought from a local farm which has undergone a period of anaerobic storage under piggery slats.

Costs are difficult to estimate at present because of the prototype nature of the equipment. They may also be different when treating fresh slurry because the separation efficiency may be higher and the dose of flocculant required for de-watering sludge may be less. As a rough guide, the cost per pig fattened could be £0.50-£1.00 more than for simple uncontrolled land spreading, a cost comparable to straw bedded systems. This will obviously depend on the degree of sophistication employed and how much can be built by farm staff because there is scope for a "do it yourself" system.

Conclusions

The rapid developments in the world energy situation during the last year have changed the emphasis on slurry handling from disposal to re-cycling to land. This situation was anticipated by research workers several years ago, although perhaps such rapid changes were not expected. The result is that much practical and theoretical work has been done on re-cycling the plant nutrients in slurry efficiently and farm trials are planned or in progress. The results of this work will provide farmers with firm guidelines and improved techniques for using on-farm sources of plant nutrients instead of manufactured fertilizers, and at the same time should

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provide solutions to the management problems occurring with increasing frequency where conventional land-spreading systems are used.

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The development of agriculture in Iran

by Sir Emrys Jones BSc LLD

(Principal, Royal Agricultural College, Cirencester)

Summary of the first Douglas Bomford memorial lecture, at the National College of Agricultural Engineering, Silsoe, Bedford, on 13 March 1975

IRAN is the second largest country in the Middle East. It has experienced the most profound social and economic transformation during the last decade and the very speed at which this has occurred has generated many complicated problems and challenging situations. Like all seats of ancient culture, its traditions and beliefs impede social change and technological advancement. This is particularly evident, in the rural areas where village life has not changed much in the last thousand years or more. Ignorance, scepticism, lack of finance, and deficiencies in administration are all too common. But the greatest limiting factor of all is water supply.

Iran is largely an arid country with a poor seasonal distribution of precipitation, most of which occurs at the end of the winter season or early spring, while for the rest of the year ie during the growing season, precipitation is minimal. Vast projects are in hand to construct reservoir dams and irrigation networks. Many have already been completed but some of these installations have not come up to expectations.

The cultivated area of Iran is about 15½ million hectares, of which 6½ million hectares are irrigated and nearly 9 million hectares are rainfed. There is probably another 15 million hectares of land which could be cultivated, given adequate supplies. However, of the 15½ million hectares already cultivated a third was in fallow last year and grew no crop. Three-quarters of the cultivated area is in wheat or barley, yielding 1.40 tonnes/hectare on irrigated land and about 0.60 tonnes/hectare on rainfed land. These yields are very low in comparison with the yields of some Mexican dwarf varieties grown on experimental plots where over 4 tonnes/hectare are common. This disparity suggests that close attention to cultural factors such as date of sowing, depth of sowing, optimum nutrient level, varieties and the use of herbicides etc would undoubtedly give a tremendous boost to yields of cereals in Iran.

One of the main objectives of the Fifth Plan is to achieve a very substantial increase in the livestock sector. This will involve the development of American style beef lots, large dairy units and a rapid expansion of industrial broiler and egg-producing units. The sheep is the most important meat producing animal in Iran and there are over 30 million of them. The Plan envisages the introduction of "improved sheep-farming techniques by the use of pens, so that the number of free-grazing animals is limited to what the pasture-land can support, and policies to prevent soil erosion from over-grazing will be enforced." The future for the nomadic tribes looks bleak indeed; their sheep and goats will no longer denude the land of all vegetation, as they have done for centuries.

An important objective of the Fifth Plan is to organise *all* farmers into co-operatives and farm corporations even though their emancipation from serfdom has only materialised in the last few years. In addition there will be special incentives available to the proprietors of large "agro-industrial units". These developments are intended to hasten the adoption of modern technological practices and especially to exploit the full potential of irrigated areas. The Fifth Plan envisages the establishment of agro-industrial units, such as large meat and dairy complexes, covering a total area of 300,000 hectares. It is intended that these new ventures will have centralised management, reinforced by the most advanced technology that money can buy. In areas such as Fars, Azarbaijan and Kordestan, where nomadic tribes predominate, these complexes will be established by the Government, while in other regions they will be established by the private sector.

The strategy for accelerated agricultural development will therefore hinge on both the improvement of cultural practices on existing traditional land through extension of the farm corporations and the spread of high technology through the introduction of agro-industrial units into sparsely inhabited or virgin lands. Among subsidies offered by the Government to private investors are grants of up to 85% of irrigation costs, 50% towards the cost of constructing canals and between 60% and 20% of the cost of land reclamation. In addition, the Iranian Government will match agro-industrial development with 80% of the value of the investment made in the form of four per cent loans to both Iranian concerns and foreign investors.

