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Mitchel-Lincoln optimizes the efficiency of its boilers by micromodulation

Mitchel-Lincoln Packaging (ML), a leader in corrugated packaging production, has several factories in Québec. This company manufactures customized corrugated board for assembly of boxes or display cases. Its Ville Saint-Laurent factory uses steam produced from natural gas for its corrugator machine operations. In spring 2009, seeking to improve its production costs and reduce its energy consumption, ML decided to evaluate the possible ways of optimizing the energy performance of its steam boilers. To accomplish this, the company retained the services of Deval Combustion for its cutting-edge expertise in evaluating and optimizing industrial processes.

First of all, Deval Combustion wanted to obtain a concrete assessment of the boilers' operational performance under the operating conditions encountered at the Ville Saint-Laurent factory. Deval Combustion thus began its project with a steam boiler energy study. To establish an energy balance and evaluate its performance, they proceeded with continuous measuring of the boiler's operating parameters—chimney fumes, purges, natural gas and steam produced.

Three measures were clearly identified based on the results of the audit: control of (continuous) purges, control of chimney draft and optimization of the air-gas mixture for the entire operating range by micromodulation.

What exactly is micromodulation?

Micromodulation is an elegant technique that seeks to improve the operational efficiency of industrial technologies, such as steam boilers. To obtain better results, a boiler audit is recommended before implementing this energy saving measure. The purpose of this efficiency study is to ensure savings, which will be realized once the work is completed. The typical applications covered by this control technique are industrial processes, especially industrial steam boilers.

High-capacity steam boilers are very often used in industry to meet the thermal needs of manufacturing processes, such as calenders or dryers that require large and instantaneous thermal intakes. Thus, it is frequently observed that the burners of this equipment show difficulties in maintaining an optimum air-gas mixture, at least for certain operating regimes.

The most common example observed is perfect high regime combustion, while at low regime, the air-gas mixture is no longer adequate. This results in a poorer mixture during combustion and weaker energy yield. The many production startups/shutdowns are conditions conducive to repeated efficiency losses.

Such conditions can be improved significantly by micromodulation. The use of electronic controls and servomotors allows maintenance of optimum combustion regardless of the regime imposed on the burner. This leads to better combustion, a gain in efficiency and energy savings.

Production context at the Ville Saint-Laurent ML factory

The factory's corrugator requires large quantities of high-pressure steam. This is produced with two 500 BHP boilers, each fueled by natural gas. The exhaust system does not include any energy recovery system. The combustion efficiencies measures were initially 71% to 75% depending on the operating regime. The exhaust gas temperatures ranged from 430°F to 630°F (221°C to 332°C).

Since the corrugated board manufacturing process is subject to frequent starts, the boilers must adapt constantly to the machine's whims.

TECHNICAL DATA	
Boilers	2 x 500 BHP (only one of the boilers is used for production; the other one is redundant)
Feed water temperature	328°F
Purge water temperature	392°F
Steam	200 psig

Analysis of the results

The study performed by Deval Combustion revealed two energy saving measures necessary to optimize ML's boilers: purge reduction and control and improvement of burner efficiency by micromodulation. See Tables 1 and 2 for this purpose. Also the curves illustrated in Graph 1 clearly show the performance gain at different loads before and after implementation of micromodulation.

Improvement – Purge optimization

TABLE 1
BALANCE OF PURGE OPTIMIZATION AND ITS COSTS

Annual savings			
MMBtu/year	GJ/year	m³/year	$/year
1,831	1,932	50,986	26,255

Investments	Subsidies		Pay back period
	GM	OEÉ	
$11,000	0	0	0.42

Conclusion

The energy analysis and measuring performed by the firm turned out to be an invaluable and crucial stage for this project. The professional approach revealed the energy savings and the boilers' improved energy performance. Implementing micromodulation made it possible to realize natural gas savings estimated at 54,889 m³/year with a pay back period of 2.3 years without financial assistance. The efficiency study performed by Deval was supported by financial assistance from Gaz Métro Energy Efficiency Programs and application was supported by the Implementation Incentives Program.

