at its high value, 500 °C. As a result, the temperature difference between the hot and cold streams is higher than it was in the previous example, where the temperature of the hot stream was allowed to drop and get closer to that of the colder stream. By increasing the flow rate, the process was further removed from the assumptions of quasi-static operation and thus became more irreversible.

Question: It is suggested by a member of the engineering team that if the heat bath were operated with some suitable fluid, other than steam, it might be possible to decrease the generation of entropy. How should we respond to this suggestion?

Answer: We respond by pointing out that the entropy change of the bath does not depend on the properties of the hot stream. It depends only on the amount of heat that is exchanged, and on the temperature of the bath. Any substance under the same conditions would make exactly the same contribution to entropy generation. The suggestion has no technical merit.

Example 6.4: Heat Bath
Steam is to be heated in a flow process at constant pressure of 1 bar, from 150 °C, to 300 °C. Calculate the entropy generation.

Solution We are not given information about the stream that accomplishes this heating; therefore, we must make some assumptions about its conditions. Clearly, the heating fluid must enter at a temperature that is *at least* 300 °C, otherwise the steam will not be able to reach the desired final temperature. In theory, any temperature above 300 °C will do; in practice, we must have a sufficient temperature difference in order to accomplish the heat transfer within reasonable time. Let us assume that the inlet temperature of the heating fluid is 305 °C. We will further assume that the flow rate of the heating fluid is very high so that the temperature of the unknown stream remains practically constant through the exchanger. With these two assumptions the problem reverts to the exchange of heat between a system (steam) and a bath (the unknown heating fluid), as in the previous example:

$$S_{\text{gen}} = S_2 - S_1 - \frac{Q}{T_{\text{bath}}}.$$

The heat was found to be $Q = 298$ kJ/kg. With $T_{\text{bath}} = 305 + 273.15 = 518.15$ K, the entropy generation is

kJ/K kg

$$S_{\text{gen}} = (8.2171 - 7.6147)\ \text{kJ/kg} - \frac{298\ \text{kJ/kg}}{518.15\ \text{K}} = 0.0871\ \text{kW/K kg}.$$

Comments The entropy balance is applied to the system *plus* its surroundings, and for this reason, an exact calculation requires the detailed knowledge of processes in the surroundings. In this example we filled in the missing information by making *assumptions*. In particular, we assumed that the unknown stream is a *heat bath* with a temperature determined by