Intelligent Energy Solutions

HRSG Operational Challenges and Siemens' Solutions

Gary Gong Ph.D P.E.

Siemens Energy Inc
4400 N Alafaya Trl
Orlando, FL 32766

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Agenda

Challenge: HRSG Design for today's Flexibility

Solution: Flex-Plant HRSG Design

Fossil Products and Solutions
Market Drivers

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Shaping Renewables

Competitive in Changing Markets

Improve Efficiency/Output

Eliminate / Reduce Water Consumption

Reduce Emissions

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Two Primary Concerns for Fast Start HRSG

Thermal Stress on High Pressure Steam Drum

- Severe operating conditions require thick component wall
- Fast startup produces high thermal gradient in wall
- Component fails after fatigue life is consumed

Drum Level Control

- Gas turbine startup produces rapid boiling in evaporator
- If water level in drum rises too fast during flash, water carryover may occur
- Typical response is to trip or slow GT load ramp
- Integration of feed water systems highly complex

SCC6-5000F 1x1 Flex-Plant™ 10
- One pressure CCPP for peak to intermediate

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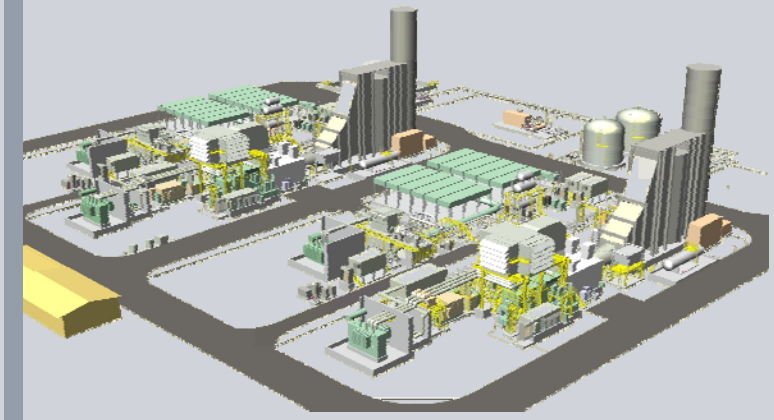
SGT6-5000F → Flex-Plant 10



The best solution for economic peaking to intermediate duty dispatch

- 275 MW, 48.8% efficiency
- Non-spinning reserve/ancillary service
  - 10-minute start gas turbine
  - 30 MW/min load regulation
- Lowest total emissions
- Lowest water consumption
- Low gas pressure requirements

Low Capacity Factor Peaking ⟷ **Intermediate Duty** ⟷ **High Capacity Factor Continuous Load Duty**

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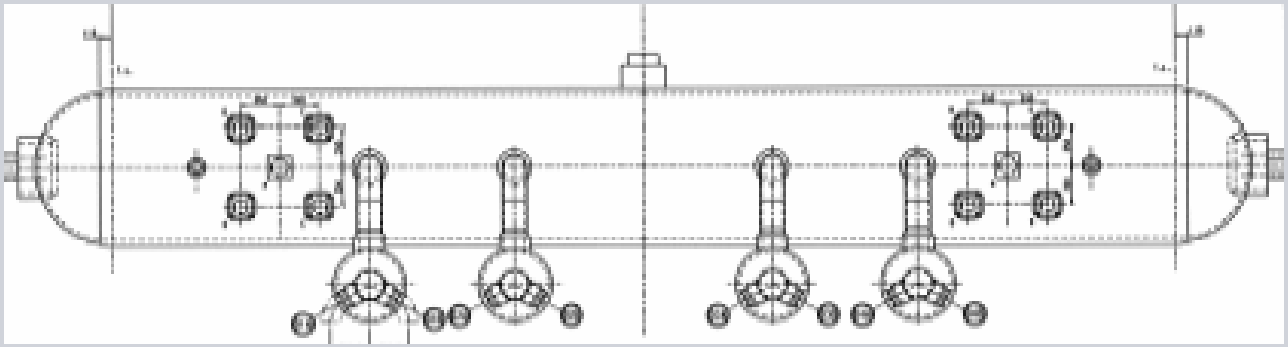
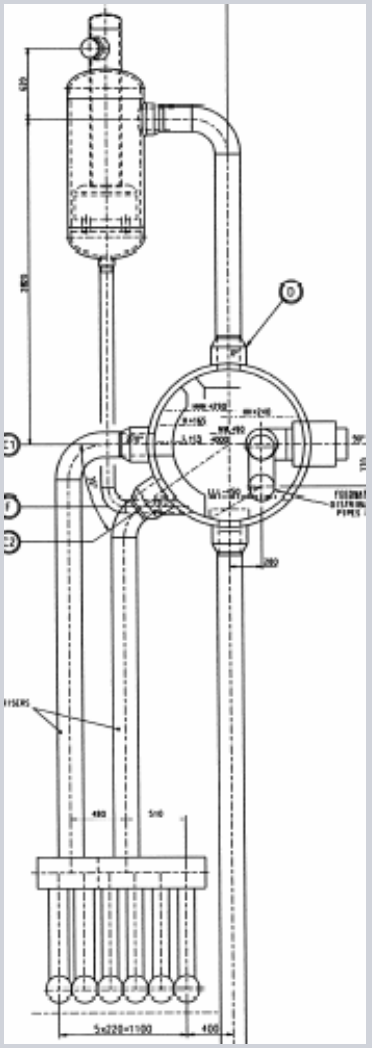
One Solution - Flex-Plant HRSG Drum Design

