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GOOD PRACTICE CASE STUDY 372

Long-term success with advanced controls

Blue Circle Industries plc

- Many installations still operating effectively after ten years
- Energy savings at Hope of 8%
- Average payback period of 1-2 years
- Improved throughput, quality and reliability
- Lower staffing and maintenance costs
- Lower NO_x and other emissions

GOOD PRACTICE CASE STUDY 372

BEST PRACTICE PROGRAMME

ENERGY EFFICIENCY

BEST PRACTICE PROGRAMME

HOST ORGANISATION

I have been actively involved in the development of the LINKman system for more than 15 years. I have seen it transformed from a simple in-house prototype to a high quality, easy-to-use commercial product that is now employed by one of our main competitors and is installed on more than 100 cement kilns world-wide.

Many of our older LINKman systems are still operating effectively after 10 years of continuous operation. We have been able to maintain run times of over 80% by installing reliable sensors, by maintaining them correctly, and by an ongoing programme of in-house training to ensure that operators understand how the system works.

Both operators and managers are committed to ensuring the effective operation of the LINKman system. The company is also currently upgrading all its older systems to ensure their continued operation well into the 21st century.

Our company is pleased to commend this technology to other large energy users.

T Lowes

Tom Lowes

BCI HBM Energy Development Manager

BLUE CIRCLE INDUSTRIES PLC

Blue Circle Industries plc is a major manufacturer of Portland Cement in the UK, and has subsidiary and associated cement manufacturing companies in North and South America, Denmark, Nigeria, Zimbabwe, Kenya, Malaysia and the Philippines. Within the UK, the company is one of the largest users of energy in the private sector at around one million tonnes of coal equivalent and one terawatt hour (TWh) of electricity per year.

PROJECT BACKGROUND

Cement manufacturing is a complex and energy intensive process. A key stage in this process is the conversion of ground raw materials (calcium carbonate and clay or shale) to 'clinker' in the kiln. A typical operation uses kiln exhaust gases to pre-heat the raw materials before they enter the kiln. Further heating, to about 1,500°C, takes place in the kiln's 'burning zone', where the materials partially melt and react to form the clinker. Subsequent processing to convert the clinker to cement involves adding small amounts of gypsum and grinding the mix to a fine powder. Fig 1 shows the kiln at the heart of the cement-making process.

Effective kiln control is critical and, in the early 1980s, Blue Circle set about developing an advanced control system to address this issue. The first LINKman system, installed at the Hope Works in 1985, achieved considerable success, and Blue Circle has since introduced it at most of their UK and overseas sites.

More than 100 LINKman advanced control systems are now operational throughout the world, and the first of these are still performing effectively, more than ten years after their initial installation. Understanding the reasons for this ongoing success is important. There are many opportunities within industry for the application of advanced computing and control techniques to improve performance and reduce energy use (further details are given in Energy Efficiency Good Practice Guide 215, *Reducing energy costs with advanced computing and control*), but organisations need to be sure that such systems will continue to provide benefits.

