Second Batch of Domestic TOP TENs List

France Industrial BAT List

BAT1: Infrared Technologies for Drying and Baking Thin Products or Coating

1. Technology description

(1)Infrared tunnels:

Infrared tunnels are facilities for baking powder coatings,drying of liquid paint or items warm-up. Final hardening of the powders is achieved by baking in a conventional oven.

Infrared radiation: Infrared is electromagnetic radiation like light or UV rays, radio waves etc. Any bodies brought to temperature emit radiations that carry energy in the form of vibrational waves. Conversely, the receiver absorbs some of this energy and transforms it

into heat.

The emitted radiations are spread over a wide spectrum of wavelengths. Infrareds for industrial applications range from 0.76 to 10 μ m (short infrareds from 0.76 to 2 μ m,medium infrareds from 2 to 4 μ m and long infrareds from 4 to 10 μ m). Two factors can limit the energy received by the item: the shape factor (related to the geometry of the emitter and of the item) and the capacity of absorption of the material to be treated.

(2)Technologies used:

• Electrical infrareds emitters

An electrical infrared emitter is a body brought to high temperature (1500° C to 2500° C for the short infrareds. 500° C to 1200° C for medium and long infrareds) by an electric current through a resistive element. These transmitters enable an accurate regulation as long as the exact room temperature is known.

(3)Gas infrared emitters:

The combustion is stabilized in a porous or perforated surface. The radiation is produced by this surface, brought at a certain temperature range (500° C to 1200° C, medium and long infrared) and not by the radiation of a flame.

2.Level of Energy Savings

Energy saving:20% to 80% depending on the application.

3.Market prospect

- Liquid paint drying;
- Gelling and baking powder coatings;
- -Pre-drying and textile powdering.

-Coatings polymerization technology like PTFE coatings (Polytetrafluoroethylene),chrome or aluminium for the aerospace industry;

-PVC (Polyvinyl chloride) and latex gel induction;-Flame treatment effect (pizza,biscuits,burned creams etc.)

4.Reliability

The choice of an infrared tunnel depends on many parameters:

- The material of the items;
- The shape of the items;
- The type of interlocking parts;
- The number of parts and the speed of the conveyor

5.Economic Characteristics

Payback time: 2 to 3 years

6.Social Characteristics and cobenefits

(1)Speeds the parts temperature rise

Infrared radiation provides a direct transfer of energy between the heat source and the receiving parts without using air movement. Thus the pieces rise in temperature quickly which improves the final quality of the coating (tense,shine ...).

(2)Reduce the use of space

By rising the temperature faster, the product obtains the required temperature in a shorter time. The cooking tunnel uses less space.

(3)Improves layer quality

In the case of powder coatings, the use of infrared pregelling avoids a blend of powders in the convection zone and improves the tense (quality) of the paint layer.

- •Space saving
- •Energy saving: 20% to 80% depending on the application
- •Transition to solvent-free products
- •Reduced cycle time
- •Productivity gain.

BAT 1 Application Examples

Application 1: Car painting touch-up using infrared

1. Technical Principle

Conventional process:

- Forced convection hot air oven
- Blowing oil burner
- Cycle time: about 45minute
- Annual consumption: 210,000 kWh

Short wave infrared solution:

- IRT Installation
- Infrared power of 54kw
- Dimensions: 2.5 x 2.0 x 0.5 m³
- Cycle time: 13 min

2. Technical Schematic

Refer to Figure 1 to 4.

3.Main Specifications

Conventional process:

- Specific consumption of about 126 kWh of fuel / touch-up.

Infrared solution:

• Specific consumption of about 18 electrical kWh / touch up.

• Gain with IR process: 30000 kWh / year.

corresponding to more than 80% of the conventional method.

• Cycle time reduced by 3.

4.Scope of Application

Cars paint touch-ups

5.Cost-effectiveness Analysis Investment

- € 30 000 for 50 kW.
- Approximately 300 to 600 € / kW.
- Payback time 2 to 3 years

6.Benefits

Other benefits of the IR solution:

- Energy saving: 80% (selective heating)
- Reduction of cycle times and waiting time
- Increased production
- Shift to solvent free products
- Space saving (storage of vehicles)



Figure 3 : Conventional process heat balance

Application 2:Pre drying of textiles

1. Technical Principle

Conventional process:

- Hot air drying tunnel KRANTZ
- 9 blowing natural gas burners Valupak
- cycle time: 40 seconds
- Annual consumption: 5,000,000 kWh

Gas Infrared solution:

- Installation MATHERM
- IR power of 320 kW
- Heating zone dimensions : $1.0 \text{ x} 1.5 \text{ m}^2$
- Cycle time: 2.5 seconds

2. Technical Schematic

Refer Figures 1 to 4.

3. Main Energy Specifications

Conventional process:

- Specific consumption of about 4.1 kWh of gas / kg of evaporated water

IR process:

- Specific consumption of about 3.4 kWh of gas / kg of evaporated water.

