Centerpoint Energy

Energy Efficiency & Technology Conference

"Steam and Process Heat Recovery"

May 23, 2017

Kinergetics LLC

Energy Planning, Design & Optimization

Madison, WI
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Principal

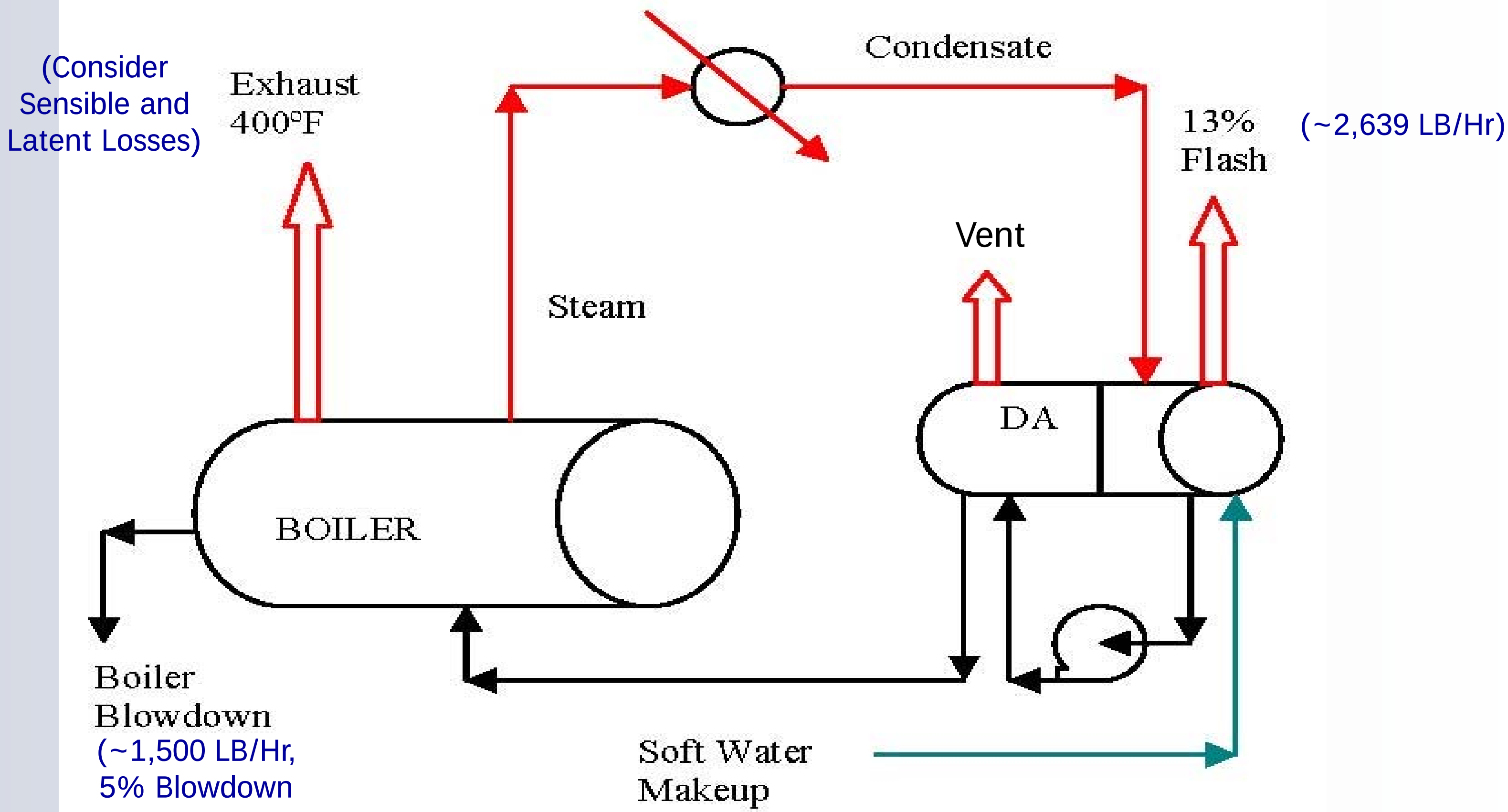
General Agenda

- About Kinergetics
- Boilers and Steam Systems
- Steam Plant Energy Efficiency
- Process Energy Efficiency
- Checking Heat Exchangers
- Tips for Identifying Thermal Opportunities

Some History on Kinergetics

- Founded March 2006. Focus on industrial energy efficiency (steam and process heat recovery, cogeneration, evaporation, cooling/refrigeration, fans, pumps, etc.).
- Staffed by chemical engineers with support by professional associates as needed.
- Services include high level and investment grade energy investigations, design and custom engineering.
- Work throughout the USA, in South America, Mexico, Canada, Czech Republic and Europe.