A booming oil-based economy and a stable political situation have made possible a significant upward revision in the original targets set out in the Fifth Plan. For a number of years the economy has grown at an annual rate of 10—12% at constant prices. The target for the annual rate of growth in GNP has now been raised to no less than 25% and the target for growth in agriculture is now set at seven per cent, which is double the agricultural growth rate achieved in recent years. This will call for a vast and sustained agricultural expansion programme. Nevertheless, even if these objectives are achieved by the end of the Fifth Plan (1978) Iran will still be a substantial importer of foodstuffs. Both the growth and increasing affluence of the urban population will vastly increase the demand for food in the years ahead and changing consumption patterns will have profound effects on the demands for new crops and livestock products. Agricultural imports are rising rapidly, especially of animal products and the gap between domestic agricultural production and the total domestic demand for food is widening ominously. Since the Fifth Plan was formulated the world situation has changed dramatically *and agricultural investment in Iran is now allotted the highest priority.*

Predicting the climatic environment for pigs

by A D Trapp

Summary

AGRICULTURAL advisers are often required to predict the climatic environment that can be expected within a particular piggery. Simple performance charts have been produced to enable the task to be completed with reasonable accuracy, the minimum of effort and without a detailed knowledge of the processes involved. Ratios relating to ventilation rate, structural heat loss and moisture output are used to give the charts general application. Using these charts it is possible to predict the average internal temperature and humidity for a range of external winter conditions. A worked example and procedure is given for a typical finishing piggery and the effects of varying some of the building details is demonstrated. This analysis should also prove to be a worthwhile teaching aid enabling students to assess the relative importance of the factors that combine to determine the climatic environment.

1 Introduction

The climatic environment that can be maintained within an intensive pig production house is important. It influences the overall productivity and hence the profitability of the enterprise. The problems involved in maintaining the required conditions of temperature and humidity are well described by Carpenter and a method that can be used to determine the internal temperature in a particular instance is described by Baxter[2].

The procedure for evaluating the internal conditions that occur in pig housing is well known. To avoid tedious and repetitive calculations it is convenient to use digital computer techniques to provide rapid and comprehensive data. This can describe the conditions of temperature and humidity, and also give a breakdown of the heat losses through the ventilation system and building structure. The analysis can take account of the heat and moisture gains from the stock and any supplementary heating. The losses that occur to the ventilating air and through the building structure, including the effects of night-time radiation from the roof can be included. This type of procedure has been described by Bruce[3].

It is relatively easy for the researcher to construct the type of mathematical model described above and thus to gain a good insight into the interaction between the various factors that affect the internal conditions. However, there is also a need for the agricultural adviser to be able simply to determine the conditions of temperature and humidity that could be expected for particular housing conditions. This paper has been written with this aim in mind. A detailed understanding of the analysis is not essential before using the general building performance charts provided.

2 Analysis of climatic environment

The starting point for this analysis is the heat balance equation. It is likely that cold night-time conditions will produce the most adverse combination of temperature and humidity and it is therefore reasonable to include the effects of heat radiation from the roof of the building.

$$\text{Thus } Q_a + Q_{sup} = Q_v + Q_{st} + Q_r \qquad - (1)$$

where Q_a = sensible heat output from pigs (kW)
Q_{sup} = supplementary heating (kW)
Q_v = heat loss to ventilating air (kW)
Q_{st} = heat loss through building structure (kW)
Q_r = additional roof heat loss due to radiation (kW)

Dr A D Trapp is from the Department of Agricultural Engineering, Edinburgh School of Agriculture.

The level of radiation heat loss will depend on the outer skin temperature of the roof, and the emissivity of this surface. For typical British conditions this radiation level will vary between about 65 and 95 W/m^2, but for the degree of accuracy required in this analysis a constant value of 80 W/m^2 has been chosen.

The structural heat loss, Q_{st}, is proportional to the temperature difference between the external and the internal atmospheres, and the ventilation heat loss is very nearly proportional to this temperature rise. However, the pig heat output, the supplementary heating and the radiation heat loss are assumed to be independent of the temperature rise.

It is convenient to group the constant heat quantities,

$$\text{thus } Q_a + Q_{sup} - Q_r = \text{NHI (Net Heat Input)} \qquad - (2)$$

If V is the ventilation rate (m^3/h), and ST is the total heat transfer 1°C (W/°C) for the building structure,

$$\text{then } Q_v + Q_{st} = \frac{(K \times V + ST) \times TR}{1000} \qquad - (3)$$

where TR = internal temperature rise (°C)
K = constant (W h/m^3 °C)