4.Scope of Application

Textile

5.Cost- effectiveness Analysis

Investment:

•Energy savings with IR process on drying operation: 300 000 kWh / year being 20% of the conventional method

•Investment of approximately 150 to 200 €/kW

•Payback time 2 to 3 years

6.Benefits

- Energy saving: 20%
- Limit the number of train passages
- Increased production of 20% to 40%
- Space Saving
- Cost 📕



Figure 1 : Conventional process - drying paddle



Figure 2 : infrared process - IR pre dryer



Figure 3 : Conventional process heat balance (textile paddle) Figure 4 : infrared process heat balance (IR predryer)

Application 3: Powder paint baking

1. Technical Principle

Conventional process:

- Hot air tunnel SUNKISS
- Blowing natural gas burner
- Cycle time: about 15 minutes
- Annual consumption: 1,540,000 kWh

Gas Infrared solution:

- SUNKISS Installation
- IR power of 288 kW
- Heating zone dimensions : $4.0 \text{ x} 1.0 \text{ m}^2$
- Cycle time: 5 min 30 seconds

2. Technical Schematic

Refer to Figure 1 to 4.

3. Main Energy Specifications

Classical solution:

- Specific consumption of 6.4 kWh gas per painted item

Infrared solution:



4.Scope of Application

Powder coating and baking

5.Cost- effectiveness Analysis

Investment:

•Gain with IR process: 540 000 kWh / year,or 30% of the conventional method

- Reduction of the cycle time by 3
- Saving of approximately € 15,000 / year
- Additional cost of 20%
- Payback time of 2 to 3 years

6.Benefits

Benefits of IR solution:

- Better tense
- Flexibility in the regulation
- Heating kinetics
- Energy saving (20%-40%)
- Limited over cost compared to the conventional technique (20%-30%)



Figure 1 : Conventional process







BAT2: Variable Speed Drives(VSD) Applied to Centrifugal and Dynamic Machines (Pumps, Fans, Compressors)

1. Technology description

Centrifugal pumps with Variable Speed Drives (VSDs): VSDs installed on pumping systems allow the optimization of the electric consumption.

Most centrifugal pumps operate flow regulation using adjusting devices installed on the hydraulic circuits,like valves. These installations use the energy in a non-optimized and non-efficient way. The energy consumption of the circuit can be optimized by reducing the pump rotational speed by adapting the speed of its electrical motor.

VSD is the most appropriate technical solution to adjust the exact energy to the real need.

2. Technology schematics

Refer to Figure 1&2.

3.Level of Energy Savings



Example: Energy Gain on pumping facility with a VSD



Figure 1 Adjustement through throttle

Figure 2 Adjustement through VSD valve

4.Market prospect

All industrial processes using pumps,compressors,fans etc. with electric motors.

5.Reliability

•The dimensioning parameter for the VSD is the power of the engine.

•The installation location must be chosen before supplying the VSD: existing electrical panels, electrical room or the pump warehouse. The VSDs must be located and protected in a dedicated cabinet.

6. Economic Characteristic

Financial savings are achieved by reduction of electricity consumption.

7. Social Characteristics and co-benefits

Benefits of VSD:

•Reducing the electricity consumption especially when flow variations are important

•Flexibility and precision in operation (smooth start/stop/ regime changing,se control).

•Presence of automation loops and easier automation of the pumping process.

•Reduced mechanical stress on the pump and pipes

- Pumps noise reduction.
- Smoother start of the motors
- Reduction of reactive power consumption.
- Reduction of CO₂ emissions.

BAT 2 Application Examples

Application1:Replacement of a classic compressor by a Variable Speed Drive Compressor

1.Technical Principle

Context & Issues:

Eternit is a company specialized in the manufacture of roofing,facade and construction materials. After a set of measures carried out on the site of Terssac,a great potential of energy savings has been identified on compressed air production. The introduction of VSD compressors replacing the classical fixed speed compressors brought about 15% of energy savings.

The VSD is the only type of regulation that allows to make energy saving almost proportional (not centrifugal) to the flow rate (on a range from 15% to 100% of the nominal output). Moreover, this technic allows a better precision in maintaining set pressure.

2.Picture



New screw VSD compressor

3.Main Specifications

Fixed-speed air compressors are the most commonly used type of compressors,but VSD compressors today are quite well known in industries and enterprises but not mostly used. They are about 25% more expensive at purchase than a fixed speed compressor,depending on power,but they bring high economies on the life cycle of the product.

4.Cost-effectiveness Analysis

- Financial gains: 3 528€ per month
- Payback time: 11.5 years . 2.5 years on over cost

5.Benefits

- Reduction of polluting emissions, reduction of the consumption of drinkable water for cooling the process.
- •No more use of water for compressed air cooling.
- •72 MWh / year, being 9% saving on compressed air production.

