Energy Efficiency for industrial boiler houses - State of art and latest innovations

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Energy Efficiency for industrial boiler houses

State of art and latest innovations

Agenda

1. Why implement High energy & environmental efficiency boilers technologies
   a) Energy audits & Energy balance of the plant
   b) Best practices To increase Energy efficiency of steam production
2. Best available technologies for industrial boilers
3. New combustion technologies : Flameless Combustion for Boilers
4. Conclusions
Why implement High energy & environmental efficiency boilers technologies

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Industrial Steam and Energy Efficiency

- Process heating
- Vacuum jets
- Heat Ventilation Air Conditioning
- Shaft work for mechanical drives
- Power generation
- Space heating

Process heating accounts for an average of more than 60% of thermal energy use in industries, predominantly in the form of steam.

\[ \frac{\text{kg Steam}}{\text{kg products}} = \text{KPI} \]

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Energy Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Super Heated steam</td>
<td>Electricity production</td>
</tr>
<tr>
<td></td>
<td>60 bar, 480°C</td>
</tr>
<tr>
<td>Saturated Steam</td>
<td>Processes; vessel</td>
</tr>
<tr>
<td></td>
<td>15-20 bar, 190°C</td>
</tr>
<tr>
<td>Saturated Steam</td>
<td>Process vessel</td>
</tr>
<tr>
<td></td>
<td>4 bar</td>
</tr>
<tr>
<td></td>
<td>Heat exchanger, vacuum,</td>
</tr>
<tr>
<td></td>
<td>HVAC</td>
</tr>
</tbody>
</table>
1.a Energy audits & Energy balance of the plant
High level of energy & environmental efficiency for industrial boilers

Energy & Environmental efficiencies are key criteria of profitability of industrial activities.

Energy & environmental directive reinforce drastically the needs of reduction on Energy consumption & pollutant emissions (NOx; Sox…)

- 4 main strategies to improve efficiency of industrial Boiler houses

1. Energy audits of Boilers house & steam grid
2. Implement high efficiency solutions ➔ high efficiency boilers, flameless combustion, Control command
3. Do heat recovery in order to reduce heat losses
4. Adapt operation conditions to real needs of the factories
a- Energy audits – Contents

Energy audits:
✓ Collect existing data
✓ Do specific complementary measurements /monitoring
✓ Analyze data and study possible actions of progress

Output / Interests:
✓ Have a complete view of main consumption posts
✓ Quantify consumption per process
✓ Define priorities and targets
✓ Do benchmarking between factories or competitors

Energy & fluid flux on plants:
✓ Pinch analyze
✓ Energy/utilities flux diagram
✓ Quantities per process
✓ Analyze et studies of trends

Standards:
EN 16 247
Good Practices X30-120
ISO 50 001

RESULTS
a - Energy audits, energy flux optimization; advanced control & energy factory dashboard
Consultancy services on Energy Efficiency on industrial processes – CRIGEN Services offers on Energy Efficiency

- **Energy Audit**
  - For improving your energy efficiency

- **Services on Thermal processes & utilities**
  - For securing & optimizing Production

- **Services on Electrical Equipments**
  - For securing & optimizing electrical network

- **Special Energy Study**
  - For studying new processes or convert to new energies
CRIGEN Key figures

100 expert interventions carried out each year

more than 20 years of experience and research into the rational use of energy in all industrial sectors

30 experts on hand to help you

5% to 25% energy savings frequently achieved by our customers
Consultancy Expert services in industries:
Metallurgy, Food, Glass, automotive, Chemical
1.b Best practices To increase Energy efficiency of steam production
Steam utilization & energy efficiency
4 Key actions for Energy Saving and good KPI (kg Steam / kg products)

1. Adapt production to the needs (HP steam or LP Steam or hot water?)
2. Steam Supply according to the «daily» needs
3. Investigate potential areas for condensate return
4. Steam grid & traps: The primary purpose of a steam trap is to discharge condensate
Example of industrial Steam production Grid

Boiler house ➔ steam grid ➔ heat recovery (condensate return)
Best practices
Adapt steam production & networks to real needs:
“Use the right enthalpy level”

