

AVAILABLE ENERGY

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Assume that a given amount of energy q in Gas 1 at $T = 1500^\circ\text{K}$ is transferred to Gas 2 at $T = 1200^\circ\text{K}$ or to Liquid 1 at $T = 900^\circ\text{K}$ or to Liquid 2 at $T = 600^\circ\text{K}$. In each case the secondary fluid absorbs all the heat without loss. If work could be extracted from any of the four fluids by a heat engine with a heat rejection temperature $T_0 = 300^\circ\text{K}$ (27°C) it is seen that as the fluid temperature T is reduced the amount of available energy in the fluid is reduced. At lower temperatures the potential for doing work is reduced and the efficiency decreased. There is a corresponding increase in Δs for a given value of q . Note that $\Delta s = q/T$.

A change in the value of the heat rejection temperature T_0 will alter the amount of available energy and hence the potential efficiency for converting heat to work. An analysis of the amount of available energy in a fluid at various points in a thermodynamic cycle will give some insight into the usefulness or value of the fluid under those conditions assuming that the fluid could be put to work to generate useful energy (mechanical or electrical).

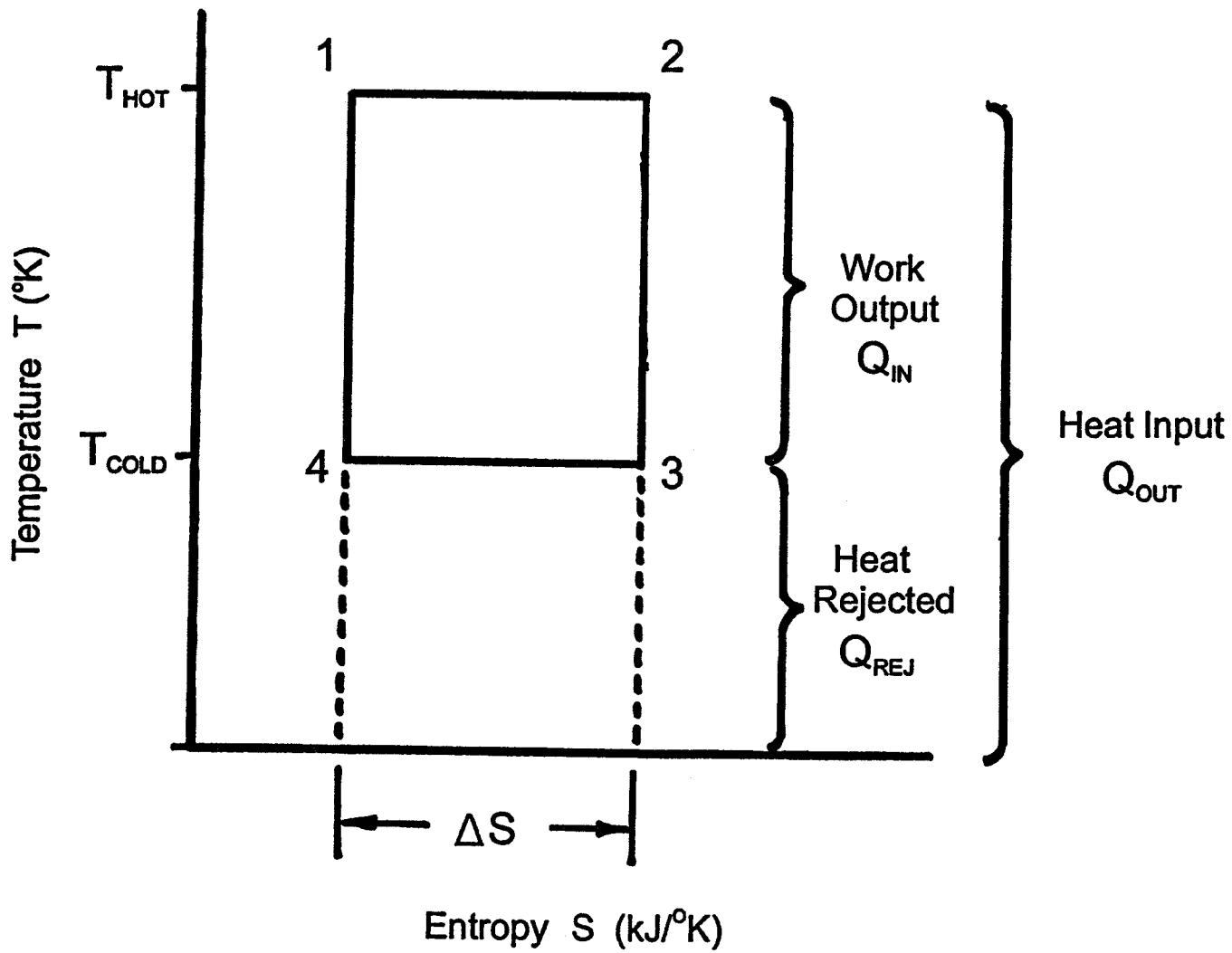


Figure 1 Carnot cycle

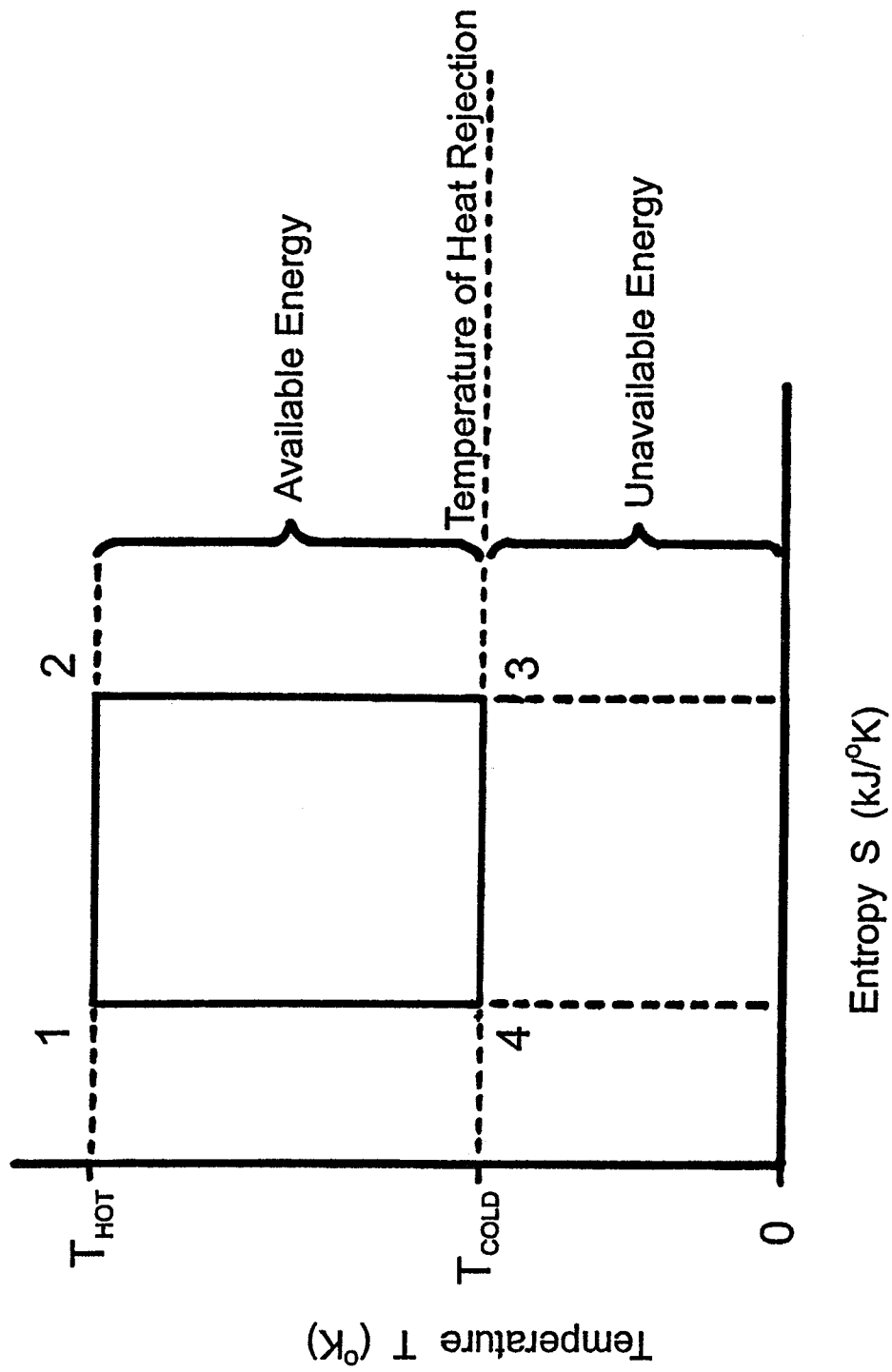


Figure 2 Available and unavailable energy

