WASTE HEAT RECOVERY SYSTEMS

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**INTRODUCTION**

**Transparent** has developed wide variety of superefficient Heat Recovery Systems for harnessing all types of waste heat, originating from various fuels and from different industrial sources.

The Waste Heat Recovery Boilers are provided with Economizers which improve their thermal output and efficiency.

Transparent superefficient Waste Heat Recovery Systems find ideal applications in Cogeneration Systems working on Reciprocating Engines and Gas Turbines.

**Various sources of waste heat.**

- Exhaust heat recovery from Reciprocating Engine driven Gen-sets used for Captive Power Cogeneration and Independent Power Production.
  - Heavy fuel fired
  - Gas fired
  - Diesel fired
- Exhaust heat recovery from Gas Turbine exhaust.
- Jacket heat recovery from Engine
- Hot Waste Gases from
  - Scrap melting steel furnaces
  - Cement kilns
  - Industrial furnaces
  - Incinerators
  - Process Waste Gases

**Converting into useful form**

Energy is consumed in various forms like steam, hot water, Chilling, refrigeration etc. at different places. Please refer next page for separate matrix to check different useful forms of energy to which this waste heat can be converted. **Transparent** has expertise in converting this waste energy into the most beneficial form of energy for any customer.

**Various models of heat recovery systems**

**Transparent** has developed following wide range of ‘application specific designs and constructions’ of Waste Heat Recovery systems / HRSGs for above applications.

Various designs of Waste Heat Recovery Systems are:

- Recostar – FI: Finned Water tube IBR.
- Recostar – S: Smoke tube IBR.
- Recostar – WC: Bare Water tube, IBR.
- Recostar – WCOF: Water tube, co-flow (concurrent flue-gas flows) IBR.
- Recostar – WCRF: Water tube cross tube IBR.
- Recostar – CC: Cylindrical coil type once through.
- Recostar – PC: Pancake coil type once through.
- Recostar – SCMP: Smoke tube, composite unfired plus fired type.
- Recostar – JW: Engine jacket water heat recovery system.
**Product Details**

- **Type**: Finned, Water Tube, IBR
- **Installation**: Horizontal & Vertical, Indoor as well as Outdoor
- **Tube Orientation**: Horizontal & Vertical
- **Waste Gas Flow Direction**: Horizontal/Vertical (Upwards & Downwards)
- **Quality of Waste Gases**: Normally clean dust free gases
- **Acceptable dust in waste gases**: Moderate dust level acceptable for Boilers having vertical fin orientation with mechanized soot removal and collecting facility.
- **Type of output**: Steam- D&S/ Superheated, Hot Water, Hot Thermic Fluid
- **Media of Waste Heat**: Hot gases, Hot bulk powders, hot liquids, hot vapours.
- **Typical applications**: Process heating, hot water generation, Thermic Fluid heating, Power generation, Cogeneration applications.
- **Number of heat recovery stages possible**: 3 to 4 stages of heat recovery possible e.g. super-heater evaporator, economizer, water preheater

**Case study**

- **Waste heat source**: Engine generator exhaust
- **Capacity of Engines**: 800KW X 1 No.
- **Fuel fired in Engines**: HSD
- **Total flue gas quantity**: 4000 Kg./Hr.
- **Flue gas inlet temp.**: 518°C
- **System configuration**: Main WHRB + Economizer
- **Flue gas outlet temp.**: 151°C
- **Output type**: Steam at 10 Bar(g)
- **Output at 100% load**: 700 Kg./Hr (F & A 100°C)
**Product Details**

- **Type**: Smoke Tube IBR
- **Installation**: Horizontal & Vertical, Indoor as well as Outdoor.
- **Tube Orientation**: Horizontal / Vertical.
- **Waste gas flow direction**: Horizontal / Vertical (upwards & downwards)
- **Quality of Waste Gases**: Low dust level acceptable.
- **Type of heat recovery output**: 1) D & S / superheated 2) Hot Water 3) Vapour phase Thermic Fluid Heating
- **Media of Waste Heat**: Hot gases, hot liquids, hot vapors
- **Typical applications**: Exhaust of steel furnaces, cement kilns, metal smelters, Incinerators, Industrial furnaces, DG set exhaust, process waste gases, Incinerator exhaust, furnace exhaust, Gas turbine exhaust.
- **Output capacity possibilities**: Typically 15 TPH
- **Number of heat recovery stages possible**: 3 to 4 stages of heat recovery possible e.g. super-heater, evaporator, economizer, water preheater.