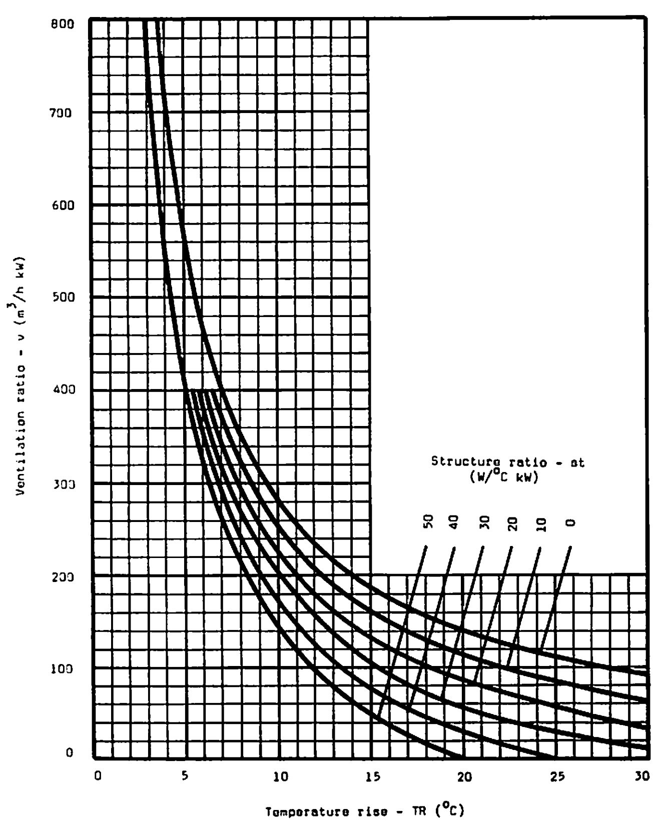
Substituting into eqn 1 and re-arranging

$$\frac{1000}{TR} = \frac{K \times V}{NHI} + \frac{ST}{NHI} \qquad - (4)$$

Now define $v = \frac{V}{NHI}$ = ventilation ratio (m^3/h kW)

$st = \frac{ST}{NHI}$ = structure ratio (W/°C kW)

Fig 1 Temperature rise obtainable for various building conditions.



From eqn 4 it is possible to plot temperature rise vs ventilation ratio for a range of values for the structure ratio as shown in fig 1. The information presented in this figure has been calculated for an external temperature of 0°C but is sufficiently accurate for use with external temperatures in the range –8° to 8°C.

To obtain the relative humidity that will occur for any particular set of conditions it is necessary to consider the moisture balance.

$$M_i + M = M_o \qquad - (5)$$

where M_i = moisture contained in incoming air (g/h)
M = moisture given off by pigs (g/h)
M_o = moisture contained in outgoing air (g/h)

From eqn 5 it is possible to determine the moisture content of the outgoing air stream. The problem is to express the quantities in terms of relative humidity. To simplify the procedure it is assumed that the incoming air stream has a constant relative humidity of 88% which is a reasonable approximation for the Edinburgh area[4]. It is necessary to take account of the external and internal temperatures and the moisture output of the pigs together with the ventilation rate.

To reduce the number of variables and provide generalised charts define:

$$m = \frac{M}{V} = \text{moisture ratio (g/m}^3\text{)}$$

A chart covering the normal ranges of temperatures and moisture ratios is shown in fig 2 and is constructed from data given in the IHVE guide[5].

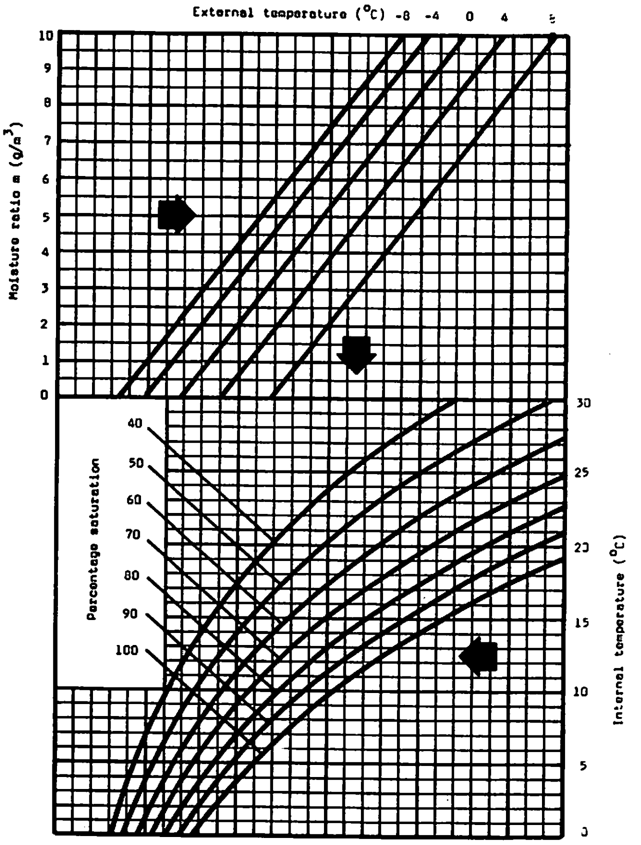


Fig 2 Relative humidity obtainable for various building conditions.

