SUMMER/13

VOLUME 26 / ISSUE 2

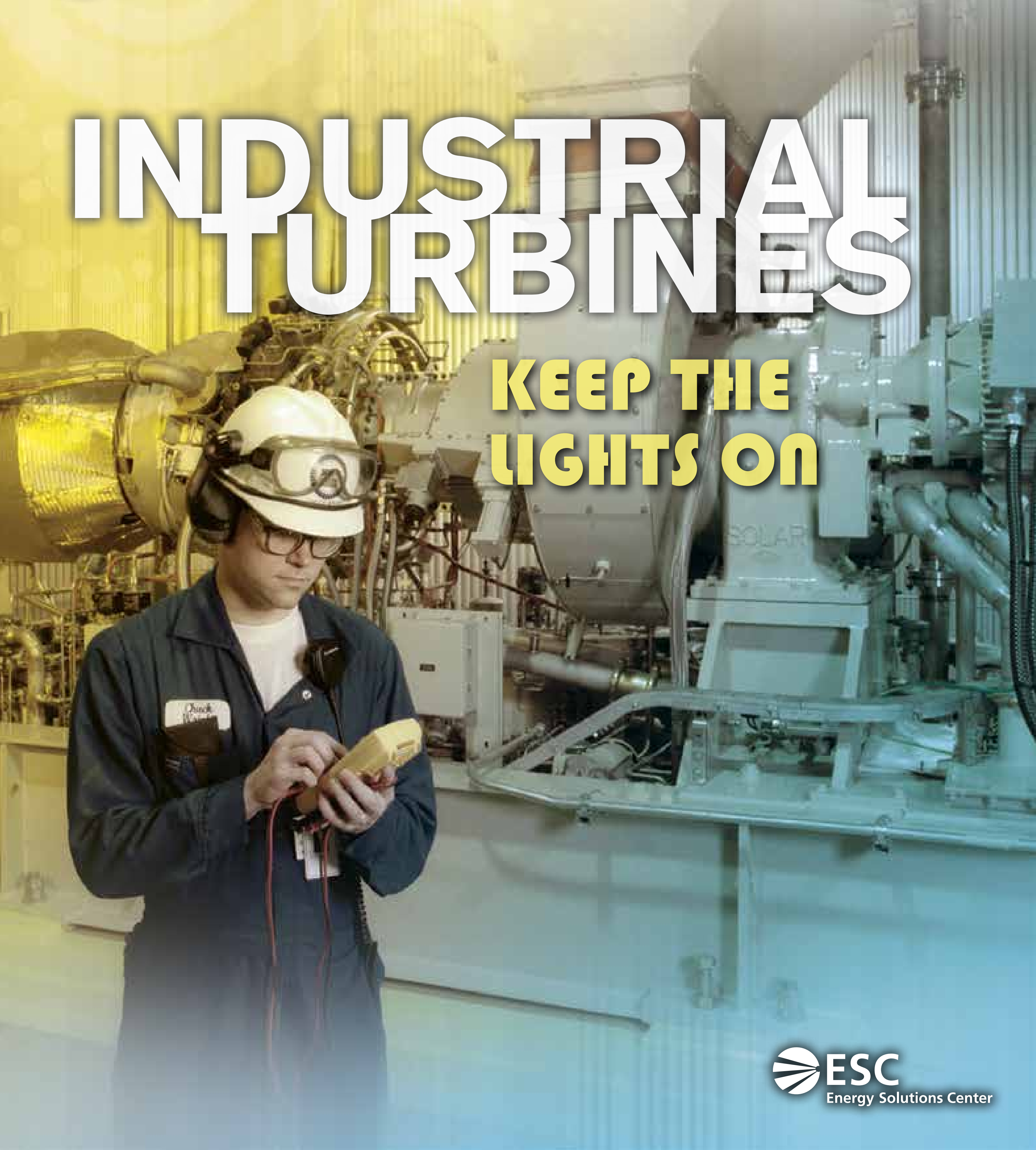
gastechnology

THE SOURCE FOR ENERGY SOLUTIONS

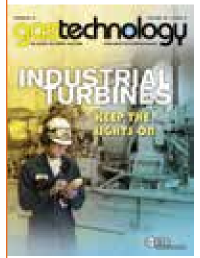
WWW.ENERGYSOLUTIONSCENTER.ORG

INDUSTRIAL TURBINES

KEEP THE LIGHTS ON



ESC
Energy Solutions Center



on the cover

Today's industrial turbines fired by natural gas assure reliable on-site power and provide a rich thermal resource for steam, hot water and absorption cooling. Photo courtesy Solar Turbines.

ESC Energy Solutions Center

Gas Technology is a trademark of Energy Solutions Center Inc. and is published in cooperation with CFE Media, LLC.

