NATURAL RESOURCES CANADA - INVENTIVE BY NATURE

Gas turbine heat transfer to process Modeling and optimization

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Outline

- The complexity of industrial cogeneration system sizing and conceptual design
- Step-by-step approach
- Illustration using COGEN software

Integrated Industrial Cogeneration

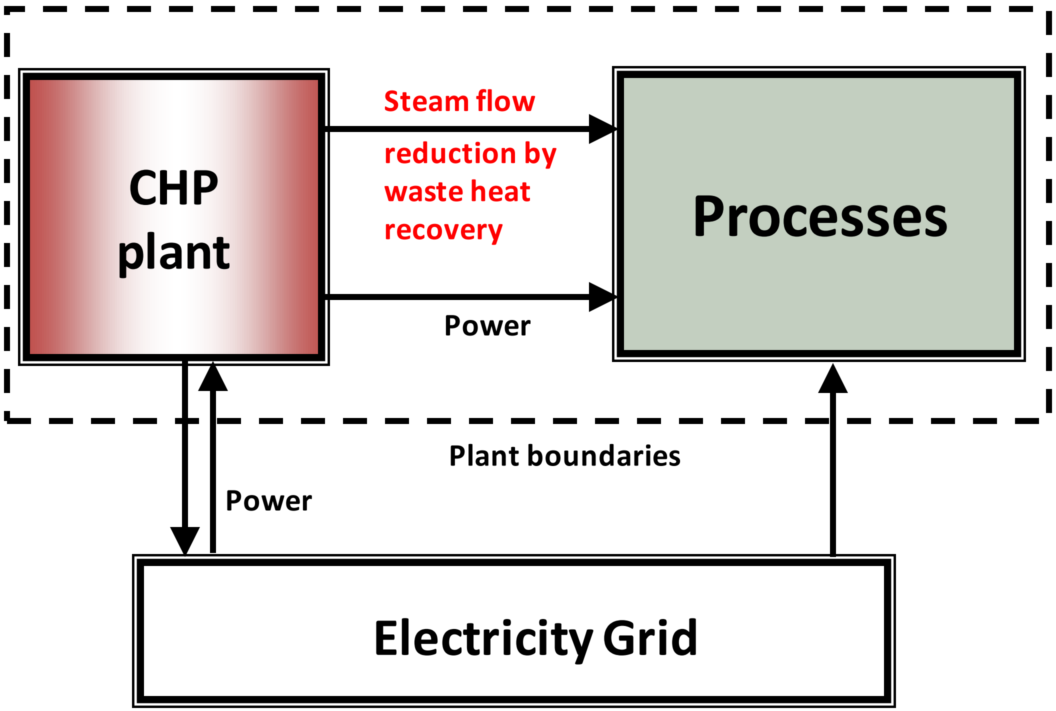
Equipment availability and performance

Variability in process heat demands

Fluctuating power and fuels prices

Contractual constraints

Steam value for different operating scenarios

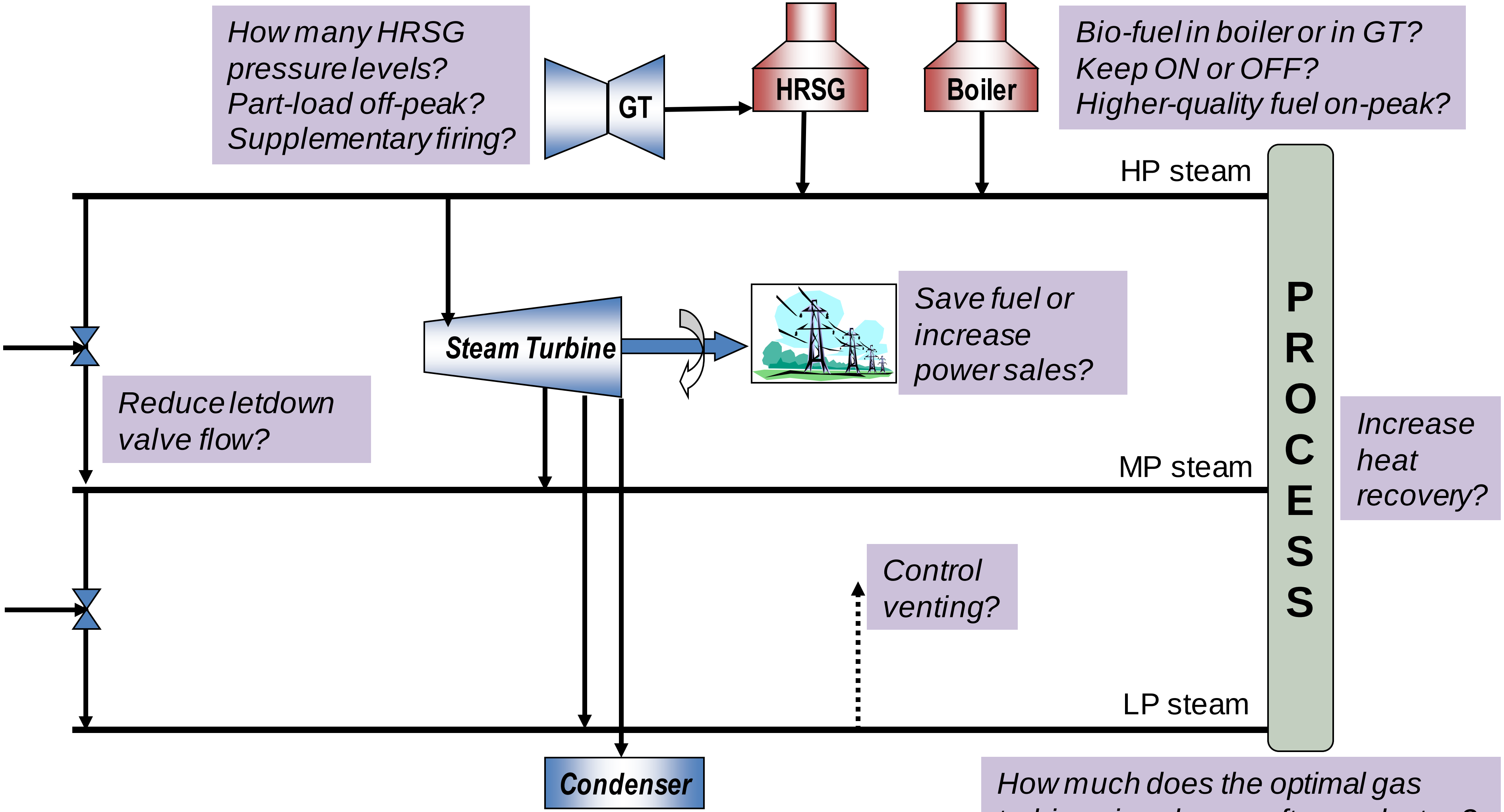


Potential for heat recovery

Production schedules

Energy efficiency projects

Identifying Optimal Pathway to Profit



Step-by-step approach

1. Identify possible gas turbine sizing criteria
   - Thermal load before and after potential process heat recovery projects from process integration
   - Electrical limits, physical and contractual
   - Fuel availability (anaerobic digester etc.)
   - Other (CO_2 emissions limit, etc.)
2. Model what-if scenarios
   - Some power contracts require a multi-period model
3. Compare!

Step-by-step approach

- Example from a gas turbine integration with a pulp dryer
  - Flat electricity rate and steady operation
  - Dryer would directly mix turbine exhaust, recycled humid air and fresh air make-up (pre-heated or not)
  - Similar sizing problem as HRSG with same heat load

Gas turbine sizing method (what-if scenarios)	**Size (MW_{el})**
Meet dryer load – no dryer make-up air pre-heat	12
Meet dryer load – make-up air preheat with process heat recovery	**10**
No net CO_2 increase – in combination with process heat recovery	**10**
No net CO_2 increase – in combination with anaerobic digester	12
Use anaerobic digester bio-gas exclusively (no fuel mixing)	2.5
Meet all on-site electricity demand	35

Best economics!

Illustration using COGEN software

COGEN software

to simulate and optimize cogeneration and condensate return systems

COGEN Software Introduction

- COGEN is a flowsheeting-type modeling software able to simulate and optimize industrial cogeneration systems