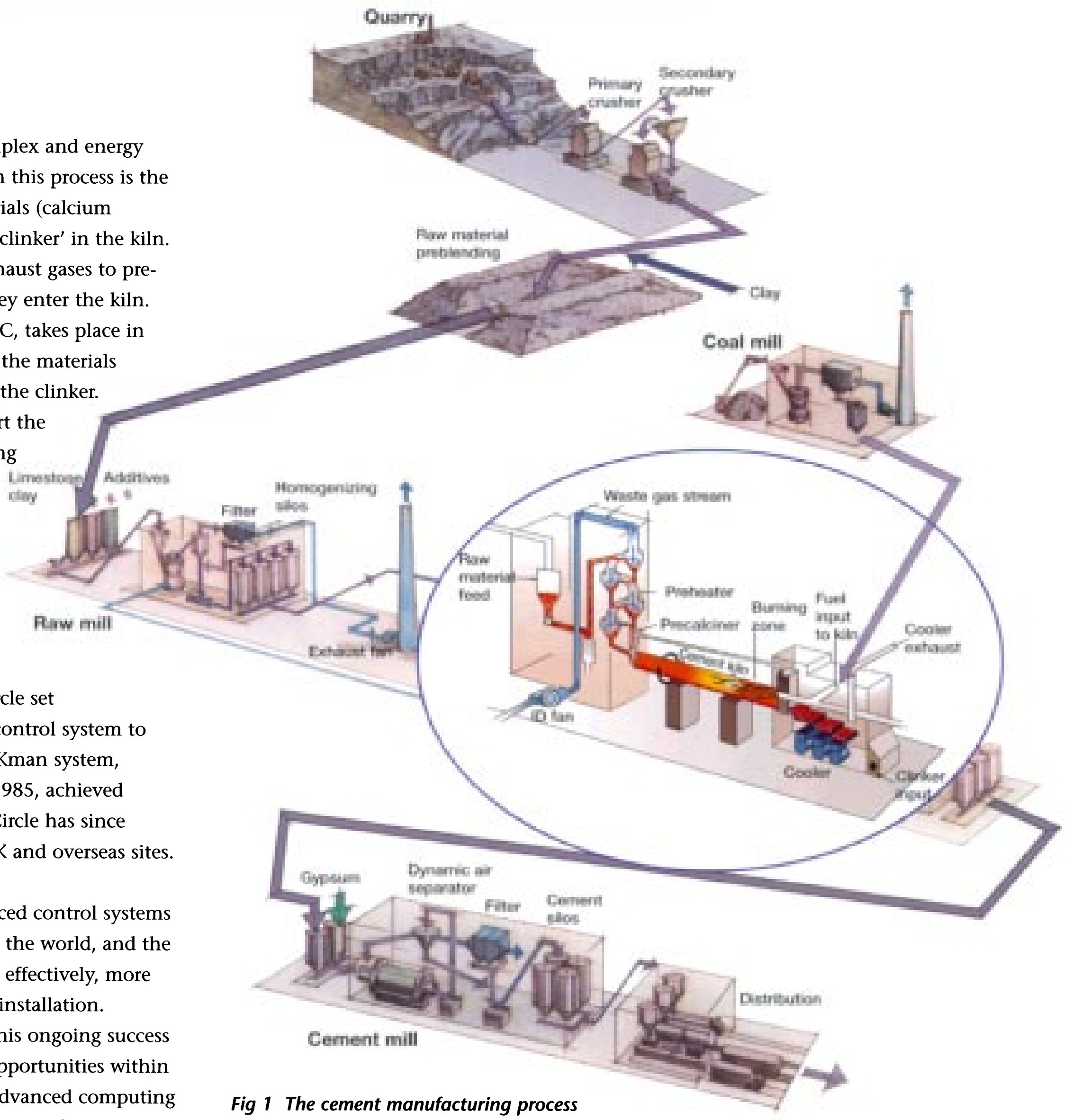


Fig 1 The cement manufacturing process

This Case Study seeks to provide that assurance by highlighting some of the key factors identified during assessments at two UK sites (Hope and Aberthaw) and two US sites (Atlanta and Tulsa).

The project was monitored independently by Hart Consultants. Tel: 01737 249714.

Equipment supplier: ABB LINKman Ltd. Tel: 0181 778 1200.

There are other suppliers of similar systems in the market.

Please consult your supply directories or contact ETSU who may be able to provide you with more details.

ADVANCED KILN CONTROL

Conventional control of a cement kiln has its shortcomings. It requires an experienced operator who will constantly interpret process conditions and make frequent adjustments to control set points. This task is made more difficult by complex responses, time delays and interactions between the individual process variables. As a result, conventional kiln control results in conservative kiln operation, with temperatures that are higher than the optimum, and in unnecessarily high energy use.

The LINKman system developed by Blue Circle improves on conventional control by constantly interpreting kiln conditions and initiating appropriate actions. Its various input and output signals are identified in Fig 2.

