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PWPS Organic Rankine Cycle Technology

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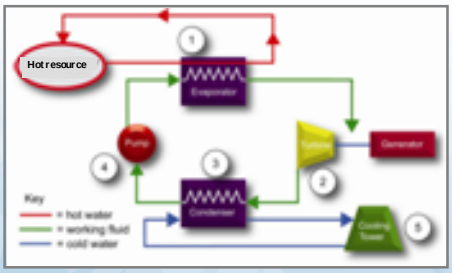
Organic Rankine Cycle Technology

Similar to the steam rankine cycle



Heat In – Power Out

Organic Rankine Cycle Technology

Significant advantages

O Organic
R Rankine
C Cycle

Technical features

- High cycle efficiency
- High turbine efficiency (~ 85%)
- Low mechanical stress turbine
- Low turbine RPM allow direct drive generator (no gearbox)
- No blade erosion (no liquid particles)
- No oxidation (metal friendly working fluid)

Operational advantages

- Simple start-stop procedures
- Automatic, unattended operation
- Quiet running
- High Availability (>98% proven)
- Turn-down to 10% of nominal power
- Good efficiency at partial load
- Long life
- High efficiency with low / moderate temperature sources
- NoBFW water treatment!
- Minimum O&M

United Technologies Corporation

$59.8 Bn in 2008 sales
62% revenues outside US


Pratt & Whitney


Hamilton Sundstrand


Sikorsky


Otis


Carrier

UTC Fire & Security


UTC Power

180 countries
225,000 employees

PRATT & WHITNEY
POWER SYSTEMS

Gas Turbines

In the industrial aero-derivative gas turbines business since 1960

IGT After market

Developed Hi-tech repair business for large heavy duty gas turbines in 2001

Mobile Power

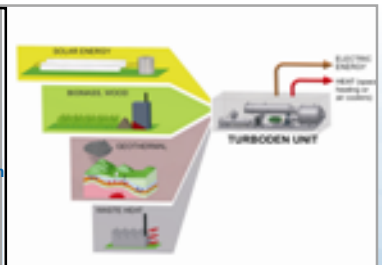
Developed Power on wheels solution in 2004

Heat to Electricity

Expands into Renewable energy in 2009 and acquired Turboden

Turboden – ORC Leader in Europe

- Turboden designs and manufactures Organic Rankine Cycle (ORC) products
- 30 years of ORC experience
- Standard sizes from 500 kW to 6 MW
- Customized to 10 MW
- Many renewable sources apart from waste heat



- More than 110 units are in operation and about 30 units are on order.

ORC in low temp application

Energy Source : Hot water, LP steam

The PureCycle® Power System

Low temp energy resources (up to 90° C)

- 280 kW Gross Power
- Free fuel
- Zero emissions
- Renewable basload power generation
- 90°C – 150°C resource range
- Modular and scalable for larger plants
- Short lead times
- 24/7/365 remote monitoring
- High availability

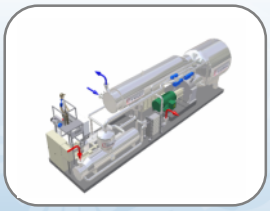
* 91°C – 149°C

ORC Hi-temp Application

Energy Source : Hot water, LP steam, Thermal Oil

Turboden Product Line

Medium temp energy resources (up to 180° C)



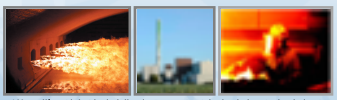
- High cycle efficiency
- Size flexibility: 400 kW to 6 MW
- High field availability (> 98%)
- Partial load operation (down to 10%)
- Low Operation & Maintenance requirements (~ 150-250 hrs/yr)
- Long life
- Simple start-stop process
- Direct drive generator
- Remote monitoring

Heat to electricity – Organic Rankine Cycle

Wide variety of heat sources

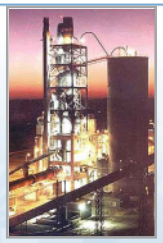
Diesel and Gas Engines | Solar Thermal | Geothermal | Biomass | Oil & Gas

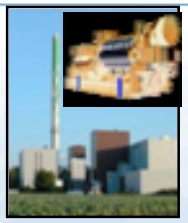
Industrial Waste Heat*



* Many diferent industries including glass, cement, metals, chemicals, petrochemicals, etc.