Gas Technology is an educational supplement from:
Energy Solutions Center Inc.
400 N. Capitol St., N.W.
Washington, DC 20001
(202) 824-7150
www.energysolutionscenter.org

David Weiss, Executive Director
Jake Delwiche
Contributing Editor
Comments may be directed to:
Gas Technology Editor
Plant Engineering Magazine
1111 W. 22nd Street, Ste. 250
Oak Brook, IL 60523
(630) 571-4070
Printed in the USA

energy solutions center websites

www.aircompressor.org
www.cleanboiler.org
www.energysolutionscenter.org
www.naturalgasefficiency.org
www.gasairconditioning.org
www.understandingchp.com

inside

CAPTURE MORE TURBINE ENERGY WITH CHP

Thermal Applications are the Key

IN THE EVOLVING WORLD of combined heat and power (CHP), the use of natural gas-fired industrial turbines rated at 1 MWe and higher with heat recovery has become increasingly attractive. These machines are built for long running hours, heavy loads and high fuel efficiency. Technology for extracting high temperature exhaust heat has also improved, so total system efficiencies of 80% and higher are often achievable.

CHP Is On the Rise

CHP applications powered by natural gas are burgeoning in popularity. One reason is the continued attractive price of the fuel. Ed Mardiat is a Principal and Director of Project Development for Burns & McDonnell, an international engineering, architectural and consulting firm. Mardiat has been extensively involved in a wide range of CHP projects.

He notes, "The abundance of and lower price for natural gas have dramatically helped CHP economics. The other related factor is environmental regulations such as the Industrial Boiler MACT [Maximum Achievable Control Technology] requirement, which is forcing many of the older coal-fired assets to be replaced with natural gas-fired units."

Energy System Security

Mardiat also points out that there is growing interest in micro grids. "These in combination with on-site CHP systems can improve energy security. Many industrial, institutional and government facilities are exploring these alternatives."

Turbine CHP can be used for a wide range of beneficial purposes. It makes the most sense to use turbines where the need for heat is large, the preferred thermal output is steam rather than hot water, the run-hours will be long, and the output is generally at the upper end of the turbine power range.

In a recent presentation at a Technology Marketing & Assessment Forum (TMAF) sponsored by the Energy Solutions Center, Chris Lyons from Solar Turbines and Mike Devine from Caterpillar discussed the opportunities for both large engines and combustion turbines for CHP applications. They noted that natural gas-powered CHP of both types is attractive now because of the low and stable price of the fuel, the need to control emissions, the proven nature of both technologies, high reliability and low life-cycle costs.

Industrial facilities such as this dairy processing plant have extensive need for steam and hot water. Thus they are ideal candidates for gas turbines for site power plus a major part of their thermal requirement. Photo courtesy Burns & McDonnell.

Larger industrial turbines are an especially good selection, as at this pharmaceutical plant, because of their higher electrical efficiency and large volume of heat for steam.
Photo courtesy Burns & McDonnell.

Choosing Between Turbines and Engines

Turbines are often the choice where the thermal load requirement is high, steam is preferable to hot water, and where the electric requirement is continuous and relatively even. These units produce large quantities of waste heat at temperatures ranging from 700° to 1,000° F – a range where high-energy steam can be efficiently extracted using a heat recovery steam generator (HRSG).

In certain applications, CHP using larger industrial turbines is an excellent fit. According to Lyons, common applications include food processing, dairy plants, breweries, pulp and paper, pharmaceuticals, district heating and cooling, colleges and universities, healthcare facilities, hotels and resorts, and penal institutions. "This is an ideal choice where there are major thermal or chilling loads."

Take Advantage of Higher Temperatures

Mardiat from Burns & McDonnell echoes this opinion, saying, "Because turbine simple cycle heat rate efficiency is lower than reciprocating engine systems, with exhaust temperatures in the 700 to 1,000 degree F range, industrial, institutional and government facilities that require an abundance of steam for heating or process loads provide the best fit for this prime mover technology." He points out that for most applications, it is important to make full use of the thermal output. "The highest efficiency and most economic CHP systems use 100% of the waste heat to provide steam or hot water." This then results in very high total system efficiencies.

Range of Sizes Available

Solar offers turbines ranging in size from the 1.2 MWe Saturn 20 unit to the two-shaft Titan 250 unit rated at 21.7 MWe. In some situations, owners prefer to have multiple units to further increase system reliability, and to allow the selected units to operate near their peak efficiency.

Lyons points out that the smaller turbines do not have efficiencies as high as with larger units, ranging from 25% to 39%. "But in CHP applications, the overall thermal efficiency can range from 70% to 90%." He suggests that most buyers size the units to match their thermal load requirement. "However the decision is also very dependent on overall electric rates and factors such as the need for plant reliability."

Longer Service Intervals

Today's combustion turbines have high reliability and designers have extended required service intervals. For Solar Turbines, Lyons explains, "Most of our turbines are designed for 30,000 hours between overhauls. However some of the smaller units go well beyond 40,000 hours." He notes, "From time to time there are issues that might require attention to prevent a premature failure."

