INCREASING THE ENERGY EFFICIENCY OF YOUR KILN OR LEHR

by Mike Arkelin

In today’s business the main topic of conversation is profitability. Business experts have written numerous self-help books with strategies and programs that promise to increase profits if you just follow their plan. John J. McGowan of the Johnson Controls Company asks the question “So with all the studies focused on profitability, is it possible that a simple and thoroughly effective approach has been missed by many companies?” There is a common ingredient in the businesses of the traditional ceramics and decorators, manufacturers of advanced ceramics for electronics industry, metals processing or manufacturers of advanced materials and that is the use of heat in their process. With this in common, then the concern for growing energy costs and its effect on competitiveness has to be a major concern, especially with the increased pressure from the imports. This is the simple approach John McGowan is talking about, cutting operating costs for energy by investing in efficiency. He goes on to say that reducing operating costs is not a new concept but it seems that expenses like advertising, salaries, outsourcing and downsizing are scrutinized while energy costs are viewed as fixed costs. While we have little control on the low labor costs of some foreign exporting companies, we have some control of the energy usage in our manufacturing process.

It is essential to identify all operating cost components including energy to continuously improve profitability. For example some companies are measuring operating costs in terms of energy with such terms as BTU’s/hamburger or property managers measuring BTU’s/square feet of office space so why not BTU’s per pound of ware. It is easy to see that increased energy efficiency in new kiln design is one important aspect of energy cost control, but the efficient operation procedures and maintenance of existing equipment is equally important to controlling costs.

SO WHAT DOES THE FUTURE LOOK LIKE?

Let’s look at some recent news clippings on electrical power costs.

Massachusetts

Saturday, June 30, 2001 -- (BOSTON AP) “State regulators on Friday approved rate hikes of between 8 and 11 percent for five of the state’s six electric distribution companies.”

California

American City Business Journals Inc. March 26, 2001 –“According to both the Los Angeles Times and Associated Press, some sources speculate that power rates could go up by 50 percent or higher. That would come on top of a 19 percent rate increase already scheduled through a combination of an increase and elimination of a 10 percent rate reduction that was due to be phased out under the state’s 1996 electricity deregulation law.”
Washington

Seattle Post-Intelligence Reporter January 30, 2001—“Seattle City Council members hit with a "perfect storm" of an unusually dry winter and skyrocketing electricity costs unanimously approved an 18 percent increase in electric rates yesterday, less than a month after a 10 percent rate boost went into effect New Year's Day.”

Florida

Sun-Sentinel Mar. 13, 2001—“State regulators on Tuesday approved a 9 percent jolt in electric rates for the rest of this year, rather than offering a measure of insulation by spreading a portion of the increase into 2002.”

And now some recent news clippings on natural gas costs.

Missouri

The Associated Press March 8, 2001—“Bills for southern Missouri customers of UtiliCorp -- which does business as Missouri Public Service -- will rise 33.6 percent, averaging about $31 more for March, the commission said. Rates for northern Missouri will increase 28.8 percent. The commission said the average customer's bill would increase by about $31 for March. Eastern Missouri UtiliCorp customers will see 25.7 percent rises. The average bill in that region for March will increase by about $38, the commission said.”

Nevada

Las Vegas Review-Journal January 24, 2001-For midsize commercial gas customers, Southwest Gas is asking regulators to raise rates by 34 percent in Southern Nevada and 41 percent in Northern Nevada.”

Texas

Texas Electrical Cooperatives -- “Rapidly escalating natural gas prices are forcing Texas electric co-ops to make monthly rate adjustments. Natural gas prices have set historic highs in January, pushed up by freezing temperatures and low supplies.”

California

The Dominion Post May 12, 2001--“Natural gas rates will soar this fall.”

Natural Gas is an energy source whose price can affect you whether you have an electrical or gas fired kiln. Natural gas is one of the fuels used to fire the generators that produce electricity. No price relief is expected in the near future. Not only is the current price high, but also the price paid today for delivery at a future date (i.e., natural gas futures). Currently, natural gas futures through 2001 are in excess of $9 per million British Thermal Units (BTUs). This compares to $2.58 per million BTUs last February.
Despite all the projections, not even the so-called expert’s crystal ball has 20/20 vision in forecasting energy costs. There are two things that are true besides death and taxes and they are: 1) Energy costs are a significant % of a decorator’s manufacturing costs and 2) neither our government nor the energy users have much control over the energy costs. If we can accept these as truths, then we can agree that increasing energy efficiency of your firing operations is of prime importance.