- HP Drum: Moisture Separation occurs in separator instead of drum, which reduces drum size.
- Small drum for primary steam separation and water steam separators.
- Large capacity emergency blowdown to condensate system to manage severe transients

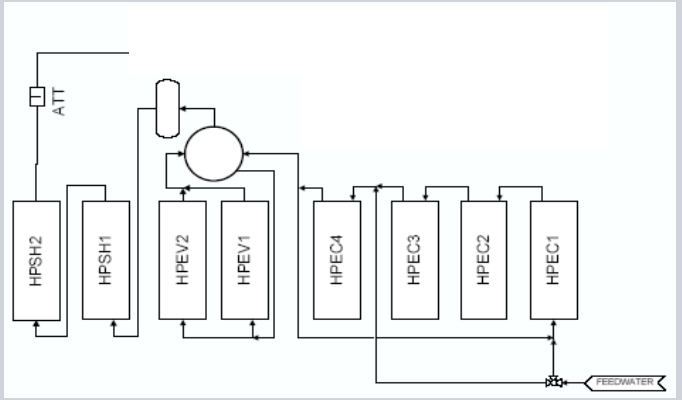




Flex-Plant HRSG Transient Analysis

Purpose:

- Develop input data for lifetime analysis
- Evaluate system response in transient events
- Analyze behavior for emissions performance

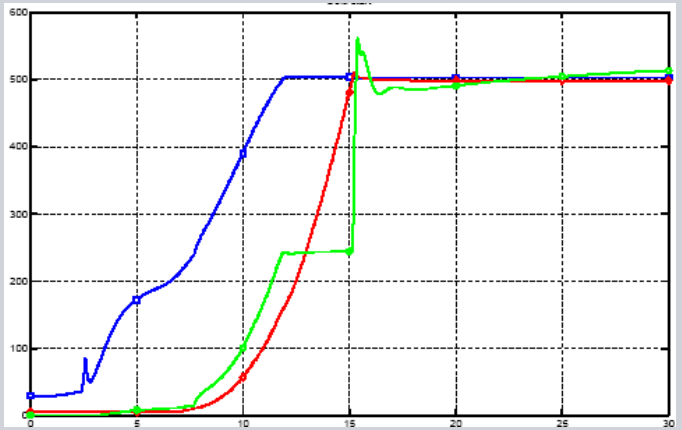


Analyses:

- GT startup / shutdown
- FW pump trip
- ST trip

Results:

- Full pressure & temp in < 20 min
- Impact of increased ramp rate has been minimized
- All transient flow control criteria fulfilled



Critical Component Lifetime Analysis

Purpose:

- Identify critical components
- Verify design meets lifetime criteria

Analyses:

- 200 Hot / 50 Warm / 10 Cold starts per year
- FE analysis of critical components
- Creep analysis – API 530 & ASME III, Div. 1
- Fatigue analysis – EN 12592-3

Results:

- Fatigue consumption meets design life reqt's
- Magnetite stresses below EN 12592 limits
- Relationship of fatigue life to start profile