Energy balance:

Before:817 MWh of electricity for compressed air production

After: 7745 MWh per year for

production compressed air

- •Energy saving: 72 MWh/ year being 9% saving on compressed air production
- •Financial gain: 3 528 euros per year

BAT3: Selective and Mass Heating by Microwaves

1.Technology description

Two types of electromagnetic radiation are used for industrial applications: high frequency radiation,whose usual frequencies are between 10MHz and 30 MHz. and the microwave radiation whose frequencies are between 800 MHz and 3000 MHz.

Although the heating processes by high frequency or microwave are based on the same principle, the effect on the product to be heated is different:

-With high-frequency, the wavelengths are bigger than the dimension of the equipment. thus, the laws of electricity at low frequency are still applicable. The generators are oscillators. Voltage and current are carried out through isolated conductors and electrodes distribute the energy to the to- be-heated-products.

-In contrast, with microwave, the wavelengths are smaller than the dimensions of the equipment, the technology is based on the propagation of electromagnetic waves and its properties.

Features of the use of heating by microwaves:

•The electromagnetic energy is dispersed inside the product as a function of the electric beam distribution: it is a distant heating.

•The heating system is said « selective » because it directly depends on the permittivity of each product.

•The heating is heterogeneous in the case of a mix of different materials with different permittivity.

•This system is very effective, because it is possible to generate intense field distributions and to apply high power densities (10 kW per litre of product). It is also possible to heat rapidly because the setting of the generators is instantaneous.

•Non-polluting, this system allows a gain of time compared to conventional techniques. Heating by microwaves is often used in complement to traditional techniques such as hot air, infrared radiation

2. Technical Scheme

Principle of a microwaves heating installation:

Microwave facilities at 915 MHz and 2450 MHz are used mainly in industry. They are constituted of a generator, an applicator, and connecting and measuring circuits.

For these frequencies, the industrial generators are







magnetrons, their rated power is between 1.5 kilowatts and 70 kilowatts.

Refer to Figure 1.

Multimode tunnel for continuous processes:

Industrial cavities (such as domestic microwave oven) are used for discontinuous processes. For continuous processes,tunnels are used. They are actually a succession of several multimode cavities. Sealed airlocks,hermetic to microwaves leakage ensure the introduction and exit of products.

Refer to Figure 2.

3.Level of Energy Savings

The energy saving potential is of course closely linked to the application, but the use of Microwaves and High Frequencies only makes sense when this solution brings significant advantages compared to conventional solutions. In most cases, this heating method generates energy savings of more than 50% of the initial consumption of a process. It can achieve 80% for some applications.

4.Market prospect

The industrial applications of high power microwaves are

numerous: drying,baking,pasteurization,vulcanization, waste treatment. In the food industry: cooking,pasteuri zation,sterilization,drying,defrosting,flavour extraction

5.Reliability

This technology has a good maturity, but each application requires a specific design study because the effect of MW and HF depends directly on the product they are used on. The sizing of the applicator must be made case-by-case.

6.Economic Characteristics

To be seen case-by-case.

For MW generation, as a general average, pricing is such that 1kW power is $1k\in cost$.

7. Social Characteristics and co-benefits

The microwaves used for heating purposes bring benefits,often decisive, in the industrial processes they are used in: fast heating, improving the quality of treated products, energy savings, flexibility of use and control, absence of pollution.

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BAT 3 Application Examples

Application 1: Pre-vulcanization of rubber pieces

1. Technical Principle

Heating by microwaves is mainly used for preheating operation before pressurized moulding, and for heating operations of the extruded pieces until they reach the vulcanization temperature (rubber is stiffened with sulphur-based additives). The temperature is then maintained using an electric resistance furnace.

On the rubber pieces' industrial line, the successive operations are:

•Plasticizing: aims to soften the rubber through mechanical working. The temperature reached varies between 75° C and 110 ° C;

•Extrusion: the rubber pieces are shaped by passing the rubber through a profile;

•The vulcanization itself comprises two phases:

-The heating of the material up to its vulcanization temperature in a microwaves oven;

-The preservation at temperature in a resistance furnace until the end of the vulcanization process;

•Cooling: brings the temperature down to 80 ° C. It is followed by the packaging of the products;

2. Technical Scheme

Refer to Figure 1.

3.Main Specifications

The microwaves applicators used are generally some sort of resonant cavity at 2450 MHz,or waveguide. A line of 5 kW power microwaves and 20 kW power for the resistance furnace can treat around 100 kg /hour of rubber. Microwaves line of 25 kW power and 45 kW power for the resistance furnace are the most commonly constructed. They can process around 500 kg /hour of rubber pieces with a total consumption of 0.15 kWh / kg to 0.17 kWh / kg,which corresponds to a significant energy saving compared to more conventional systems.

4.Scope of Application

Preheating before moulding operation

5.Cost- effectiveness Analysis

Significant energy savings compared with more conventional systems.

6.Benefits

The advantage of microwaves heating is its ability to quickly raise the rubber's temperature throughout all its mass (for traditional techniques,the complete warming is very slow because the rubber is a poor heat conductor). moreover,the state transition is rapid, which is a guarantee of the good dimensional stability of the products.