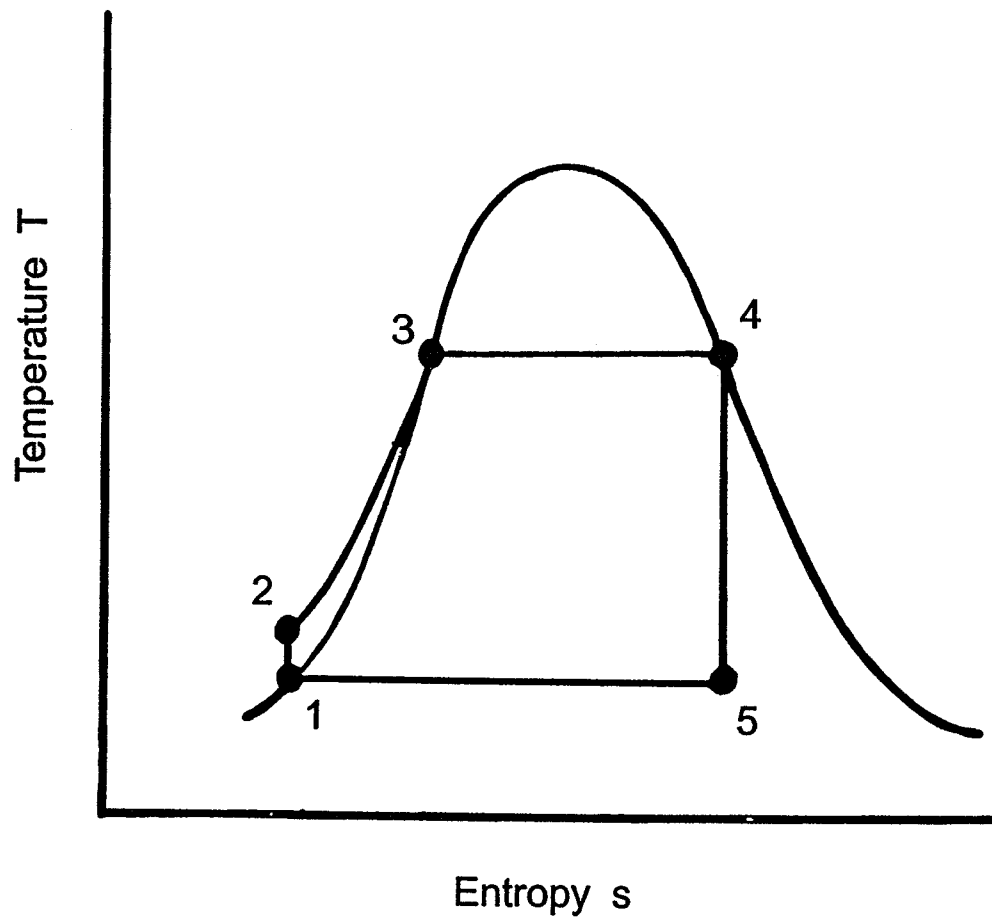


Figure 3 Rankine cycle

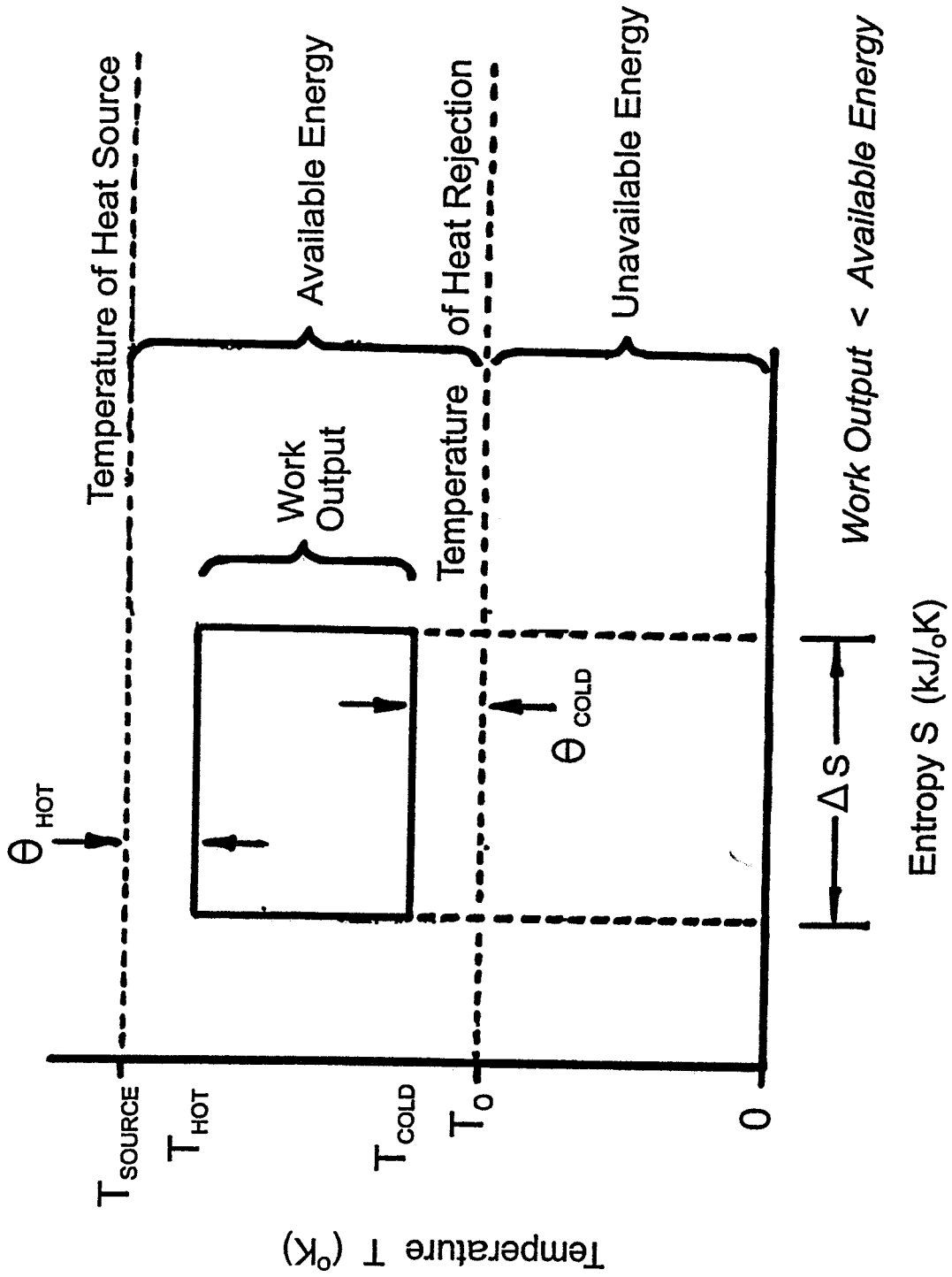


Figure 4 Available energy and work output

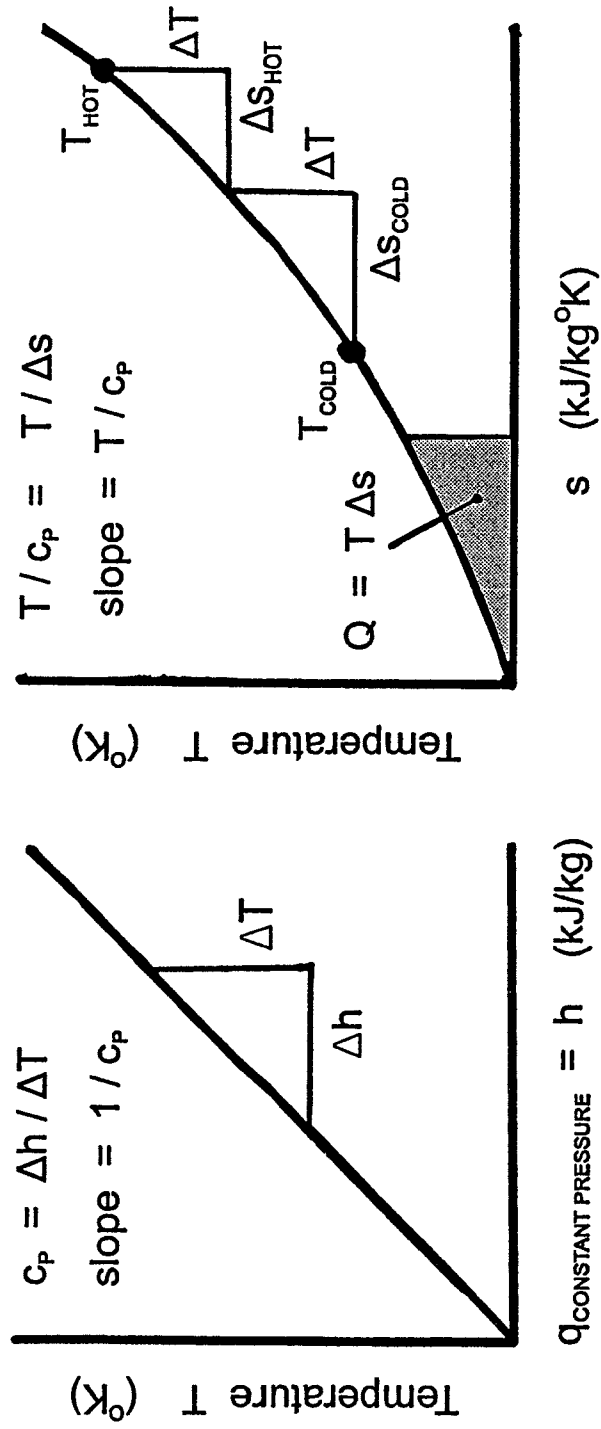


Figure 5 Temperature-heat added and temperature-entropy at constant pressure

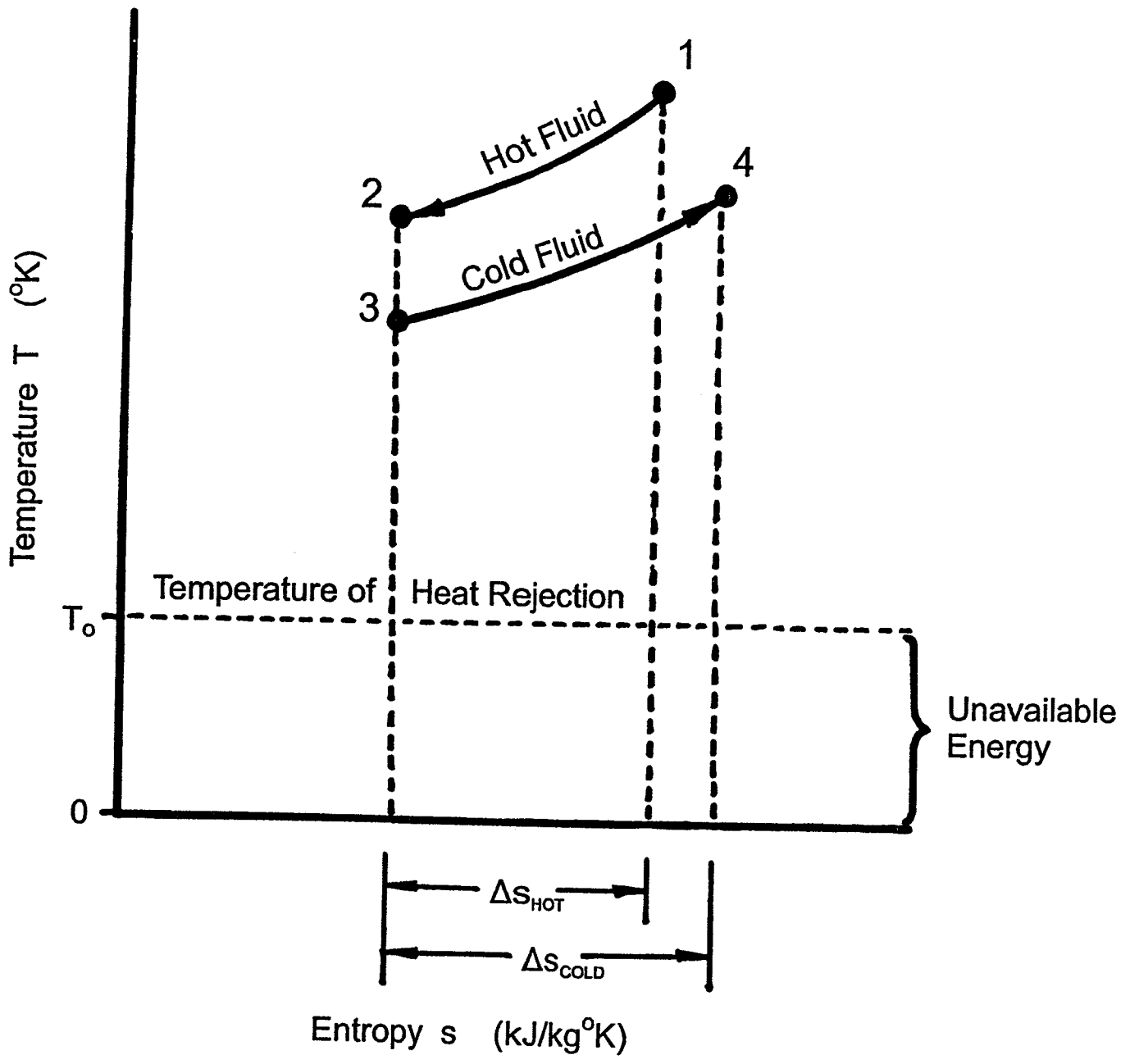
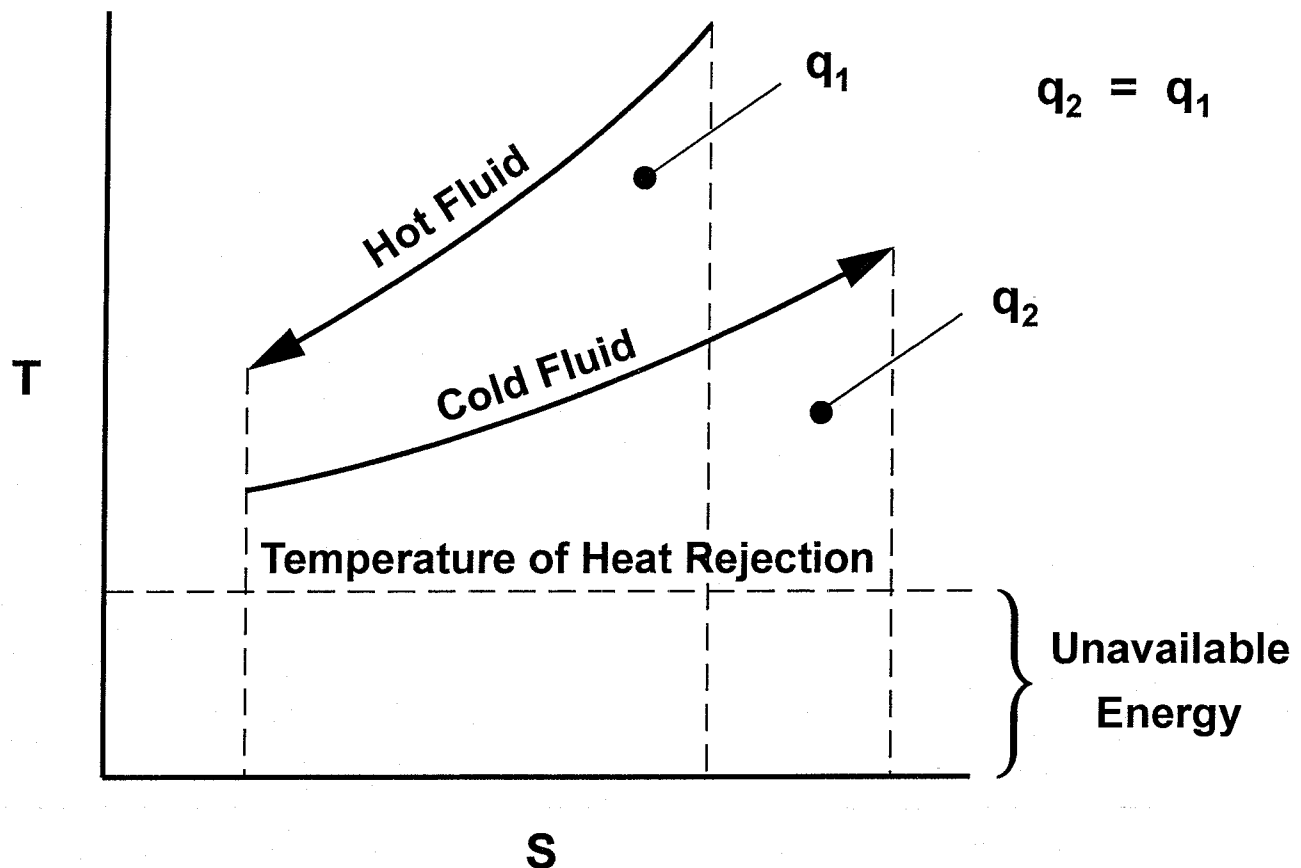