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**Case study**

- Waste heat source: Engine generator exhaust
- Capacity of Engines: 1 MW X 1 No.
- Fuel fired in Engines: Furnace oil (Heavy oil)
- Total flue gas quantity: 24000 Kg./Hr.
- Flue gas inlet temp.: 305°C
- System configuration: Main WHRB + 2 stage Eco.
- Flue gas outlet temp.: 181°C
- Output type: Steam at 10 Bar(g)
- Output at 100% load: 1500 Kg./Hr (F & A 100°C)
**Product Details**

- **Type**: Water tube, coflow (Cocurrent gas flow) IBR
- **Installation**: Horizontal / Vertical, Indoor as well as Outdoor
- **Tube Orientation**: Vertical.
- **Waste gas flow direction**: Vertical
- **Quality of Waste Gases**: Specially suitable for dust laden gases. Provided with special mechanized soot removal and collection system.
- **Acceptable dust in waste gases**: High dust level readily accepted
- **Type of heat recovery output**: 1) Steam– D & S/Superheated  
  2) Hot Water  
  3) Hot Thermic Fluid
- **Media of Waste Heat**: Hot gases, Hot vapours
- **Typical applications**: Process heating, hot water generation, thermic fluid heating, power generation, cogeneration.
- **Output capacity possibilities**: No Limits.
- **Number of heat recovery stages possible**: 3 to 4 stages of heat recovery possible e.g. super-heater, evaporator, economizer, water preheater
- **Protection against sulphur corrosion on cold end side**: Provided by various means to ensure that metal temperature is maintained above the actual incipient limit.

**Recostar WCOF : Flow diagram ( Vertical )**

**Case study**

- **Waste heat source**: Engine generator exhaust
- **Capacity of Engines**: 3.8 MW X 1 No.
- **Fuel fired in Engines**: Furnace oil ( Heavy oil )
- **Total flue gas quantity**: 32180 Kg./Hr.
- **Flue gas inlet temp.**: 327°C
- **System configuration**: Main WHRB + Economizer
- **Flue gas outlet temp.**: 185°C
- **Output type**: Steam at 10 Bar(g)
- **Output at 100% load**: 1950 Kg./Hr (F & A 100°C)
**Product Details**

- **Type**: Water tube cross flow IBR
- **Installation**: Vertical, Indoor and Outdoor.
- **Tube Orientation**: Vertical.
- **Waste gas flow direction**: Horizontal
- **Quality of Waste Gases**: Moderately clean gas desired. Provided with mechanized Soot removal and collection System.
- **Acceptable dust in waste gases**: Moderate dust level accepted
- **Type of heat recovery output**: 1) Steam– D & S / Super-heater
  2) Hot Water
  3) Vapour phase thermic fluid
- **Media of Waste Heat**: Hot gases
- **Waste heat source suitability**: Exhaust of steel furnaces, cement kilns, metal smelters, incinerators, industrial furnaces, DG set exhaust process waste gases, Incinerator exhaust, Furnace exhaust, gas turbine exhaust. (Gases with temperature less than 550°C)
- **Typical applications**: Process heating, hot water generation, thermic fluid heating, power generation, cogeneration.
- **Number of heat recovery stages possible**: 3 to 4 stages of heat recovery possible e.g. super-heater, evaporator, economizer, water preheater.

