(3) A perfect heat engine, or combination of heat engines, has as its only input equal amounts of hot water at 90 °C and cold water at 10 °C. As its only output it squirts all this water out in one high-speed jet. What can you say about the temperature and speed of the water in the jet?

Assume the specific heat of water, c_v, is constant between the temperature of the cold water, $T_1 = 283$ K, and that of the hot water, $T_2 = 363$ K. If the process does not change the total entropy the temperature T of the water in the jet must be such that $\ln(T/T_1) - \ln(T_2/T) = 0$. Hence $T = (T_1 T_2)^{1/2} = 320.5$ K, or 47.5 °C. The thermal energy of a kilogram of cold water has been increased by $c_v(T - T_1)$ while that of a kilogram of hot water has been lowered by $c_v(T_2 - T)$. The difference, in this case 5.0 c_v, becomes the kinetic energy of 2 kg of water in the jet. Taking $c_v = 4000$ J/kg deg, we get 140 m s^{-1} for the speed of the jet. These are limiting values. Any irreversibility in the process will result in a higher temperature and lower velocity for the output water. In fact, to achieve the ideal performance we would need a sequence of heat engines, operating over infinitesimal temperature steps, to transfer heat reversibly from the hot to the cold water.