To enable the charts presented in fig 1 and 2 to be used it is necessary to determine values for the ventilation ratio, structure ratio and moisture ratio. To find the heat and moisture production of the pigs, linear equations as suggested by Baxter[6] have been used, thus:

$$\text{Sensible heat produced/pig (W)} = 1.17\,WT + 25.5 \qquad - (6)$$

$$\text{Moisture respired/pig (g/h)} = 1.35\,WT + 28.7 \qquad - (7)$$

where WT = liveweight (kg)

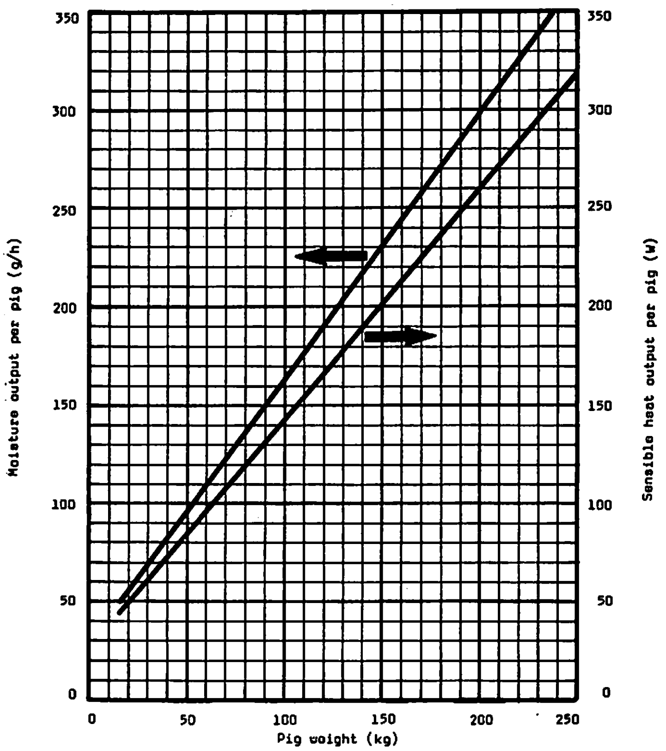


Fig 3 Heat and moisture production curves for pigs of different weights.

Heat and moisture production curves relating to eqns 6 and 7 are shown in fig 3. These curves can be used for dry sows, weaners and finishing pigs. Knowing the number and average weight of pigs in a particular house, it is possible to produce figures for the total heat and moisture production, Q_a and M. To determine the heat loss due to radiation, Q_r, it is necessary to know the thermal transmittance ('U' – value) of the roof structure. For low wind velocities (1 m/s), the radiation heat loss from the roof plan area is given by:

$$Q_r = \frac{0.084 \times U_{roof} \times 80\ (\text{W/m}^2) \times \text{building plan area}}{1000} \qquad - (8)$$

Knowing the level of supplementary heating to be used, the value for NHI can be found using eqn 2.

→ *page 46*

Table 1 Typical 'U' values for use with building performance charts

	Structure	*'U' value (W/m² °C)*
1	Steel framed asbestos cement roof	5.23
2	Timber framed asbestos cement roof 50 mm fibre quilt, polythene vapour barrier, 12.5 mm insulating fibreboard false ceiling	0.51
3	Timber framed asbestos under-drawn with 25 mm polyurethene insulation sheet	0.72
4	Flat galvanised steel roof decking finished with bituman felt, 12.5 mm insulating fibreboard	1.54
5	Timber framed wall with weatherboard cladding	2.70
6	As (5) with 75 mm mineral fibre mat and polythene liner, oil tempered hardboard lining	0.4
7	Light-weight aggregate block wall 280 mm thick, 50 mm cavity	0.69
8	Solid 230 mm brick wall	2.12
9	280 mm brick/breeze block wall with 50 mm cavity	0.95
10	Concrete floor (no bedding)	0.50

For a particular building it is possible to calculate the total heat transfer coefficient, ST (W/°C temperature rise), for the structure. Thermal transmittance values can be estimated using standard references such as the IHVE guide[7] or by using the representative values given in table 1. A knowledge of the performance of the ventilation fans can assist the estimation of ventilation rate. Calculated values for v, st and m can now be used to determine the conditions of temperature and humidity for a range of external temperatures. The process can be repeated for different ventilation rates, stocking densities and structural components to enable the reader to obtain a "feel" for the relative importance of the various parameters.

3 A practical example

To facilitate the use of the charts presented in fig 1 and 2 a simple procedure has been evolved and is shown below using the example of a finishing piggery.

Building reference	:	*specimen finishing house*
length L = *30* m		eaves height HE = *2* m
width W = *10* m		ridge height HR = *3* m
average pig weight	WT =	*62* kg
total number of pigs	N =	*360*

Item	*Area* (m^2)	*U-value* ($W/m^2\ °C$)	*Heat transfer/°C* 'U' x area
Roof	*306*	*0.51*	*156*
End Walls	*50*	*1.8*	*90*
Side Walls	*120*	*1.8*	*216*
Floor	*300*	*0.5*	*150*
Total heat transfer (W/°C)		ST =	*612*

