EEN-E2002 Combustion Technology / 2019

Learning Exercise 5

The exercise is meant to be completed as pair work. However, it can also be completed individually or in a group of three students.

The solution is to be returned as a single pdf file. Only one solution is needed from a pair or team. On the first page of the solution you have to write your name and student number and, if you worked in pairs or groups, the names and student numbers of everyone in your pair/group.

The solution must be clear and readable, and it may be hand-written or created with a computer. The equations and input data that you are using must be clearly specified, as well as any sources you have used. Include tables and diagrams to illustrate your results as requested in the problem. Please note that all students are expected to follow the Aalto University Code of Academic Integrity (see https://into.aalto.fi/display/ensaannot/Aalto+University+Code+of+Academic+Integrity+and+Handling+Violations+Thereof).

Name the uploaded pdf-file so that it tells the name of the course, learning exercise number, and your name, like Combustion_Technology_LE5_Lastname.pdf.

No single question/problem is compulsory, but a minimum of 50 % of points is required in order to pass the exercise. A proper length of an answer for the whole learning exercise would be maximum 8 pages. The time for answering this exercise is estimated not to exceed 8 hours, provided that you have attended lectures.

Return deadline of LE5: Monday, 18th March, 2019 at 16:00 pm.

Please read the problem statement carefully! Note that there are two pages.

Task 1 (6 x 6 p. = 36 p.)

We will continue analyzing the situation outlined in LE 4. You may want to have a copy of the problem statement and model solution of LE 4 at hand when you start working.

In all following calculations, it is assumed that ethanol is used as a fuel and the firing rate is 3.5 MW (based on LHV). It is also assumed that both fuel and combustion air enter the furnace at 25 °C. The oxygen mole fraction in dry flue gas is assumed to be 2.0 %.

Please note that the problem has been composed in the following way. Items a), b) and c) are not very time-consuming, and solving them correctly will give you 50 % of the maximum score. So those of you who are just now having some other urgent work to do and are only aiming at the required minimum of 50 % of points for this learning exercise, try to concentrate on these three items with maybe a little work on subsequent items just for the sake of safety. Items d), e) and f) are much more time-consuming and are meant for those who are after the highest grades and really want to immerse themselves in the details of energy balances in combustion. I would have been quite happy with a simpler task for items d), e) and f), but the nature of the phenomena that we are studying just makes the whole business so much more tedious.

a) The exit temperature of the flue gas is 127 °C. Calculate the flue gas loss (kW) and estimate furnace efficiency (%) based on LHV of the fuel. In estimating the furnace efficiency, you only need to include the flue gas loss in the efficiency calculation.
b) Calculate the higher heating value (HHV) of ethanol based on your knowledge of the chemical composition and LHV of ethanol.
c) Calculate the firing rate based on HHV and estimate furnace efficiency (%) based on HHV of the fuel. (It is assumed here that the fuel flow rate is the same, but the firing rate will be different because the values of LHV and HHV are different.) In estimating the furnace efficiency, you only need to include the flue gas loss in the efficiency calculation.
d) Now consider a mixture of 15 % of water (by mass) in ethanol. Calculate the HHV and LHV of the mixture.
e) Write the reaction equation for the combustion of this mixture in air with an air factor λ. What will be the value of λ if the oxygen mole fraction in dry flue gas is assumed to be 2.0 %?
f) Calculate the flow rates of fuel, combustion air and flue gas for this mixture. Firing rate is assumed to be 3.5 MW (based on LHV). Calculate the flue gas loss (kW) and estimate furnace efficiency (%) for this mixture (on LHV basis). In estimating the furnace efficiency, you only need to include the flue gas loss in the efficiency calculation. The exit temperature of the flue gas is 127 °C.

Attach a list of your sources (a reference list) in your solution. When you present your findings, specify the sources using the normal conventions of scientific writing (see, e.g., http://libguides.aalto.fi/citation_guide . Please include also the page number containing the information.

Task 2 (this does not affect the grading)

Your free feedback on the first weeks of part II of the course and time spent on this learning exercise.