Steam System Overview



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Example Steam System

- Example: 1200-HP boiler, 70% load, 80% efficiency, gas at $5.00/MMBTU
- 8,400 hours per year operation
- Steam rate: 29,000 LB/Hr (100 PSIG, 338°F)
- 70% condensate return
- Fuel rate: 36.3 MMBTU/Hr

Example Steam System

- Blow down cost: ~$18,000/Yr
- Exhaust cost: ~$275,000/Yr
- Flash cost: ~$150,000/Yr
- Fuel cost: ~$1.5 million/Yr
- Waste Recovery potential: ~$440,000/Yr
- So what do you do about it? Can vary quite a bit – some basic ideas...

Boilers and Steam Systems

- Gas boilers are usually ~80 to 83% efficient, excluding economizer.
- Myth: "Old boilers are not efficient"
- Approximate boiler energy losses:
  - Stack loss: ~18.5%
  - Blow down loss: ~0.75 to 1.5%
  - "Skin" loss: ~0.5%

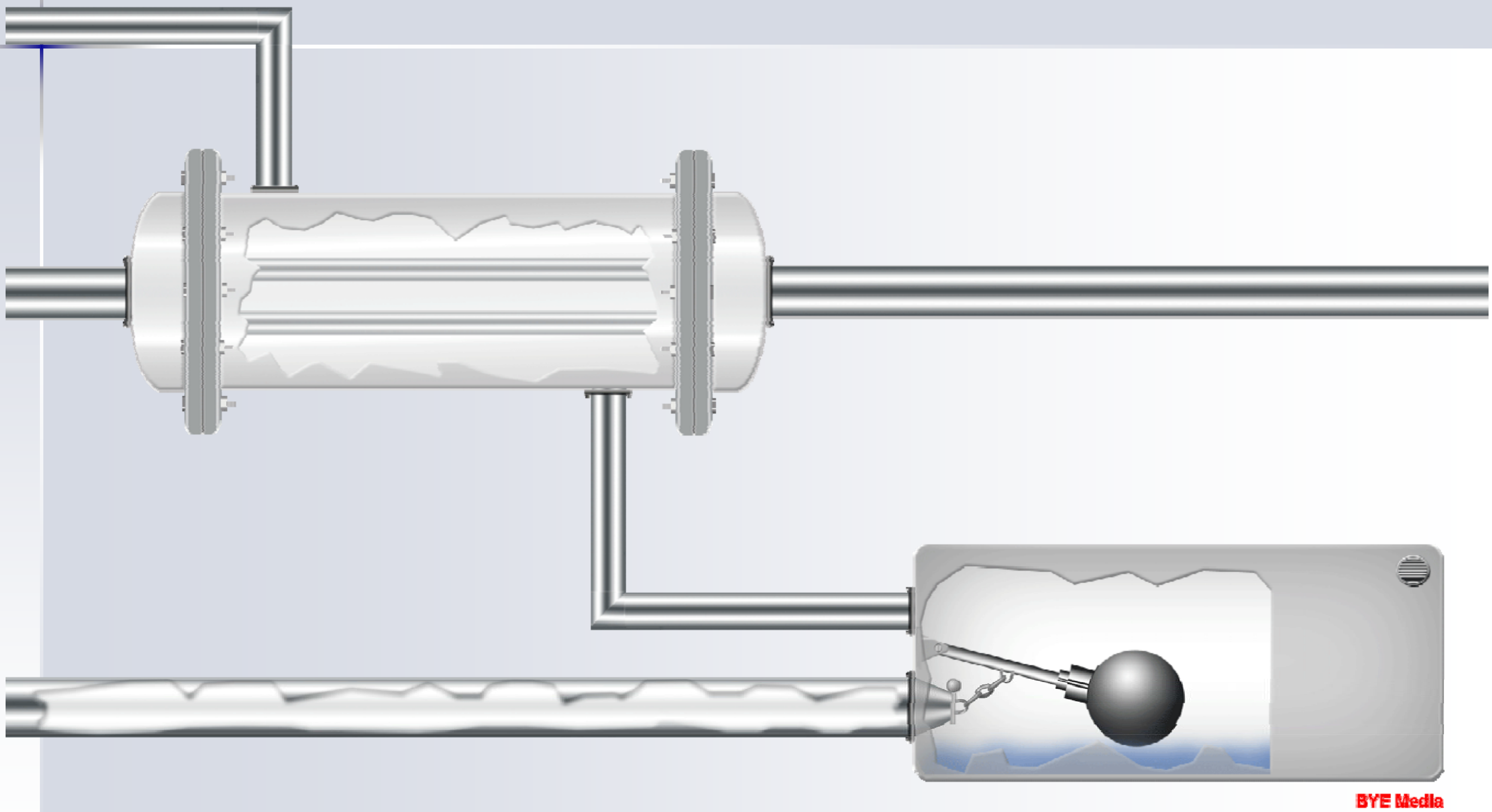
1. Reduce Boiler Pressure

- ~1% fuel savings each 40°F exhaust temperature drops
- Exhaust temperature drops about the same as steam temperature
- Reduce pressure: 100 PSIG to 80 PSIG
- What is the savings? ~$5,300/yr
- Not including distribution savings (+)
- Not including economizer influence (-)

2. Reduce Flash Loss

- Flash steam results when "saturated" hot condensate has a pressure drop:
  - Passes through a steam trap
  - Passes to a vented vessel (receiver)
- Make sure traps have not failed
  - Where is the loss? Is there loss? Find it
  - Steam motivated condensate pumps? Can be maintenance issue
  - Steam traps and pressurized condensate returns
  - Savings ~$111,000/Yr

Reduce Flash Loss



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3. Burner Related Controls

- Linkage-less Controls (LC): No real gain for reasonably maintained boiler.
- Add oxygen trim if LC is being considered: ~½ to 1% gain typically.
- Cycling boiler - Burner de-rating? Reduces burner output.
- To get to ~88% efficiency, must cool exhaust to ~150ºF, almost condensing. Control alone will **<u>NOT</u>** do this (that pesky first law).
- Savings ~$11,250/yr

4. Excessive DA Venting

- DA tanks often over-vent due to worn gate orifice, improperly set vent valve or reduced output from initial start-up.
