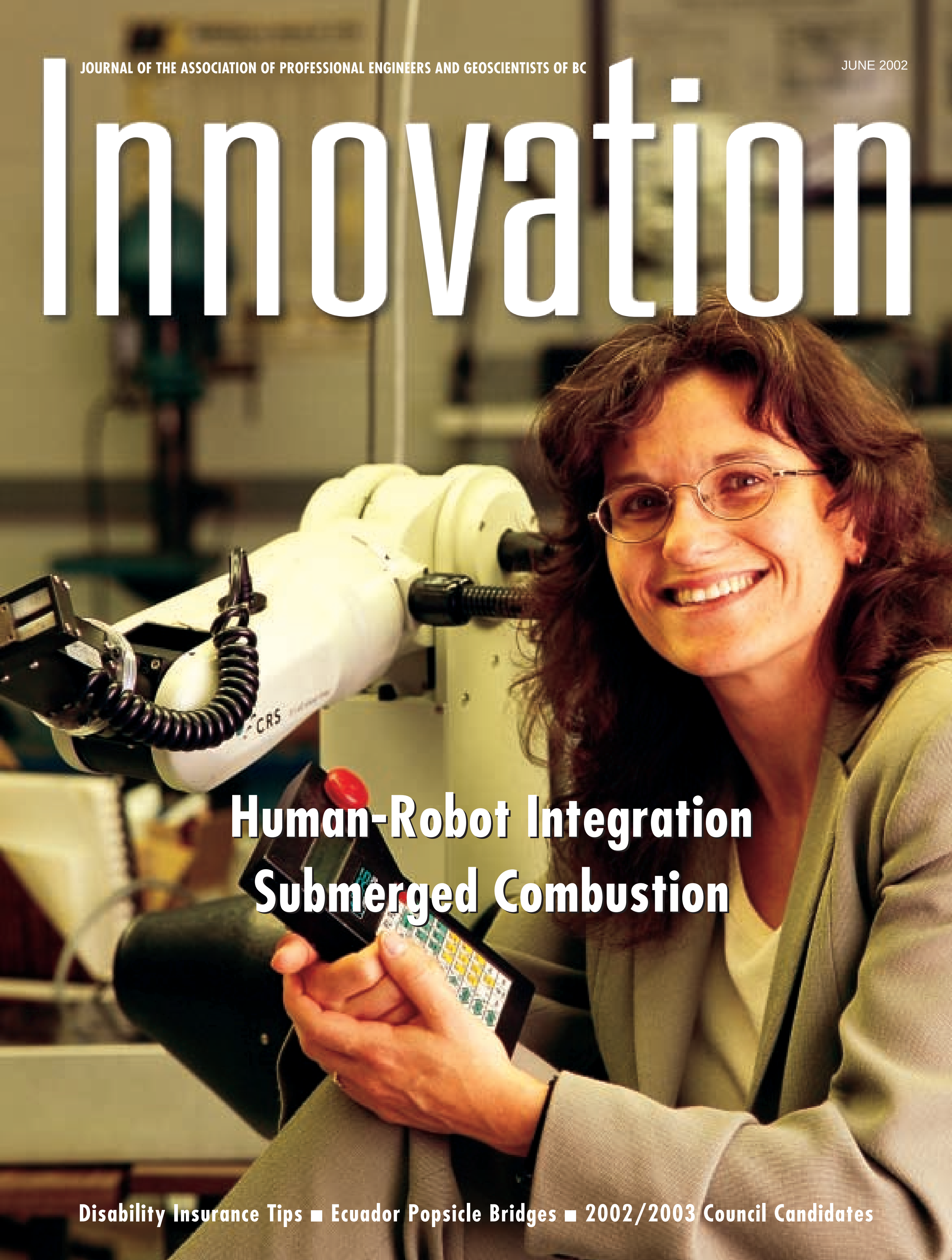
JOURNAL OF THE ASSOCIATION OF PROFESSIONAL ENGINEERS AND GEOSCIENTISTS OF BC

JUNE 2002

Innovation



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Submerged Combustion

Turning Down the Heat on Global Warming

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The problem of human-produced greenhouse gas (GHG) emissions and their role in disrupting the world's climate is widely regarded as the most serious environmental threat facing our planet. Carbon dioxide, or CO_2, is by far the main contributor to global warming because of the quantities released through human activities, especially the burning of fossil fuels. While the use of fossil fuels has helped industrialization enormously, there is now 30% more CO_2 in the earth's atmosphere than before the Industrial Revolution.