DOES THE CHOICE OF THE STYLE OF KILN MATTER?

Continuous Kilns

The bulk of the worldwide ceramic production is fired in continuous kilns. The energy consumption of a continuous kiln can be as much as half that of periodic firing systems. One of the reasons is that the refractory needs to be heated only once for the entire period of the continuous operation so the heat storage in the walls does not have to be replaced with each firing cycle as with a periodic kiln. Traditionally, continuous kilns are constructed of insulating firebrick for structural strength and because of bricks higher heat storage. Once the firebrick has been heated, it holds the heat making it very energy efficient and has very good temperature stability while the kiln is in operation. If a high production rate of consistent product and continuous operation identifies your application then a continuous kiln is probably the correct kiln for you. If this kiln is not to be used 24/7, your production requirements should be closely evaluated before making the kiln selection. If a continuous kiln is still chosen, the kiln can be idled at an intermediate temperature during the non-working hours so energy is being expended at a lower rate while there is no production. The other option is to shut the kiln off prior to the weekend and accept the extended time required to bring the kiln back up to temperature at the start of the week, which again uses energy with no production. In gas fired continuous kilns there is another energy saving advantage in that the counter flow of the exhaust gases heats incoming product where as in a batch kiln it is lost up the exhaust stack.

Periodic / Batch Kilns

Since we are now asking questions “Where does the energy go?” and since periodic kilns are generally the SUVs of fuel consumption, using twice the equivalent fuel per piece than their continuous counterpart, when exactly is the periodic kiln the correct solution? It is application dependent. To use an old English expression “there are different horses for different courses” and there are different kilns more ideally suited for different operations. The main advantage of the periodic kiln is its flexibility and, despite the fact that they are less energy efficient, is the reason more periodic kilns are manufactured than continuous kilns. The batch kiln allows you to fire different batch sizes and allows you to fire several different products with different or unusual firing profiles in the same week. This would be difficult with a continuous kiln. If the flexibility of a periodic kiln is required for your operation, then concentrate on making it as energy efficient as possible.
DOES THE CHOICE OF REFRACTORY MATTER?

Increased energy costs are causing kiln manufacturers to review the efficiency of refractory used in their kilns. Often the older equipment still in operation is lined with conventional firebrick, which has poor insulating qualities. While this lining offers long life, it function as a heat sink, absorbing a significant amount of thermal energy to heat the lining itself. It also has a high thermal conductivity leading to excessive heat loss through the lining. Two (2) energy-saving options are:

**Insulating Firebrick**

Lightweight insulating firebrick (IFB) has far better thermal efficiency and lower heat loss while still providing structural properties reducing the need for a supporting steel structure. For example, low-temperature IFB grades are approximately three to six times more thermally efficient than similar temperature-rated dense firebrick, high-temperature IFB grades are approximately four to eight times more thermally efficient than similar temperature-rated dense firebrick.

**Ceramic Fiber Modules**

Lightweight fiber modules offer even lower thermal conductivity and higher energy efficiency than the lightweight IFB. They are available in a variety of ceramic fiber compositions and attachment anchoring systems. Ceramic fiber modules are easier to install, however, they are not structurally supporting and can be somewhat more vulnerable to chemical attack.

The comparison of power requirements of for a simple batch kiln will provide a quick snap shot of the differences of energy efficiency of the three refractories mentioned above. For this example let’s assume the following.

120 Cu Ft Batch Kiln  
Maximum Temperature 1600°F  
8 Inches of Refractory  
Weight of Load Ware and Kiln Furniture 2000 Lbs  
Time Required to Raise the Load to Temperature 3 Hrs

<table>
<thead>
<tr>
<th>Refractory Type</th>
<th>Heat Loss BTU/Hr/Sq-Ft</th>
<th>Heat Storage BTU/Sq-Ft</th>
<th>Power required THOUSAND BTU/HR</th>
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<tbody>
<tr>
<td>Conventional FB</td>
<td>1138</td>
<td>17703</td>
<td>1,198</td>
</tr>
<tr>
<td>IFB</td>
<td>212</td>
<td>3759</td>
<td>452</td>
</tr>
<tr>
<td>Ceramic Fiber</td>
<td>181</td>
<td>1009</td>
<td>320</td>
</tr>
</tbody>
</table>
DOES KILN FURNITURE/CARS MAKE A DIFFERENCE?