**Case study**

- **Waste heat source**: Engine generator exhaust
- **Capacity of Engines**: 6.7 MW
- **Fuel fired in Engines**: Natural Gas
- **Total flue gas quantity**: 41000 Kg./Hr.
- **Flue gas inlet temp.**: 418°C
- **System configuration**: Water Tube Cross Flow
- **Flue gas outlet temp.**: 159°C
- **Output type**: Steam at 10 Bar(g)
- **Output at 100% load**: 5060 Kg./Hr (F & A 100°C)
**Product Details**

- **Type**: Smoke tube, composite (i.e. unfired plus fired zone)
- **Installation**: Horizontal, Vertical, Indoor.
- **Tube Orientation**: Horizontal / Vertical.
- **Waste gas flow direction**: Horizontal / Vertical (upwards & downwards)
- **Quality of Waste Gases**: Low dust level desired.
- **Type of heat recovery output**: 1) Steam-D & S / Super-heat. 2) Hot water 3) Vapour phase Thermic Fluid Heating.
- **Media of Waste Heat**: Hot gases, Hot vapors, Hot liquids
- **Typical applications**: Where heat recovery from waste heat needs to be supplemented with fuel firing and installation of two separate boilers unfired and fired has space limitation.
- **Supplementary firing possibilities**: Firing in internal furnace provided in boilers.
- **Number of heat recovery stages possible**: 3 to 4 stages of heat recovery possible e.g. Super-heater evaporator, economizer, water preheater.

**Recostar SCMP : Flow diagram (Vertical)**

**Case study**

- **Waste heat source**: Engine generator exhaust
- **Capacity of Engines**: 1.1 MW X 1 No.
- **Fuel fired in Engines**: Natural gas
- **Total flue gas quantity**: 4780 Kg./Hr.
- **Flue gas inlet temp.**: 598°C
- **System configuration**: Main WHRB+Fired zone+ Eco.
- **N.G. firing in fired zone**: 60 SM³/Hr.
- **Flue gas outlet temp.**: 205°C
- **Output type**: Steam at 10 Bar(g)
- **Output at 100% load**: 2000 Kg./Hr (F & A 100°C)
PRODUCT FEATURES

CONTROL PANEL
The Control Panel is wired with solid conductor single strand wires for easy tracebility. Indications for all temperatures, safety trips provided on panel. Facilities for auto-manual switching of individual devices provided.

EASE OF FLUE GAS SIDE INSPECTION
Front and rear doors are hinged type to provide simple & quick opening for full access to fireside tube surface. This job can be done by a single person.

MAXIMUM HEAT RECOVERY
Heat recovery in multiple stages (3 to 4) with help of single/double stage economizers plus water preheater ensures maximum possible heat recovery from the waste gases. Customer gets nearly 7 to 19 % of additional output compared to other makes.

CUSTOM ENGINEERED / CUSTOM BUILT
Every TRANSPARENT Boiler is specifically engineered and built to every customer’s needs and specifications. Special sizes, sources of heat and auxiliary equipment are no problem with TRANSPARENT.

DIVERTOR VALVE
Specially Designed Three way automatic pneumatically operated, Diverter valve allows facility of bypassing the WHRB without stopping the source equipment. Linear movement of valve assures and positive pneumatic pressure eliminates possibility of any leakage.

INSULATION
Insulation thickness is selected scientifically to minimize heat loss even at a high flue gas temp. (Typical thickness used is 300 mm for 500°C)
Matrix for of converting waste heat in useful form

<table>
<thead>
<tr>
<th>Useful Form Of Output</th>
<th>Source of Waste Heat</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HOEE</td>
</tr>
<tr>
<td>Low Pressure Steam</td>
<td>√</td>
</tr>
<tr>
<td>Medium Pressure Steam</td>
<td>√</td>
</tr>
<tr>
<td>High Pressure Steam</td>
<td>√</td>
</tr>
<tr>
<td>Hot Thermic Fluid</td>
<td>√</td>
</tr>
<tr>
<td>Hot Water (Pressurized)</td>
<td>√</td>
</tr>
<tr>
<td>Hot Water (Non Pressurized)</td>
<td>√</td>
</tr>
<tr>
<td>Hot Air for Process (Dryer etc)</td>
<td>√</td>
</tr>
<tr>
<td>Chilled Water</td>
<td>√</td>
</tr>
<tr>
<td>Chilled Brine</td>
<td>√</td>
</tr>
<tr>
<td>Ice Making</td>
<td>√</td>
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<tr>
<td>Cold Storage</td>
<td>√</td>
</tr>
<tr>
<td>Waste Water Recycling</td>
<td>√</td>
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<tr>
<td>Power</td>
<td>√</td>
</tr>
<tr>
<td>Combustion Air Preheating</td>
<td></td>
</tr>
<tr>
<td>Inlet Air Cooling</td>
<td>√</td>
</tr>
</tbody>
</table>