Figure1:Drawings of a rubber pieces extrusion line using microwaves heating.

Application 2:Paint drying on foundry moulds

1. Technical Principle

Conventional process:

- •Hot air oven
- •Propane gas atmospheric burner
- •Cycle time: around 110 minutes
- •Annual consumption: 750 MWh (750 000 kWh)

Micro-waves process:

- •KUTTNER installation
- •Micro-waves power potential: 30kW –frequency:

2450Mhz

•Dimensions: 1.6 x 1.6 x 1.5 m³

•Financial investment: 115 k€

2.Technical Schematic

Refer to Figure 1 to 4.

3.Main Specifications

Conventional Solution:

Specific consumption of 250 kWh gas / tons of

moulds

Micro-Waves solution:

Specific consumption: 63 kWh electric / ton of moulds

4.Cost- effectiveness Analysis

Investment:

•Overcost compared with classical solution: 40%

•Estimated payback time: 2 years

5.Benefits

Advantage of MW solution:

Gain with MW process: 561 000 kWh / year, being 75% of conventional process

Reduction of treatment time by 15.



Figure 3 : Conventional process heat balance

Figure 4 : Microwave process heat balance

BAT4: Heat, Cold and Electricity Generation by Tri-generation

1.Technology description

Power generation method (combined cycle) with a very high energy efficiency,generally exceeding 80% to 95%.
It is about producing,from a primary energy (natural gas mostly) 3 different kinds of usable secondary energy:
A thermal energy,which is used for heating,drying,greenhouse heating,swimming pools,hot water,industrial processes...

•A cold production (produced mechanically or indirectly through absorption refrigeration plant) .

•An electric power. produced with a turbine + dynamo system (direct current) or an alternator(AC), with a transformer to adapt the tension.

The most commonly used primary energy is natural gas,but in theory any kind of energy can be used like gasoline,oil,gas,biogas,waste gases produced by some industries (gases from industrial processes and often wasted),etc.

2. Technical scheme



Principe de la trigénération

3.Level of Energy Savings

Trigeneration is particularly interesting on an energy level because it allows to use the waste heat from cogeneration outside of the heating periods and to produce cold plus heat for additional uses (domestic water). In the best cases the overall efficiency of the plant is around 85%.

4.Market prospect

This system is to be used in industrial processes in need of simultaneously these three kind of energy: heat,cold and electricity.

5. Social Characteristics and co-benefits

Reduction of CO₂ emissions:

Optimization of energy consumption.

Trigeneration technology generates an energy saving and an environmental gain while being economically profitable.

BAT 4 Application Examples

Application1: TRIGENERATION with « double effect » absorption– space centre in Toulouse

1.Technology Principle

In general, a trigeneration plant consumes natural gas in order to produce simultaneously electricity, heat and cold. Compared with the cogeneration solution (which is a simple recovery of lost heat during electricity generation process) or 'simple effect' trigeneration (which consists in transforming into cold a part of the recovered heat), the 'double effect' trigeneration solution chosen by the Toulouse's site presents a better energy performance and a better payback time for a reasonable investment cost.

2. Technical Scheme

Refer to Figure 1.

3.Technical Specifications

The trigeneration in the Space Center relies on the use of two 'Caterpillar CAT 3532 HR SITA' motors that develop an engine nominal power of 2140 kW for a unit consumption of 5 690 kilowatts LHV (lower heating value) of natural gas. Each of these motors drive a SR 4828 type Caterpillar generator of a 2080 kW electric power for a total net electricity generation of 4000 kWe.

4. Main energy specifications

Annual energy needs of the site (initial):

- Electricity: 8900 toe *
- Natural gas: 2233 toe *

Energy Balance of the 'double effect' trigeneration (period: from November 1 to March 31):

-Production of 14 GWh of electricity,10 GWh of heat and 9 GWh of cold,which represents a saving of around 2 000 toe.
-The heat losses generated by the electricity production are recovered and exploited (in the form of heat or cold) to 80%.



Figure1

-82% of hot water needs and 85% of cold water needs are
covered by this 'double effect' trigeneration
* Toe: ton oil equivalent

5.Market prospect

The operation carried out in the Toulouse Space Center is an exemplary environmental approach and it also constitutes an important step for advanced technology and sustainable development. Indeed,with a reasonable over-cost investment,the "double effect" absorption trigeneration system is now clearly identified as the most efficient solution compared to cogeneration or "single action" trigeneration.

6.Cost- effectiveness Analysis

Investment: € 3.85 million

• ADEME Grants: € 457,000 and the

Region's grants: € 152,000

•Over the regulatory period of operation (November 1-March 31)
-Before tigeneration:
€ 425,000 annual expenditures (value 2001)

-With trigeneration: € 243,000 of income (2003- 2004 season) an annual operating profit of €668,000

•Payback period: 5 years (with subsidies)

7.Benefits

The use of 6000 Tons Oil Equivalent and the emission of 19,000 tons of CO_2 were avoided. (over the 12-years power resale contract)

BAT5: Mechanical Steam Compressor

1.Technology description

Mechanical steam compression allows the recovery of waste heat contained in the steam derived from a process of concentration,drying etc.