Although not the main contributor on a global scale, combustion by industry has been associated with localized high volume and high concentration sources of CO_2 emissions. This is especially true for industries characterized by high energy consumption such as the pulp and paper, chemical, gas and petroleum, steel and mineral processing industries. In addition, the high exhaust temperatures of stack gases (350°F to 2000°F) generated by these industries adds even more heat to the atmosphere.

Reducing both CO_2 production and high stack exhaust temperatures at the source is a logical step in addressing the GHG pollution and global warming problem, and BC engineers are at the forefront in developing innovative technologies to reduce industrial emissions from fossil fuel combustion. Chief among these is submerged combustion technology, a proprietary heating method that is highly energy efficient, reduces stack exhaust to near ambient temperatures, and is especially suited for heating dirty and corrosive fluids or for evaporative processes.

A Heating Alternative

Canada, with its resource based economy, has some of the largest resource industries in the world. These industries, as heavy users of fossil fuels to heat large volumes of industrial solutions, are continuously seeking ways to both reduce operational costs and comply with environmental emissions regulations.

Current conventional methods of industrial liquid heating include steam boilers, thermal oil heaters and immersion tube heaters. All rely on indirect heat transfer, where the heating medium transfers its energy to the liquid solution via radiation, conduction and convection.

With conventional methods, not all the available heat energy can be fully absorbed by the solution due to the size and condition of the heat transfer area. In addition, latent heat in the products of combustion is difficult to recover and is usually vented to the atmosphere. These factors result in energy losses of up to 30%.

About 27 years ago, when the forest industry in Western Canada began seeking more efficient and reliable methods of plant water heating, Eric Panz Ing (Austria) of Vancouver-based Inproheat Industries began to develop submerged combustion technology, a heating method that currently provides efficiencies of 90-100% and stack exhaust temperatures close to ambient. This increased heating efficiency translates to a 15-30% reduction in fuel consumption and emissions and a 200-300°F reduction in stack temperatures compared to traditional heating methods.

Years of research and development and field experience have led to various performance improvements that have allowed the application of submerged combustion technology, known as Sub-Com™, to a wide range of industries including forest products, copper and gold mining, gas processing, potash mining, natural gas and petroleum, and municipal waste plants.

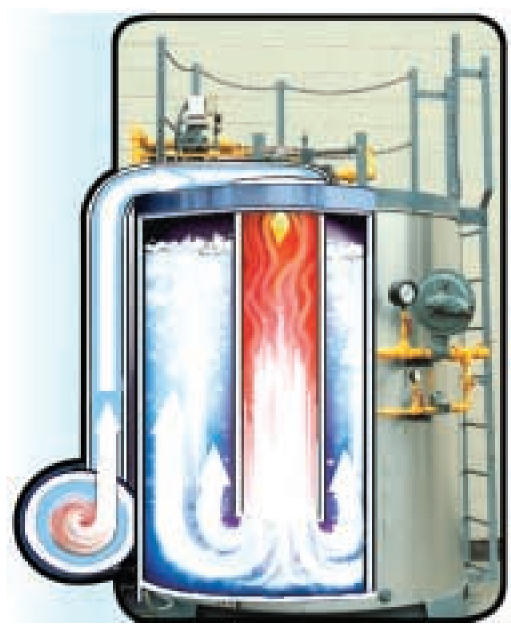
How Submerged Combustion Works

The principle of submerged combustion is very simple: take a glass of water and a straw, blow air into the straw and watch the bubbles rise to the surface. Now imagine that the bubbles are very hot. As they rise to the surface, they heat or evaporate the water in the glass.