LINKman is an expert system in which the 'expertise' embedded in the system is expressed as a set of rules. These determine from the process inputs what control action(s) should be implemented at any given time. Fig 3 illustrates a typical 'rule block', while Fig 4 shows the operator interface.

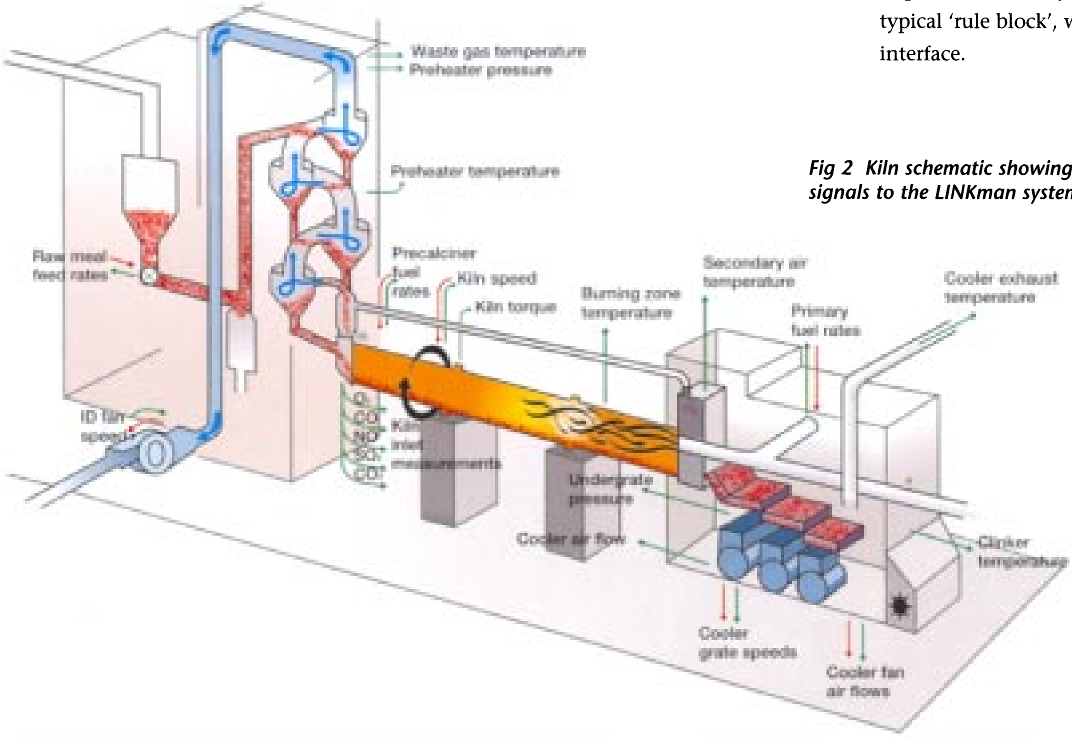


Fig 2 Kiln schematic showing input and output signals to the LINKman system

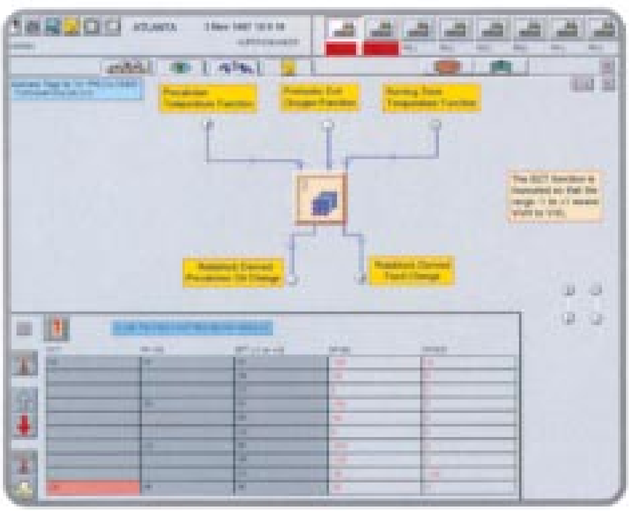


Fig 3 Part of a typical 'rule block' screen dump from the Atlanta LINKman Graphic system

