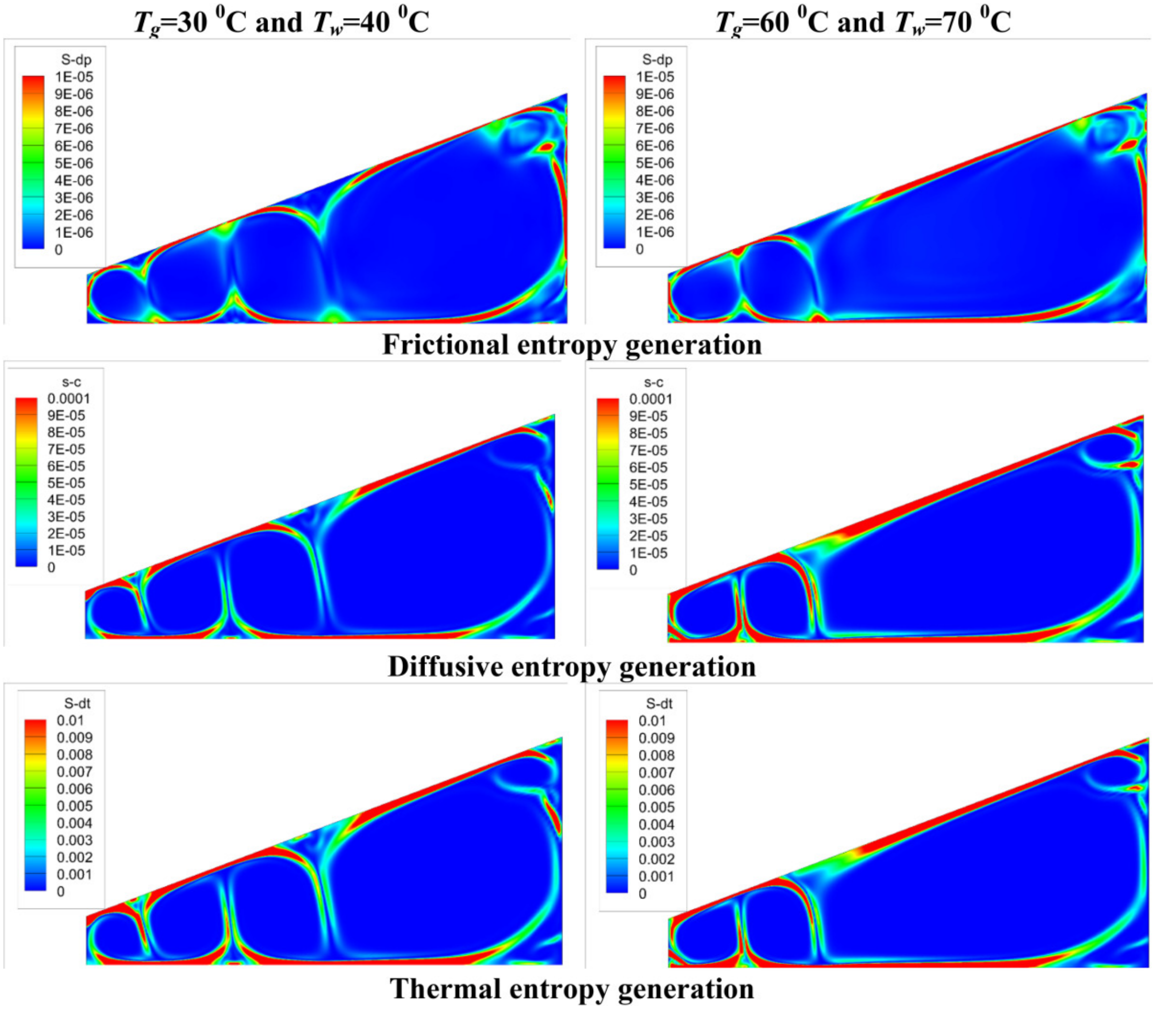


ME 200 (Thermodynamics I)
Lecture 27

More Discussion on Entropy Production

Recall the Entropy Equation,

$$\frac{dS}{dt} = \sum_{in} \dot{m}s - \sum_{out} \dot{m}s + \int_{b} \frac{\delta \dot{Q}_{into}}{T} + \dot{\sigma}$$

or, after integrating in time,

$$\Delta S = \sum_{in} ms - \sum_{out} ms + \int_{b} \frac{\delta Q_{into}}{T} + \sigma$$

The entropy production/generation $(\sigma, \dot{\sigma})$ is used to determine if the process is:

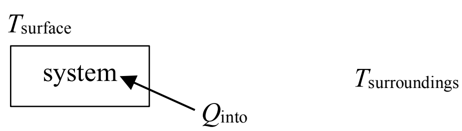
- internally reversible $(\sigma, \dot{\sigma} = 0)$
- internally irreversible $(\sigma, \dot{\sigma} > 0)$
- impossible $(\sigma, \dot{\sigma} < 0)$

When considering a collection of components in a system, e.g., a turbine, a compressor, a boiler, etc., the entropy production can be used to determine which component introduces the most irreversibility, i.e., which component should be the focus of design improvements. The larger the σ, the more the irreversibility.

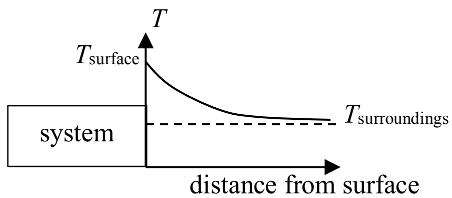
When evaluating the heat transfer term,

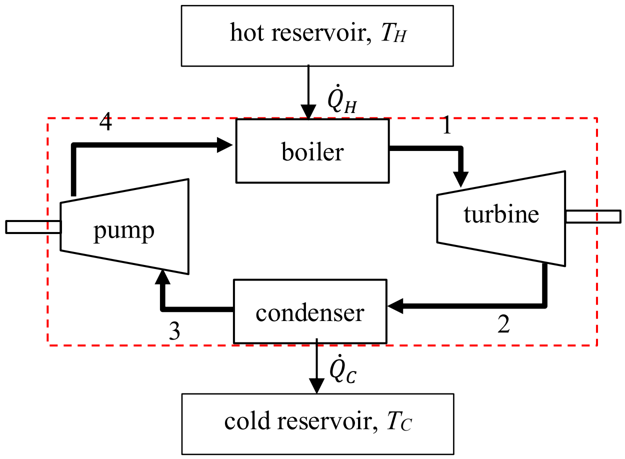
$$\int_{b} \frac{\delta Q_{into}}{T}$$

one must know the temperature value <u>where the heat transfer is crossing the system boundary</u>.



What if the temperature at the system boundary isn't known? In reality, "thermal boundary layers" exist adjacent to an object's surface where the temperature changes in a continuous manner to match the temperature of the surroundings.





$$\frac{dS}{dt} = \sum_{in} \dot{m}s - \sum_{out} \dot{m}s + \int_b \frac{\delta \dot{Q}_{into}}{T} + \dot{\sigma}$$

Example (SecondLaw_22)
Air expands isothermally at steady state with no internal irreversibilities through a turbine from 10 bar (abs) and 500 K to 2 bar (abs). Determine the heat transfer per unit mass flow rate of air and work per unit mass flow rate of air.

Example (SecondLaw_23)

An isolated system of total mass m is formed by mixing two equal masses of the same liquid, assumed incompressible with the same specific heat c, initially at the absolute temperatures T_1 and T_2. Eventually the system attains an equilibrium state.

a. Determine the amount of entropy produced in terms of m, c, T_1, and T_2.

b. Demonstrate that s must be positive.