The steam is compressed by a centrifugal compressor.

The resulting product is used on the same process to provide the heat required for the vaporization of a new quantity of steam. Once the process started, it maintains itself without any additional heat energy.

2. Technical scheme



Principle of mechanical steam compressor

3.Level of Energy Savings

The electricity consumption associated with the compressor operation is usually very low compared to the amount of energy recovered by the system.

It mainly depends on the compressor's compression

ratio, which is the difference between the inlet and outlet vapour temperature.

Coefficients of performance (COP) are variable and can reach very high levels, ranging from 5 to 30.

Depending on the application the mechanical steam compression system allows the use of 7 to 50 times less energy than heating from boilers and 4 to 5 times less energy than a multi-effect technology.

4.Market prospect

This technique has many applications like in the industrial effluent concentration (e.g.: black liquor from paper mills) or food products (grape juice,tomat oes,etc.),crystallization,surface treatment,desalination of sea water,agro food industry,paper,chemistry etc.

5. Social Characteristics and co-benefits

This technique consumes little electricity: 10kWh / tones to 20 kWh / tones of evaporated water (which corresponds to the motor power supply).

Advantages:

•Reduced primary steam needs

Space saving

•Reduction of the effluents volume

Disadvantages:

•Compressor's maintenance and control

•Risk of corrosion (quality of inlet steam)

•Decreased performance with the product concentration

BAT5 Application Examples

Application1: Mechanical steam recompression in a dairy company: steam recompression, reused and reintroduced into the industrial process

1.Technical Principle

Original process:

• Steam is injected into an evaporator in order to heat the milk. Use of an -- 6 effects -- evaporator (3 tons of steam / hour).

- Required steam: 15 bars-110 gr steam for 1kg of water
- The steam is condensed and discharged into the natural environment (T 57 $^{\circ}$ C < too low to be reused in the process).

MVR process:

- A MVR is installed on the evaporator
- The MVR recover the steam and recompress then
- The steam thus produced is reintroduced in the

Vapeur d'eau

evaporator

2.Technical Scheme Refer to Figure 1.

3.Benefits

Allows to reduce the steam need by:

• Modification of the buildings and construction of a concrete foundation to support the compressor.

- Adaptation of piping: modification of evaporation inputs and outputs (to allow an exchange between the incoming milk and the outgoing condensates, in order to cool the condensates before their storage and to recover calories for milk heating) ,modification of condensates and washing piping.
- Implementation of measuring devices in order to permit the automation of the compression system
- Implementation of sheaths to recover steam milk.





BAT6: Gas Absorption Heat Pumps

1.Technology description

The system functions in a closed cycle:

•Absorption of the ammonia (NH_3) gas in the presence of water to form a concentrated ammonia solution (NH_4OH) . This action releases a large amount of high temperature heat.

•This ammonia solution (NH₄OH) is desorbed, which allows the release of ammonia (NH₃) gas. This desorption action needs heat.

The principle is the use of ammonia (NH_3) in a secondary cooling cycle that will 'pump' the heat from a cold source (in the evaporator) and return it to the hot source (the condenser): this heat is free.

By combining the release and the absorption of heat along the whole process, the energy balance is clearly positive.

2. Technical Schematic



3.Level of Energy Savings

Some manufacturer claims performance (Coefficient of Performance) of about 150%. The performance gas absorption heat pump is influenced by the parameters shown in the table below:

Influent parameters	Level of Influence
Cold source temperature	low
Hot source temperature	average
Charge rate	high

4.Market prospect

An innovative solution to meet the thermal requirements of collective housing and tertiary buildings, for construction as for rehabilitation.

5.Economic Characteristics

An economical solution:

• Significant operating gains thanks to very high returns on primary energy.

• The geothermal version is immediately profitable thanks to heat recovery from the absorption reaction: the required probes size is reduced to 70% compared to an equivalent electric heat pump.

The net price for the installation of a geothermal heat pump absorption gas is about €14,000 VAT (source: CEGIBAT-GRDF).

6.Social Characteristics and co-benefits

- Respect of the environment
- Use of eco-friendly refrigerants fluids that respect the ozone layer (without HFCs or HCFCs).
- Qualities of natural gas: cleanliness,flexibility,and use of combustion products with low levels of CO₂ and NO_x.
- Contribute to sustainable development by minimizing the greenhouse effect.
- Source: Energie plus / ATEE

BAT7: Electrical Injection Moulding Press

1.Technology description

An electric press uses electric motors instead of the hydraulic activation system of the cylinders. Therefore,all losses linked with the hydraulic system are eliminated.

The electrical power of the machine is the power rating indicated on the press.