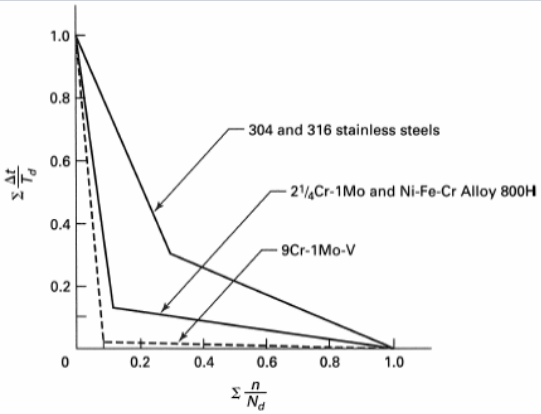
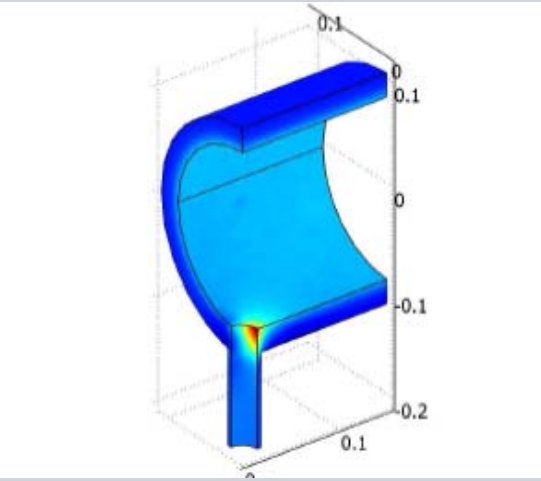


FIG. T-1420-2 CREEP-FATIGUE DAMAGE ENVELOPE



SCC6-5000F 2x1 Flex-Plant™ 30
Three pressure RH for intermediate to continuous

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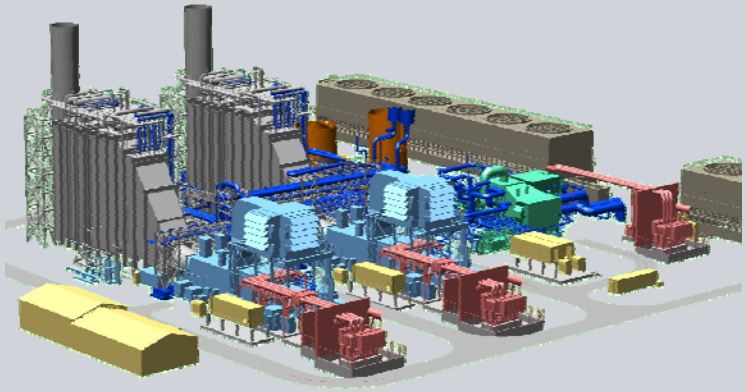
SGT6-5000F → Flex-Plant 30



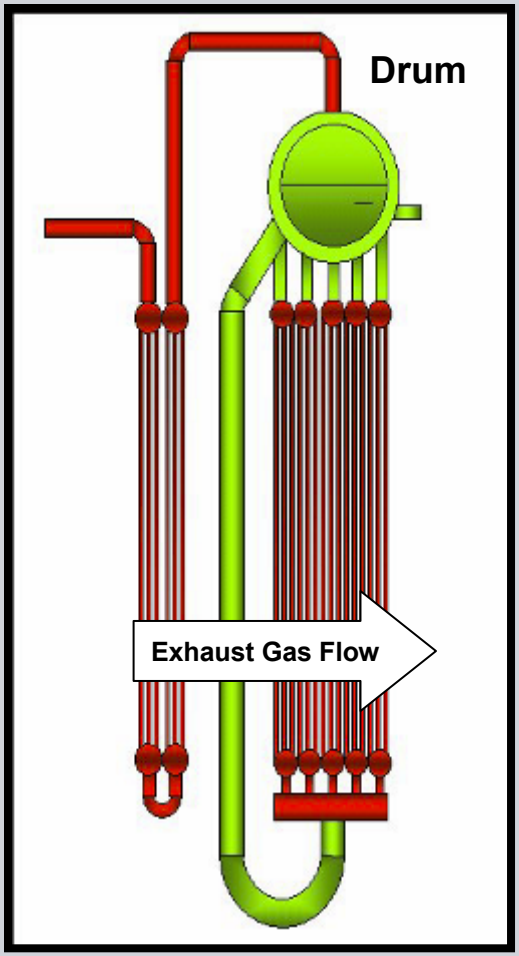
The best solution for intermediate to continuous duty needs

- 618 MW, 57+% efficiency
- Faster start-up times than traditional CC
- Low start-up emissions
- Low start-up fuel consumption

Low Capacity Factor Peaking ⟷ **Intermediate Duty** ⟷ **High Capacity Factor Continuous Load Duty**