Fig 4 The LINKman advanced control system operator interface

HOW ENERGY SAVINGS ARE ACHIEVED

Burning zone temperatures (BZTs) are crucial to product quality as they affect the proportion of free lime (unreacted calcium oxide) in the finished product. Fig 5 shows how free lime levels vary with temperature at the Hope plant. Although actual figures quoted will vary from site to site, the principles are always the same: low BZTs produce a softer clinker with higher free lime levels; high BZTs produce a harder clinker with lower free lime levels. The increased kiln energy cost associated with a high BZT has two components:

- the greater fuel input required to raise temperatures;
- the higher clinker grinding power requirements.

It is also clear from Fig 5 that BZT levels affect the stability of kiln operation. A high BZT is associated with stable kiln operation: too low a BZT will cause instability and increase the possibility of kiln shutdown. Unstable kiln operation adds to the thermal stresses on refractory brickwork in the kiln, reducing refractory life and increasing refractory costs. Unnecessary kiln downtime increases energy use per unit of clinker produced: this is because of the high energy base load of a cement works and the energy use associated with kiln start-up.

Proper, stable kiln operation can reduce energy consumption and maintenance costs, increase kiln output and improve product quality. However, while optimum operation involves maintaining BZT at the minimum level consistent with stability, this is difficult to achieve for three reasons:

- variations in raw material feed composition;
- the complexity of kiln operations;
- long time delays between kiln operational changes (e.g. set point changes) and their effects.

The LINKman advanced kiln control system operates the kiln in the optimum manner, thereby ensuring a good quality product, lower burning zone temperatures and lower energy costs. The system achieves this by applying the appropriate expertise on a consistent and regular basis, i.e. by making small changes every three or four minutes.

COST-EFFECTIVENESS

The cost of installing LINKman is approximately £200,000 per kiln, including hardware, engineering, installation and commissioning, licence fees and training. Actual figures vary with site conditions but can range from £200,000 to £300,000, depending on the equipment already available.

Based on energy savings alone, the simple payback period at Hope was less than six months. However, the average payback period is normally between one and two years once ordering, installation and commissioning time has been included.