- Look for ~2-inch gap over vent, 2 to 3 foot plume (bigger may equal excess). ROT: 1/10 of 1% of BFW flow is adequate.
- If you change vent rate, tell water chemistry provider - don't assume DA works well.

4. Excessive DA Venting

5. Boiler Blow Down (BD)

- Boiler BD rate:
  - 3 to 5% typical with traditional treatment
  - ½ to 1% with reverse osmosis (RO)
- Heat recovery is option, but first consider reducing blow down rate.
- Estimate blow down rate from the steam rate and % blowdown (%BD):

BD{LB/Hr} = LB-Stm/Hr x (%BD)/(1-%BD)

Savings ~ $14,230/Yr (5% blowdown)

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6. Repair Steam Leaks

- Planned and unplanned leaks
- Its accepted that leak repair is worth doing, but what is the value?
- As with many things, experience helps
- The following slides provide some guidelines & examples.

~10 LB/Hr (leaking valve; 1/2” pipe, ~$420/Yr)

Black: ~75 LB/Hr ($3,150/Yr)
Red: ~25 LB/Hr ($1,050/Yr)

High pressure condensate used for valve heat tracing.

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Failed Thermostatic Steam Vent

~25 LB/Hr
$1,050/Yr

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Failed Condensate Piping

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Dryer Impacted By Steam Condensate Leak

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7. Boiler Exhaust Feed Water Economizers

- Feedwater economizers are time tested for feedwater preheating; it is a "myth" that they are not reliable, but they can be misapplied.
- Typical fuel reduction is 2% to 3%, but can be greater pending stack temperature.
- Feedwater must be hot to avoid condensing. Dewpoint is about 130°F to 140°F (natural gas).
- In general, the fuel reduction is about:
  - 1%/11°F the feedwater temperature increases
  - 1%/40°F the exhaust temperature decreases

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Wood Fired Boiler Exhaust Heat Recovery for PROCESS preheating. You don't have to use a standard boiler feedwater economizer on a boiler or other stack. However, be careful....