2. Technical Scheme

All electric injection press (source FARDI).



3.Level of Energy Savings

Electricity consumption reduced by 50% to 70%. Energy savings from hydraulic to electric press (source FARPI).

4.Market prospect

Automotive, medical, electronics (mobile phones ...), packaging, technical mouldings (household appliances, furniture gardens, toys.)

5.Economic Characteristics

In terms of profitability, the fully electrical press has

a decisive advantage on the conventional hydraulic press which is his very low operating cost: electricity consumption up to 60% lower, very low cooling water consumption, no waste oil treatment, little maintenance.

The electrical press also brings an increase in productivity (shorter cycle times), an improved production quality, decrease number of pieces which contribute to a significant improvement in the profitability of electric presses.

6.Social Characteristics and co-benefits

- \bullet Electricity consumption reduced by 50% to 70%
- · Accuracy and repeatability starting from the early cycles
- More oil
- Low water consumption
- Low noise level <65dB

• High measurement accuracy for positions and speeds:

-Positioning accuracy to 0.01 mm

- -Accuracy 10 times higher than for a hydraulic press
- -No set point overshoot risk
- -Accuracy and repeatability on all machine movements

•Direct impacts on the quality of the moulded parts:

- -Accuracy and consistency of the injected volumes
- -Reduction of waste (due to the reduction of noncompliant pieces) decrease of material cost...)
- Facilitates automation (robotics, gripper,...)
- Accuracy and repeatability of the opening movement and ejection

(Source BILLION 2011)

BAT8: Regenerative Self-recuperative Burners

1.Technology description

Recuperative and self-regenerative burners have been developed to allow the direct recovery of waste heat by preheating the combustive air.

A recuperator is a heat exchanger that extracts the heat from furnace outgoing flue gases to preheat the combustive inlet air. Compared with ambient air combustion systems, energy savings can reach 30%. They usually preheat the air to a maximum temperature of 550°C to 600°C. It is then possible to use recuperative burners in high temperature processes (700°C~1 100°C) Regenerative burners work by pairs and on the principle of short-term heat storage using ceramic heat regenerators (see drawing). They recover between 85% and 90% of the waste gas heat. therefore the incoming combustion air can be preheated to very high temperatures of up to 100°C to 150°C below the operating temperature. It can be applied to temperatures ranging from 800°C to 1500°C. The decrease in fuel consumption can reach 60%.

2. Technical Scheme



Figure:Operating principle of the regenerative burners.

3.Level of Energy Savings

In industrial furnaces, combustive air can reach temperatures of between 800° C and 1350 ° C, through a high performing heat exchanger. For example, a modern regenerative heat exchanger switched on a high cycle can recover of about 90% of the waste heat, which generates large energy savings.

4.Market prospect

Widely Applied.

5.Reliability

The main technological constraint for recuperative/regenerative burners is the conflict between technologies designed to reduce emissions and those focused on energy efficiency.

The formation of NOx, for nitrogen-free fuels, usually depends on the temperature, the oxygen concentration and the residence time. Due to the high temperatures of the preheated air and to the residence time, the flames have a peak of temperature that lead to an increase in NOx emissions.

6.Economic Characteristics

These burners have the disadvantage of their investment cost. Reducing energy costs alone rarely permits to compensate the initial additional investment. This is why the increase in productivity within the furnace and the reduction of emissions of nitrogen oxides are important factors to include in the cost / benefit analysis.

BAT 8 Application Examples

Application 1: Heat recovery on an industrial furnace burner

This sheet concerns the implementation of a regenerative or a self-recuperative burner (self-regenerative or pair of regenerative burners),or the implementation of a centralized heat recovery of fumes to preheat the combustive air of an industrial natural gas furnace,at a temperature over 600°C.

A gas burner is a mechanical element which ensures the production of heat by mixing a fuel gas with air containing oxygen. This mixture produces combustion.

Except in the few cases for which it is possible to consume most of their heat, the fumes leave the furnace at a temperature which may still be high, often close to the operating temperature. It is therefore interesting, to limit energy consumption, to recover the thermal energy contained in the fumes before they are released to the atmosphere to preheat the combustion air. Thus, the inlet air is already preheated and allows a reduction of as much as the spared gas consumption.

1.Technical Principle

The devices to implement the recovery are described below.

(1)The hot air burners: heat recovery on exhaust or centralized recovery system

The system works with a gas heat exchanger placed at the furnace outlet to preheat the intake air. The heat recovery is called 'centralized' because all the exhaust leaving the furnace as well as all the air injected into the furnace pass through this exchanger. The efficiency of the recovery is related to the system ability for preheating the combustive air. The recovery efficiency of this type of burner is between 40% and 50%. In some cases, the furnace fumes are diluted with some fresh air before entering the heat exchanger in order to avoid damaging it.