Generally, combustion turbines operate at their peak electrical efficiency near full load. When at part load, a greater part of the fuel energy goes to the thermal load and less to the electrical. Lyons emphasizes that for combined heat and power situations, the efficiency at part load is still quite good. In situations where the turbine operates at a low level for an extended period of time, a supplemental heat source to the HRSG may be desirable.

Frito-Lay Takes the Step

An example of an ideal installation of a combustion turbine in a CHP installation is at the Frito-Lay plant in Killingly, Connecticut. This large scale producer of potato and corn snack products uses daily a quarter-million pounds each of corn and potatoes in a 24-hour manufacturing operation, with a peak electrical demand of 3.8 MWe and a minimum of 1.5 MWe.

In addition, the facility has a peak annual steam demand for up to 90,000 lbs/hr of saturated steam at 325°F for process applications. The minimal steam demand is on summer weekends, at 12,000 lbs/hr.

Because the plant was in an area with power reliability problems caused by distribution constraints, the plant had experienced significant interruptions in service. This created issues in terms of lost production, wasted stock in production and required re-inspections. According to Christopher Wyse, Communications Manager for Frito-Lay North America, the area also has high electric rates.

Further, the company needed additional steam generation capacity to keep up with growing production. Wyse indicates that they knew that "CHPs are common in other industries and have a proven reliability record, provided the owner follows a proactive maintenance program." Beginning in 2006, working with consulting support from Dana Technologies, they investigated and began the engineering and permitting process to install a CHP system powered by a combustion turbine with heat recovery for process steam.

Major Part of Plant Energy Needs

In July, 2008 they began construction. The system uses a Solar Turbines 4.6 MWe Centaur 50 turbine with heat recovery by a Rentech HRSG, along with a Coen supplemental duct burner for additional

MORE info

BURNS & MCDONNELL
www.burnsmcd.com

DOE INFORMATION ON FRITO-LAY CHP SYSTEM
www1.eere.energy.gov/manufacturing/distributedenergy/pdfs/chp_food_processing.pdf

ENERGY SOLUTIONS CENTER: UNDERSTANDING CHP
www.understandingchp.com

KAWASAKI GAS TURBINES
www.kawasakigasturbines.com

SOLAR TURBINES
mysolar.cat.com

and standby steam capacity. The turbine can provide nearly 100% of the site electrical requirement, and releases heat to generate 24,000 lbs/hr of steam without supplementary firing. With supplemental firing, the unit produces 60,000 lbs/ hr. This represents nearly 90% of the site steam requirement. The company maintains a connection to the electrical utility and purchases a small amount of power to maintain the connection.

After a short and trouble-free startup and commissioning, the system went into operation in March, 2009. In the first two years since beginning operation, the turbine had 96.5% availability. In that period, the CHP project has saved the company $930,000 in operating costs, as well as assuring improved reliability and reduced emissions.

Taking into account an incentive payment from the State of Connecticut, the payback on the project was calculated at 6.9 years. The current low natural gas prices are rapidly lowering the expected payback period. Also, this does not include the benefits to production from improved electrical reliability. On several occasions the plant was spared significant operating losses during grid power interruptions.

Dual Fuel Where Appropriate

Manufacturers do offer combustion turbine units designed for dual fuel operation – usually natural gas and fuel oil. In most parts of North America natural gas has a significant advantage in price. Lyons from Solar Turbines notes, "Dual fuel applications are more prevalent in the Northeast of the United States, where most of the large users have interruptible gas supply contracts. However in places such as California, Texas, Louisiana, etc. dual fuel is not as common." Where dual fuel is necessary, most owners have a few day's supply of fuel oil on hand to use as needed.

Another provider of combustion turbines for industrial and large commercial users is Kawasaki Gas Turbines – Americas. Kawasaki offers base load turbines in seven size classes from 600 kWe to 18 MWe. In addition, Kawasaki has a separate line of standby power turbines in sizes from 750 kWe to 4.8 MWe. The base load units would be the equipment suitable for heat recovery and full-time CHP operation.

As an example of CHP benefits, Kawasaki installed a 1.5 MWe cogeneration plant in 2007 for a major East Coast pharmaceutical company. The unit was supplied with an unfired heat recovery boiler providing over 11,000 lbs an hour of steam to the plant. The plant incorporated a KGTA pre-wired extended electrical skid which facilitated a quick installation on site.

This plant installation provides power plus steam at an overall 80% thermal efficiency rating. This plant also qualified for a state grant for its CHP energy savings. This facility uses Kawasaki Dry Low Emissions (DLE) technology ensuring lowered exhaust emissions, with NOx less than 20 ppm and CO less than 50 ppm.

