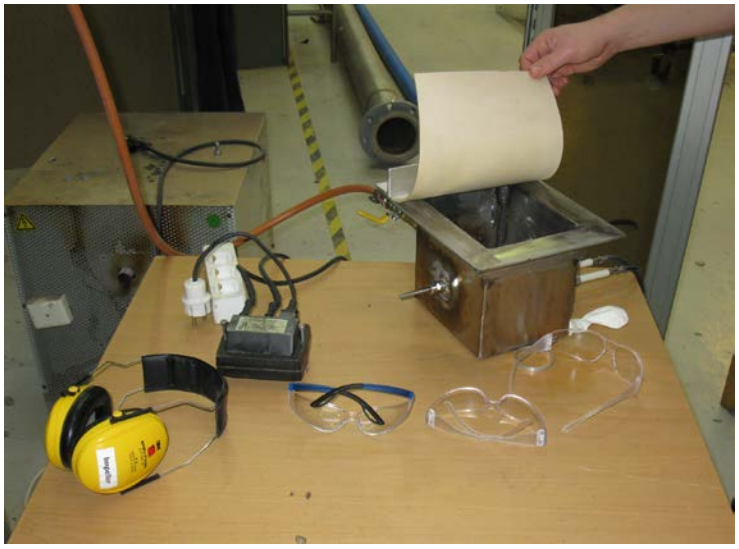
Department of Energy and Process Engineering, NTNU
TEP4170 Heat and Combustion Technology

Mar15/Mar16/ise

Lab exercise II: Premixed combustion



The experiment, simply described:
-Measure a certain amount of fuel. The (pure) fuel will fill the volume of a spherical balloon.
-Lead the fuel (methane) into the box, which is filled with air. Mix air and fuel.
-Ignite.
-Observe whether it burns or not.

Work before entering the laboratory:
Make a spreadsheet where you can vary the stoichiometry (in terms of % fuel in fuel-air mixture), temperature, pressure and volume. The temperature will be that of the laboratory air (not far from 20 °C). The pressure in the box will be approx. that of the air (1 atm = 1.013 bar =101.3 kPa). The pressure in the balloon where you measure the fuel volume will be a little above air pressure – you may have to estimate it. The volume of the box is 4.1 liter (4.1 dm^3). The fuel is methane.

During the experiment, the fuel concentration in the box shall be varied, while the *V*, *T* and *p* of the box (before combustion) can be assumed constant during the series of experiments (but in principle unknown before you enter).

Your spreadsheet should tell you the necessary diameter of the sphere (balloon) containing the fuel, when you have estimated the pressure (of the balloon), know the temperature and pressure of the box and have decided the resulting content of fuel in the box (% of fuel in the air-fuel mixture).

Reminders:
Volume of a sphere with radius *r* and diameter *d*: $V = \frac{4}{3}\pi r^3 = \frac{1}{6}\pi d^3$
Universal gas constant: R_u=8.314 J/(molK)
Pressure: 1 atm = 1.01325 bar = 101325 Pa; Pa = N/m^2 = Nm/m^3= J/m^3
For ideal gases: mole fraction = volume fraction

Hint: With the relevant fuel-air mixtures, *T*, *p* and *V* of the box, the balloon diameter will have an order of magnitude of 1 dm. Much bigger – or much smaller – values will most likely demonstrate that you have made an error in the spreadsheet model.

Equipment:

- The combustion “box” w. fuel supply, a balloon, mixing, electric ignition etc.
- Vernier caliper (Norw: Skyvelære)
- Thermometer (of the lab air).
- Air blower, pressurized air, vacuum cleaner or similar.
- Adhesive tape (Norw: limband), knife/scissors.
- Earmuffs (Norw: øyreklokker) for hearing protection.
- Protection glasses

Conduct of the experiment:

- Chose the desired % fuel in the box. Determine the diameter of the balloon when it contains the necessary fuel. Your spreadsheet should do this for you.
- Close the valve between balloon and box. Open (carefully) the valve between fuel bottle and balloon. Fill the balloon until it has the right diameter. Use the Vernier caliper to measure the diameter. Keep in mind that there might be a slight over-pressure in the balloon.
- Close the valve.
- Open the valve between balloon and box. Let the fuel flow gently into the box. Make sure that the balloon is empty. Close the valve. You can assume that the fuel has displaced pure air from the box.
- Tighten the lid with adhesive tape along the edge.
- Use the mixing device to mix fuel and air well.
- If you have done everything right and well, you now have the box filled with the chosen air-fuel mixture.
- Stay away. **Make sure that hearing protection and glasses are correctly fitted**. Ignite.
- Did anything happen?
- After the trial, blow the box with air to remove reaction products or (if nothing happened) fuel gas.
- Return to the first step, repeat for a new % fuel (or repeat with the same to confirm).

The lower and upper flammability limits (LFL and UFL) are the minimum and maximum content of fuel that burns. They are given as % fuel (mole based) in the air-fuel mixture.

Determine the LFL and UFL.

Hints: approx. 5% and 15% (according to literature)

After the experiment:

- Make a report of the experiment and resulting LFL and UFL.
- Determine (and include in the report) the lower heating value (LHV) of the mixture in the box at LFL, at stoichiometric mixture and at UFL.
- Discuss possible error sources.