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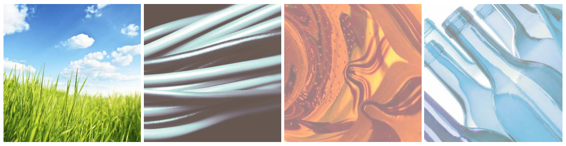

36th ASEAN GLASS CONFERENCE

SEPTEMBER 24th - 27th, 2012
SHERATON HANOI HOTEL
Hanoi, Socialist Republic of Vietnam

ASEAN Federation of Glass Manufacturers (AFGM)
Flat Glass and Hollow Glass Manufacturers

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A Safer and Greener Life joins Waste Gas Enthalpy Recovery Systems in the Glass Manufacturing

Water

One of the most important natural resources we have is water as it is a necessity in our survival. However, there has been a lot of fear that we are running out of clean water sources as the global population continues to grow

Renewables & Solar Energy

Some renewable resources have essentially an endless supply, such as solar energy, wind energy and geothermal pressure, while other resources are considered renewable even though some time or effort must go into their renewal, such as wooden biomass

Waste Reduction

Recycling has become a standard practice for many people in recent decades. The stuff that was formerly thrown away and trucked off to the landfill is now turned into useful products. It helps the world to be greener

Energy Recovery from intensive industrial processes: avoid to waste heat

It is an immediate way to save energy and to reduce the CO_2 emission by and to protect the environment from pollution by mean of:

High Entahalpy recovery from exhaust gases (flues)

It can help the industries to recovery >20% of the electricity and > 50% of the thermal power used during the production processes

Cooling down the exhaust gas to allow pollution abatement by low temperature filtration (filter bags or sleeves)

It will allow the use of less expensive abatement system to avoid heavy pollution outcoming from the industrial exhausted gases, making a stronger effort toward a safer and greener life

Introduction

At the global level, we have adopted patterns of material and energy consumption that are simply unsustainable

If enterprises are to survive such troubled times, they will need to strengthen their capacity to compete, to increase productivity, to reduce production costs, and to take advantage of new opportunities.

In all of this, as the prime manufacturer of the goods and services societies consume, **industry has a critical role to play**.

Many enterprises use more materials and energy than their production processes require, because they continue to use obsolete and inefficient technologies and fail to adopt proper management systems.

As a response to these manifest health and environmental impacts, the last forty years have seen an unparalleled growth in environmental legislation aimed at getting industry to "clean up its act"

The project

The most advanced industrial sector in US and EU accounts for approximately one third of all energy used in their countries.

Capture and reuse the lost or "waste heat" that is intrinsic to all industrial manufacturing

20 to 50% of the energy consumed is ultimately lost via waste heat contained in streams of hot exhaust gases and liquids, as well as through heat conduction, convection, and radiation from hot equipment surfaces and from heated product streams.

In some cases, such as industrial furnaces, efficiency improvements resulting from waste heat recovery can improve energy efficiency by 10% to as much as 50%

Numerous technologies and variations/combinations of technologies are commercially available for waste heat recovery. Many industrial facilities have upgraded or are improving their energy productivity by installing these technologies. However, heat recovery is not economical or even possible in many cases.
Technology needs are identified in two broad areas:

- extending the range of existing technologies to enhance their economic feasibility and recovery efficiency
- exploring new methods for waste heat recovery, especially for unconventional waste heat sources

In general, estimates of waste heat loss in exhaust gases were based on estimated fuel consumption and expected specific enthalpy (Btu/lb or MJ/Kg) of exhaust streams, which depends on temperature and chemical composition of the exhaust stream

Waste heat loss in a given application can be expressed as:

$$WH = M * Eth$$

WH = waste heat (MJ)
M = mass (Kg)
Eth = Enthalpy of each species (MJ/Kg)

The project

The glass industry consumes approximately 300 Tbtu/yr and some sources estimate that as much as 70% of this energy consumption is devoted to glass melting and refining processes in high temperature furnaces

The theoretical minimum energy for melting glass is only about 2.2 million Btu per ton. However, some furnaces consume as much as 20 million Btu/ton. We normally assume an average energy amount of 4.0 million Btu per ton

Furnaces used in large glass melting operations include

Recuperative | **Regenerative** | **Directfired** | **Oxyfuel** | **Unit melters** | **Mixedfuel**

Best practice furnaces have efficiencies of about 40%, with stack heat losses about 30% and structural losses accounting for another 30%.

Waste heat recovery in the glass industry

Regenerators

Regenerative furnaces employ two chambers with checker bricks. These chambers alternately absorb heat from exhaust gases and transfer heat to the incoming combustion air. The direction of airflow changes approximately every 20 minutes so that one chamber receives heat from the stack exhaust while the other one rejects heat to incoming air. Final exhaust temperatures vary between about 600 and 1,000°F [316-538°C] throughout the cycle.

