

Steady State versus Unsteady State

A steady state system is one that is invariant over time. In the context of mass and energy balances, steady state is equivalent to an accumulation term that is ZERO.

Mass and energy balances can be considered over different time scales, which means considering whether the system is at steady state or not can change with the different time scales. Over your entire life, the system that is your body has accumulated considerable mass. Whereas, our body is in steady state from a mass perspective over 5 year period if we weigh the same when we are 25 years old as we did when we were 20. Looking at your system at a finer time resolution shows many short periods of mass gain (3 times per day while eating) and longer periods of mass loss (burning fuel while not eating). Each time scale has value and which one to use in a particular analysis depends on the goal of the analysis.

A steady state system does not mean that nothing is happening. Your house can have a time invariant temperature (a nice steady 20 °C) as a result of your furnace working hard to match the energy loss through your walls and out your open windows. The energy IN due to the burning of natural gas is just balanced by all of the energy OUT terms on a cold January night.

It is important to recognize that a system could be in a steady state condition with respect to one parameter while being in an unsteady state condition with respect to another parameter. A steady temperature of 20 °C while the carbon monoxide concentration is slowly climbing to lethal levels (steady in energy terms, steady in total mass of air in your home and quite unsteady in the mass of carbon monoxide).

Steady state systems are much simpler to analyse as a result of the absence of the ACCUMULATION term. The ACCUMULATION term frequently takes the analysis of a simple system from algebra to single variable calculus and more complex systems from single to multi variable calculus. Thus, the appropriate decisions regarding whether a system can be considered to be at steady state is an important in context judgment by the engineer involved.