BURNING QUESTIONS ABOUT BOILERS

High Performance Boilers

&

Boiler Controls

peaker

Energy Engineering Services for Massachusetts & the Northeast Since 1990

B A L E S   E N E R G Y   A S S O C I A T E S

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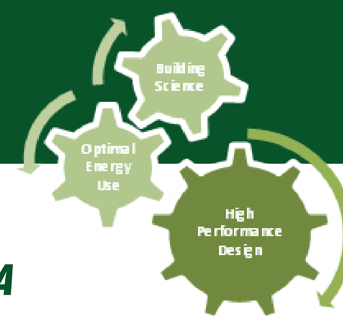
BEA



uestions to be sked & nswered

!!

- hat do you get when you cross a lovesick elephant with a rhinoceros?

- s condensing latent heat out of the combustion gases of a boiler desirable?
- hy are we interested in the return water temperature for a boiler system?
- hat is "excess air" and why do boilers need to operate with some "excess air"?

► easured ombustion fficiency?

- ?

easured ombustion fficiency?

- he percent of the thermal energy in the fuel burned is in the stack gases

here is the energy going that is not in the stack gases?

???

here is the energy going that is not in the stack gases?

- nto the boiler water
- nto the mass of the metal making up the boiler
- ost from the surface of the boiler

here do you want the energy to be?

- n the boiler water or the water serving the building's distribution loop

hat affects how much heat is transferred to the water?

- ??

hat affects how much heat is transferred to the water?

- low rate of the water entering and passing through the boiler
- emperature of the entering water

In routine operation of a cast iron boiler from where does this water come?

- (ssume single supply, single return boiler system)

▸n routine operation of a cast iron boiler, from where does this water come?

- (ssume single supply, single return boiler system)
- he return water from the building heating loop

t what temperatures?

- ▸ i ve range.

t what temperatures?

- ive range.
- . . to . . .
- hy is the low end of the range so high?

t what temperatures?

- i ve range.
- t o .
- hy is the low end of the range so high?
- o avoid condensation of “icky” things from the combustion gases

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- o avoid condensation of “icky” things from the combustion gases
- cky = ?

hy is the low end of the range so high?

- o avoid condensation of “icky” things from the combustion gases
- cky = ulfuric acid, etc.
- hich does what?

hy is the low end of the range so high?

- o avoid condensation of “icky” things from the combustion gases
- cky = ulfuric acid, etc.
- hich does what?
- orrodes cast iron of boiler and galvanized metal of the exhaust stack.

ondensing oiler

- .n routine operation, what temperatures may the return water be?

ondensing oiler

- n routine operation, what temperatures may the return water be?

- to... or is the high up to ?

hy can the low temperature be lower in a condensing boiler than a standard boiler?

hy can the low temperature be lower in a condensing boiler than a standard boiler?

- int: aterials

hy can the low temperature be lower in a condensing boiler than a standard boiler?

int: aterials

ondensing boilers are constructed with stainless steel components which can tolerate exposure to the acidic condensate.

rick uestion

- n routine operation of a <u>condensing</u> boiler, can return water temperatures be as high as ?

rick uestion

- n routine operation of a <u>condensing</u> boiler, can return water temperatures be as high as . . ?
- **nswer:** n a boiler designed for condensing operation, the boiler may operate with return water temperatures higher than . . ut.....?

nswer

- n a boiler designed for condensing operation, the boiler may operate with return water temperatures higher than .

  .

- ut, when so operated, it will not actually be condensing because?

nswer

- n a boiler designed for condensing operation, the boiler may operate with return water temperatures higher than .
  .
- ut, when so operated, it will not actually be condensing because: **the latent heat in the exhaust requires lower stack temperatures to condense.**

▸ ore on ondensing oilers ▸ ater

- ur second speaker, \oger arris, will go into great detail about condensing boilers in his presentation in the second half of this session.

ombustion

- hat determines how much thermal energy is left in the stack gases?

  ?

ombustion

- **hat determines how much thermal energy is left in the stack gases?**

  How hot the fluid in the stack is

  How much total flow there is through the stack

- **hat's in the gases that go up the stack?**

hat determines how much thermal energy is left in the stack gases?

- How hot the fluid in the stack is
- How much total flow there is through the stack
- **hat's in the gases that go up the stack?**
- Combustion products, excess air (nitrogen, oxygen), water vapor

xcess i r

- hy i s t here excess ai r?

xcess ir?

- hy do we need to have a little excess air?
- hy have more than the stoichiometric amount?

xcess ir?

- hy do we need to have a little excess air?
- hy have more than the stoichiometric amount?
- (To avoid having to pronounce stoichiometric?)

xcess ir?