Consider Your Application

Not every application will benefit from combustion turbine CHP, but if you have major thermal requirements for process steam or absorption cooling, plus a relatively continuous need for electric power, it may be your solution. An onsite plant can improve your power supply reliability, and could also lower your carbon footprint and reduce total emissions.

Help is Available

Ed Mardiat indicates that there are multiple sources for guidance in developing a CHP installation. "The first place I would recommend is the U.S. EPA CHP Partnership, which has developed several resources for CHP screening, spark spread analysis, emission calculators and a database for CHP incentives listed by state. Beyond that, I would recommend the owner find an engineering consultant that has experience preparing CHP Feasibility and Economic Investment Grade Audits at the specific type of facilities being considered." For large energy users, industrial turbine CHP is here, and it's better than ever. GT

This Frito-Lay plant in Killingly, Connecticut benefited greatly from the installation of the Solar Turbines unit. It resolved long-standing power reliability issues and by providing steam from the turbine exhaust, reduced plant expenditures for energy.
Photo courtesy Frito-Lay.

Today's boiler burner controls are sophisticated and allow a wide range of options, including using boiler exhaust gas analysis to optimize combustion. Photo courtesy Cleaver-Brooks.

KEEP THE BOILER, REPLACE THE CONTROLS

New Designs Offer Increased Efficiency, More Turndown

By updating the controls on all of the boilers, sophisticated strategies can be used to optimize the mix of units on line, and hold them near their peak efficiency. Photo courtesy Siemens Combustion Controls.

TODAY'S EFFICIENT NATURAL GAS boiler is an amazing blend of traditional heat exchange technology and sophisticated design improvements. With metallurgical improvements and computer-aided design tools, the boiler structure itself has been made more efficient and reliable. But the most striking advancements have been made with the burners and their associated controls. In many cases, a sound older boiler can be dramatically improved in efficiency and turndown capability by replacing an obsolete burner and control system. Further, taking this step can reduce boiler emissions.

Opportunity for Savings

According to the DOE, there are more than 45,000 industrial and commercial boilers larger than 10 MMBtu/hr in the United States with a total fuel input capacity of 2.7 million MMBtu/hr. A report by DOE's Federal Energy Management Program states, "Efficiency of existing boilers can be improved in three ways; replacement with new boilers, replacement of the burner, or installation of a combustion control system. While installation of a new boiler or replacement of the burner can lead to the greatest efficiency gains, the higher costs associated with these measures typically leads to longer payback periods than installing a combustion control system."

The report notes that many combustion control systems lack continuous oxygen, carbon monoxide and nitrogen oxide emissions monitoring capability as well as the automated controls needed to improve fuel performance. Such controls allow continuous adjustments of the fuel-to-air mixture to maximize efficiency while controlling operation to ensure emissions levels meet regulatory requirements."

Linkage Slop Hurts Efficiency

Older boilers use mechanical sensors and linkages to adjust fuel and air flow to the burner. Commonly, these don't allow a turndown to much more than 35% load. For steam or hot water demands below that, the boiler needs to cycle. With the required purges and reheat cycles, this can be highly inefficient.

Further, where the fuel-air mixture is controlled by mechanical linkages, the response is slow and often inaccurate. The system needs to be regularly checked and rebalanced to account for changes in the linkage controls (linkage joints can wear and set screws can loosen). Alan Silver from SCC Inc. (Siemens) was recently a presenter at a Technology & Market Assessment Forum sponsored by the Energy Solutions Center.

Silver notes, "Eliminating mechanical linkages minimizes the "hysteresis" associated with the burner operation. Hysteresis, or "linkage slop" as it is commonly referred to, can cause burners to operate in a rich condition or a lean condition or both. These conditions impose inefficiencies in fuel consumption." As the controls incur mechanical wear, hysteresis increases, even where the control is calibrated as closely as possible.

Parallel Positioning Advantages

He explains, "Reducing this hysteresis allows the burner technician to set the burner operating condition closest to its design, thus maximizing efficiency." Siemens, like many other current control providers, uses a parallel positioning system for boiler firing control. With this feature, a positioning control mechanism, usually servo activated, moves to a preset position in response to system needs. The system uses a master control signal to control the boiler system, causing a change in both the flow of fuel and air when there is a needed change in steam flow.

Silver notes, "Parallel positioning systems typically allow for greatly increased repeatability and much less hysteresis than linkage-based systems due to direct coupling of the actuators with the drive motors. A typical parallel positioning system will have 900 positions of movement through 90 degrees of rotation." With this level of precision, getting an ideal match of fuel and air for the required steam load is possible.

Stack Oxygen Monitoring

Another aspect of newer control systems is their adaptability to stack oxygen monitoring. This allows for digital feedback of stack oxygen levels, allowing oxygen trim for optimum combustion even with changing atmospheric conditions or fuel pressure variations. Silver explains, "This is similar to what happens in newer automobiles with oxygen sensors in the vehicle exhaust."