GRAPH 1 : ACTUAL COMBUSTION PERFORMANCE AND COMBUSTION PERFORMANCE WITH MICROMODULATION

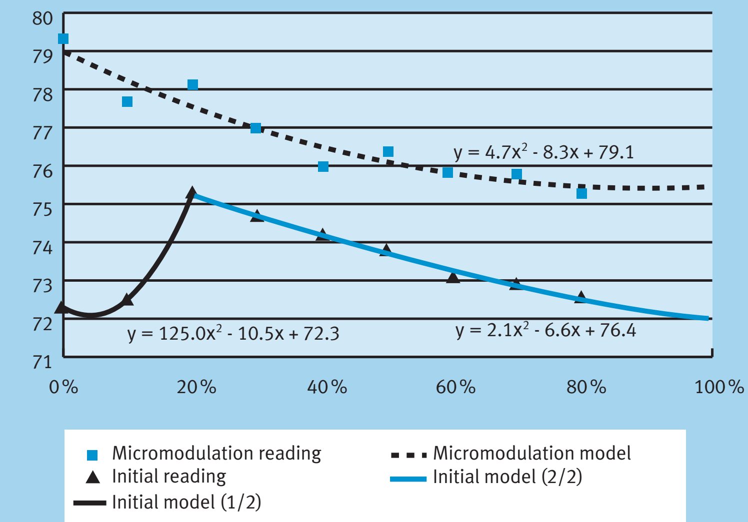

TABLE 2
BALANCE WITH MICROMODULATION

Annual savings			
MMBtu/year	GJ/year	m³/year	$/year
1,971	2,080	54,889	28,266

Investments	Subsidies		Pay back period	
	GM	OEÉ	No subsidies	With subsidies
$65,000	$13,722	$2,528	2.30	1.72

Finally, we should mention that the implementation cost, which amounted to $65,000, included the expenses required for a new certification of the boilers. This cost to obtain a new certification varies according to the project and the equipment. It is recommended to include these expenses in the cost of the project so as to reflect its profitability adequately.

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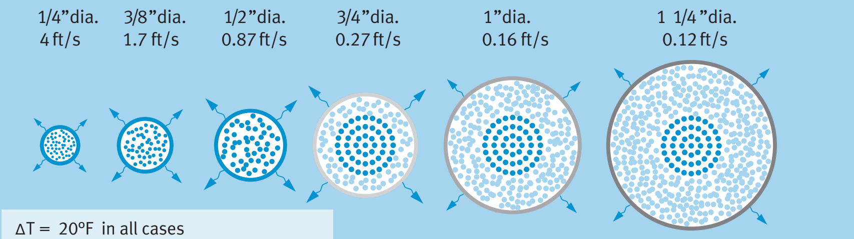
Maximizing condensation boiler efficiency through wide range temperature modeling (ΔT)

Energy performance is a core concern for designers, and choosing efficient equipment, such as the condensation boiler, is often unavoidable. However, to achieve a level of energy efficiency commensurate with what this type of equipment can offer, it must be associated with a low temperature heating system that makes it possible to obtain the expected performance level or design a network with a high temperature differential to obtain a cold return.

When designing a heating system, selection of conventional heating elements can be summed up as choosing between 3/4″, 1″ and 1 1/8″ diameter pipes. The design criteria require attention to the flow velocity in the pipe so that the flow remains turbulent, and thus maximize heat transfer.

With existing networks, the possibility of reducing the flow becomes more critical, the greater the diameter of the serpentine coil, because the laminar state can be reached faster. The arrival on the market of new serpentines producing high temperature differentials contributes to obtain a water return favouring condensation in the boilers. The new elements require much less flow to meet the demand and offer a high ΔT due to their exceptionally efficient performance. It is possible to achieve a ΔT as high as 47°F with certain configurations using 1/2″ tubes. To obtain a lower return temperature to a boiler, the reduction of the flow within the existing elements often seems to be an easy solution.

