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Enhancement of Energy Efficiency of Indian Industries

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Abstract— *For decades, scientists – from biologists to climatologists – have warned that the unregulated burning of fossil-based fuels could have devastating effects on the ecosystems of our planet. Despite these dire repercussions, we still rely heavily on fossil fuels for almost all of our daily needs. A large portion of today's prominent industries have either been created or drastically changed by the use of such fuels. It is the general belief that the use of fossil fuels has allowed today's society to experience current freedoms and liberties. However, our dependence on a finite fuel source will lead to catastrophe if today's consumption practices are not curbed and the process of weaning ourselves from environmentally-degrading energy sources does not begin.*

1. INTRODUCTION

This must begin to change if we want to see a downturn in global GHG emission levels by the middle of the century. Energy efficiency improvements offer an excellent opportunity for industry to reduce its environmental footprint while simultaneously saving millions of dollars and becoming more economically competitive with very little overhaul of current facilities or processes. Curbing consumption requirements at the processing level (through equipment and system improvements) could help make Canadian manufacturing more eco-friendly and also cost-effective. 8 Information on how to determine the most prominent areas of inefficiency and the best ways for companies to meet their energy reduction targets is available from a number of sources including government agencies such as Natural Resources India's Office of Energy Efficiency, energy corporations such as Hydro One in Ontario, and energy management organizations, who work to develop energy solutions for companies. Energy reduction strategies and technologies for companies to begin to improve their overall energy efficiency already exist and have been around for quite some time, however, they are simply not being capitalized on. A number of major energy pitfalls will need to be addressed in order for Canada to significantly improve its manufacturing energy efficiency track record. In fact, recent studies have shown that, even with up-to-date plants and industrial processes, industrial energy efficiency can be improved by as much as 20% or more.. These efficiency improvements can come from a number of different areas, including recycling waste energy from equipment and process streams, using auxiliary equipment with more efficient motive systems, and reducing idle power requirements within facilities.

II. LITERATURE REVIEW

While it is true that an immense amount of information surrounding energy efficiency and strategies to improve it does exist, it is always the same type of information.

Handbooks, sourcebooks, and textbooks (some dating back several decades) have been dedicated to telling companies how to detect an energy sink or an area of inefficiency and even more have been developed to offer them a variety of options that can be deployed to improve the efficiency of their equipment and systems. Table 2 below references a small sample of the resources available to companies looking for information pertaining to industrial energy efficiency.

Table 3: Potential waste heat sources and end-uses [22]

Waste Heat Source	End-use (general)
Combustion exhausts from:	Combustion air pre-heating
Glass melting furnaces	Boiler feedwater pre-heating
Cement kilns	Load pre-heating
Boilers	Power generation
Fume incinerators	Steam generation
Aluminum reverberatory furnaces	Space heating
Process off-gases from:	Absorption cooling
Steel electric arc furnaces	Domestic water heating
	Transformation of liquid and gaseous process streams via condensation or evaporation
Aluminum reverberatory furnaces	
Cooling water from:	
Furnaces	
Air compressors	
Internal combustion engines	
Conductive, convective, and radiative losses from equipment	
Conductive, convective, and radiative losses from heated products	

Rotary regenerator (heat wheel)

Rotary regenerators, sometimes referred to as air pre-heaters or heat wheels, operate in a manner similar to fixed regenerators in that heat transfer is facilitated by storing heat in a porous media and by alternating the flow of hot and cold gases through the regenerator [22]. Using a rotating porous disc, composed of a high heat capacity material, placed across 2 parallel ducts, one containing the hot waste gas, the other containing cold gas, the disc rotates between the 2 ducts and transfers heat from the hot gas duct to the cold gas duct, as seen in Figure 1 below .

Heat wheels are generally restricted to low and medium-temperature applications due to the thermal stress created by high temperatures. Likewise, large temperature differences between the 2 ducts can lead to differential expansion and large deformations, compromising the integrity of duct wheel air seals [22]. Another challenge with heat wheels is preventing cross contamination between the 2 gas streams, as contaminants can be transported in the wheel's porous material. One advantage of the heat wheel is that it can be designed to recover moisture as well as heat from clean gas streams [22]. This makes heat wheels particularly useful in air conditioning applications, where incoming hot humid air transfers heat and moisture to cold outgoing air.