The move to low-mass kiln furniture has increased dramatically in recent years. Low-mass kiln car superstructures based on recrystallized silicon carbide were first introduced in the mid-1970s. Recently a new system was introduced that combines standard cordierite/mullite formulations with lightweight refractory aggregate, providing up to 40% savings in refractory weight. This weight reduction enables shorter firing cycles and increased fuel savings. Since then, a number of other silicon carbide manufacturing processes have been developed and are now used to produce a variety of new and innovative kiln furniture components. An understanding of the material options currently available and their respective advantages and applications can allow the kiln furniture user to select intelligently from among them. This has especially been true in the bone china industry, where the refractory-to-ware ratio is often quite high. With traditional kiln furniture, some bone china manufacturers might be firing with a furniture-to-ware ratio as high as 6:1 or 7:1, which means that most of the energy in the firing process is being used to fire the furniture rather than the ware. Careful placement of ware to maximize the load per car will also improve these ratios.

LOSSES ASSOCIATED WITH EXHAUST GASES

After taking all the above factors into consideration, the other predominant energy loss in gas-fired kilns is the heat content of the exhaust gases. Even if these exhaust gases are contaminated it is possible with careful design to recuperate this energy. While using these exhaust gases to save energy may not be feasible in all applications, the potential cost saving warrants consideration.

When possible, the combustion air should be preheated. In some applications a system to preheat the combustion air to increase the efficiency thereby decreasing its fuel use, may be worth the investment. Depending on the size of the oven, dryer or kiln simple annual paybacks will vary. Retrofits on gas fired kilns, dryers, and ovens ranging from 0.2 to 8.52 MM Btu/hr yield an average a pay back of 3.2 years. Installation of an air-to-air heat exchanger package will be required for each kiln. The heat exchanger
will preheat the outside air supplied to the oven or kiln. This can be accomplished by ducting the exhaust gases and combustion air through opposite sides of a heat exchanger so that the combustion air will be preheated. Another clean alternative is to route the cooling section exhaust air to provide preheated combustion air. Even in an electrically heated continuous kiln this air might be routed to a pre-heat zone.

**INSTRUMENTATION**

Major advances in control technology and electronics in recent years have made this an optimum time to consider upgrading your kiln control system. Modern control systems are scalable lending themselves to applications for most any size of operations and budget. Many plants can receive faster and more significant returns simply by upgrading their kiln control systems rather than making alternative investments. Realizable gains from an upgrade can impact plant operations in many areas, including lower operating expenses from energy costs through heating, cooling, power and fuel control, as well as improved product quality, increased production and reduced maintenance costs.

A pulse-controlled burner firing system is a prime example of an advanced control system that regulates the kiln energy input according to the demand requirements dictated by the control system or temperature controller. It adjusts the thermal input by sequencing the cycling of multiple burners (within a specific zone) from high-to-low for controlled periods of time. The burner control provided by the pulse-controlled system produces maximum heat transfer of the kiln gases for optimum temperature uniformity, resulting in better product quality and increased production. The on-ratio precision of a pulse-controlled system ensures efficient heat transfer with a minimum of fuel consumption, reducing one of any plant’s most costly operational expenses.

Note that no matter how good a control system is it cannot fix mechanical problems. Once you have determined that your kiln’s mechanical systems are adequate, upgrading your kiln’s control system may be the most viable solution to dramatically improve its performance while reducing operational costs.

**WHAT CAN BE DONE FOR USED EQUIPMENT?**

Many of the existing kilns were built in a time when energy costs were far less of a concern than they are today. In addition, modern materials are much more energy efficient than they were just a few years ago. The same energy saving considerations discussed above applies to used equipment but what can actually be done is maybe somewhat limited by the original design. In some applications refurbishing an existing kiln may be a more economical solution than acquiring a new one. We caution you however to think before you rebuild. Evaluating all the possibilities before refurbishing a kiln can lead to unexpected kiln benefits. Selecting an experienced kiln service organization to survey your systems for heat losses, inefficient burner settings, improper control settings and calibrations, and to make recommendations for kiln repairs to improve the energy efficiency is well worth the small investment. This same service organization can assist in implementation, reducing downtime of a production kiln by planning ahead where possible to prefabricated subcomponents.

Immediate improvements in energy efficiency without modification of the kiln maybe possible through lighter weight kiln furniture and more efficient loading of the kiln to reduce the amount of dead space and thus the refractory to ware ratio.