With newer controls that have parallel positioning features and exhaust oxygen feedback, it is possible to achieve stable lower firing levels. This allows greater turndown ratios and reduced need for boiler cycling. This in turn promotes energy savings and reduced emissions.

Getting the Flue Gas Right

Cleaver Brooks offers a broad line of both boilers and boiler burners with digital controls. According to Rakesh Zala from that company, flue gas monitoring is important for burner efficiency, and accurate oxygen monitoring is critical. "A lot of the burner controls now include an O2 sensor. Typically, the sensor requires periodic calibration. Control systems are sometimes designed to perform automatic calibration. Check with your control system provider to confirm this."

Most boilers have a "sweet spot", where they operate most efficiently. Especially if your plant has multiple boilers, it is valuable to stage them to keep as many as possible operating at peak efficiency. Modern controls with stack gas monitoring can help you find that sweet spot and hold the boiler in that area. Zala says, "Typically steam boilers operate at peak efficiency when firing at 60%-80% rate. Condensing hot water boilers operate at peak efficiency when at lower firing rates."

Range of Retrofit Options

Cleaver Brooks and other manufacturers offer retrofit digital control packages for boilers as well as other control options. In addition to the boiler burner controls, owners often choose to install packaged boiler water controls to monitor and maintain condition of feedwater and makeup water. Another important offering is master boiler controls. These tie together individual boilers and other boiler room equipment for optimum operation together. These controls can be remotely located, allowing regular adjustment and observation of boiler operations without a trip to the boiler room.

Paybacks Can Be Short

Because boilers are such significant users of energy, the payback for a boiler burner/control upgrade can be short – sometimes less than a year. If the boiler structure is sound but the controls predate the digital control age or are otherwise inadequate, it will pay to look into a control or burner upgrade. Be sure to include stack gas monitoring and oxygen trim if available. It could be a brilliant investment. GT

MORE info

CLEAVER BROOKS
www.cleaver-brooks.com

ESC BOILER & BURNER EFFICIENCY
www.cleanboiler.org

DOE CALCULATOR FOR BOILER EFFICIENCY
www1.eere.energy.gov/femp/technologies/eep_boilers_calc.html

SIEMENS COMBUSTION CONTROLS
www.scccombustion.com

Improved Melters Save Energy

Reduced Emissions Also Targeted

FEW INDUSTRIAL PROCESSES CONSUME ENERGY at the scale of metal melting equipment. According to a recent DOE study, the metal castings industry uses about 55% of its energy in metal melting alone. Ferrous and non-ferrous scrap metal reprocessing facilities and specialty steel smelters use similar large proportions.

Two challenges are finding practical new energy-conserving technologies, and deploying steps already demonstrated on existing equipment. Many different energy sources are used in these processes, and the thermal performance can often be improved. Natural gas is a major energy source for metal melting, and will increase in this role in a new, more efficient future.

Oxy-fuel firing, as at this Kentucky aluminum recycler, reduces energy consumption. Photo courtesy Owls Head Alloys.

Obstacles to Energy Improvements

The path to efficiency improvement is not easy. Much of the use of melted metal is in the various castings industries, and many of these are small businesses that are capital-constrained. Few can afford to deploy cutting-edge technologies or experimental applications. For most, energy improvement must come from practical process steps and improvements to existing equipment.

The range of these metal melting industries is broad, from companies that melt down aluminum waste to those that make cast iron and steel automotive and other parts. It includes crucible melting of brass and bronze, and production of specialty steel alloys. Each industry is different, and no single technology has the potential to make universal savings.

Tough Environment for Materials

Further, because of the high temperatures encountered, especially with iron and steel, there are major limitations on the types of materials that can be used for equipment improvements, as well as limitations on the working life of these parts when installed. Promising improvements include development of sophisticated new ceramic refractory materials that resist abrasion and last far longer than earlier products. In some cases these can replace existing refractory surfaces and keep the melter on line longer. This longer running life reduces energy use and total emissions.

With products such as aluminum, owners need to avoid excessive handling of the molten metal and excessive introduction of oxygen in the processes. Still, there are very promising areas for improvement, and often natural gas is a fuel that plays a primary role.

Capturing Process Energy to Improve Efficiency

One major source for energy recovery is in combustion exhaust. Whether coal, coke or natural gas are the fuels, with existing technology much of the process heat goes up the stack. Recuperation or regeneration systems are practical tools for recovery of this heat. The recovered heat in turn can be used for pre-heating combustion air, or in some cases for preheating the furnace charge materials such as scrap metal or ingots.