Figure 6 Heat transfer across a temperature difference

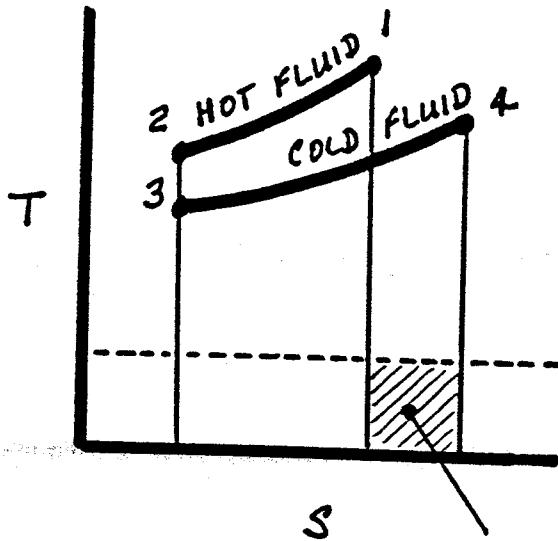
HEAT TRANSFER ACROSS A TEMPERATURE DIFFERENCE

Typical Heat Exchange Process



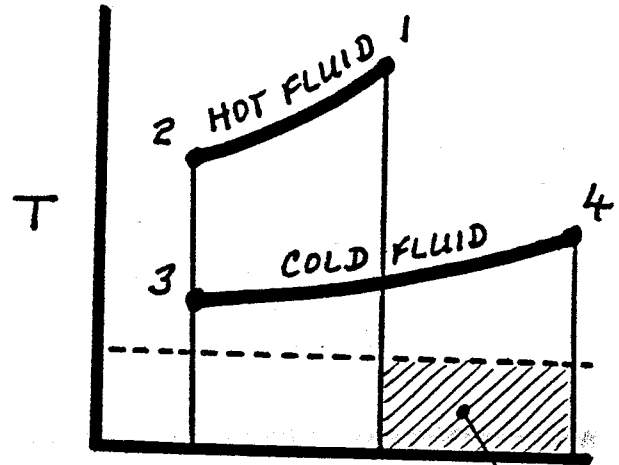
- Heat lost by hot fluid $q_1 =$ heat gained by cold fluid q_2
- Hot fluid decreases in temperature and cold fluid increases in temperature
- Heat is transferred across a temperature difference (irreversible process)
- Entropy change of each fluid results in a net increase of entropy
- Unavailable energy (that must be rejected in a thermodynamic cycle) is increased

EFFECT OF ΔT ON UNAVAILABLE ENERGY



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INCREASE IN UNAVAILABLE ENERGY



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INCREASE IN U.E.