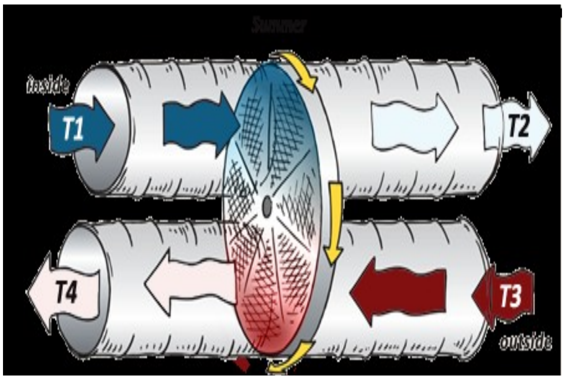


Figure 1: Rotary regenerator (heat wheel) design

III. METHODOLOGY

Currently, a growing trend has emerged among industry in which many companies try to grasp a better understanding of their energy needs and sources of inefficiency by performing internal energy audits or hiring third party contractors to conduct audits for them. While this process is effective in generating a concise list of actions (ranked according to potential impact) for companies to pursue, it can be quite costly and time consuming. As well, there is often a trade-off depending on what route is pursued.

Internal audits require trained auditors to already be on staff, which is not always possible, and utilizes personnel hours to conduct the necessary surveys. If resources are limited within an organization, it may be best to contract the auditing process to an external company and allow personnel hours to remain focused on tasks pertaining to major company projects. While the use of external contractors will allow personnel hours to be reserved for key project work, the cost of hiring professional auditors to conduct the work may be an added expense many companies cannot afford. This is especially true in the case of SMEs, which are typically limited in terms of both their financial and human resources. This can lead to companies simply pursuing what they think is the best solution for their facility, which can result in ineffective solutions, wasted resources, and, in some cases, escalate the problem. It is for this reason that a thorough understanding of a facility's primary energy users, production schedules, and essential system interactions is required before attempting to implement any plant modifications or efficiency strategies.

Case Studies

Purpose of the Performance Test

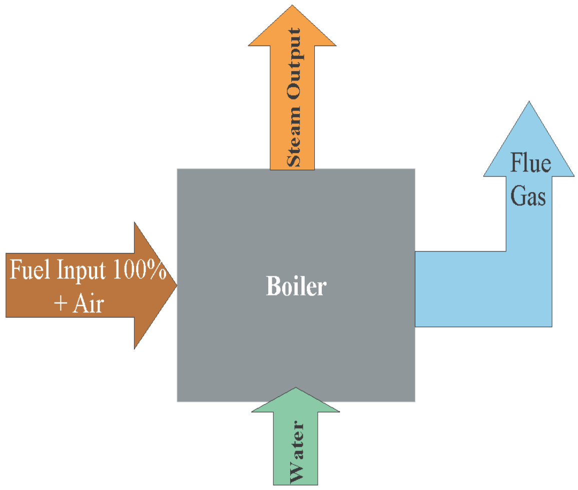
To find out the efficiency of the boiler .To find out the Evaporation ratio the purpose of the performance test is to determine actual performance and efficiency of the boiler and compare it with design values or norms. It is an indicator for tracking day-to-day and season-to-season variations in boiler efficiency and energy efficiency improvements.

Performance Terms and Definitions

$$1.\ \text{Boiler Efficiency}, \eta = \frac{\text{Heat output}}{\text{Heat Input}} \times 100$$

$$= \frac{\text{Heat in steam output(kCals)}}{\text{Heat in Fule Input (kCals)}} \times 100$$

$$2.\ \text{Evaporation ratio} = \frac{\text{Quantity of heat Generation}}{\text{Quantity of fule consumption}} \times 100$$



$$\text{Efficiency} = \frac{\text{Heat addition to Steam} \times 100}{\text{Gross Heat in Fuel}}$$

Figure 2: Block Diagram Boiler Efficiency

Boiler Efficiency = (Steam flow rate × (steam enthalpy – feed water enthelpy))/(Fule firing rate × Gross calorific value) x 100

The following losses are applicable to liquid, gas and solid fired boiler

L1. Loss due to dry flue gas (sensible heat)
L2. Loss due to hydrogen in fuel (H2)
L3. Loss due to moisture in fuel (H2O)
L4. Loss due to moisture in air (H2O)
L5. Loss due to carbon monoxide (CO)
L6. Loss due to surface radiation, convection and other unaccounted*.

