Welcome!

Webinar #4: RECIPROCATING ENGINES & HEAT RECOVERY in TFX
05 JULY 2017

Agenda:

* Introduction
* Reciprocating Engine component in TFX: Database or User Defined
* Available Heat from Exhaust Gas and Engine Cooling
* Heat Recovery for Hot Water, Steam and Chilled Water
* Multiple Engines
* Off Design Simulation
* Q & A Session

Presenter: IGNACIO MARTIN (SPAIN)
Support: Meritt Elmasri (U.S. HQ)
Thermoflow Training and Support

- Standard Training
- On-site Training course
- Advanced Workshop
- Webinars when new version is released
- Help, Tutorials, PPT, Videos
- Technical Support

→ Feature Awareness Webinars
Feature Awareness Webinars

1- Assemblies in THERMOFLEX
2- SCRIPTS in Thermoflow Programs
3- Multi Point Design
4- Reciprocating Engines
Reciprocating Engine Component in TFX

- Database
- User Defined
Reciprocating Engine Database

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Data source: Jenbacher Engineering Information 2001 CD
Date of last revision: 11/9/2001
Now level: less than 500 mg/m³
Applicable standards: Based on DIN-ISO 3046. Based on VDE 0530 RIEM with specified tolerance; Intake air temperature: 25°C; Barometric pressure: 1000
Reciprocating Engine User Defined
Reciprocating Engine User Defined - 2

### Reciprocating Engine Set

<table>
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<tr>
<th>Input Menu</th>
<th>Edit Mode</th>
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<tr>
<td>File</td>
<td>GTP/GTM/STM</td>
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#### Engine Parameters

<table>
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<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>Coolant Computation Method</td>
<td>Subcooled Load</td>
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<tr>
<td>Coolant Outlet Phase</td>
<td>Superheated Vapor</td>
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<td>Coolant Water Temperature Rise</td>
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<td>Coolant Water Outlet Temperature</td>
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<td>Coolant Water Outlet Quality</td>
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<tr>
<td>Coolant Water Path dp/P</td>
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#### Third Cooling Connection

- Choose Heat Adder: No Heat Adder connected

#### Fourth Cooling Connection

- Choose Heat Adder: No Heat Adder connected

### Notes

- Exhaust Temperature
  - 100% Load: 410°C
  - 75% Load: 405°C
  - 50% Load: 216°C
  - 25% Load: 250°C
- Generator Efficiency
  - 100% Load: 95.0%
  - 75% Load: 99.4%
  - 50% Load: 94.21%
  - 25% Load: 90.12%
- Genset LHV Efficiency
  - 100% Load: 41.56%
  - 75% Load: 39.06%
  - 50% Load: 34.88%
  - 25% Load: 26.4%
- Engine LHV Efficiency
  - 100% Load: 43.36%
  - 75% Load: 40.94%
  - 50% Load: 37.02%
  - 25% Load: 29.25%
Reciprocating Engine Heat Balance Envelope

Q1: Heat transfer from the cooling water jackets (primary cooling)
Q2: Heat transfer from a high temperature charge air cooler (secondary cooling)
Q3: Heat transfer from a low temperature charge air cooler
Q4: Heat transfer from the lube oil cooler
# Reciprocating Engine Inputs

## NOMINAL

<table>
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<tr>
<th>Power</th>
<th>Efficiency</th>
<th>Exhaust mf</th>
<th>Exhaust T</th>
<th>Generator Eff</th>
<th>Heat Recovery-4</th>
<th>CW T, DT</th>
<th>Fuel Consumption</th>
<th>Air mf</th>
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## OFF DESIGN

<table>
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<th>Power</th>
<th>Efficiency</th>
<th>Exhaust mf</th>
<th>Exhaust T</th>
<th>Generator Eff</th>
<th>Heat Recovery-4</th>
<th>CW T, DT</th>
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Heat Balance: Available Heat Recovery

Reciprocating Engine Set [1]
1464 kW

(Gas cooled to 150 °C)

-711.2 kW

-756.4 kW

3523 kW
Available Heat Recovery, Hot Water & Steam

(Gas cooled to 150 ºC)

(Hot Water @ 85C)

Steam @ 10 bar 200C)

3523 kW

... Simple
Exhaust Heat Recovery - Combined Cycle

Gross power: 19891 kW
Net power: 19630 kW
Net electric efficiency (LHV): 49.18%
Number of Engines in operation: 1

-1823,3 kW

Pump (PCE) [1]: 1.639 kW
Pump (PCE) [22]: 9.984 kW
Pump (PCE) [23]: 1.482 kW

Air-cooled Condenser (PCE) [9]: fan 44.91 kW

G1: 1569.6 kW

Detailed
Cooling Water Circuit: 4 Heating Sources
Cooling Water Circuit: 4 Heating Sources

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Cooling Water Circuit

- Gross power: 1413 kW
- Gross electric efficiency (LHV): 41.88%
- CHP efficiency: 86.67%

Net process heat output: 1527.2 kW

342 kW
177 kW
337.2 kW
669.8 kW

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Cooling Water Circuit (detailed)

Sample S3-21

- Cylinder Jacket Cooling
  - Design target temperature: 80°C
  - Design inlet T: 85°C

- HP Charge Air Cooling
  - Design inlet T: 44.5°C
  - Lube Oil HX
  - Lube Oil Circuit
    - Range 62°C - 75°C

- LP Charge Air Cooling
  - Design inlet T: 44.5°C

Design cooled T: 43°C
Heat Recovery, Chillers

HX + Water/Steam Chiller

Exh Gas driven Chiller

-756.4 kW

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Heat Recovery with Water / Steam Absorption Chillers

Reciprocating Engine Set [1]
8490 kW

Total current load 3535 kW
Current COP 1.1

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Water / Steam Absorption Chillers

Diagram showing the flow of water and steam through absorption chiller components:
- Hot water entering the system
- Chilled water exiting the system
- Cooling water
- Stream condensate subcooling
- Standard conditions: 1) 44°F (6.67°C) chilled water exit temperature
  2) 85°F (29.4°C) cooling water supply temperature
  3) Steam source pressure of 20 psig (1.4 bar) for single-stage units, and 130 psig (9 bar) for two-stage units

Chiller load set by network-determined heating flow
- Chiller load:
  - 1000 tons
  - Auxillary load / chilling load: 0.005
  - Place of chilled output (as process): 1

Evaporator, Condenser, Absorber, 1st Generator, 2nd Generator

Chilled water exit temperature:
- 3.5°C

Chilled water pressure drop:
- 0.0189 MPa

Cooling water flow

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Heat Recovery, Exhaust Gas driven Absorption Chillers
Exhaust Gas-driven Absorption Chillers
Reciprocating Engine Trigeneration

**Net power**: 3163 kW

**CHP Eff**: 84.4%
Multiple Engines

... if different Engine models or running at different loads
Multiple Engines

... or

Use “Fluid Specification components” as Flow multipliers / dividers

Define “Energy Accounting” for Power / Heat multipliers / dividers
Recip Engines “modeless”
Just enter the “desired power”
to simulate part load

OD calculations from the Tables

Rest of the parameters computed
“User define” your part load case to match the Engine specs