(2) The self-recuperative burners

The combustion chamber is a metal or a ceramic tube open at its end. The entering air passes near the return of hot fumes. The burner possesses fumes recirculation system (fins,asperities on the burner tube) to increase the exchange surface with the incoming combustion air. It is used 'alone'for direct heating or encapsulated in a radiant tube. These burners are used for two types of temperature ranges: 600°C~1000°C and 1000°C to 1300°C.

The areas of application are first heat treatment batch furnaces or other furnaces with long treatment duration. The recovery efficiency of this type of burner is between 50% and 70%.

(3)Self-regenerative burners and pairs of regenerative burners

These burners are associated in pairs: the first one works while the other, stopped, 'vacuums' the fumes of the first one and heats a thermal mass ceramic (the regenerator). Then the air of the second warms passing through the regenerator. They alternate the operations each minute.

If installed with well-sealed valves and complete control systems, the burner can be self- regenerative and vacuum its own fumes through a set of heat loads disposed locally around the burner nose.

These burners used at high temperatures (700°C

~1400°C) are very economical in operation but still require a big initial investment and should operate in a clean environment (absence of clogging or pollution of evaporated metal).

These systems allow preheating the air up to 50°C below the process temperature.

The main application areas are those where the temperature is high enough for the investment to be relevant. Today it mainly concerns glass melting furnaces, aluminium reflow ovens, steel reheating furnaces and heat treatment furnaces.

Burners of this type have a recovery efficiency of 70% to 90%.

2. Technical Scheme

Refer to Figure 1 to 4.

3.Scope of Application

The data from the literature and from manufacturers demonstrate that these burners only bring significant energy gain for the furnaces of over 600°C. Thus,the considered park concerns industrial furnaces whose temperature is higher than 600°C. The available statistical data are based on the CEREN Study No. 0305 'extrapolation of equipment in 2008 in the industry ' in September 2011. Refer to Table1.

4. Energy Saving Capacity

The energy savings brought by replacing classical burner by heat recovery burner only come from the preheating of the air in the burner. They depend on the following criteria:

Criterion 1: Nominal power of the burner. It represents the furnace gas power need.

Criterion 2: Annual average load factor of the burner. This is the ratio between the energy supplied during a determined time interval, and the nominal power in continuous operation multiplied by this time interval.

Criterion 3: Annual operating time.

Criterion 4: Gains related to the combustion air heating. This is the function of the outlet fumes temperature and the temperature of the preheated air.

The values of recovery efficiency (noted ε) for different types of recuperators are as follows:

-40% to 50% for centralized heat recovery systems, which



Figure 1: centralized recovery

Figure 2: self-recovery system



Figure 3: pair of regenerative burners

Figure 4: self-regenerativesystem

Application	600- 750°С	750- 1000°C	1000- 1250°C	> 1250°C
Fusion de ferreux				Х
Fusion d'alliages légers (aluminium)		Х		
Fusion d'autres non ferreux (cuivre, bronze)		Х	Х	
Traitement thermique de ferreux	X	Х	Х	
Traitement thermique de non ferreux	X			
Chauffage avant formage de ferreux (forge)			Х	
Chauffage avant formage de non ferreux (forge)	X			

Table 1

preheats the air for a hot air burner. -50% to 70% for self-recovery burners.

-70% to 90% for (self) regenerative burners.

5.Implement Cases

Increase of the capacity of a rotary hearth furnace for heating steel billets by continuous regenerative heat exchanger (Valti): 20% in specific fuel consumption,+33% at max production. Construction of a new forging mobile hearth furnace equipped with self-regenerative burners (Forecast): -50% of CO_2 emissions,NOx <250 mg/ Nm³ to 3% O_2 .

BAT9: Very High Efficiency Electric Motors

1.Technology description

The operating principle of electrical motors is very simple. In physics, we know that the application of an electric current in a magnetic field generates a mechanical force.

An electric motor contains coils of wire (same wire as the one used to carry the current). This coil winding is perpendicular to the magnetic field of the electric motor. As a magnetic field has always two poles,the ends of the wires are placed in opposite directions. This configuration creates a rotary motion.

The torque is controlled by increasing the wire windings on the armatures. The magnetic field is generated by an electromagnet. This design allows the rotor to pivot under the influence of the electromechanical force. Very few parts are exposed to wear. With these two factors combined,the electric motors can operate for extremely long periods of time,almost without wearing.

The efficiency of an electric motor is given by the ratio between the delivered mechanical power and the electrical power consumption. The increase in efficiency allows for the same delivered mechanical power,to consume less electricity. For the manufacturers,the search of electrical efficiency is driven by the environmental objective,but also by looking for economy and performance.

The purpose of using efficient engines is to achieve the

same work than with a traditional engine while consuming less energy. It is therefore very important to choose the right motor for the job. For optimal performance, it is recommended that the engine load level corresponds to about 75% to 90% of the nominal motor power.

2. Technical scheme



•The frame: it contains all the components of the electric motor.

•The shaft: It receives the energy generated by the motor rotation. It transmits it to an external system via a mechanical connection. A metal part extends outwardly of the frame.