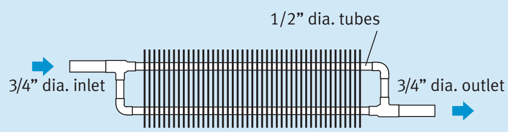
TABLE 1: FLOW VELOCITY VARIATIONS FOR DIFFERENT DIAMETERS



ΔT = 20°F in all cases
Outlet water temperature = 180°F
Ambient air temperature = 65°F

					Element lenght
5,000 Btu: (0.5 gpm)	0.87 ft/s	0.27 ft/s	0.16 ft/s	0.12 ft/s	6 ft
10,000 Btu: (1 gpm)	1.8 ft/s	0.5 ft/s	0.36 ft/s	0.24 ft/s	11.5 ft
17,000 Btu: (1.7 gpm)	3.0 ft/s	1.01 ft/s	0.61 ft/s	0.39 ft/s	18.5 ft

FIGURE 1 : ELEMENTS WITH A CONFIGURATION OF 2 PARALLEL 1/2" TUBES TO CONNECT TO EXISTING 3/4" COUPLINGS



In general, in a classic tube, the flow is definitely laminar when the velocity is lower than about 0.25 ft/s. It remains laminar or becomes transient at different speeds ranging from 0.26 to 0.49 ft/s depending on the diameter. The turbulent state is secured above 0.5 ft/s. Table 1 shows the impact of variation in flow velocity on the flow. It emerges that 1″ and 1 1/4″ diameters significantly underperformed in the presence of a flow ranging between 0.5 usgpm and 1.0 usgpm. Smaller tubes remained turbulent in the three cases. Use of a large-diameter tube thus is not interesting when a higher ΔT is sought to improve a condensation boiler's performance, despite excellent flow control at the serpentine inlets. It is then necessary to consider replacing the old elements or adding new ones, offering high ΔT, elsewhere on the system, lowering the return temperature enough to allow condensation. Since most of the existing systems have 3/4″ pipe diameters to feed the serpentines, a new serpentine configuration designed with two 1/2″ tubes can then be used (see Figure 1).

Other configurations to meet the needs for greater capacities can be considered (four 1/2″ tubes with a single 3/4″ coupling at the outlet and at the inlet). For extreme applications, the use of 3/8″ tubes allows even higher ΔT to be achieved with a three-pass serpentine configuration.

The new serpentines using 1/2″ and 3/8″ tubes have many advantages compared to classical elements. They thus become very interesting to optimize condensation boiler performance and obtain significant heating capacities even with hot water at low temperatures around 100 to 120°F. They allow high ΔT, thanks to their constantly turbulent flow, which optimizes the system's performance while consuming less energy than a conventional system. Retention of a high ΔT favours better boiler performance. It can also exploit the full performance of a smaller boiler when the project involves several small-capacity units instead of a single very high-power unit.

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Based on an article published in IMB

Natural gas vehicles, an emerging responsible alternative

Today, due to concern for our environment, many green solutions are being developed, even in the most polluting sectors, such as transportation. One of these transportation solutions has something to attract decision-makers, manufacturers and consumers: natural gas vehicles (NGV).

1. Québec and GHG

Every year, the Ministère du Développement durable, de l'Environnement et des Parcs publishes the province's greenhouse gas (GHG) emissions inventory sheet, providing the breakdown of these emissions by economic sector. Industry and transportation mainly stand out in this balance sheet.

However, the trend of their annual share is very different. While the industrial sector reduced GHG emissions by 7.1% between 1990 and 2006, the transportation sector saw its emissions grow by 21.9%, so much so that in 2006, transportation accounted for 40% of the province's total GHG emissions.

Between 1990 and 2006, total GHG emissions remained stable (slight increase of 1.6%). The 2020 target for Québec is 20% lower than the 1990 level.

In this context, innovations in the transportation sector seem to be an opportunity to explore, certainty offering a wide range of solutions capable of converging on this goal.