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Fin-tube Coil Failure Due to Plugging

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8. Condensing Recovery Systems

- Water vapor in boiler exhaust contains ~10% of the fuel input.
- Recovering 8% to 15% of the exhaust is realistic, *depending on the situation.*
- Need cool inlet water for high recovery and ~55°F to 60°F is ideal.
- Possible applications: boiler makeup/process water heating, dryer inlet air preheating, process solvent preheating, other?

Condensing Recovery Systems – Cont’d

Type 1: Direct contact: Exhaust and water come in “direct” contact.

- Max water temperature is about 140°F for natural gas boilers (limited by wet-bulb).

Type 2: Indirect contact:

- Exhaust water vapor condenses on a surface, like a tube or plate.
- Higher water temperature possible, but more costly per BTU recovered.

8. Vent Steam (Condensing) Heat Recovery – Univ. of Chicago Power House

BEFORE

AFTER

8. Vent Steam (Condensing) Heat Recovery – Univ. of Chicago Power House

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Process Condensing Heat Recovery – Soybean Seed Oil Extraction, Paraguay

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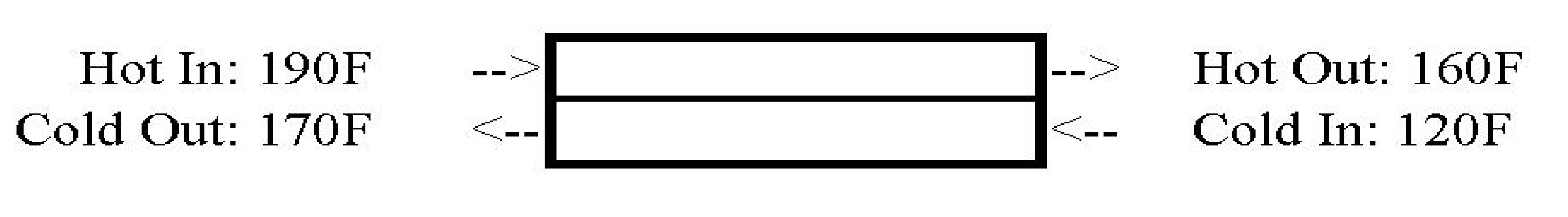
How Do I Check an Exchanger? (a guide only)



$\Delta T_{1:}$ 190ºF – 170ºF = 20ºF

$\Delta T_{2:}$ 160ºF – 120ºF = 40ºF

- $\Delta T_{min} = \Delta T_1$ = 20ºF. Not bad but may be improved depending on the fluids, flows & exchanger.
- Lower ΔT_{min} means more heat recovery & more pressure drop (usually).
- The optimal solution usually requires multiple considerations, BUT……

How Do I Check an Exchanger? (a guide only)

- A few guidelines for minimum approach are:

-Plate with water both sides: 5°F to 10°F

-S&T with water both sides: 15°F to 30°F

-S&T with steam/water: ~ 10°F

-Boiler economizer: 60°F to 90°F

-Air/Air: 120°F to 180°F (like boiler exhaust to heat combustion air)

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Suggestions on Identifying New Thermal Opportunities

- Make a list of heat "sinks" (heat needed) and sources (heat available).
- Do not focus on the heat source first. This is a common error.
- Consider whether additional heat could provide benefit.
- Follow the concept of "temperature matching."

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Suggestions on Identifying New Thermal Opportunities

The "Resource" is any energy source and the "Approx. % Relative Availability" is the potential of the resource to do work.

Note the steam examples. This is why power plant boilers operate at high pressure and temperature.

"Resource"	Approx. % Relative Availability
Electricity	100
Fuel	79
Hot Oil	45
600-psig Steam (725°F)	32
125-psig Steam (353°F)	22
50-psig Steam (298°F)	15
15-psig Steam (250°F)	7
Hot Water	0

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Suggestions on Identifying Thermal Opportunities

- Understand why design decisions were made before they are changed.
- Don't assume if it worked in one plant it will in another, even in the same process.
- Consider equipment modifications or changes in operating conditions. Can provide opportunity where none existed.