- COGEN 1.0 is intended for capacity-building among engineers in the Canadian industry and will be free for course participants
- Emphasis is on modeling steam/condensate systems and on using state-of-the-art optimization algorithms (GAMS language)
  - For example, the gas turbine model fits by regression user data or generic data (fuel input, power output, exhaust temperature), but is not based on separate compressor / combustor / turbine sub-models
- Availability March 2017; looking for beta testers this Winter!

COGEN Software Capabilities

- Simple and detailed models for cogeneration related equipment
  - Boilers, steam and gas turbines, pumps and fans, heat exchangers, desuperheaters, flash tanks, steam headers, condensate systems, etc.
  - Detailed models rigorously* simulate equipment part-load operation
- Complex layouts (steam / condensate / fuel / air / electricity) can be modeled in full detail
- Modular approach – drag and drop interface that automatically generates the model equations and variables
- World-class solvers used for highly complex, large scale, linear and non-linear problems

Powerful simulation and optimization platform

* Rigorous in the context of having a reasonable number of equations for a simultaneous resolution of the entire flowsheet. Not to be compared with engineering models to predict off-design performance

COGEN Software Features

- Steam path and fuel mix optimization
  - Trade-off between fuel savings and power sales
- What-if scenarios
  - Topological modifications
  - Equipment modifications
  - Operational changes
- Calculation of the true cost of incremental steam
  - Can vary by fuel type, steam generator, pressure level, steam load in other processes, time of day
- Condensate recovery/management

Conclusion

- Industrial cogeneration is complex because of process variability, contractual constraints, varying part-load efficiencies, etc.
- The potential for internal heat recovery in the process affects the optimal turbine sizing
- A software tool such as COGEN helps generate what-if scenarios to optimize and compare

Acknowledgment

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