Detect what is not useful

<table>
<thead>
<tr>
<th>Capex</th>
<th>Energy savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Need detailed study</td>
<td>&lt; 7 %</td>
</tr>
</tbody>
</table>

Example of non optimize Steam production system
Best practices: Adapt steam production & networks to real needs: Centralized/Decentralized Steam production?
Best practices:
Energy efficiency of boiler house – Heat recovery/Economizer heat exchanger

Implemented between boiler & chimney, it use to preheat crude/feed water for boiler

Reduce temperature of flue gas by 20°C increase 1pt energy efficiency of boiler

But implementation need to be studying (vs fuel-oil)
Best practices:
Energy efficiency of boiler house – Heat recovery
/(Condensing heat exchanger)

Implemented between boiler & chimney, it uses to preheat water of feed water tank of the boiler

Case study:

Data:
- boiler 5 t/h
- Process water:
  - Temperature input: 30°C
  - Temperature output: 55°C
- Operation time: 16 h/day
- Steam
- CAPEX: ~100-150 kSGD

Results:
- Costs saving: 83 kSGD/y
- CO₂ emissions saving: 302 tones
- ROI: 1.9 years
Best practices: Optimization of condensate returns & reduce steam leaks

Reduce Steam leaks could achieve 3 to 5 % energy saving!
Case study: Energy efficiency Data for industrial Boilers:

40 MW boiler for Saturated Steam

- Operating time 8000 h / y
- 12 stops and restarts per year for process
- Steam pressure & temp. 30 bars - 234°C
- Nominal Efficiency of boiler 94.5 % vs NCV

2 case studies for different rate of condensate return

1. Condensates return 30 %
2. Condensates return 70 %
Energy efficiency data for industrial boilers

1- Condensates return level 30%

SEC= 840 kWh/t ➔ 63 SGD/ton

Energy saving: 4.3%

2- Condensates return level 70%

SEC= 804 kWh/t ➔ 59 SGD/ton
Best practices – Dearation syst. for energy efficiency (1/2)

<table>
<thead>
<tr>
<th>CAPEX (SGD)</th>
<th>Energy savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>312 042</td>
<td>1,5% boiler consumption (Blow-down =3%)</td>
</tr>
</tbody>
</table>

- **Water**
- **Condensates From utilisation**
- **Feedwater tank**
- **Continuous blow-down**
- **Air heater**
- **Extraction**
- **Combustion gas**
- **Steam utilisation**
Best practices – Dearation syst. for energy efficiency (2/2)