Oxygen – in Limited Amounts

A second important tool for many metal operations is oxy-fuel firing. Current burner technology allows introduction of a controlled amount of oxygen for combustion, which makes a hotter flame and quicker melt. The more quickly metal gets to the molten stage, the less energy is needed. But tight controls on oxygen levels are also important, because for some metals – especially aluminum – excess oxygen causes metal oxidation and a lower economic yield of molten metal. For these applications, increasing the oxygen level from the atmospheric 21% to perhaps 30% or 35% may be the optimum. Beyond this, the waste of metal becomes unacceptable.

Eclipse Inc. is a major manufacturer of burners for industrial processes, including melting furnaces. According to Jim Fisher from Eclipse, the company's emphasis in this area is on oxy-fuel burners for ferrous and hard non-ferrous metals such as copper. "For non-ferrous metals we use a series of velocity burners that deliver very high stir motions that keeps the melt pool surface very uniformly heated."

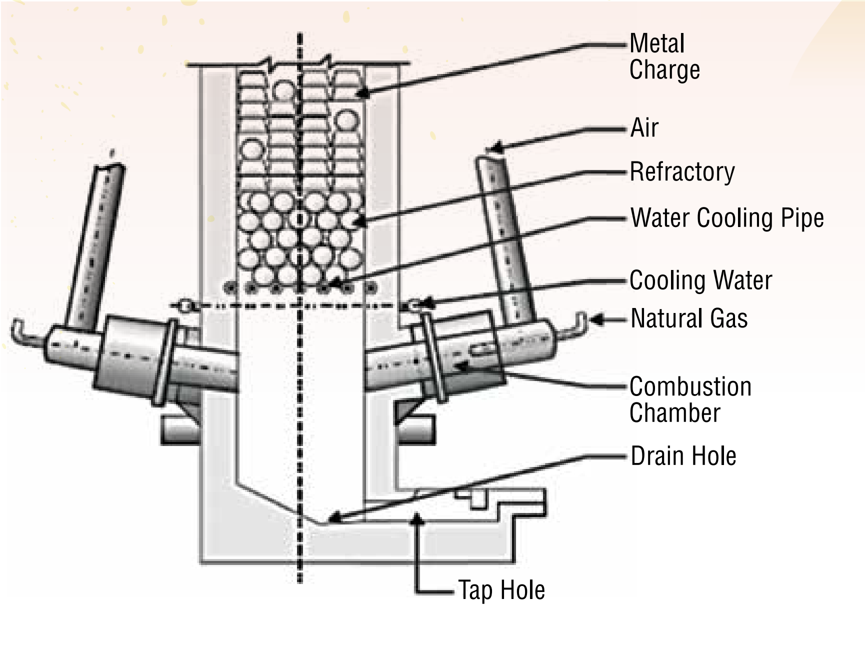


Illustration of the method of melting used in a cokeless cupola furnace. Note the use of ceramic refractory balls for heat transfer in lieu of the use of coke. Illustration from DOE-EERE.

Reducing Coke Volume

Coke is refined from bituminous coal and is a rich source of carbon. Historically, coke served in the charge of certain melters such as cupola furnaces as both a fuel and a source of carbon for steel alloys. However, as a furnace fuel coke is expensive, and contributes significantly to carbon emissions and particulates. Today, cupola designs are available to operate without coke, or in some cases need only a small charge for metallurgical purposes.

ROBOTEC LLC is a Birmingham, Alabama firm which does engineering and provides designs and equipment for improved industrial melting furnaces. According to Stefan Graf from ROBOTEC, changing a cupola furnace from coke to natural gas is not a simple step. "It requires a process change for the customer, including charge material, charge composition and furnace process characteristics. However with this changeover and commitment, the customer can expect huge benefits."

MORE info

DOE METAL MELTING TECHNOLOGIES
www1.eere.energy.gov/manufacturing/resources/metalcasting/pdfs/advancedmelting-technologies.pdf

Eclipse Burners
www.eclipsenet.com

ROBOTEC LLC
www.robotecllc.com

Reduce Use of Expensive Coke

He notes that with an oxygen-enriched natural gas-fired cupola, one ton of liquid metal can be produced for about $8.00 for natural gas and $7.00 for oxygen for a total of $15 per ton. This compares with about $50 to $75 per ton using coke.

According to Graf, a cokeless cupola furnace uses a system of superheated ceramic spheres as heat exchange media to hold the heat in the melting zone. These spheres will need to be added with each furnace charge. Graf indicates that companies such as ROBOTEC can assist with a cost comparison study and will help to design the required furnace charge for maximum molten metal production and minimum emissions.

He points out that with the elimination of coke, the emission reductions are an important benefit, and in fact may be necessary to keep the plant operating. "We see a reduction of the carbon footprint by 70% compared with coke-fired cupolas. Particulates are about 1.0 mg per cubic meter, which will reduce the baghouse size. The exhaust gas temperature is about 200 degrees C with low carbon monoxide levels."