**Source of Waste Heat**

- HOEE: Heavy Oil Engine Exhaust
- LOEE: Light Oil Engine Exhaust
- GEE: Gas Engine Exhaust
- EJH: Engine Jacket Heat
- GTE: Gas Turbine Exhaust
- IEG: Incinerator Exit Gases
- CPKG: Cement Plant Kiln Gases
- SPF: Steel Plant Furnaces
- HGP: Hot Gases From Process
- GFG: Glass Furnace Gases
- FGFH: Flue Gases From Fired Heaters
- AC: Air Compressors
- HPC: High Pressure Condensate
WHRB INSTALLATION

WHRB Installed on Natural Gas Fired Engine.

Power Generation from waste heat in Cement Industries - Simple Rankine Cycle

WHRB Installed on Heavy Fuel Oil fired engine

Power Generation from waste heat in Cement Industries - Organic Rankine Cycle
COMPARISON

**Safety of Source Equipment**

Back pressure control on flue gas side

*Transparent* provides automatic flue gas monitoring & control system. If the back pressure exceeds the predetermined value, the Diverter Valve automatically diverts the flue gases to stack. This saves the source (Engine or turbine) from getting subjected to excessive back pressure.

No such system exists in other make whrb (standard model). This is quite unsafe for the engine or turbine on which the WHRB is installed.

**Safety of Waste Heat Recovery Boiler**

High steam pressure control

*Transparent* provides automatic steam pressure monitoring & control system. If the steam pressure exceeds the predetermined value, the flue gases are automatically diverted to stack. This eliminates frequent operation of safety relief valve.

No such system exists in other make whrb (standard model). This is quite unsafe for the WHRB. In such case one has to solely depend on safety valve.

Note: Frequent operation of safety valve is an undesirable situation since it is meant for ultimate safety of boiler & supposed to operate once in a while.
**COMPARISON**

**Safety of Waste Heat Recovery Boiler**

**Low water level safety trip**

*Transparent* provides automatic boiler water level monitoring & control system. In case the level falls below safe level, the flue gases automatically bypass the WHRB & go to stack. This eliminates boiler tubes overheating.

No such system exists in other make WHRB (standard model). This is quite unsafe for the WHRB. Overheating of tubes can result into cracking & leakage.

Note: Generally the feed pump & drum level controller system maintains desired level. Anyhow in case of abnormal situation the level can drop in spite of above system due to various reasons such as unavailability of water in F.W. tank, malfunctioning of drum level controller etc.

**Efficiency and Outputs**

*Heat From the Gases*

*Transparent* WHRB recovers maximum possible heat from the gases. It gives at least 7 to 10% extra output compared to other make. This needs a much bigger economizer & high manufacturing cost for *Transparent* but gives benefit to user in terms of more savings.

In other makes, eventhough economizer is provided, heat is recovered up to a temperature level where the manufacturing cost is less. This results in cost savings for WHRB supplier but recurring loss to the user.
**COMPARISION**

**Divertor Valve**

**Transparent Make**

- **Automatic** pneumatically operated.
- Linear movement of valve(poppet). **No possibility of jamming.**
- Positive pneumatic pressure acts as good sealing force continuously when the valve reaches the respective positions. The poppet is pressed against the valve seat by pneumatic pressure **eliminating possibility of any leakage.**
- Force is applied at center of poppet ensuring equal distribution throughout the sealing edges.
- Made of **Stainless steel which can work upto 850°C continuously.**

**Other Make**

- **Manually** operated.
- Swing type movement of valve(flap). **Possibility of jamming.**
- No positive force is applied after the flap reaches its respective positions. The mechanical play in the gearbox results in small opening due to self weight of flap & flue gas back pressure. This **can result in leakage in the long run.**
- Force is applied at one end of flap. This results in unequal force distribution. The distant edge gets less force.
- Made of carbon steel alloy which is not suitable for **more than 500°C.**
Transparent Group of Companies

Transparent group companies, are technology leaders working in the field of Co-generation Systems, Ammonia Absorption Refrigeration Plants (AARP), Energy Conservation Contracts, Water Recycling Plants. Superefficient Boilers, Heat Recovery Systems, Pollution control, Drying Plants etc.