**CAPEX ($S)**

| Energy savings | Detailed Study | 0,4 % 1,5% boiler consumption |

**Condensates From utilisation**

**Water Heat & Treatment**

- 30°C
- 50-90°C

**Steam utilisation**

- 160 - 250°C
- 80 - 250°C

**Combustion gas**

- 130°C

**Air heater**

- 90°C

**Extraction**

- 10-20°C

**Extraction**

- 30°C
Audit of Boilers performance and boiler houses

<table>
<thead>
<tr>
<th></th>
<th>Boiler house 1</th>
<th></th>
<th>Boiler house 2</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Boilers</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Power (KW)</td>
<td>2453</td>
<td>2453</td>
<td>2453</td>
<td>2453</td>
</tr>
<tr>
<td>Efficiency (%)</td>
<td>83,1</td>
<td>88,2</td>
<td>89,48</td>
<td>89,2</td>
</tr>
<tr>
<td>New modern</td>
<td></td>
<td></td>
<td></td>
<td>95,2</td>
</tr>
<tr>
<td>boilers efficiency</td>
<td></td>
<td></td>
<td></td>
<td>(%)</td>
</tr>
<tr>
<td>Efficiency deviation in</td>
<td>21,9%</td>
<td>16,7%</td>
<td>15,5%</td>
<td>15,8%</td>
</tr>
<tr>
<td>regards of Best</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>available boiler</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>technology (Condensing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>boiler)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Deviation</td>
<td></td>
<td>17,5%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Boiler recommendations**
  - Hydraulic balancing to checked to establish the levels of distribution and possible optimizations
  - Retrofit natural gas blowers system with only one blower to avoid pressure variations
  - Upstream natural gas supply pressure increasing (discussion with the natural gas operator) to use high efficiency burners
  - Replace the 7 boilers by 4 boilers and adapting to a pressure of 4 bar (don’t change pressure for these boilers).
<table>
<thead>
<tr>
<th>Purpose</th>
<th>Action</th>
<th>Energy Savings ($SGD)</th>
<th>CAPEX ($SGD)</th>
<th>Payback (year)</th>
<th>Detailed CAPEX</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steam</td>
<td>Hydraulic balancing + steam design improvement + adjustment of NG boiler pressure adjustment</td>
<td>Max = 420000 (5%)</td>
<td>20 000 + Invest Materials</td>
<td>&lt; 0,5</td>
<td>Detailed study by CRIGEN, implementation, adjustments, tests,</td>
</tr>
<tr>
<td></td>
<td>Maintenance program steam traps</td>
<td>&gt;140 000 (2%) &lt; 420000 (5%)</td>
<td>10 000+ news traps</td>
<td>&lt; 1</td>
<td>steam traps maintenance definition, retrofit if required</td>
</tr>
<tr>
<td></td>
<td>Retrofit boilers House 1</td>
<td>540 000</td>
<td>1 008 000</td>
<td>2,1/1,4 (w/o condensation.)</td>
<td>Detailed study by CRIGEN definition of new boiler, implementation, test</td>
</tr>
<tr>
<td></td>
<td>Retrofit boilers House 2</td>
<td>290 000</td>
<td>500 000</td>
<td>1,7/1,6 (w/o condensation)</td>
<td>Detailed study by CRIGEN + new boiler definition, implementation, test</td>
</tr>
<tr>
<td>Air conditioning</td>
<td>Adjustment air conditioning by zonal set-point</td>
<td>20% of air conditioning consumption</td>
<td>50 000 &lt; 100 000</td>
<td>&lt; 1</td>
<td>Detailed study by CRIGEN + process control upgrading + tests.</td>
</tr>
<tr>
<td>Cold water</td>
<td>Adjust the cold water temperature to needs</td>
<td>3% to 5% cold water production</td>
<td>20 000</td>
<td></td>
<td>Detailed study by CRIGEN + adjustments + tests</td>
</tr>
<tr>
<td></td>
<td>Assessment by frequency inverters cooling towers should be strengthened..</td>
<td>3% cold water production</td>
<td>Detailed study, + materials + tests</td>
<td>&lt;</td>
<td>Detailed study by CRIGEN + adjustments + tests</td>
</tr>
<tr>
<td>Air compressed</td>
<td>Reduce operated pressure</td>
<td>&lt; 15% of air production consumption</td>
<td>3000</td>
<td>&lt; 0,4</td>
<td>Detailed study, + adjustments + tests</td>
</tr>
</tbody>
</table>
Best available technologies for industrial boilers

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Industrial Boilers:

Three main types:
- Flue gas pipe Boilers
- Water tubes Boilers
- Flash boilers

Two main components of Boilers:
- Heater Body & Heat exchangers
- Burner/combustion system
Flue Pipe Boilers: Small & medium size

Power Range

Steam capacity:
- ≤ 30 t/h of steam for a mono heating chamber
- ≤ 50 t/h of steam for a double-heating chamber

Steam pressure up to: 30 bars

Specifications:
- High water volume
  - Inertia for starting / shutdown
  - Punctually, Capacity prod > nominal capacity
- CAPEX less than other type (~ 24 kSGD/ton - series making)
- Easy to maintain and operate
- Could operate automatically
- Easy & simple water treatment system

Industrial appliances

All type of industries:
(paper, food industries, general industries.....)

Heating of buildings

Warning!

- Body sensible to rapid temperature and high variation of load (welding damages)
- Body sensible to over heating (cracks on steel plate Long term effect)

Energy Efficiency = 92 to 95%
Water tubes Boilers: Medium & Large size
Water tubes Boilers: Medium & Large size

Energy Efficiency = 89 to 92%
Water tubes Boilers : Medium & Large size

**Power Range**
Large Range: Some MW to several Hundred MW

**Steam capacity:**
From 30 t/h to more than 400 t/h of Steam

**Steam pressure up to:**
several hundred Bar

**Industrial appliances**
All type of industries: Super heating steam (Energy production) ..... Saturated Steam (industrial appliances - heavy industries)
Multifuels (gas, process gas, fuel-oil, coal....)
Biomass Boilers