Energy and Emissions Projects

Regardless of the size of operation, owners are increasingly looking for ways to improve process efficiency, recognizing that a more energy-efficient process inherently has lower emissions. The DOE Energy Efficiency and Renewable Energy division has done extensive work on melting technologies. In addition, there are experienced private consultants that can evaluate individual operations and make practical recommendations. Metal melting will always be energy-intensive. But major improvement is possible. GT

START SAVING WITH BI-FUEL DIESEL ENGINES

Replace Diesel Fuel with Natural Gas

TO AVOID CONFUSION, let's define what we're going to discuss: bi-fuel engines -- sometimes called dual-fuel engines -- use diesel fuel and natural gas simultaneously for stationary on-site electric generation. The terms "bi-fuel" and "dual-fuel" can have various meanings. They are both used at times to describe engines that can burn multiple fuels, but individually, or engines that use combinations other than diesel fuel and natural gas. This discussion focuses on diesel and natural gas as combination fuels for reciprocating engines.

Fuel Challenges

Owners of both standby and continuous-duty engine generators operating on diesel fuel alone face several challenges. It is expensive and space-consuming to have enough diesel fuel on site for continuous use or to supply standby generation that may need to operate for several days or longer. Diesel fuel is likely to continue to rise in price. Keeping liquid fuel in good condition also adds cost. Further, emissions from diesel engines operating long hours on diesel fuel only may exceed federal, state or local air quality standards.

A practical solution is to equip an existing engine or purchase a new engine to replace 70% to 80% of the diesel fuel with natural gas supplied via pipeline. Diesel fuel is still needed for pilot compression ignition but the necessary stored fuel quantities are much smaller. Natural gas on a $/MMBtu basis is far less costly in most markets, and bi-fuel operation dramatically reduces emissions of sulfur oxides, particulates and carbon dioxide.

This Cummins engine has been retrofitted with a GTI-Altronic conversion system to allow simultaneous operation on diesel fuel and natural gas, thereby lowering the operating cost and reducing the on-site fuel storage requirement. Photo courtesy Altronic LLC.

Convert an Existing Engine

Several companies supply systems for conversion of recip engines to bi-fuel operation. These require no or minimal engine internal changes, and can be installed in a matter of hours. Because of lower fuel costs with natural gas, some owners of peaking generation systems may choose to operate these over longer hours or even continuously, thus reducing electric demand and energy charges. With longer operating hours comes the increased practicality of heat-recovery, making these installations true combined heat and power (CHP) systems.

Multiple Caterpillar engines with bi-fuel conversions. Photo courtesy Altronic LLC.

Even pure standby diesel generation units can benefit from installation of bi-fuel capability, because the necessary onsite fuel storage and fuel holding costs are dramatically reduced, and system reliability improves with two potential fuel sources.

Package Conversion System

One system for converting existing diesel engines to bi-fuel operation is the GTI Bi-Fuel® system from Altronic LLC. With this addition to the engine, natural gas is introduced downstream of the engine air cleaner and upstream of the turbocharger. The gas is supplied at approximately atmospheric pressure using a proprietary air-fuel mixer that provides a high level of gas mixing. The air-gas mixture is compressed in the turbocharger and distributed to each cylinder by the engine air-intake manifold.

The lean air-gas mixture is compressed during the compression stroke of the piston and ignited by the diesel injector. Flow of gas to the engine varies with the engine load. The system varies gas flow according to changes in engine vacuum level, thus allowing it to respond to engine fuel requirements while maintaining the integrity of the OEM governing system.

Short Paybacks for Prime Power

According to Steven Roix, Altronic GTI Sales Manager, the bi-fuel approach offers major savings to owners. "They are seeing rapid payback and huge savings on prime power and peak shaving applications. The lower fuel cost allows extending runtimes by 300% or more, depending on the type of installation." For standby applications, the bi-fuel approach dramatically reduces the on-site fuel storage requirement.

Roix also points out that because of the cleaner burning characteristics of natural gas, typical installations reduce air emissions significantly. He notes that although the engine burns cleaner in the bi-fuel mode, the recommended service intervals do not change. "We always encourage customers to follow engine OEM maintenance instructions."

The Altronic system monitors engine and fuel flow characteristics, and can quickly revert to all-diesel operation if there is an interruption or change in the flow of natural gas. Roix says, "It's a simple add-on system that can be taken on and off easily."

Bi-Fuel Capability from the Factory

Some generator package manufacturers offer bi-fuel capability with new generator sets. Generac offers bi-fuel as an option on its offering of standby diesel generation systems. Although these units are designed for standby service only, the bi-fuel capability still reduces fuel cost and makes a major reduction in the amount of standby fuel needed on site.

According to Michael Kirchner, Technical Support Manager for Generac, bi-fuel makes sense for many buyers of standby engines. "Because they run on both diesel and natural gas, they capitalize on both the availability of on-site diesel fuel (required by many authorities) and the long running times that come from utility-supplied natural gas. Because they typically run on a mix of about 75% natural gas, their running time is extended by a factor of four without a fuel delivery."