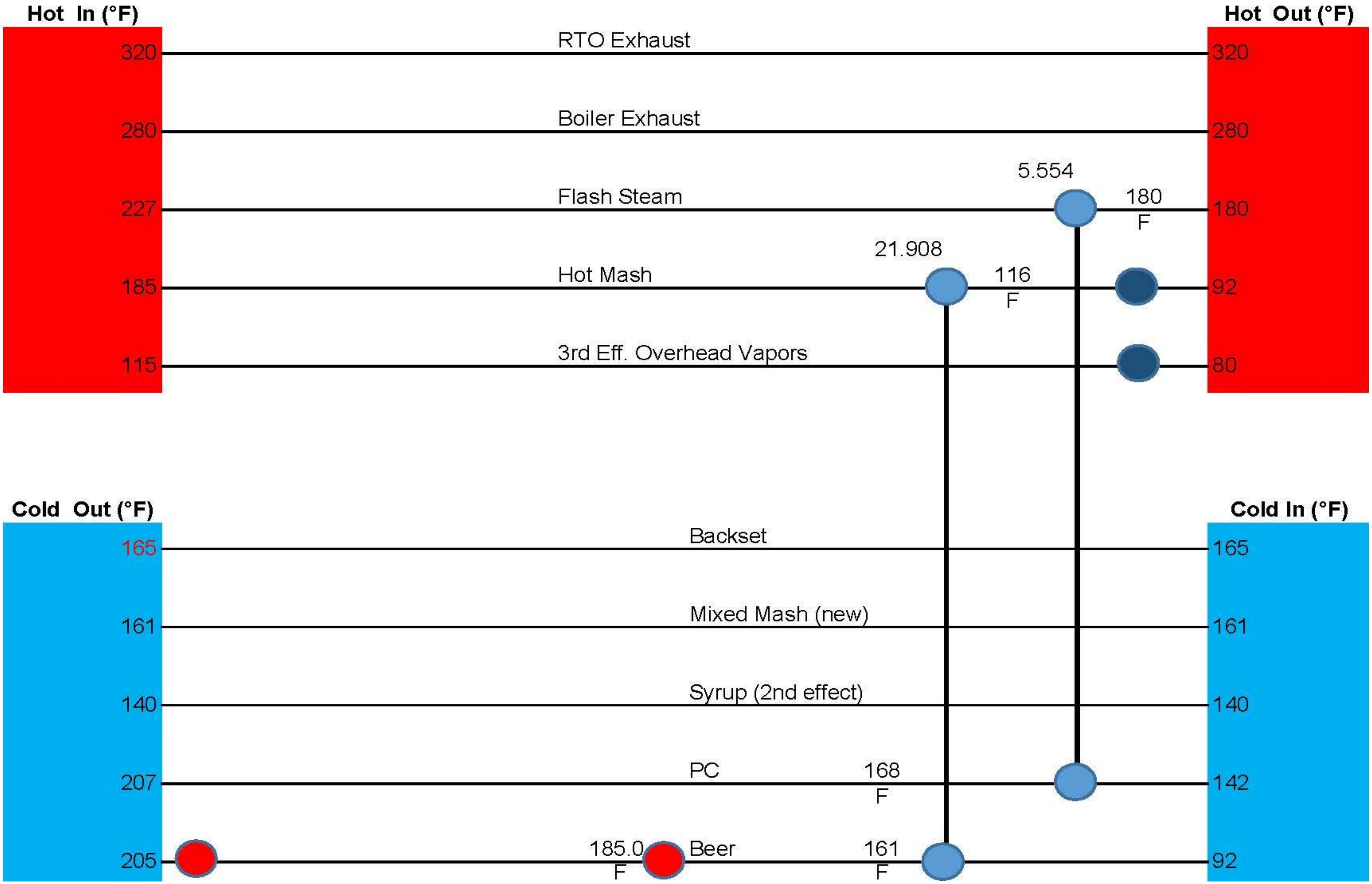
Example Approach for Illustrating Measures

- Challenge-Target process is fairly well integrated.
- There are opportunities for energy recovery, but the question was: “Can we do better”?
- Applied what Kinergetics has termed “PseudoPinch”