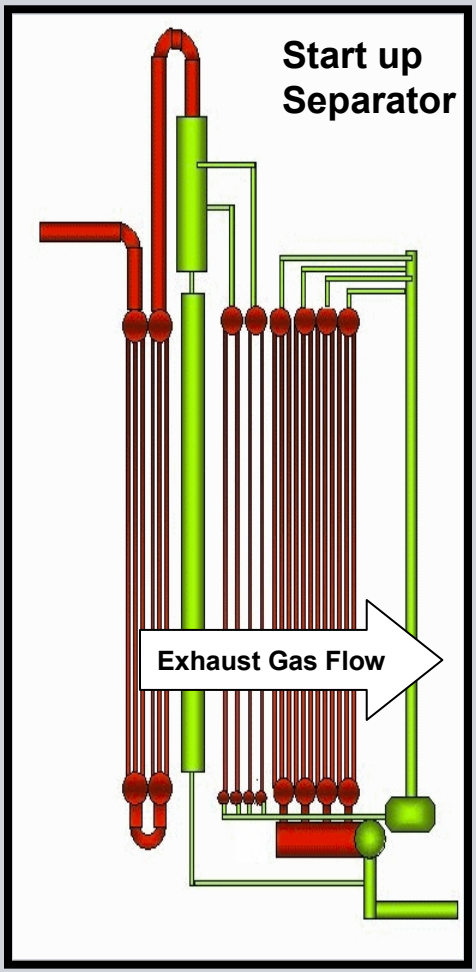
Benson HRSG

Conventional Drum vs. Benson OTSG



Drum-Type

- Vertical tube modules in horizontal gas path
- Thick-walled HP drum
- Natural circulation principle



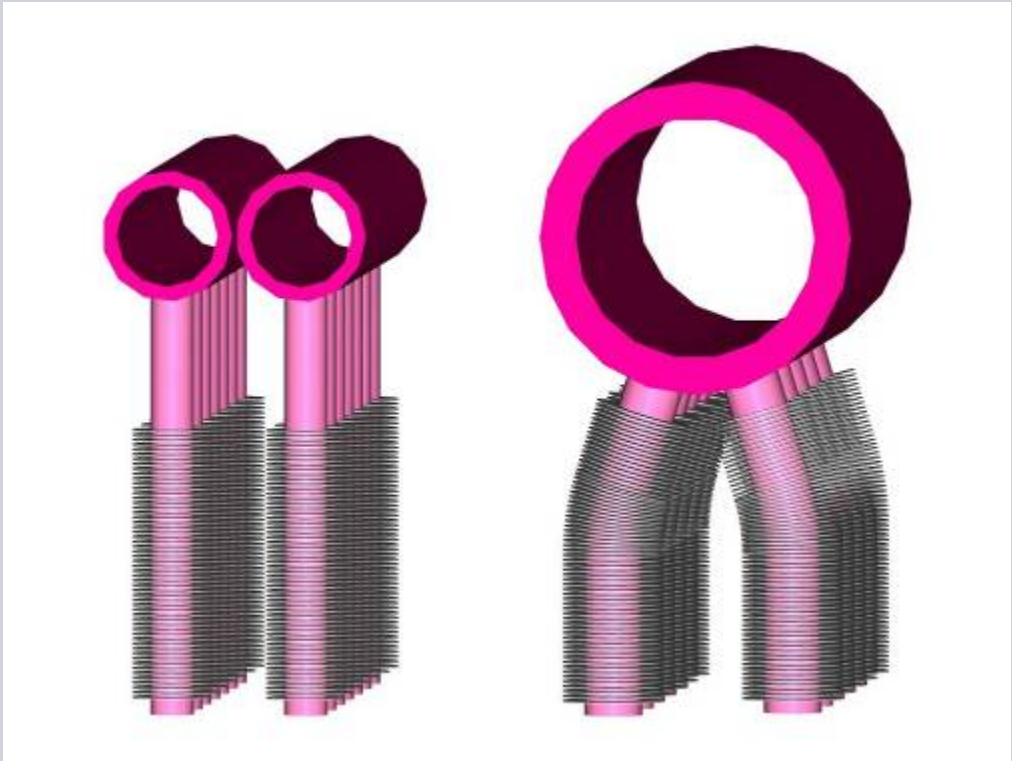
Benson OT

- Vertical tube modules in horizontal gas path
- Replace drum with thin-walled components
- Maintains natural circ flow characteristics

Benson HRSG

Superheater Designs

1. Single row of tubes between headers
2. Finned tubes with no bends
3. Smaller diameter headers with multiple header connections (thermal stress reduced by 60%)
4. Seamless tubes



OT Design

Conventional Technology

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Summary

- Identified primary concerns for fast start of HRSG's
- Worked with key suppliers to establish & verify design
- Conservative, thorough analysis methodologies
- Transient behavior understood and can be controlled
- Analysis shows positive results for design life