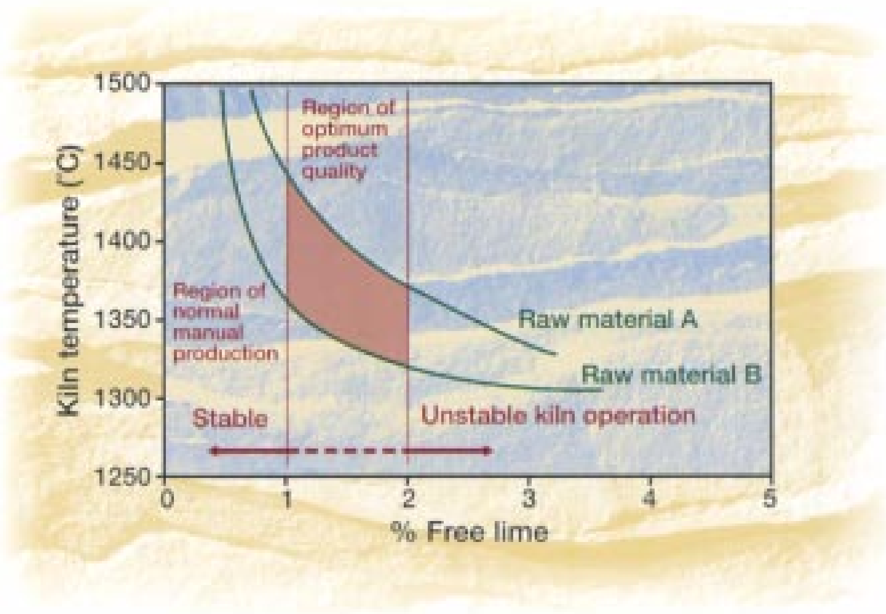


Fig 5 Burning zone temperature vs free lime: Hope cement kilns

LONG-TERM PERFORMANCE

An evaluation of LINKman systems at four Blue Circle sites has shown not only that they are still operating effectively after many years but that kiln control is continuing to improve. At the Hope works, LINKman is now typically in control of the kilns for more than 80% of kiln run time (Fig 6). Furthermore, calculations based on measured free lime and oxide of nitrogen (NO_x) levels before and after LINKman installation estimate that the system is achieving savings in fuel consumption of 8% per kiln.

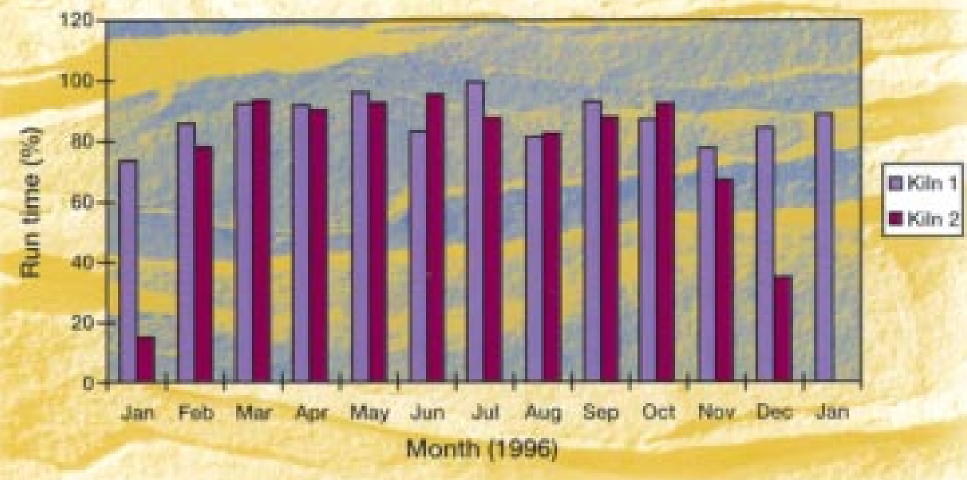


Fig 6 LINKman run times for the two Hope kilns in 1996

REASONS FOR LONG-TERM SUCCESS

Three factors have contributed to the success of the LINKman advanced kiln control system over more than 12 years:

- the business benefits of operating the system;
- the effectiveness and ease with which the system can be used;
- the enthusiasm of those involved.

The same factors will be important in its continued success.

Business Benefits

Effective operation of the LINKman system has had a significant impact both on kiln performance and on the performance of the Blue Circle business as a whole. Benefits include:

- increased kiln output (by as much as 10%);
- lower energy costs (down by 8% at Hope);
- improved product quality;
- lower environmental emissions (NOx);
- lower staffing requirements for kiln operation;
- improved kiln stability;
- improved understanding of kiln operation.

These benefits were the driving force for the development of LINKman and are still as relevant today. Furthermore, Blue Circle needs to operate LINKman to remain competitive since its rivals operate similar systems[1].

[1] Although LINKman was developed in-house by Blue Circle it was subsequently sold because, at the time, the costs of modernising and maintaining it could not be justified in-house. It is now available to Blue Circle's competitors and has been adopted by the Holderbank Group (one of the largest cement manufacturers in the world).

RESULTS

Operational Advantages
There are several reasons why the LINKman system is operationally effective:

- the control strategy is effective under most circumstances and is acceptable to kiln experts and operators;
- the software and hardware used are robust;
- system failure is not a problem — control simply reverts to manual;
- the operator interfaces are user-friendly, particularly the more recent graphical versions;
- the system is well supported by Blue Circle (technical support and regular training) and by the equipment suppliers;
- LINKman is being constantly developed to make sure it remains modern and relevant: this is vital to the system's survival.