In practice, a fuel/air mixture delivered at an elevated pressure is discharged and ignited in a cylindrical combustion chamber submerged in a solution. The combustion is completed within the confines of the chamber; the positive pressure and the flow of the products of combustion prevent the solution from reentering the chamber.

The hot products of combustion — at 2500-3000°F — are discharged into the solution through a series of orifices located around the circumference of the combustion chamber near its bottom end. As the hot bubbles contact the solution, their thermal energy is released through heat and mass transfer. The gas bubbles collapse and become 100% saturated with the evaporated liquid. As the bubbles rise to the surface they cool, while the temperature of the surrounding solution increases.

In a typical single stage submerged combustion system, the temperature of the gas leaving the solution is equal to the temperature of the liquid. In a two-stage system the stack temperature is lower than the solution discharge temperature. It is, in fact, possible in certain conditions to achieve a stack temperature lower than the ambient air temperature.



The use of submerged combustion technology in a variety of industries to replace traditional but inefficient methods of industrial liquid heating is helping to reduce CO_2 and heat emissions to the atmosphere. Photo shows a SubCom™ system recently installed at Konica's manufacturing plant in Whitsett, North Carolina.

Top: **10 MM BTU/hr system for Rio Algom is used to heat the raffinate solution in a copper leach operation in northern Chile. *Middle:* 14 MM BTU/hr system for Ainsworth Lumber in Lillooet heats the recycle water used to condition timber blocks prior to veneer production. *Bottom:* 6 MM BTU/hr system for the Cameco uranium mine in northern Saskatchewan is used to prevent effluent ponds from freezing in winter.**

Industry Applications

As the technology has been refined and improved over the years, SubCom™ systems have been applied to a wide range of industrial process, a few of which are described below:

Homestake Nickel Plate Gold Mine

The Homestake mine in Penticton, BC was exhausted in 1996 and is currently undergoing a reclamation process. Part of the reclamation involves eliminating existing large process water ponds and deep wells, which contain various minerals and chemicals used in the past for gold extraction. Before the water is discharged to the local river system, it has to be heated to 68°F, chemically treated and cleaned.

A 4 MM BTU/hr, propane-fired system installed in 1996 is used to heat a continuous 120 USGPM flow of water by 30°F with a stack temperature of 67°F. The resulting overall system efficiency is calculated at 98.4%.

Cameco Uranium Mine

Underground water pumped from the Cameco mine in McArthur River, Saskatchewan is stored outdoors in large ponds with plastic liners to prevent soil contamination. Before the water is pumped out and discharged to the river, it has to be chemically treated and cleaned.

During the winter, when temperatures drop to below minus 40°C (-40°F), a layer of ice as thick as eight feet forms that can reach almost to the bottom of the pond. This ice not only reduces pond capacity, but its movement when water is pumped into or out of a pond can rip the plastic liner, leading to contamination of the surrounding soil.

A 6 MM BTU/hr, propane-fired system installed in 1997 is used to control the ice thickness on the ponds. The system heats a variable flow of up to 1,000 USGPM of hard pond water containing minerals to 54°F with a stack temperature of 52-55°F. The resulting overall system efficiency is calculated at 98.5%.

Great Salt Lake Minerals Salt Mine

A 41 MM BTU/hr, natural gas-fired system was installed in 1998 at the Great Salt Lake Minerals mine in Ogden, Utah to provide extra capacity for process water heating.

The process water at 80°F is pumped at a rate of 800-1,500 USGPM and is heated by a two-stage system with three burners in a series. A portion of the water is removed after the first burner at 120°F and the remainder of the flow is heated to 170°F. The exhaust gases from all three burners are pumped through the cold incoming water in a preheating stage of the heat recovery unit.

This arrangement results in a low stack temperature of 105°F and the resulting overall system efficiency is calculated at 96.5% as compared to 75% boiler efficiency.