Here is an overview of the emissions caused by combustion of each fuel likely to be used in transportation. In short, a greater share for natural gas in transportation would help achieve the objective.

TABLE 1: GHG EMISSIONS

Fuel	GHG (kg CO_2e) per unit of energy (GJ)	Difference from natural gas emissions
Natural gas	50,198	0
Propane	60,477	+17%
Diesel	72,125	+30%
Gasoline (automobile)	68,145	+26%

2. Natural gas vehicles (NGV)

Several NGVs have been on the road worldwide for many years. These are mainly fleets of urban public vehicles, such as buses or dump trucks. In the past few years, they have increased from 2.8 million in 2003 to about 9.4 million currently.

Natural gas combustion drastically reduces the presence of pollutants compared to the fuels generally used for vehicles. These pollutants are responsible for the smog present in major metropolitan areas. The use of natural gas in urban vehicles thus contributes to obtain cleaner air.

Challenges arise, because the liquid fuel industry has developed for over 100 years. The distribution logistics run very smoothly and are well assimilated by users. Natural gas is delivered by pipelines and requires a refueling point configuration, especially since natural gas tanks are less autonomous than gasoline or diesel tanks.

Although maintenance and refueling costs are lower than for conventional vehicles, the initial purchase costs are higher. In many regions of the world, these difficulties have already been overcome by logistics adapted to this promising fuel.

3. NGV technologies

Natural gas vehicles have cylindrical fuel tanks made of steel, aluminium, fiberglass or carbon fibre. Most of the time, the tank is installed in the vehicle's trunk, but it can also be located under the vehicle. Vehicles can use two types of fuel, compressed natural gas or, more rarely, liquefied natural gas.

A tank is filled with compressed natural gas the same way as a gasoline tank. The compressed natural gas engine works very similarly to internal combustion engines using other fuel sources.

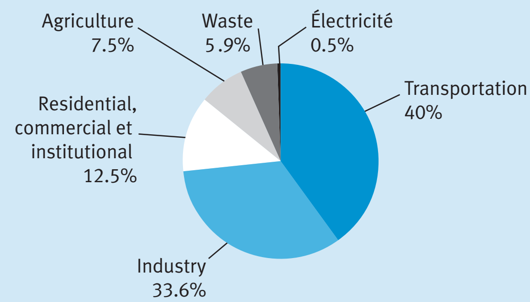
Other vehicles have the possibility of using gasoline (or diesel) and natural gas, thus providing more flexibility. Originally designed to run on gasoline, they have been modified to use natural gas as well. These vehicles are generally less efficient than those originally designed to run exclusively on natural gas.

Finally, research is continuing and teams are also considering the use of a mixture of compressed natural gas and hydrogen. General Motors has also developed an engine capable of using compressed natural gas, alcohol and gasoline. A Fiat subsidiary has produced a car which can run on ethanol, gasoline or natural gas, depending on the power required by road conditions.

4. Natural gas in Canada

In Canada, natural gas is a reliable solution, thanks to the quality of its distribution networks and its price, which is less subject to international market fluctuations.

FIGURE 1 : BREAKDOWN OF GREENHOUSE GASES IN QUÉBEC BY SECTOR (REFERENCE: MDDEP) – 2006



Natural gas is used for vehicles in most Canadian provinces. Government fuel efficiency standards, expressed in kilograms of carbon dioxide per kilometre, are conducive to increasing adoption of natural gas by manufacturers and users.

A FEW STATISTICS

- There are 9.4 million natural gas vehicles around the world.
- There are 14,000 refueling stations. Three quarters of the new stations are intended for the public.
- On the average, natural gas costs about 33% less than gasoline at the pump.
- Over 50 different manufacturers produce 150 natural gas vehicle and engine models. GM alone manufactures 18 natural gas vehicle models around the world.

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Source: "Les véhicules à gaz naturel, une option de plus en plus prisée", Gaz Québec, summer 2009, Association québécoise du gaz naturel (AQGN), pp. 4-5.

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