MORE info

CAPSTONE TURBINE CORPORATION
www.capstoneturbine.com

ALTRONIC LLC
www.altronicinc.com

CUMMINS DUAL FUEL CONVERSION
http://cumminsengines.com/dual-fuel

CATERPILLAR DUAL FUEL GENERATOR CONVERSION INFORMATION:
www.cat.com/cda/files/3593991

GENERAC
www.generac.com/Industrial/Bi-fuel_Product_Line

Where Reliable Power is Essential

According to Kirchner, Generac bi-fuel units are the only ones on the market that have this capability from the factory: Others need to be modified in the field. He notes that common applications for this product are health care facilities, data centers, and other facilities such as wastewater treatment plants and 911 call centers, where continuous access to electric power is essential.

Kirchner says that emission reduction by adoption of the bi-fuel option is variable, but the company has seen evidence of reduction of emissions of NOx and particulates in excess of 25%.

Might be an Opportunity

If your facility is currently using diesel fuel only for engine generation, it is worth considering the benefits of changing to a bi-fuel system. If you are looking at adding standby generation, it certainly is an important option. Ask your consulting engineer to look into potential savings and reduction in the need for on-site fuel storage.

GT

This Generac standby generator is factory-equipped for bi-fuel operation. For standby systems such as this, bi-fuelling reduces fuel cost, storage requirements and plant emissions. Photo courtesy Generac.

Stirling Engines Show Promise

Remote Sites, Unattended Operation

MORE **info**

ESC STIRLING ENGINE INFORMATION
www.energysolutionscenter.org/gas_solutions/stirling_engines.aspx

INFINIA CORPORATION
www.infiniacorp.com/en/home

STIRLING ENGINE EXAMPLES
en.wikipedia.org/wiki/Stirling_engine

WHISPERGEN
www.whispergen-europe.com

ALTHOUGH IT WAS ORIGINALLY CONCEIVED IN 1816, the adoption of Stirling engine technology has been slow. It is powered by cyclic compression and expansion of a working fluid, powered by an external thermal energy source. The working fluid can be air, nitrogen, carbon dioxide, helium, or hydrogen, just to name a few, and the compression and expansion is done by a piston or series of pistons. The attraction is its high theoretical efficiency and the fact that the operating thermal energy can come from a wide variety of sources.

Reusing Heat Energy

To date, most commercial or experimental Stirling engines have been small in scale. Their unique aspect is the use of a regenerator to capture and reuse thermal energy, thus contributing to their high efficiency. The regenerator is an internal heat exchanger and temporary heat storage system placed between the hot and cold spaces such that the working fluid passes through it first in one direction then the other.

Stirling engines have been built to a wide variety of designs, including those with two separate pistons – one for the hot side and one for the cold side – and those with a single piston that operates in a two-ended cylinder with one end hot and the other cold. Modern metallurgy and computer modeling of thermodynamic flows make them more efficient than in the past. Several manufacturers today offer units for European and North American residential and commercial markets.

In European Homes

A current manufacturer of cogeneration units powered by Stirling engine technology is WhisperGen, headquartered in Spain and selling residential-scale units. The WhisperGen engine is a patented four-piston unit with a unique "wobble yoke" that connect the engine to the generator. The WhisperGen residential package is primarily marketed in Europe through a distribution network.

Another current manufacturer of commercially available Stirling engines is Infinia Corporation, headquartered in Ogden, Utah. The Infinia engine design uses a free-piston technology that can accept heat from a variety of sources including natural gas, biogas, propane, or from a solar receiver. One high profile application for Infinia is a 1.5 MWe multiple generator complex powered by solar collectors at Toele Army Base in Utah.

Ideal for Remote Applications

The same technology is ideal for operation at other remote sites where there is no central station power but there is access to natural gas or another fuel. According to Jeffrey Williams, CFO for Infinia, the engines are capable of reliable operation with minimal maintenance or supervision required. This characteristic and their fuel source flexibility also make them good candidates as power sources for villages in Third World countries.

Williams notes that currently the Infinia engine has an electrical output of up to 10 kW. He points out, "It is possible to parallel multiple units to increase power output. Infinia is currently developing a packaged paralleling controller to provide this option." He stresses that the product has large growth potential. "This small gas fueled generator is a great fit for smaller, remote sites where long term reliability and minimal maintenance is needed."

Worth Watching Developments

To be sure, the Stirling engine technology today is in no position to overtake turbines or conventional reciprocating engines in size or number of units deployed. But with its unique advantages, this technology is evolving and broader application in the future is likely. It's one more technology we need to watch. GT

This Infinia packaged generator powered by a Stirling engine is ideal for remote applications and can run on natural gas or bio-gas. Photo courtesy Infinia Corporation.