- **hy do we need to have a little excess air?**
- Because the mixing and burning of fuel and air is imperfect

- hat happens to boiler performance when there is too much excess air?

oo uch xcess ir?

- hat happens to a boiler when there is too much excess air?
- Reduces stack temperature by diluting the combustion gases with excess room air,
- Reduces combustion efficiency

oo ittle xcess ir?

?

oo ittle xcess ir?

- Soot, smoke,
- Carbon monoxide, other bad things

art :

valuating the avings chieved y urner ontrols

oals

- ombustion theory basics
- escribe how burners work
- escribe the
  - imitations of mechanical linkages
  - apabilities of electric actuator controls
- iscuss specific burner control systems
- easuring performance & gas usage
  - xisting case

ombustion heory asics

- ombustion?

ombustion heory asics

- ombustion?
  - ombining (burning) a fuel with air resulting in hot exhaust gases
- esirable eat ransfer?

ombustion heory asics

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  - eat transfer from gas gases to the walls of the tubes and then to the boiler water
- hat then happens to the water?

ombustion

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- hat then happens to the water? t gets hot and may boil…

ombustion heory asics

- hat then happens to the water? t gets hot and may boil…
- hat determines whether it boils or not?

ombustion heory asics

- hat then happens to the water? t gets hot and may boil…
- hat determines whether it boils or not?
  - ow much heat is supplied
  - \esulting temperature and pressure in the boiler
- hy does a hydronic boiler not make steam?

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  - he hot water or steam produced
- here does the rest of the energy go?
  - owhere.
  - uh?
  - t stays where it has been which is where?

ombustion heory asics

- here does the rest of the energy go?
  - owhere.
  - uh?
  - t stays where it has been, in the hot gases
- hat do we do with these hot gases?

ombustion heory asics

- here does the rest of the energy go?
  - owhere.
  - uh?
  - t stays where it has been, in the hot gases
- hat do we do with these hot gases?
  - xhaust them up the chimney

ombustion heory asics

- e exhaust hot gases up the chimney because?
  - ultiple choice:
    - . t is cheaper to make boilers that have hot exhaust
    - . uel waste is good for the economy
    - . he boiler is limited by thermodynamic laws & there must always be some waste heat
    - . f the gases were cooler, they would make the chimney “yuccify” and the boiler to “croak”

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- e exhaust hot gases up the chimney because?
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    - nswer: , , and a little

ombustion heory asics

- f the gases were cooled enough
  - the acidic parts of the exhaust will condense
    - on the chimney
    - on the boiler heat transfer surfaces
  - nd damage them

ombustion heory asics

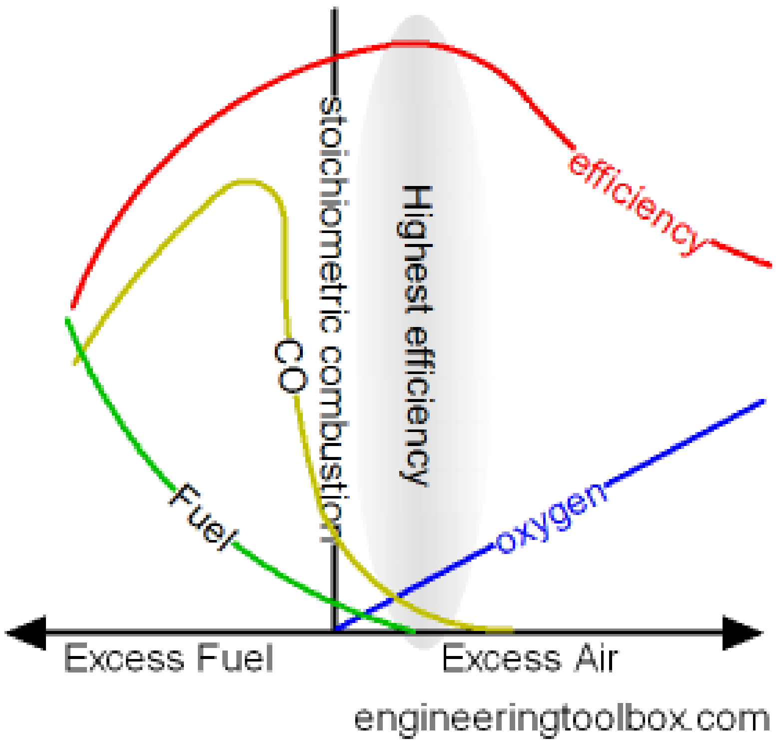
- o ensure complete combustion of the fuel used, combustion chambers are supplied with excess air.
- xcess air increases the amount of oxygen and the probability of combustion of all fuel.
- hen fuel and oxygen in the air are in perfectly balance - the combustion is said to be stoichiometric .
- he combustion efficiency will increase with increased excess air, until the heat loss in the excess air is larger than than the heat provided by more efficient combustion.
-
- ypical excess air to achieve highest efficiency for different fuels are
- . - % for natural gas
- . - % for fuel oil

ombustion heory asics

- pproximate inimum as emperatures to void orrosion roblems

  - atural as-
  - il uel – ypical sulfur %, > . %
  - il uel – ow sulfur %, < . %

ombustion heory asics



ombustion heory asics

- arbon dioxide - . - is a product of the combustion and the content in the flue gas is an important indication of the combustion efficiency.

  fter combustion:

  _ ptimal content of carbon dioxide - . —

  ~% for natural gas

  - ~% for light oils.