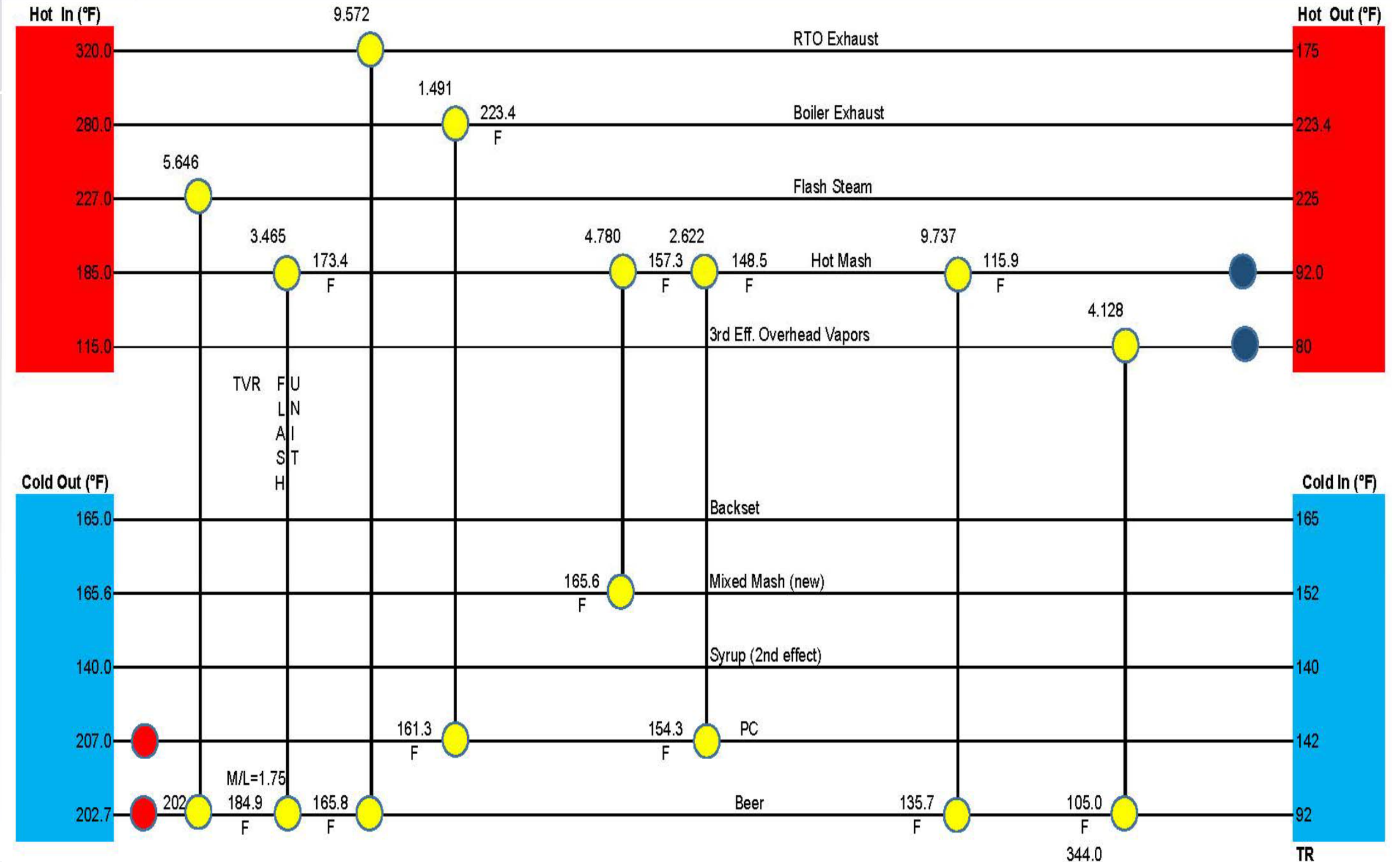
Dry Grind Ethanol Plant

- "PseudoPinch": Application of Pinch Analysis & 2nd Law principles in an iterative design process (includes temperature matching concept).
- Result is a practical design that can be implemented.

Existing Recovery Network



Improved Recovery Network



Albert Einstein…

"Any fool can know. The point is to understand."

Questions? (any is ok)

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