Ventilation rate V (equivalent to 0.375 m^3/h kg liveweight) = *8370* m^3/h

Heat output/pig (fig. 3) = *98* W

Total heat output of pigs $Q_a = \frac{360 \times 98}{1000} = 35.3$ W

Radiation heat loss $Q_r = \frac{U_{roof} \times L \times W}{150}$

$Q_r = \frac{0.51 \times 30 \times 10}{150} = 1.02$ kW

Supplementary heating Q_{sup} = *0* kW

Net heat input NHI $= Q_a + Q_{sup} - Q_r$

NHI $= 35.3 + 0 - 1.02 = 34.3$ kW

Ventilation ratio $v = \frac{V}{NHI} = \frac{8370}{34.3}$

$v = 244$ m^3/h kW

Structure ratio $st = \frac{ST}{NHI} = \frac{612}{34.3}$

$st = 17.8$ W/°C kW

Temperature rise TR = *9.6*°C (from Fig 1)

Moisture output/pig (Fig 3) = *112* g/h

Total moisture output M = *40 320* g/h

Moisture ratio $m = \frac{M}{V} = \frac{40\,320}{8\,370}$

$m = 4.8$ g/m^3

External temp (°C)	*Internal temp* (°C)	*Relative humidity (%)* (fig 2)
−8	*1.6*	*100*
−4	*5.6*	*100*
0	*9.6*	*96*
4	*13.6*	*86*
8	*17.6*	*78*

A graphical representation of the "performance" of this finishing house is shown in fig 4. Only a calculator or slide rule is required to conduct the simple analysis demonstrated above and it is not necessary to understand the detailed processes of heat transfer. The impression of a high degree of accuracy in the figures given is misleading, and the performance characteristics that are

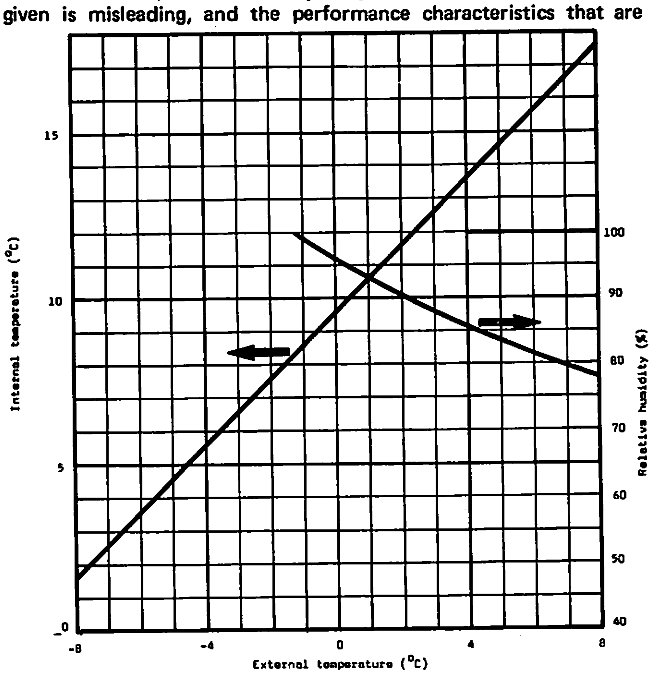
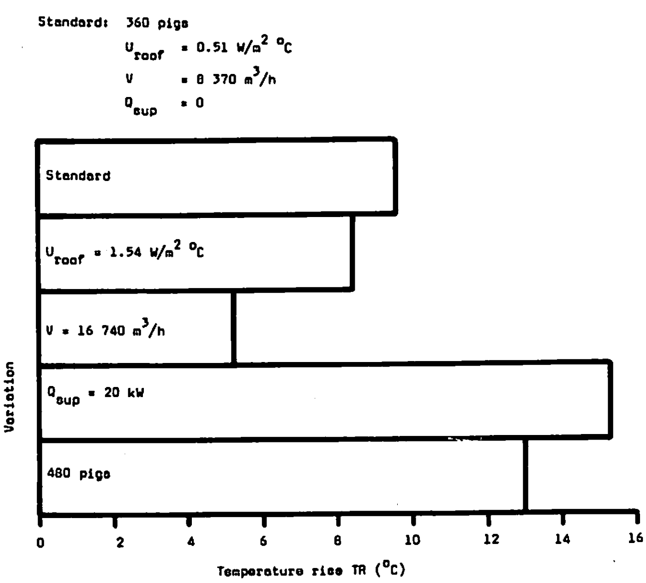


Fig 4 (above) Performance curves for specimen finishing house.
Fig 5 Effect on performance of varying building conditions.



obtained should be regarded only as an indication of the likely performance. However, they do clearly demonstrate the effects of changing the various parameters. Fig 5 shows the effect on performance of varying some of the important parameters in the example given earlier.

4 Conclusions

A simple analysis of the main factors that affect climatic environment in pig housing during cold night-time conditions has been given. The factors can be reduced to three ratios: ventilation, structure and moisture ratio. Charts relating these ratios to temperature rise and relative humidity have been shown.