SMALL ΔT BETWEEN HOT AND COLD FLUIDS

SMALL INCREASE IN UNAVAILABLE ENERGY

SMALL LOSS IN AVAILABLE ENERGY

HIGH EFFECTIVENESS OF AVAILABLE ENERGY TRANSFER

LARGE ΔT BETWEEN HOT AND COLD FLUIDS

LARGE INCREASE IN UNAVAILABLE ENERGY

LARGE LOSS IN AVAILABLE ENERGY

LOW EFFECTIVENESS OF AVAILABLE ENERGY TRANSFER

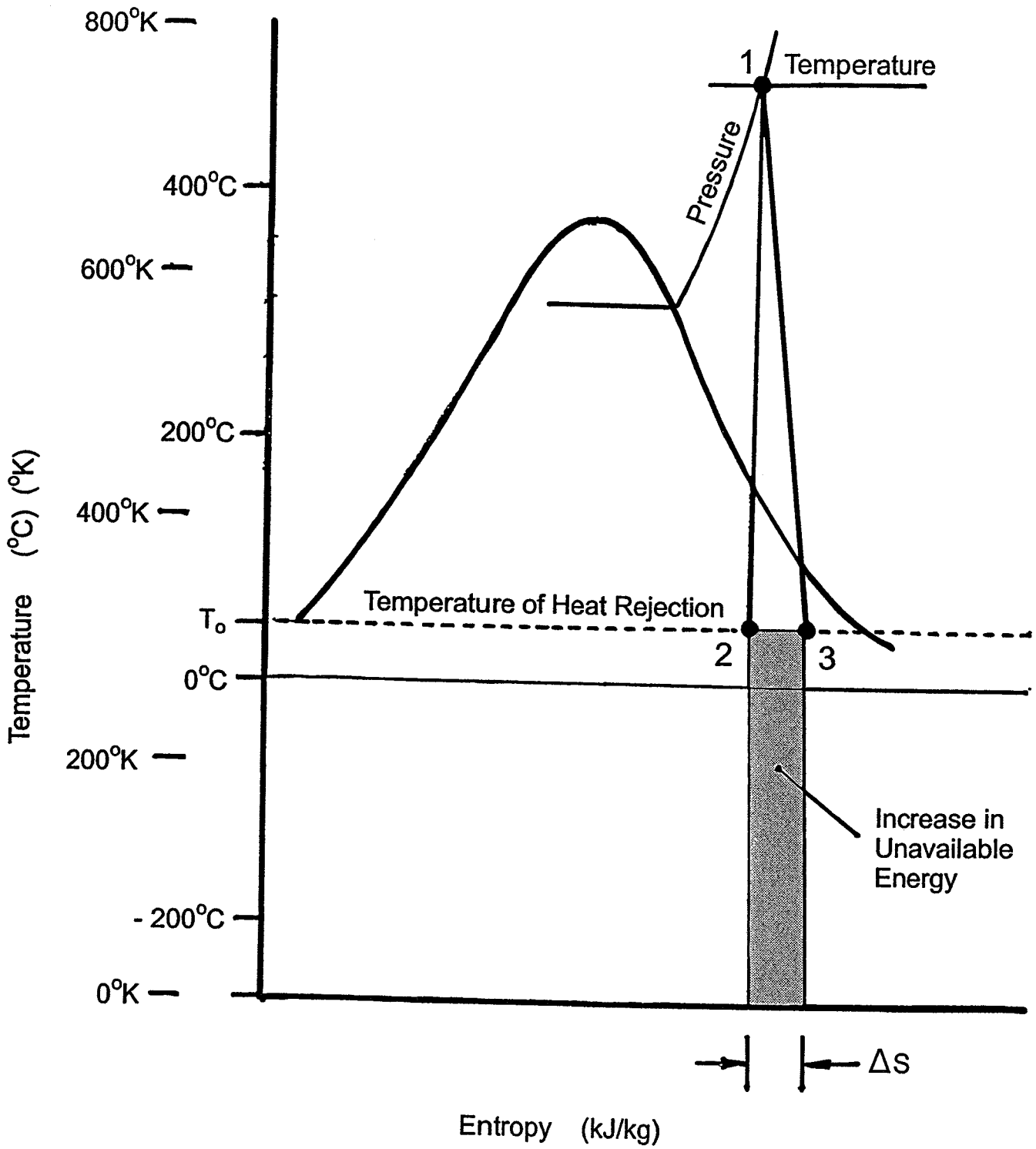


Figure 7 Fluid friction in a steam turbine

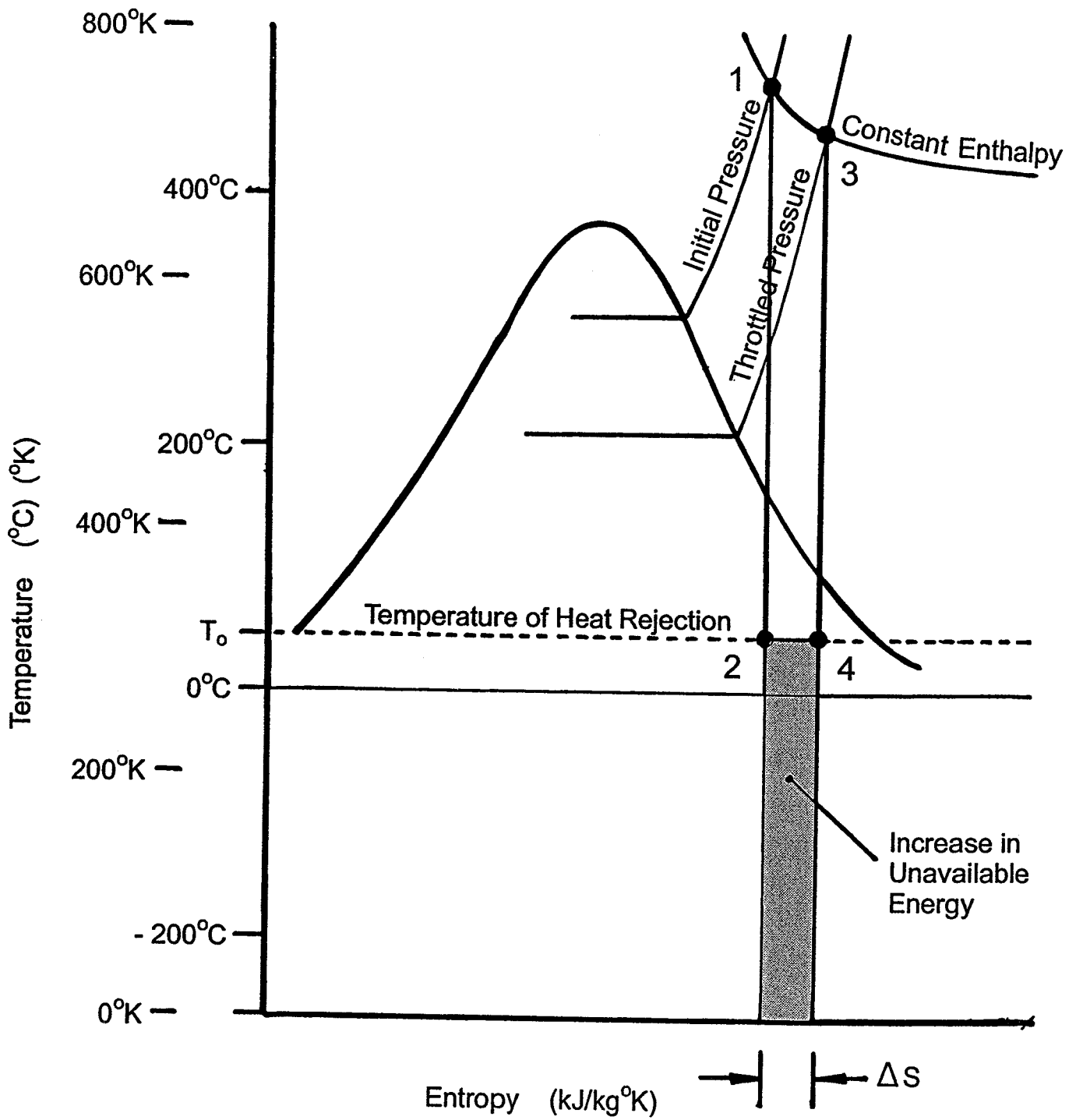


Figure 8 Throttling in a steam turbine

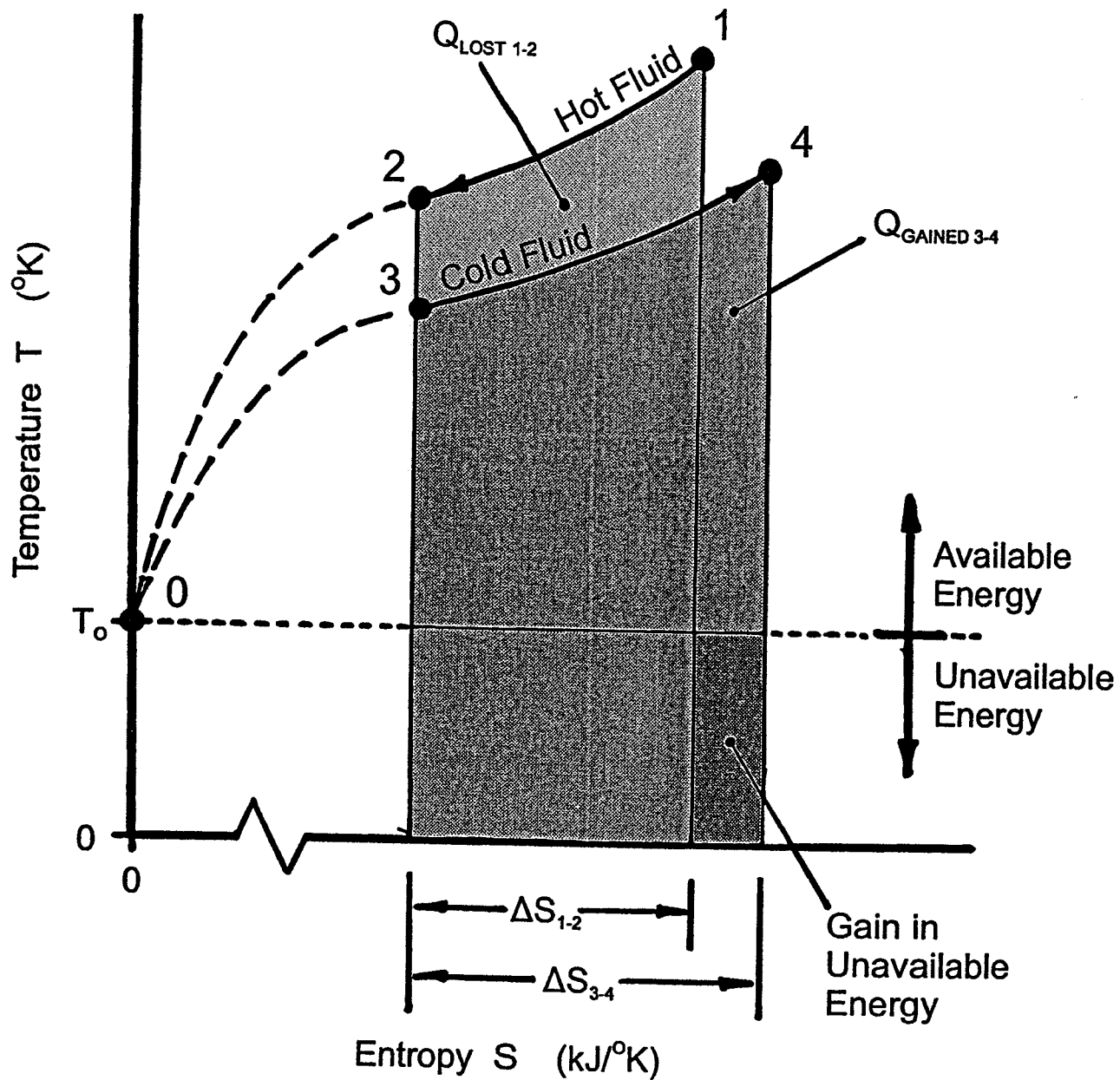


Figure 9 Available and unavailable energy changes