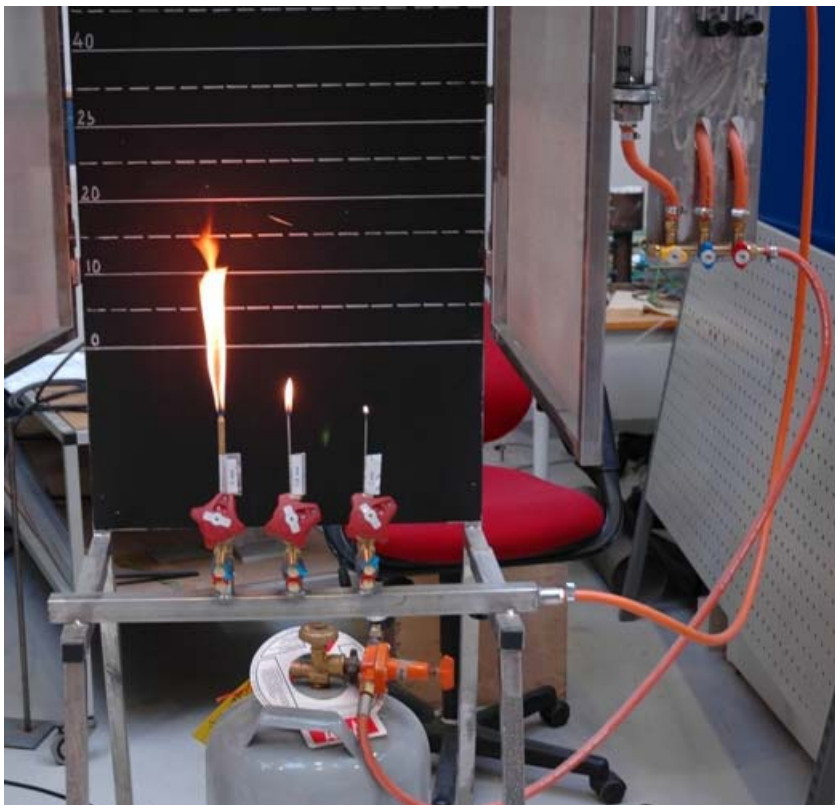
Department of Energy and Process Engineering, NTNU
TEP4170 Heat and Combustion Technology

Lab exercise I: Diffusion flames

Measuring flame length, lift off, blow off and NOx emissions of a non-premixed flame (diffusion flame) of propane in air.

The exercise should take about 35-40 minutes in the lab and a few minutes afterwork.
Each group should present their results in a report that is submitted.



In this exercise you are going to determine different characteristic quantities for a vertical flame. The fuel is propane and three different nozzles (diameters) are available. The velocity of the fuel flow can be estimated from the flow rate, which is measured by a rotameter.

Hint: Conduct all the measurements for one nozzle before changing to another nozzle.

Problem 1: Flame height

The flame height for a diffusion flame can be described by the relation

$$\frac{H}{d} = A \cdot \mathrm{Fr}^n \tag{1}$$

where H is the flame height, d is the (internal) nozzle diameter, $\mathrm{Fr} = u^2/(gd)$ is the Froude number, u is the (average, bulk) fuel flow velocity in the nozzle and g is the gravitational acceleration (9.81 m/s^2). A and n are constants.

Measure the flame height with three different nozzles, each with three different velocities, and determine the constants A and n.

Problem 2: Lift off

At a certain flame height the flame will be lifted from the nozzle. The distance from nozzle to flame is called the lift-off height and can be described by the relation

$$\frac{h}{d} = C \cdot \left(\frac{d}{u} \right)^{-1} \tag{2}$$

where *h* is the lift-off height and *C* is a constant.

Measure the flame height with three different nozzles, each with three different velocities, and determine the constant *C*.

Problem 3: Blow off

When the nozzle velocity becomes too large, the flame might blow off. However, when the nozzle is above a certain critical diameter, the flame will not blow off at all. For propane, this diameter is 16 mm. All nozzles used in this exercise are less than 16 mm, and blow off will occur.

Determine the velocity at which blow off occurs for each of the three nozzles.
Can something be done to avoid blow off?

Problem 4: Estimate of NOx emissions

The emission index for NOx from a propane diffusion flame can be estimated from the relation

$$\mathrm{EI}_{\mathrm{NOx}} = 24 \cdot \mathrm{Fr}^{3/5} \cdot \frac{d}{u} \tag{3}$$

Determine the emission index at the maximum velocity for the three nozzles.

Problem 5: Maximum rate of heat

Determine the maximum rate of heat (lower heating value) that can be converted at each of the nozzles (that is, before blow off).

Propane: molar mass 44.1 kg/kmol; LHV 46360 kJ/kg