Recuperators

Recuperators are a less-efficient option more commonly employed in smaller operations that cannot afford the large costs of regenerative furnaces. A metallic recuperator is used to indirectly preheat combustion air. Preheat temperatures usually do not exceed about 1,470°F [800°C], and exhaust temperatures are reduced to about 1,800°F [982°C]

Without heat recovery, stack exhaust temperatures typically exceed 2,400°F [1,315°C]

The project

In addition to combustion air preheating (most likely in oxyfuel furnaces), methods for waste heat recovery in glass manufacturing include

preheating batch and cullet material | waste heat boilers for electricity generation

When furnaces are adapted to oxyfuel firing, the regenerators are removed, which can lead to higher exhaust temperatures around 2,660°F [1,460°C]. Although the waste heat is at a high temperature, the mass of exhaust gases is much lower, leading to lesser waste heat loss as a percentage of fuel input.

Preheating batch material is used in one plant in the United States; it is more common in Europe, where energy costs are higher. About 13 new batch/cullet preheaters have been installed since the 1980s, nine of which were located in Germany.

Challenges with batch preheating include the large amount of material that must be handled and the desire to maintain a homogeneous glass product.

Problems have been found in using the batch preheating, due to the high level of dusties that will enter the furnaces.

Waste Heat Recovery Opportunity Areas

Key opportunity areas

Low-temperature waste heat sources Based on a 77°F [25°C] reference, most unrecovered waste heat is at low temperatures. About 60% of waste heat losses are at temperatures below 450°F [230°C]

Systems already including waste heat recovery that can be further optimized to reduce heat losses. The extent of heat recovery from existing systems is often constrained by costs and temperature limits for the heat recovery system. In many cases, such as cement preheater kilns and recuperative glass furnaces, exhaust gases exiting the recovery device are still in the mediumto high-temperature range.

High-temperature systems where heat recovery is less common There are market segments where waste heat recovery is less common; this is due to barriers such as chemical constituents in exhaust gases that interfere with heat exchange, as well as limitations on economies of scale for smaller waste heat streams

Alternate waste heat sources typically not considered for waste heat recovery This study focused on combustion and process exhaust gases. However, alternate sources of waste heat were also found to be significant.

The temperature groups are defined as:
High 1200ºF [650°C] and higher, Medium 450ºF [230°C] to 1,200ºF [650°C], Low 450ºF [230°C] and lower

Economies of scale dictate the economic viability of many heat recovery systems. This can be due to lack of capital available in smaller operations, as well as relatively longer payback periods involved for heat recovery installations.
Typical furnace capacities vary in different segments of the glass industry

Smaller capacity furnaces typically have a higher percentage of waste heat losses

Waste Heat Recovery Opportunity Areas

Relationship between Typical Furnace Size and Average WasteHeat Losses in Different Segments of the Glass Industry

GLASS IND. FURNACE T/D	TYPICAL SIZE OF HEAT LOSS (%)	PERCENT WASTE
Pressed/Blown	75	58
Insulation Fiber	100	53
Textile fiber	120	56
Container	250	30
Flat Glass	580	30

Typical Furnace Capacities and Waste Heat Losses in Different Segments of Glass Industry

Glass Industry Segment	Furnace Capacity Range	Typical Furnace Capacity	Natural Gas Consumption TBtu/yr	Waste Heat TBtu/yr	% Nat. Gas Input Lost to Waste Heat
Flat Glass	300-1000	550+	41.10	11.82	30,00%
Container Glass	50-550	250	45.49	13.65	30,00%
Pressed/ Blown Glass	01/01/00	75	16.82	9.63	58,00%
Insulation Fiber Glass	20-300	100	3.24	1.73	53.00%
Textile Fiber Glass	100-150	100-150	11.05	6.14	56,00%

The EU situation

Energy intensive industrial processes (iron, steel and cement production, glass making, etc.) emit heat and carbon dioxide (CO2) into the environment.

In January 2010 the First European project concerning the mapping of waste heat recovery in energy intensive industries has started on a pilot local territory. This project, financed as LIFE08 ENV/IT/000422 "H-REII", has the objective to promote policy and governance actions to support innovative solutions for recovery and energy valorization of process effluents in Energy Intensive Industries (E.I.I.) and quantify the potentially saved CO2.

The H-REII Demo project is the continuation and implementation of the H-REII project.

Objectives

- to extend the policy results, obtained at national level with the Project H-REII, at European level
- to develop in the steel sector the first prototype of heat recovery in Electric Arc Furnace (EAC) using ORC technology, completely integrated into a fume extraction plant. This is expected to lead to an improvement in the performance of the fume depuration plant in energy intensive industrial applications (iron and steel industries, cement, glass, etc.)
- to promote a European Technological Platform creation concerning energy efficiency and sustainability in industry, thanks to the existing network of contacts and to the ongoing participation of the project partners in dedicated Italian and European working groups

The EU situation

The ambitious targets set in the EU climate and energy package "20-20-20" have activated a series of actions in member states aimed to obtaining the expected results

Among the energy efficiency actions an important role can certainly be covered by the highly energy-intensive industries, which can, in the face of limited and well defined interventions, obtain important results.