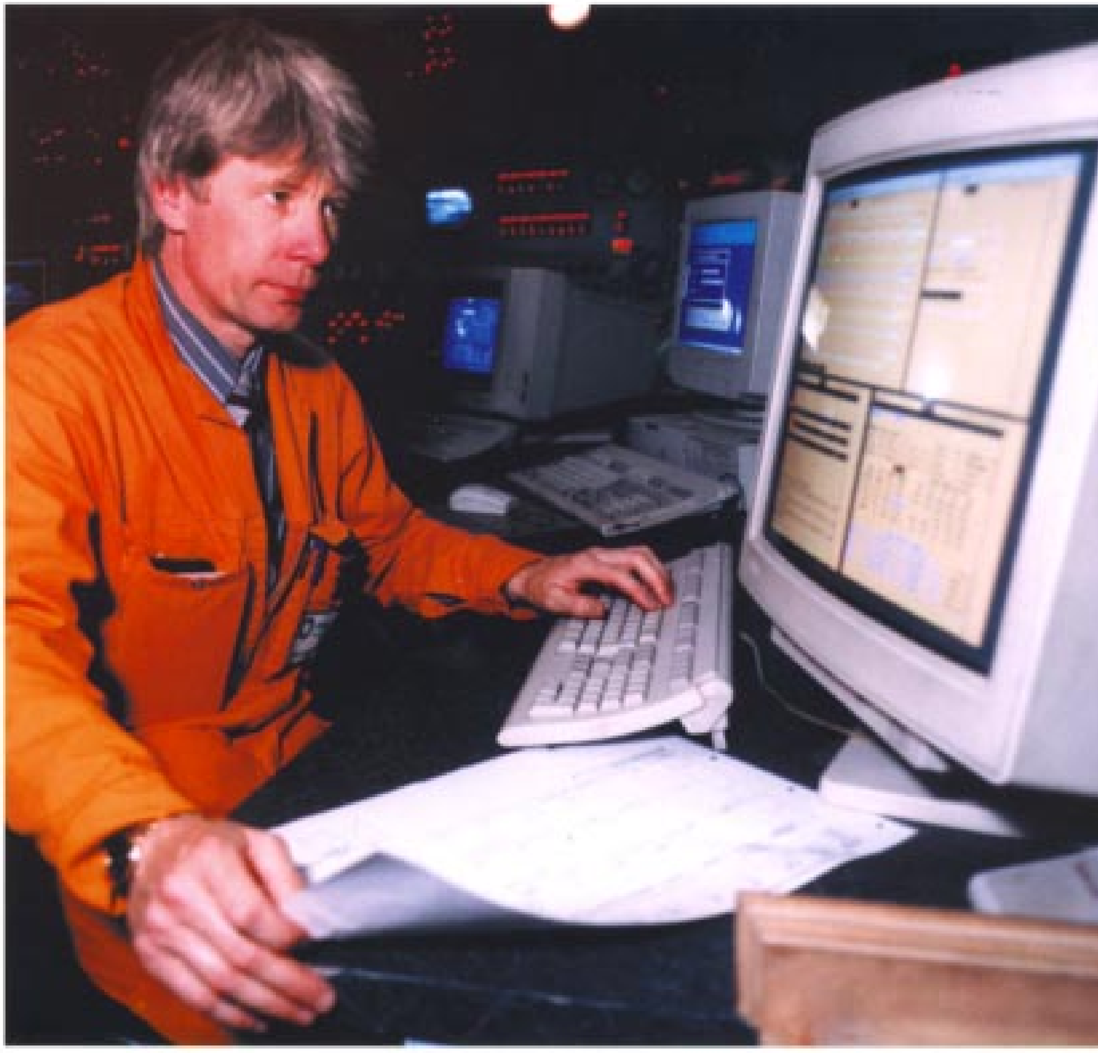


Fig 7 Process engineer at Blue Circle's Hope Plant interrogating the LINKman system

Staff Support
Much of LINKman's success within Blue Circle is attributable to the support provided by key groups within the company.