The stator: it is stationary and it is usually the magnet of the electric motor. It can be a permanent magnet or an electromagnet. An electromagnet includes windings usually made of copper wire.

The commutator: located near the stator, it reverses the direction of the current in the device. It is one of the only moving parts of the electric motor.

Brushes: The brushes are in contact with the commutator and complete the electrical circuit required for the passage of the current to the windings.

Bearings: They carry the motor shaft and are mounted in the frame walls. They allow a free rotation of the shaft with a minimal friction and eliminate interfering movements.

Armature: This conductive component is located. Through the combined effect of the magnetic field and the winding, it generates the mechanical torque which triggers the rotation of the shaft.

3.Level of Energy Savings

A motor rated IE2 reduces the energy loss by 40% on average. It is recommended to install from now on an IE3 high-efficiency motor. Although the cost of buying a highefficiency motor is higher, the energy savings will quickly offset the initial investment as energy represents more than 80% of the full cost of an engine.

It is estimated that a high-efficiency motor (IE2 or IE3) is paid back in between 24 and 36 months,for a lifetime of about 15 years. For example,for a 15 kW motor,working



Figure: Comparison of the life-cycle cost between high-efficiency motor IE2 and IE3 during 6000 hours/year,the economy will be of about 4MWh/year (being $200 \notin$ / year,with a kWh costing $0.05 \notin$)

4.Market prospect

In the industry and the tertiary buildings, the motors are everywhere. Conveying, cooling, ventilation, pumping, compressed air... It is estimated that 70% of electricity consumption in the industry is due to the motors.

5.Reliability

New standards:

- IE1: Standard efficiency, level equivalent to Eff2
- IE2: High efficiency, equivalent to Eff1 or 'Energy Efficiency' in the US (EPAct'92), applicable from June 2011
- IE3: Premium efficiency, new in Europe or 'Nema Premium' in the US (EISA) applicable starting January 2015 (or 2017 depending on the powers)
- A fourth class is under consideration: IE4: super premium performance.

For high-efficiency motors as for their conventional counterparts. power,speed,and the environment are the main criteria of choice, as well as the targeted application.

6.Economic Characteristics

High performance requirements certainly lead to an increase of the engine cost at purchase. But this increase is offset by the energy savings made throughout the whole life of the engine. In the end,the life cycle cost of high-efficiency motors (IE2 or IE3) would be much lower and made profitable on average between 24 to 36 months.

7. Social Characteristics and co-benefits

Engines consume less energy efficient and heat up less, extending the life of the bearings and windings.

BAT10: Industrial Heating Baths Using Immersed Compact Tubes (ICT)

1.Technology description

In the fabrication of the tubes, the stripping/ pickling step requires heating baths (acids baths, rinsing baths, etc ...). The heating of the bath was previously provided by a boiler:

The acid baths were heated by circulation on a graphite exchanger heated by the vapor coming from the boiler.
The rinsing baths were heated by immersed coils with condensate recovery.

In 1999,the company was confronted to the problem of compliance of its boiler with the standard for monitoring steam generators. Given the age of the existing boiler,it was decided to replace it: two options were available: -Purchasing a new boiler

-Investing in a solution with immersed compact tubes. Despite the higher initial investment, the company decided to choose the immersed compact tubes solution, that reduce by almost half the running costs, especially through the energy savings generated. To ensure a better exchange, some basins had to be modified. In other cases, the tubes have been placed in auxiliary tanks.

During the immersed combustion process, the products of gas combustion indirectly heat the liquid. The heat transfer takes place through the tube immersed in the bath and in which the hot gases are pushed from their source. The gases emerge at the end of the tube located outside the basin.

2. Technical scheme



Immersed Compact Tubes



Heating Process

3.Level of Energy Savings

By modifying its process, the company achieved a 40% energy saving on heating baths.

4.Market prospect

Surface treatment basins, every kind of industrial baths.

5.Reliability

Mature technology.

6.Economic Characteristics

Refer to Table1.

7. Social Characteristics and co-benefits

Beyond the achieved energy savings, the elimination of the steam in the pickling/stripping workshop has simplified the piping system, it has reduced the consumption of drinking water and the condensates generated and it reduces the risks associated with the generation of steam. In a more general manner, the technology of immersed compact tubes allows: -An efficiency that can reach 77% to 81% -Reduced dimensions compared to conventional systems, allowing thus the installation of the in baths of

-An excellent profitability

binding forms, narrow or shallow.

Table	1
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Bilans	ANCIEN PROCÉDÉ	NOUVEAU PROCÉDÉ
Bilan des matières Consommation d'énergie pour le chauffage des bains (MWh/an)	10 867	6 520
Économie (MWh/an)		4 347
Blan économique Economie d'énergie (€/an) Economie de frais de maintenance et de traitement des eaux résiduaires (€/an)		58 500 21 000
Économie annuelle (€/an)		79 500
Investissement (€)		75 000
Amortissement de l'investissement		11 mois