The Italian Action Plan for Energy Efficiency

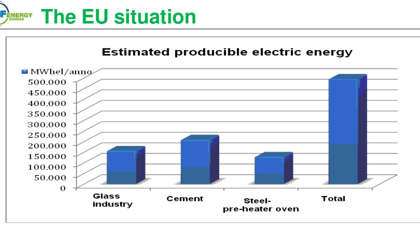
Prepared in 2007 by the Ministry of Economic Development, mentioned among the possible actions the recover waste in highly energy-intensive companies without quantifying the potential savings achievable, because of the difficulty of standardizing applications and technology to use. The sector of recovery from process' effluent is characterized by a multiplicity of possible applications with different system and technique solutions, aimed to recovery in thermal use, to produce electricity or both.

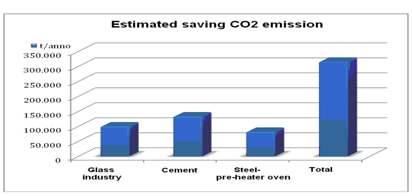
The prudential estimate, on Italian cement, glass and steel industries – only the pre-heater oven

- potential saving of 500 GWhel/year of electricity (about 93,000 tep/year)
- prevents the emission of over 316,000 tons of CO2/year

Really, considering the entire steel industry (steel production plants, coke oven, sintering plants) the potential would be much higher

The EU situation





The Italian situation

This report highlights the potential for recovery in the 3 areas already investigated, describes the existing worldwide Best Available Techniques (BAT) and estimates the required investments

The general considerations emerged are

- Applications for recovery of effluent with ORC technology are technically achievable
- The potential of dissemination of these distributed generation systems of small size are very high and replicable in Europe and worldwide
- Italy is currently the European leader in the ORC technology with enormous potential for consolidation of the sector
- The pay-back time considering the advantages due to the use of the thermal energy together with electric power (CHP-Combined Heating & Power) and the use of cheaper pollution abatement systems (Bag filters instead of ESP) is convenient

Considerations on the italian tariffs and incentives (under updating)

Incentives to be considered are referred to:
- Carbon credits policies (worldwide system): 30 €/Ton of avoided CO2 (it can vary)
- Energy Efficiency Credits: 60 €/Mweh for 5 years, now in Italy, since sept. 2011
- Other credits or contributions can be available locally, in accordance with government policies to support greener life and environmental protection.

Italy results

Against the total costs of about 20 M€ per year, it is possible to quantify benefits for more than 64 M € per year, counting only the applications for the Italian territory, contributing to the consolidation of Italian leadership in this sector, creating employment and helping to pursuit the energy efficiency goals

Case study

400 TONS/DAY HOLLOW GLASS REGENERATIVE END PORT FURNACE HEAT RECOVERY SYSTEM FROM WASTE GASES POWER COGENERATION BY ORC TURBINE

DESCRIPTION OF THE ITEMS TO BE SUPPLIED (HARDWARE)

- N. 2 Thermal oil boiler (TOB) with with recovery section for waste gases/oil;
- Thermal oil circulating pumps;
- Set of control system;
- Laminating pressure control valves;
- ORC Energy Module;
- Heating Exchanger for Water to Water thermal dissipation;
- Heat Dissipators, air cooled;
- Waste gases pipeline;
- Waste gases filtration and pollutants abatement, complete with
  - Bag Filter : Particulate matter
  - Ammonia/Urea: SCR system for NOx abatement
  - Active carbons: Dioxine and Furans
  - Alcaline dry injection: Acids, HCL, HF, Sox

Case study

400 TONS/DAY HOLLOW GLASS REGENERATIVE END PORT FURNACE HEAT RECOVERY SYSTEM FROM WASTE GASES POWER COGENERATION BY ORC TURBINE

Incoming Thermal Power (Heat)	Waste gases from the furnace of a hollow glass process natural gas fired /end port regenerative.
Gases Flow (flue)	22.400 x 3 = NM3/h (28.896 Kg/h)
Max gases temperature at the inlet connection	450°C
Average specific heat (assumed SHC)	1.123 kJ/(kg*K)
Gases density (assumed specific weight)	1.290kg/Nm3
Maximum Thermal Power to be recovered with a temperature drop (DT) of 270 °C **(*)**	2.435 KWh (**)
Gross Electric Power to be generated by Energy Module	487 KW (**)
Net ORC Electric Power output	450 KW (**)
(*) Considering 1% losses (**) Based on ORC condenser temperature range of 25-35 °C, for electricity generation only	

Case study- layout

400 TONS/DAY HOLLOW GLASS REGENERATIVE END PORT FURNACE HEAT RECOVERY SYSTEM FROM WASTE GASES POWER COGENERATION BY ORC TURBINE