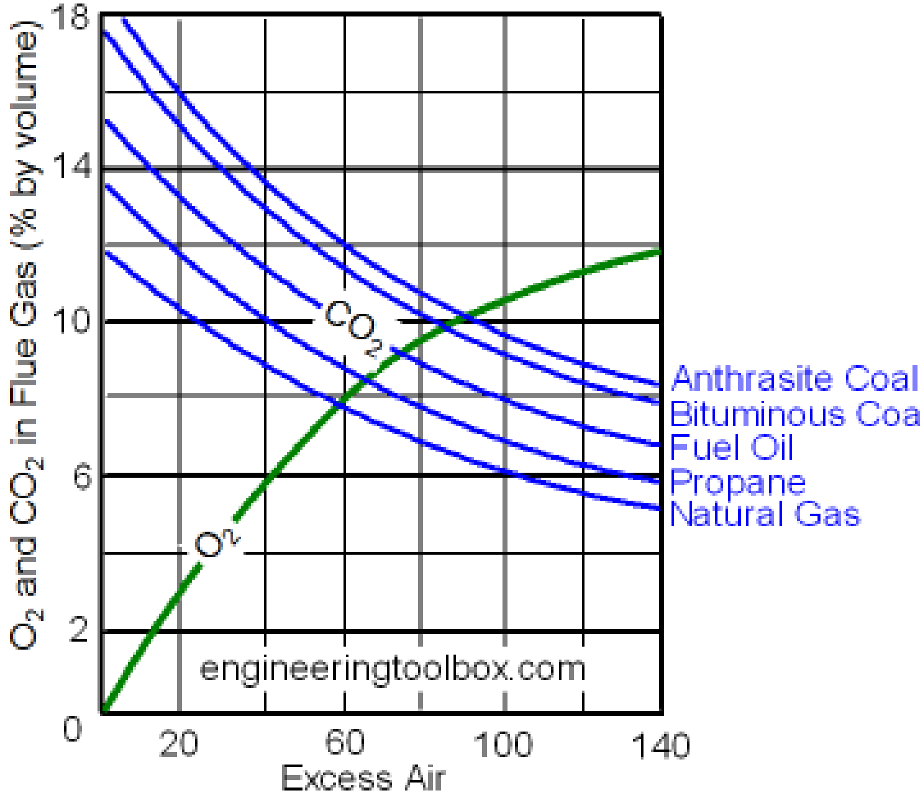
ombustion heory asics

- hat is the relationship of the stack gas percentages of:
- ?
- xygen?

ombustion heory asics

- hat is the relationship of the stack gas percentages of:
  - ?
  - xygen?

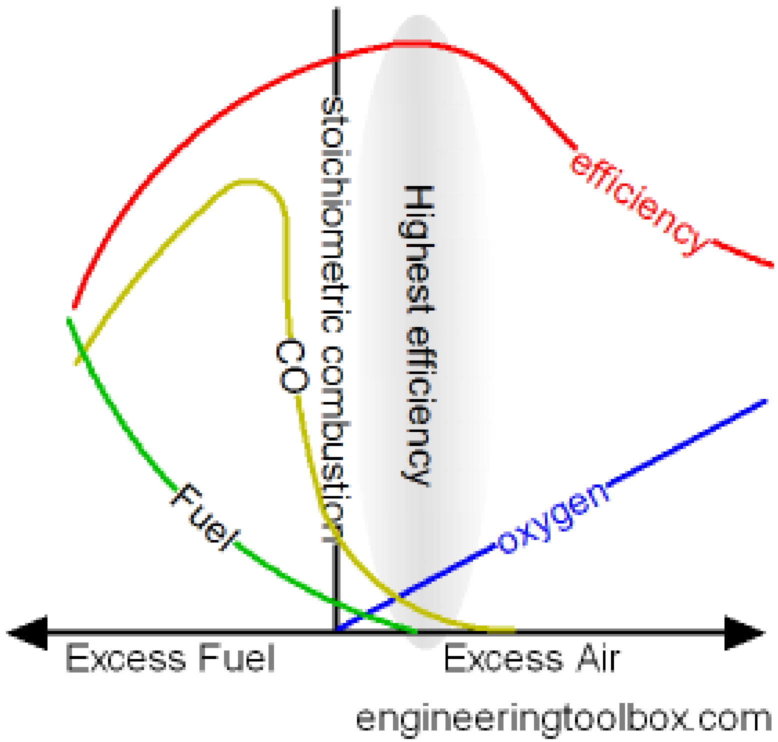
ombusti on heor y asi cs



ombustion heory asics

- ake a look at the ombustion chart again
  - ith regard to efficiency:
    - hat is the impact of oxygen levels?
    - t what level of excess oxygen become maximum?
    - hat happens to efficiency when there is too little oxygen?

