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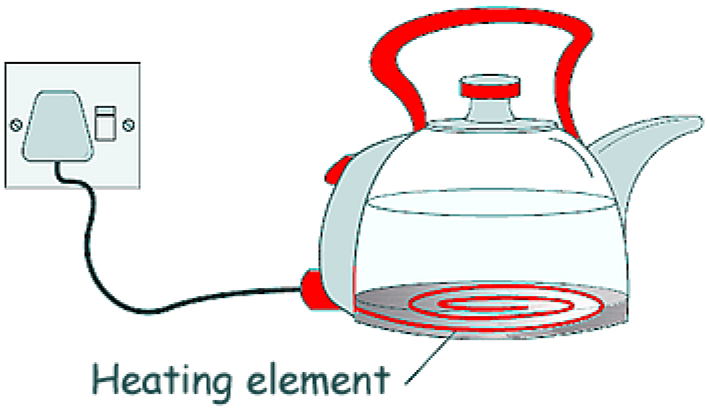
Chosen System: Electric Tea Kettle

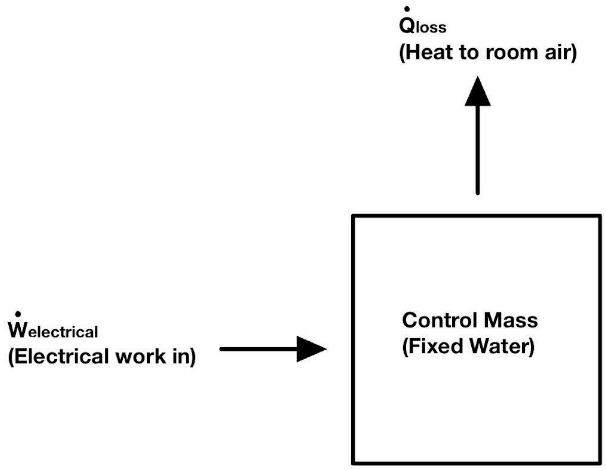
Photo of system:



Qualitative description of the device or system:

An electric tea kettle is a closed thermodynamic system containing water that is heated by an electrical resistor. The kettle takes electrical energy as its input and converts it into thermal energy through Joule heating in the heating element. This thermal energy is then transferred to the water, raising its internal energy and temperature. In our system no mass enters or leaves the kettle, as only energy crosses the boundary. Therefore, we assume that it behaves as a closed system with controlled mass.

System diagram:



Mass balance, Energy balance, and Entropy balance equations:

mass balance
$dm/dt=0$
$m=constant$

energy balance
$E=U+KE+PE$
$dE/dt=dQ/dt - dW/dt$
$dU/dt+d(KE)/dt+d(PE)/dt=dQ/dt - dW/dt$
$dW/dt =0$
$dU/dt=mc(dT/dt)$
dQ/dt_{in}=P=power
dQ/dt_{out} =heat losses=$UA(T-T_{inf})$
$d(KE)/dt=d(PE)/dt=0$ b/c nothing is moving
$dU/dt=dQ_{in}/dt - dQ_{out}/dt_{t}$
$mc(dT/dt)=P-UA(T-T_{inf})$

entropy balance equations
$dS_{sys}/dt=sum((dQ_k/dt)/T_k)+dS_{gen}/dt$
$dS_{sys}/dt=(dQ_{in}/dt)/T)-(dQ_{out}/dt)/T_{inf})+dS_{gen}/dt$
Assume incompressible liquid
$mc(dT/dt)/T=(dQ_{in}/dt)/T)-(dQ_{out}/dt)/T_{inf})+dS_{gen}/dt$

Describe a change to device or system design or operating conditions and then how that change influences device performance:

The change we have decided to make to our system is insulating the walls. This will decrease the heat transfer coefficient, which in turn decreases the power needed to change the temperature the same amount.