List of symbols

m	moisture ratio = $\frac{M}{V}$ (g/m^3)
st	structure ratio = $\frac{ST}{NHI}$ (W/^{o}C kW)
v	ventilation ratio = $\frac{V}{NHI}$ (M^3/h kW)
HE	height of eaves (m)
HR	height of ridge (m)
K	constant (W h/m^3 ^{o}C)
L	building length (m)
M	total moisture output of stock (g/h)
M_i	moisture contained in incoming air (g/h)
M_o	moisture contained in outgoing air (g/h)
N	number of pigs
NHI	net heat input = $Qa + Q_{sup} - Q_r$ (kW)
Q_a	sensible heat output of stock (kW)
Q_r	additional roof heat loss due to radiation (kW)
Q_{st}	heat loss through building structure (kW)
Q_{sup}	supplementary heating (kW)
Q_v	heat loss to ventilating air (kW)
ST	total structure heat transfer per ^{o}C (W/^{o}C)
TR	internal temperature rise (^{o}C)
U	thermal transmittance – 'U' value (W/m^2 ^{o}C)
V	ventilation rate (m^3/h)
WT	average weight of pigs (kg)

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AROUND THE BRANCHES

South East Midlands

A VERY small attendance of members listened to a most interesting paper read by Mr V Joyce, of the Agricultural Aviation Research Unit (Ciba-Geigy group), Cranfield, on methods of controlling insect pests overseas. Unlike the application of herbicides which can be applied to a single field with success, insect control due to insect mobility requires treatment over the whole area where the pest is operative. If local areas only are treated, re-infestation quickly occurs from the surrounding fields unless there are repeated spray applications or a very strong persistent insecticide which will kill everything, is used, but this is not a very satisfactory solution.

In areas where there are large concentrations of particular crops and hence pests, better and cheaper control can be effected by adopting a system of pest population management. Experiments have shown that if a 99% kill is achieved over 90% of the area, the pest population will still continue to increase due to reinfestation from the surrounding area. However, a 90% kill over the whole area will decrease the population. To achieve this control over the total population the flight activity of the pest must be understood so that spraying can be carried out in the right place at the right time.

Earlier classifications of pests into migratory and non-migratory types have not always been correct or helpful because it appears that most concentrations of pests occur as a result of the insects being carried along in the air streams and when two of these wind fronts meet an insect build-up occurs and disease outbreaks are found. These converging fronts occur in particular localities eg in the Rift valley, Kenya, and in front of a travelling tropical storm, and pest concentrations can be 10 000 times higher here than elsewhere. A knowledge of these concentrations and their movements allows control measures to be taken over the whole affected area.

For effective control the spray drop size must be such that the drops are captured by the insect and the spray trajectory is important particularly in spaced crops. For many insects the most effective drop sizes are those around 15 microns, and movement of these drops is often more a function of air currents than due to their own terminal velocities. Hence rather than spraying under still air conditions it may be necessary to spray at mid-day to make use of air turbulence to get the drops to the target. In many cases in the past the efficiency of spraying has been assessed in terms of what has missed the target rather than what has done a useful job.

Insect control based on these measures must be organised on a wide co-operative or government scale for it to be effective and if necessary the farmer can still treat his own local field to achieve better control. These techniques are more effective and use much less chemical than other methods.

South Eastern

A JOINT meeting was held between the South Eastern Branch and the Essex Grassland Society, at which Jim Connell from the National Institute for Research in Dairying spoke on the subject of grass drying on the farm.

Economic aspects were emphasised and considerable discussion was centred around the topic of "grass squeezing". Mr Connell considered that dried grass still had much to offer those engaged in milk production but very careful attention needed to be given to cost aspects, particularly budgetting. Despite the particularly difficult economic climate he did not dismiss investment out of hand.

Guy Wilsden of Dengie Crop Driers stated that from his experience those prepared to make investments were finding that it was possible to work within original planning budgets.

Mr Connell concluded that despite any consideration of dried forage there were many examples where significant progress could be made by improving grazing management in order to improve grassland utilisation.

Southern

THE Southern Branch of the Institution of Agricultural Engineers met at Rycotewood College on 21 March under the chairmanship of College Principal John Turner.

Guest speakers were C J Lucas – Chief Operations Engineer and C A Hanson – Chief Water Resource Engineer, both of the Thames Water Authority, the topic for the evening being "Supply, Drainage and Conservation".

Mr Lucas, speaking on land drainage, explained the responsibility of the water boards for land drainage and how this fitted in with field drainage. He stressed the need for greater forward thinking by farmers regarding this drainage, explaining the many constraints and problems in introducing any drainage scheme. The finance for such schemes is drawn from the county rates and therefore all improvement plans must be budgeted one year ahead at least.

Mr Hanson, dealt with water resources in great detail, explaining that the great problem for the Thames Water Authority is that of supplying London. The primary resource for water in London is the River Thames, although there are several reservoirs including Datchet which is now complete and being filled. The requirement for water does, of course, depend on population and population forecasts for the future do vary considerably.

