Lecture F12 Mud: Energy Conservation

1. **What's the difference between dE/dt and $\dot{E}_{\text{flow}}$?** (1 student)
   dE/dt is the rate of change of energy contained by the mass already in the volume. $\dot{E}_{\text{flow}}$ is haw fast energy is being brought into or out of the volume by inflowing and outflowing mass.

2. **What's the difference between $\dot{Q}_{\text{viscous}}$ and $\dot{W}_{\text{viscous}}$?** (1 student)
   Imagine a viscous friction force $\vec{F}_f$ rubbing on the surface of the CV, much like a boundary layer "rubs" on the surface of an airfoil. This force does work if there is fluid velocity at the point of application, $\dot{W}_{\text{viscous}} = \vec{F}_f \cdot \vec{V}$. But if there's a friction force, there must also be frictional heating present (a boundary layer is always slightly warmer than the effectively-inviscid fluid next to it). This excess heat will flow into the CV, and constitute $\dot{Q}_{\text{viscous}}$.

3. **How do the physical definitions of h and h_o and h_{o_∞} differ?** (1 student)
   The static enthalpy h measures only the energy of the molecules as seen be an observer moving with the mean velocity. The total enthalpy h_o is the energy seen by a fixed observer (it includes the mean kinetic energy). h_{o_∞} is just the h_o of the freestream flow.

4. **Shouldn't $\partial p/\partial t$ come into play in the last PRS? How about the velocity?** (1 student)
   No. This was a steady problem. There is no variation of the flowfield with time, so $\partial p/\partial t = 0$.

   The other term you refer to is $\vec{g} \cdot \vec{V}$. This would come into play if the channel was tilted up or down. With a horizontal channel, $\vec{g}$ and $\vec{V}$ are perpendicular, so the dot product is zero. But even with a tilted channel, gravity effects in thermal problems are usually miniscule.

5. **How can the energy equation be violated?** (1 student)
   I'm not sure what you mean. In practice it can't be violated. The First Law always works.

6. **In the PRS, how is the momentum flow $\neq 0$ while the energy flows $= 0$?** (1 student)
   That's how it works out for the flow case shown. Momentum is a vector, so the opposite flow jets have a different effect on it than on the scalar energy.

7. **How can we have a $\dot{q}$ without a ΔT at the boundary?** (1 student)
   The heat can "sneak" into the interior of the CV in the form of chemical bonds in the fuel molecules brought inside, and <u>then</u> released as the $\dot{q}$ term. This chemical energy isn't counted in the usual measure of e or h, which depend only the molecular kinetic and vibration energies. Another way energy can sneak into the CV is in the form of photons, which aren't part of the energy accounting until they are absorbed by matter. Heat flow by ΔT at the boundary constitutes $\dot{Q}_{\text{viscous}}$ in our notation.

8. **What does the porous plug do? Is it a strainer?** (1 student)
   The plug exerts a retarding friction force on the fluid passing through it. The screen

in your window does the same thing to air passing through it. In each case there must be a pressure drop across the plug or screen to force the fluid against the friction.

9. **In PRS 2, how do you know that no heat is removed from the CV as the flow is forced through the plug?** (1 student)
Once steady state is reached, the isolated plug cannot deliver or remove heat, otherwise it would continually get colder or warmer. There is no heat flow out of or into the plug to sustain this.

10. **Wouldn't the temperature be slightly lower downstream of the plug?** (1 student)
You are correct. The air downstream has been expanded to a larger specific volume v because of the pressure drop. So its ρ is smaller, hence V downstream is larger by continuity. For a constant $h_o = h + V^2/2$, a larger V implies a lower h and hence a lower $T = h/c_p$.

11. **No mud** (6 students)