**Specifications:**
- Low water volume storage
  - Low Inertia for starting / shutdown
  - Flexible
- CAPEX (~ 80 kSGD/t of steam)
- Good steam quality, Super heating available
- High pressure of steam available
- Operation & maintenance not so easy ➔ Large capacity

**Warning!**
- Quality of water to be controlled ➔ to avoid tube issues
- Need qualified operator
- Operation & Maintenance costs higher
Industrial Flash boiler: Small size

Energy Efficiency = 85 to 90%
Flash Boilers: Small Size

**Power Range**
Small Range: ~10 KW to several MW

**Steam capacity:**
From 0.1 t/h to 10 t/h of low & medium pressure Steam

Steam pressure up to: 20 bar

**Industrial appliances**
All type of industries using saturated steam:
(Food industries, small industries needing rapid variation of flow but small amount of steam)

**Specifications:**
- Low water volume storage
- Rapid starting / shutdown
- Very Flexible
- CAPEX (~30 - 40 kSGD/t)
- Low pressure of steam available
- Operation & maintenance easy
- Regulation with less constraints
- Could be use for decentralized production

**Warning!**
- Quality of water & steam to be controlled ➔ to avoid issues
- Be aware of pressure losses in the steam grid
- Operation & Maintenance costs higher
3

New combustion technologies: Flameless Combustion for Boilers

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Combustion systems & burners for Boilers
Often Multifuel and Low Nox emissions

From 1 to 7 MW
Mono blocs Burners

From 10 to 20 MW
Specific burners
Combustion systems & burners for Boilers

Burner with mecanical air/fuel control system

Burner with numerical air/fuel control system
Combustion systems & burners for Boilers – Often multifuel burners (nat gas, process gas, biogas, Fuel-oil...)

Fuel-gas (NG, petrol gas, Biogas)

Fuel-oil burners
Combustion system for boiler: (Example of modern NG combustion system)
Specifications:

- High seed fuel & gas injection 50 à 80 m/s
- Power from 300 kW to 100 MW
- Various appliances
- High level of air/fuel staging

Next challenge: Ultra Low NOx burners
The CANOE Project (Clean fIAMEless combustion for bOilEr) : An innovative ENGIE concept of Ultra-low NOx burner for boiler

Objectives:
- An innovative concept of burner to meet 2020 regulation on NOx emissions (NOx < 25 mg/Nm³@3%d’O₂)
- A Crigen patented technology & defined as advanced technology for boiler by UE (EGTEI)

Benefits:
- Respect the future emission standards (NOx)
- Improve the consistency and efficiency of heating
- Having a privileged access to new and innovative environmentally friendly technology for industrial boilers using natural gas (investment project operator heater)
4 Conclusions

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Energy & Environmental efficiencies are key criteria of profitability of industrial activities (Steam prod. ~ 60% of industrial energy uses)

Energy & environmental directive reinforce drastically the needs of reduction on Energy consumption & pollutant emissions (NOx; Sox…)

■ 4 main strategies to improve efficiency of industrial Boiler houses

1. Energy audits of Boilers & steam grid

2. Implement high efficiency solutions ➞ think innovation! (ex: high efficiency boilers, flameless combustion, Control command…)

3. Do heat recovery in order to reduce heat losses

4. Adapt operation conditions to real needs of the factories
Boilers & Energy efficiency

Reduce Exhausted gas temperature

- Improved operation and maintenance of boilers: Up to 5%
- Radiation losses: minimize by insulation and plant scheduling: Up to 1%
- Improved water treatment and boiler water conditioning (Heat transfer gas and water side): Up to 2%
- Total dissolved solids (TDS) control and minimize by water treatment: Up to 2%
- Blowdown heat recovery: Up to 3%
- Boiler and burner management systems, digital combustion controls and oxygen trim: Up to 3%
- Economizer: Up to 5%
- Combustion air pre-heating Variable speed drives (VSDs) – for combustion air fans: Up to 1%
CRIGEN is the operational R&D center of ENGIE group, dedicated to gas, new energies and emerging technologies

Research & Technology Division

"crigen"

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