Senior executives and management have a particularly important role to play as they provide the driving force for the implementation and effective use of the system. Evidence of their impact at Blue Circle is clear, and the performance of LINKman has improved considerably in the last few years following the introduction of performance reports to senior management.

However, senior management support needs to be underpinned by the effective and enthusiastic support of capable people at lower levels — process engineers, control and instrumentation engineers, operators, etc. Blue Circle achieves this by providing effective training and support, and also in other ways. At the Atlanta site, for example, payment is based on performance.

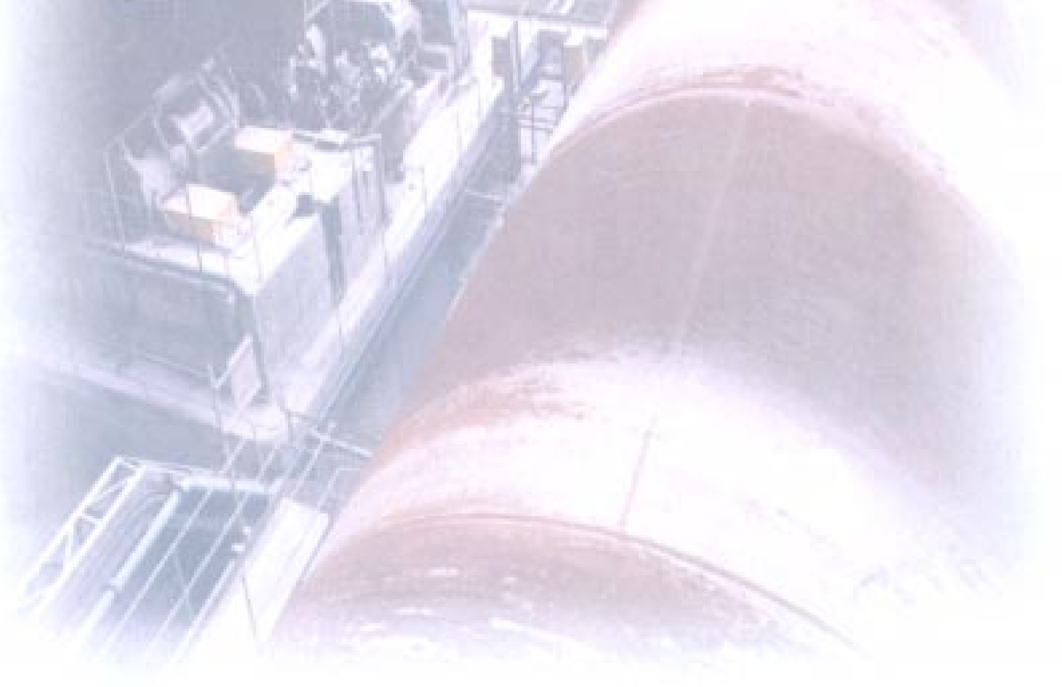
CONCLUSIONS

Although alternative control solutions are now available, the LINKman system is still perceived by Blue Circle to be the best way of optimising kiln performance and is given a high priority within the company. It is for these reasons that the system was developed, installed and is used for continuous optimisation.

The system is clearly effective as a means of optimising kiln conditions and making a significant improvement in performance. It is also sufficiently robust to operate effectively over long periods of time — ten years or more.

Blue Circle has demonstrated that, with proper attention and maintenance, an advanced control system such as LINKman can continue to provide benefits in the longer term. It has recently invested in a Telewindows system at its technical centre. This system allows all the LINKman systems to be viewed remotely and tuned in conjunction with its works world-wide.

A key issue in this is the commitment and enthusiasm of all levels of staff, especially senior management.



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Building Research Establishment
Garston, Watford, WD2 7JR
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Fax 01923 664787
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