The Ground Water Development scheme is one of the latest moves to increase the supply of water into the Thames and at present there are 35 boreholes, each of which can provide initially 2 272 980 to 4 545 960 litres of water/day. These boreholes are centred around the Rivers Lambourn and Kennett in West Berkshire and would be used in the case of summer droughts.

The Thames Water Authority also has responsibility for all rivers in its area and its activities therefore include land drainage, navigation, fishing, amenities, water sources, sewage etc.

West Midlands

THE West Midlands Branch annual dinner was held on 4 April 1975 at Leamington. The retiring Branch Chairman, Mr Stafford Burley of Massey Ferguson, reported a successful past year and thanked those organisations which provided facilities for the monthly technical meetings of the Branch. Mr John Shipman, Training Tutor for the Agricultural Training Board at NAC Stoneleigh, was inducted as the new Branch Chairman. The main speaker at the dinner was Mr J V Fox, President of the Institution, who praised the progress of the Branch and spoke of the importance of the Institution both nationally and internationally in the agricultural field.

Yorkshire

LIONEL EVANS of Massey-Ferguson presented a paper on legislation effects on total tractor design to the Yorkshire Branch at their open meeting at Holmfield House, Wakefield on 13 February.

Mr Evans opened the meeting with discussion on the changes of legislation and pointed out that it was a pity that both manufacturers and legislators could not start with a clean sheet. He then went on to outline the various bodies which were creating the different rules, such as Nordic countries, EEC, ISO and our own Ministry.

Following this he discussed the design parameters affected and the effect of weight, in that some countries had safety rules which varied according to the weight of the machine. This factor, in turn, also affected licensing requirements and insurance as well as lighting and braking regulations.

Mr Evans then moved to the engine and here several problems have arisen by legislation affecting noise, pollution and the density of exhaust smoke.

The next subject discussed was safety cabs and quite a few countries now have requirements which make the fitting of safety cabs compulsory and it was anticipated that in the very near future there would be several other countries which would not permit tractors to be used without some form of driver protection. The UK is anomalous because although in certain applications a tractor can be used without a cab eg orchard work and hop-fields, our existing laws make it impossible for a tractor to be purchased without a cab. This means that in the foregoing instances the farmer has to buy the tractor complete with cab and then take the cab off to enable him to use the machine. Israel has overcome this problem by making it possible for the user to buy the tractor without a cab as long as he indicates that it will be used only in specific applications.

Mr Evans went on to detail other areas where legislation is affected eg, type of glass fitted, number of exits and entry points to the cab, the fender clearance, position of controls, relationship of the seat to the various controls.

Finally, Mr Evans discussed one of the areas where there is most conflict and that is in the provision of the lighting.

Industrial straw usage conc

work is required and this research is unlikely to be undertaken by industry at this time of economic upheaval. At government level, however, the national interests of conserving foreign exchange and of relieving the world shortage of fibre go beyond the simple profitability of paper and board making processes. Farming is quite accustomed to this kind of thing. In the past, many agricultural products would not have survived in a free and open market. The national interest expressed through incentives either direct or indirect is a valid factor in the assessment of the viability of industrial straw usage.

It is certainly in the interest of farmers to be able to sell what, at present, is little more than a waste product and it is certainly in the national interest to use home-grown fibre but there is much less justification for industry to change over to the use of straw. Thus, it is the farmers and the researchers who must take the initiative to review critically the bulk handling problems and to promote the potential outlets for surplus straw.

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Past President	T Sherwen
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Associates	C V Brutey
	R Stokes
	C L Cawood
	J Kinross
Graduate	S W Robertson

ADMISSIONS

The undermentioned have been admitted to the Institution, in the grades stated:—

Member

Eu Weng Cheong	Singapore		29 11 74	AD
Rees M E	Dyfed		16 12 74	AD

Technician Associate

Abreo F	Kenya	–	7 11 74	
Biggar G W	Berks	13	29 11 74	FM
Fountain C G	Essex	12	16 12 74	FE
Swift J R R	Rhodesia	–	21 10 74	TS/ED
Pilcher R L	Peterborough	2	7 11 74	TS
Watson P D	Tanzania	–	29 11 74	

General Associate

Edmond M W	Warwicks	8	10 2 75	ED
Grech E	Malta	–	10 2 75	TS
Lai Chin Fook	Malaysia	–	10 2 75	TS
Nendick C G	Staffs	9	1 12 74	TS
Roberts K M	Cumbria	3	16 12 74	AD/FE
Woolley J M	Salop	9	16 12 74	ED/FM

Graduate

Black D C	Cheshire	11	16 12 74	RD
Dumelow J	Malawi	–	16 12 74	ED
Folowosele O B	Nigeria	–	16 12 74	BD/FE
Hong Kee-An	Malaysia	–	16 12 74	CS
Rodriguez J C	Argentina	–	23 10 74	–
Smith N C	Ayrshire	4	8 11 74	ED
Smout I K	Warwicks	8	10 2 75	FE
Ward R V	Rhodesia	–	21 10 74	–
Whittles T G	Salop	9	21 10 74	–
Williams D B	Yorks	10	10 2 75	DM