Business groups, Products & Systems

Transparent Energy Systems Private Limited

Our company was incorporated on 16th April, 1986 with the name of Vapor Energy Machines Private Limited. The first commercial production was started in January, 1988. The name of the company was changed from Vapor Energy Machines Private Limited to Transparent Energy Systems Private Limited on 18th December, 1995.

   Cogeneration Systems involving combined generation of
   Fuels and energy sources for Cogeneration.
   - Natural Gas - Heavy Fuel Oil (HFO) - Coal - Process Waste Heat
   - Biogas - HSD / Kerosene / LDO - Biomass
   Types of Cogeneration Systems
   - Steam Engine / Turbine Based Co-generation
   - Reciprocating Engine Generator Based Co-generation
   - Gas Turbine Based Co-generation
   Type of Industries
   - Hotels - Ceramic Industries - Commercial Complexes - Sugar Industries - Residential Complexes
   - Food Industries - Cement - Steel - Five Star Industrial Estate

2. Ammonia Absorption Refrigeration Plants - www.tesplaarp.com
   - Refrigerant Evaporators - Refrigerant Circulation Systems - Air Handling Units - Accessories
   - Flash Vessels - Ammonia Vaporizers - Turnkey Refrigeration Contracts.

   Waste Heat Recovery Boilers - Finned Tube - Water Tube - Smoke Tube
   Waste Heat Recovery Thermic Fluid Heaters
   Heat Recovery & Efficiency improvement Retrofits
   - Combustion Air Preheater - Economisers (Smoke tube / water tube / finned tube type) - Condensate Recovery Systems
   - Blow Down Heat Recovery Systems - Flash Steam Recovery Systems

   - 96% Superefficient Oil / Gas Fuelled Boilers - 93% Superefficient Thermic Fluid Heaters / Hot Air Generators
   - 89% Superefficient Agrofuelled / Coal Fired Boilers - Superefficient High Pressure steam Boilers, (Oil / Gas / Coal / Biomass Fired) for Cogenaration application

   Conservation of Electrical heating to Steam / Thermic Fluid / Hot Water Heating

6. Water Treatment Plants & Other Accessories – www.tespl.com
   - Feed Water Deaerators - Pressure Reducing Station
   - Water Softners - High / Low pressure chemical dosing systems
   - Demineralising Plants - Structural / Self supported / Guyrope supported Steel Chimney / Stacks
   - Sand Filters - Fuel Storage & Handling Systems.
   - Activated Carbon Filters - Moisture Separators

Transparent Technologies Private Limited

   Hot Water / Steam Driven Multistage Evaporators for continuous water distillation, desalination, product concentration & crystallization.
   - Falling Film Evaporators - Plate Evaporators - Fluidized Bed evaporators
   - Natural Circulation Evaporators - Forced Circulation Evaporators - Crossflow Evaporators
   - Assisted Circulation Evaporators - Agitated Evaporators - Spiral Tube Evaporators

   - Spray Dryers - Fluid Bed Dryers / Coolers / Agglomerators - Fluidized Bed Incinerators / Calciners
   - Flash Dryers - Paddle Dryers / Vacuum Paddle Dryers - Dry Powder Mixing Systems and Granulators
   - Spray Coolers - Spray Reactors cum Dryers - Disintegrators & Pulvarisers
   - Fluidized Bed / Spray Dryers - Homogenizers and Dispersion Mills

9. Pollution Control Group – www.air-pollutioncontrol.com
   Incinerators
   - Spray Dryer cum Combustion Chamber Incinerators
   - Fluidized Bed Incinerators for Liquids and Solids & Gases - Packaged Fixed Grate Incinerators for Solids
   - Liquid / Gas Incinerators - Fluidized Bed Paint Stripping Systems for Paint Coating
   Air Pollution Control
   - Cyclone / Multicones - Bag Filters - Wet / Venturi Scrubbers - Mechanical Dust Collectors - Flue Gas Desulphurisation Plants