Monticello Wastewater Treatment Plant

Environmental legislation passed by the US Congress a few years ago has resulted in increased pressure on US wastewater treatment facilities to address the problem of environmental discharge of potentially harmful pathogens in treated municipal liquid waste. This means that all new wastewater treatment facilities or modernization projects have to look for new ways of producing Class A biosolids.

A 2 MM BTU/hr system operating with digester biogas and alternately natural gas was installed in 1998 to provide this function for the Monticello wastewater treatment plant in Monticello, Minnesota. Cold activated sludge at a continuous flow of 65 USGPM enters the system at 50°F and passes through a spiral sludge-to-sludge heat exchanger with an outlet temperature of 120°F.

The sludge enters the heating unit, where it is heated to

158°F and passed to the internal flow-through tank retention compartment. Sludge leaves the tank through the other side of the spiral heat exchanger and to the anaerobic digesters at a final temperature of 100°F. The products of combustion are collected by a biofilter odor control system, making this installation the first closed-loop submerged combustion system.

This system not only preheats the sludge — eliminating the need for boiler heating of the digesters — but also contributes both evaporated moisture and heat from the products of combustion to the biofilter, which would otherwise also have to be heated by a boiler. The closed-loop nature of the process gives this installation an overall thermal efficiency of 100%.

Konica Manufacturing Plant

A 10 MM BTU/hr, dual fuel (natural gas and #2 heating oil) system was installed in April 2002 to provide water heating for Konica's photographic paper manufacturing process in Whitsett, North Carolina. This two-stage system, which displaces an 80% efficient steam boiler, heats 1,100 USGPM of water to 120-140°F with a 125°F stack temperature and an overall efficiency of 94.5%.

Future Uses

A change in emphasis by industrial users from simple fuel/cost savings to GHG emissions reduction and environmental compliance puts submerged combustion in the forefront of "green" technologies in the field of combustion.

New applications for submerged combustion technology currently being investigated include LNG evaporators; electrolyte heaters for copper electrowinning processes; evaporators for produced water reduction from oil wells; evaporators for production of concentrated acids; heating systems for iron ore slurries; and large scale, multistage process water heating applications for tar sands projects.

Conclusion

As burner technology progresses, emissions of NOx, CO and VOCs by industry will be reduced and eventually eliminated. Emissions of CO_2, however, are related not to burner efficiency but to appliance efficiency. As long as low efficiency heating methods involving boilers are used for industrial processes, their associated CO_2 emissions and stack temperatures will not be reduced to any significant degree. Alternative heating methods such as submerged combustion, with its higher efficiencies, lower CO_2 emissions and lower stack temperatures, offer an engineering benefit that helps to best utilize our energy reserves in a responsible manner.

Steven Panz PEng is Director of Energy Systems for Inproheat Industries Ltd, a 45 year old BC based company. Mr Panz has carried out project engineering on a variety of steam and power related industries throughout Western Canada.

Eric Panz Ing (Austria), President of Inproheat Industries, founded the company in 1958. He has worked in thermal process, heat and combustion technologies for over 40 years.

Joseph Jachniak PEng, who is Chief Engineer and Head of Research and Development for Inproheat Industries, is responsible for project development, execution and management as well as process engineering and system startups.

Brian LaCas Joins KWL

Kerr Wood Leidal Associates Ltd. is pleased to announce the appointment of **Brian LaCas, P.Eng.** to the position of Senior Water Resources Engineer.

Brian has over 20 years of public and private sector experience, including six years with Water Management Branch of the BC Ministry of Environment. He specializes in hydrology, river engineering, open-channel hydraulics, channel geormophology, drainage, fisheries structures, stream restoration, land development consulting and construction management.

Recently, he has become actively involved in sustainability projects using innovative Low Impact Development and Leadership in Environmental, Energy Design (LEED™) techniques.

Brian can be contacted at 604-985-5361 or at blacas@kwl.bc.ca.

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