ombustion heory asics



ombustion heory asics

Normal combustion efficiencies for natural gas at different amounts of excess air and flue gas temperatures are indicated below:

Combustion Efficiency (%)						
Excess %		Flue Gas Temperature (^oF)				
Air	Oxygen	200	300	400	500	600
9.5	2.0	85.4	83.1	80.8	78.4	76.0
15	3.0	85.2	82.8	80.4	77.9	75.4
28.1	5.0	84.7	82.1	79.5	76.7	74.0
44.9	7.0	84.1	81.2	78.2	75.2	72.1
81.6	10.0	82.8	79.3	75.6	71.9	68.2

urner ontrols
for ontrolling ir & uel

- unctions?
  - ptimize air/fuel ratio
    - ow?

urner ontrols
for ontrolling ir & uel

- unctions?
  - ptimize air/fuel ratio
    - nsure complete fuel combustion
    - aintain optimal excess-air levels
    - aintain target boiler temperature or pressure
      - \eadjust respond quickly to changes in external conditions
        - arometric pressure
        - ind
        - ther

urner ontrols for ontrolling ir & uel

- ld way:
  - djustable linkages
    - onnecting rods regulate
      - uel valve
      - ir damper opening
    - nstable efficiencies:
      - annot be optimized for all conditions
    - mprecise
      - o not track the same when
        - \amping up and ramping down

urner ontrols for ontrolling ir & uel

- ew way:
  - inkage-less ctuators with icroprocessors
    - lectric actuators provide independent control of
      - uel valve
      - ir damper opening
    - recise
      - rack the same when
        - \amping up and ramping down

urner ontrols
for ontrolling ir & uel

- f add stack monitoring capability
  - easure , , , x, x
  - icroprocessor continually optimizes for all conditions
  - table efficiencies across the firing range

urner ontrols
for ontrolling ir & uel

- uestion:
  - ow that you have this super duper control how do you apply it?
  - hall we set it up to maintain minimum stack temperatures no matter what?
  - ow well can we do?
    - ssume a typical cast-iron boiler
    - hat efficiency can we target?

urner ontrols
for ontrolling ir & uel

- uestion: ith these burner controls,
  - hat efficiency can we target?
    - %
    - %
    - %
    - %
    - %
    - %
    - %
    - % or less

urner ontrols
for ontrolling ir & uel

- uestion: ith these burner controls,
  - hat stack temperature can we target?

urner ontrols for ontrolling ir & uel

- uestion: ith these burner controls,
  - hat % level can we target?
    - % or less
    - . %
    - %
    - . %
    - %
    - . %
    - . %
    - . %
    - % or more

urner ontrols
for ontrolling ir & uel

- uestion: ith these burner controls,
  - hat % savings can we achieve?
    - % or less
    - %
    - %
    - %
    - %
    - %
    - %
    - %
    - **8% or more**

urner ontrols
for ontrolling ir & uel

he burning question:

ith these controls,

- hat % savings can we achieve?
  - hat do you need to know to estimate the savings in therms?

urner ontrols
for ontrolling ir & uel

he burning question: ith these controls:

- hat % savings can we achieve?
- hat do you need to know to estimate the savings?
  - ow many therms is the boiler using now?

urner ontrols
for ontrolling ir & uel

he burning question:

ith these controls,

- hat % savings can we achieve?
- hat do you need to know to estimate the savings?
  - ow many therms is the boiler using now?
  - hat type of boiler is it?
  - hat type of burner controls does it have now?
- hat is the key single-most important question to answer about the existing boiler?

urner ontrols
for ontrolling ir & uel

he burning question with these controls,

- hat % savings can we achieve?
- hat is the key single-most important question to answer about the existing boiler?

nswer: hat efficiency is it operating at now?

ou can’t evaluate savings meaningfully unless you know the answer to this question.

urner ontrols
for ontrolling ir & uel

he new (grammatically optimized) burning question:

t what efficiency is it operating **now**?

ow do we find out?

urner ontrols
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t what efficiency is it operating **now**?

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Questions?

???

Thank you.

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