Sources of Waste Heat



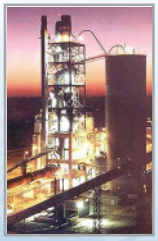


Industrial Processes:
- Cement
- Steel
- Refractory
- Glass
- Waste Incinerator

Prime Movers:
- Reciprocating engines
- Gas Turbines

Cement Production Factory

High temperature gaseous exhaust heat recovery



- Clinker production capacity: • 5.000 ton/day
- Heat source: exhaust gas @ 330°C
- Gas cooled down to 220°C
- Add'l heat used for raw material pre heating
- ORC electric power: ca. 2 MWe
- Under construction: start up in 2010
- Client: CIMAR – ITALCEMENTI GROUP

Refractory Production Factory

Heat from high temperature gaseous exhaust

- Refractory production capacity: • 250 ton/day
- Heat source: exhaust gas @ 500 °C
- Gas cooled down to ca. 150 °C
- ORC electric power: ca. 1.000 kWe
- In operation since first quarter 2009
- Client: RHI GROUP (Radenthein - Austria)

Steel Factory

Several exhaust gas streams are available

- Rolling, forging
- Heat treatment
- Strip processing

→ Relatively clean exhaust gas at moderate temperature
→ Cost effective for ORC • 600/800 kW

- Sinter
- Blast furnace
- Cupola

→ Interface between process and energy recovery unit is critical

- EAF

→ Exhaust gas: high flow, high temperature, high dust content, large variations in operating cycle, environmental constraints

Reheat furnace in steelmaking industry

Good application in many cases

Reference Case Study: Slab re-heating furnace

- Production capacity: ~ 300 MT/h
- Heat source: exhaust gas @ 450°C (840°F)
- Gas cooled down to 180°C (355°F)
- Heat carrier: thermal oil

Main Exhaust Gas Characteristics:

- Absence of dust (natural gas firing)
- Variable conditions depending on mill operation

ORC electric power: ~ 3 MW

Waste Incinerator

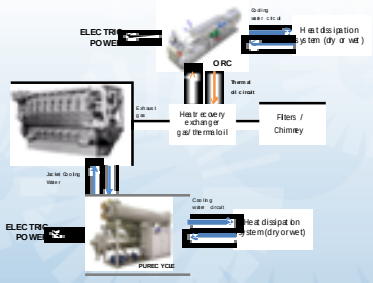
MIROM

3 MW installation in Roeselare (Belgium)

- Heat recovery from pressurized water boiler
- Commissioned 2nd Q 2008
- End customer – MIROM
- Hot water resource is at 180°C
- Return at 140°C

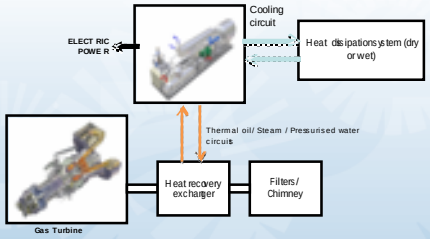
Reciprocating engines

Significant increase in overall engine efficiency



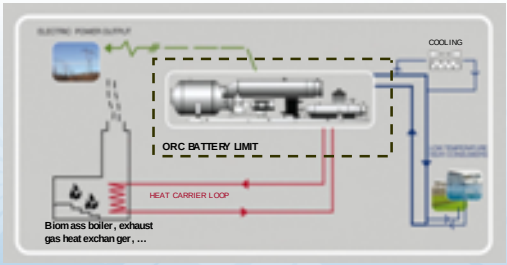
Gas turbines

Suitable for gas turbine sizes up to about 15 MW



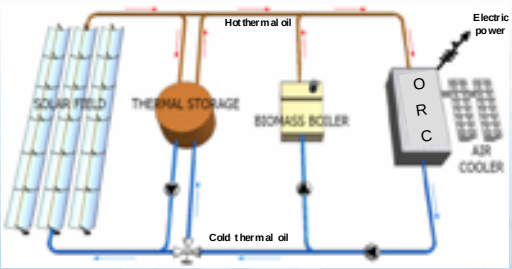
Biomass ORC Application

Potential for rural electrification is significant



ORC Hybrid Solar Thermal Power Plant

Improves the capacity factor significantly



Summary

Organic Rankine Cycle Technology

- ORC offer unique advantages compared to the steam turbines
- They have proved to be highly reliable in a variety of applications
- They have been successfully deployed in waste heat recovery from industrial processess, recip engines, gas turbines, biomass, solar CSP, geothermal, & industrial waste heat applications
- India's installed base of recip engines are a good opportunity to deploy these products in the near future
- Solar, Biomass, and Geothermal are other near to medium term applications in India

THANK YOU !

www.pw.utc.com

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