Student

Hayes A E	Hants	13	21 10 74	FE
Kalyanasundaran V S	Ayrshire	4	1 8 74	–

REINSTATEMENTS

The undermentioned have been reinstated:—

Member

Moore A L	Glasgow	4	4 1 74	–

Technician Associate

Simpson C	Avon	7	4 11 74	–

Graduate

Bin Sukra A	Beds	5	16 12 74	–

TRANSFERS

The undermentioned members have been transferred to the grades stated:—

Fellow

Olubode S O	Nigeria	–	24 10 74	–

Member

Awan M A	Pakistan	–	29 11 73	–
Beattie W	Aberdeen	4	29 11 74	–
Bell D A	Cumbria	3	22 1 75	ED
Boys P D	Canada	–	29 11 74	TS/RD
Butcher J F	Kenya	–	22 1 75	CS/FE
Castle D A	Lincs	2	22 1 75	AD/FE
Finn-Kelcey J P	Sultanate of Oman	–	24 10 74	EL
Garner C R	Suffolk	1	6 9 74	–
Handbury J M	Beds	5	21 10 74	TS
Howat D	Stirling	4	25 3 75	AD
Jackson T R	Sussex	13	25 3 75	FE
Linger B A	Lincs	2	6 9 74	–
List E J	Glos	7	7 11 74	ED
Lyford-Smith A	Worcs	8	25 3 75	DM
Mann R E	Surrey	13	5 2 74	–
Miller G R A	Essex	12	21 10 74	TS
Nelson R L	Berks	13	21 10 74	FE/TS
Nketiah A K	Ghana	–	16 12 74	–
Owen J E	Berks	13	21 10 74	–
Sims R E H	New Zealand	–	29 1 74	–
Thanki S B	London	–	22 1 75	FE
Ward N	Berks	13	22 1 75	RD
Whetnall C R	Wilts	7	22 1 75	ED
Wilcher A D	Essex	12	18 12 74	FE/TS

Companion

MacMillan D	Wilts	7	10 10 74	–

Technician Associate

Bunting G W	Essex	12	16 12 74	–

Graduate

Ford N	Yorks	10	3 4 74	–
Gunston H	London	–	10 2 75	FE/RD
Horsfield J A	Cheshire	9	10 3 75	–
Ilori I	Nigeria	–	16 12 74	–
Kittle S J	Warwicks	8	16 12 74	ED
Wood S H	Warks	8	12 3 75	–

Gilling A T	London	–	23 10 74	–
Inglis J P	Cornwall	6	16 12 74	–
Poole C M	Lincs	2	1 1 75	–
Reynolds H L	Beds	5	1 1 75	–
Towner F R	Berks	13	1 1 75	–

DEATHS

We regret to announce the deaths of the undermentioned members:—

Freeman P	Herefords	8	30 11 74	–
Morris J A	Gwent	–	31 1 75	–
Payne A T	Glos	7	8 3 75	–

RESIGNATIONS

The undermentioned have resigned from membership of the Institution:—

Baird G	Midlothian	4	31 12 74
Baird J	Essex	12	31 12 74
Bails R C	Derbys	2	31 8 73
Barrett F M	Warwicks	8	7 3 75
Benfield K	Cambs	5	25 3 75
Brown D C	Lincs	2	22 3 75
Bulmer G J	Durham	3	8 4 75
Clewley D A	Oxon	13	26 3 75
Cooch J H	Northants	2	21 4 75
Cunningham J D	Wigtown	4	31 12 74
Davies R E	Suffolk	1	31 12 74
Ditchfield T	Rhodesia	–	31 12 74
Edward J	Kent	–	31 12 74
Freer C S	Derbys	2	31 12 74
Hellier J A	Essex	12	3 3 75
Lons K	Northumberland	3	31 12 74
McLean F	Worcs	8	31 12 74
Reekie J M	Angus	4	7 3 75
Saunders K J	Devon	6	31 12 74
Spencer W C	Denbigh	9	31 12 74
Williams D J	Cambs	5	31 3 75
Wright G S	Surrey	13	31 12 74
Walford T	Dorset	7	17 3 75

ENGINEERS REGISTRATION BOARD

The undermentioned has resigned from the grade of Technician Engineer.

Saunders K J	Devon	6	31 12 74

Occupations

AD — Advisory Services; BD — Buildings; CS — Consultancy; FE — Field Engineering; PR — Technical Journalism; TS — Technical Sales, Distribution and Service; DM — Design and Manufacture; ED — Education; EL — Electrification; FM — Farming; RD — Research and Development.

Branches

1 East Anglia; 2 East Midlands; 3 Northern; 4 Scotland; 5 South East Midlands; 6 South Western; 7 Western; 8 West Midlands; 9 Wrekin; 10 Yorkshire; 11 North Western; 12 South Eastern; 13 Southern.

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