*Losses which are insignificant and are difficult to measure.

The following losses are applicable to solid fuel fired boiler in addition to above

L7. Unburnt losses in fly ash (Carbon)

L8. Unburnt losses in bottom ash (Carbon)

Boiler Efficiency by indirect method = 100 . (L1 + L2 + L3 + L4 + L5 + L6 + L7 + L8)

SUMMARY OF HEAT BALANCE FOR COAL FIRED BOILER

Sr no	Input/Output Parameter	kCal / kg of coal	% loss
1	Heat Input	3501	100
2	Losses in boiler		
3	Dry flue gas, L1	275.88	7.88
4	Loss due to hydrogen in fuel, L2	120.43	3.44
5	Loss due to moisture in fuel, L3	206.91	5.91
6	Loss due to moisture in air, L4	10.15	0.29
7	Partial combustion of C to CO, L5	90.32	2.58
8	Surface heat losses, L6	8.75	0.25
9	Loss due to Unburnt in fly ash, L7	3.85	0.11
10	Loss due to Unburnt in bottom ash, L8	61.97	1.77
Boiler Efficiency= 100 - (L1 + L2 + L3 + L4 + L5 + L6 + L7 + L8) = 77.77 %			

4. CONCLUSIONS AND RECOMMENDATIONS

As a result of the research undertaken for this study, it can be concluded that energy efficiency improvement strategies present multiple opportunities for Canadian industry – saving money, stimulating economic growth, increasing productivity, and offering a significant reduction in environmental impact. The case studies presented within this thesis highlight some of the major energy consumption and GHG emission reduction opportunities that are available to industry through the implementation of various efficiency projects.

Though research into new energy-saving technologies should continue, it is also clear that many of the techniques and strategies needed to begin to significantly lower global GHG emissions already exist. Unfortunately, many companies – especially SMEs – still shy away from the opportunities that are available to them from energy conservation due to a lack of in-house expertise, inadequate resources, or positive reinforcement through industrial feedback on the use of such techniques. Additionally, energy efficiency is still largely viewed as a problem rather than an opportunity. A number of broad recommendations have been created from the results of this study. They are summarized below.

1. Despite all the potential benefits, a single barrier still exists to wide-scale industrial energy efficiency progress: confidentiality. Until organizations and government become more transparent about consumption practices within the industrial sector, very little will change. Companies must be more willing to share their energy consumption data and an open dialogue regarding best practices must begin. Governments should encourage more organizations to share their conservation success stories in order to begin to remove the taboo industry has placed on the discussion surrounding energy consumption.
2. Organizations must begin to avail of the resources and tools (from government agencies, technological societies, and universities) that have been created to better equip industrial users to improve the efficiency of their systems, equipment, and tools. These resources have been specifically created to aid industrial users with their energy efficiency projects and many of them are free of charge. The notion that not enough information or expertise exists will soon no longer be an acceptable excuse for why energy efficiency is not promoted within an organization.
3. Individuals who are chosen as energy managers within their respective organizations should come from a strong sustainability background. They must be open to the notion that all three (3) spheres of sustainability are equally important and they must understand the importance that open dialogue plays in energy consumption and creating the necessary changes within industry to curb emissions. By placing the appropriate personnel in energy management roles, energy efficiency projects will likely be implemented more

frequently and with less opposition within organizations.

4. Lastly, it is important that energy reduction strategies remain effective and focused on the most promising solutions. Determining what these efficiency "*best practices*" are can only be achieved through effective consumption sub-monitoring, both pre and post-project implementation. Without appropriate monitoring of energy consumption it is practically impossible to know where the greatest sources of inefficiency are stemming from and how they can be remedied. Even if organizations begin to overhaul their existing systems with new equipment, design layouts, or maintenance regimes, if consumption is not adequately monitored before an alteration, it is quite difficult to pin-point specific savings and whether or not the new system is performing effectively. Accurate and sufficient energy monitoring is a key component to energy reduction success.

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