Flame height calculation

One point lesson

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Question 1:
Calculate the flame height for a 0.2 m by 0.2 m heptane fire at normal temperature and pressure.

Suggested solution:

The flame height can be calculated using Heskestads flame height equation 1.

$$L = 0.235 \cdot \dot{q}^{(2/5)} - 1.02 \cdot D \tag{1}$$

In order to use the equation, the heat release rate and diameter of the fire must be found. The heat release rate is a function of the mass loss rate, and the diameter is a function of the area.

1. Area and diameter of the fire:

$$A = l \cdot l \tag{2}$$

$$A = 0.2 \text{ m} \cdot 0.2 \text{ m} = 0.04 \text{ m}^2 \tag{3}$$

$$D = \sqrt{\frac{4 \cdot A}{\pi}} = \sqrt{\frac{4 \cdot 0.04 \text{ m}^2}{\pi}} = 0.226 \text{ m} \tag{4}$$

$$\tag{5}$$

2. Mass loss rate of the fire:

$$\dot{m}'' = \dot{m}''_{\infty}\left(1 - e^{-\kappa\beta \cdot D}\right) \tag{6}$$
$$= 0.101 \text{ kg/(m}^2 \text{ s)} \cdot \left(1 - e^{-1.1 \cdot 0.226 \text{ m}}\right) \tag{7}$$
$$\dot{m}'' = 0.022 \text{ kg/(m}^2 \text{ s)} \tag{8}$$
$$\tag{9}$$
$$\dot{m} = \dot{m}'' \cdot A$$
$$\dot{m} = 0.022 \text{ kg/(m}^2 \text{ s)} \cdot 0.04 \text{ m}^2 \tag{10}$$
$$= 0.00089 \text{ kg/s} \tag{11}$$

3. Heat release of the fire:

$$\dot{q} = \chi \cdot \dot{m} \cdot \Delta H_C \tag{12}$$
$$= 0.7 \cdot 0.00089 \text{ kg/s} \cdot 44600 \text{ kJ/kg} \tag{13}$$
$$= 27.7 \text{ kW} \tag{14}$$

4. Flame height of the fire

$$L = 0.235 \cdot \dot{q}^{(2/5)} - 1.02 \cdot D \tag{15}$$
$$= 0.235 \cdot (27.7 \text{ kW})^{2/5} - 1,02 \cdot 0.226 \text{ m} \tag{16}$$
$$= 0.66 \text{ m} \tag{17}$$

The flame height for a 0.2 m by 0.2 m heptane fire at normal temperature and pressure, is calculated to 0.66 m.

Bjarne Christian Hagen took his master degree in fire protection at University of Maryland and his Ph.D at University of Bergen. He has worked at Western Norway University of Applied Sciences (HVL) since 1995, in addition to Gassco og Rogaland Brann og Sikkerhet (RBS).

Hagen is today Associate Professor at Department of Safety, Chemistry and Biomedical laboratory sciences at HVL.

This booklet is part of a small series of books where the author addresses issues where students are known to struggle. The problems or issues are addressed if students ask questions, or the lecturers point out the problem.