THERMODYNAMICS

REVERSIBLE AND IRREVERSIBLE PROCESSES

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Imagine a process where a system goes from a starting point to an ending point. During this process, the system takes in heat from its surroundings and does some work. The question is, can we reverse this process to get everything back to the way it was with no other changes anywhere? In most cases in nature, this isn't possible. Natural processes tend to be irreversible, which means they can't easily be undone. For instance, when you heat up a part of a pot on a stove, the heat doesn't just move back to that part on its own; it spreads out. This is because of the Second Law of Thermodynamics, which says that certain things can't happen in reverse. Irreversible processes are common in nature, not exceptions.

Irreversibility happens mainly for two reasons. First, some processes, like when gas expands freely or chemicals explode, take the system to states that aren't balanced. Second, in many processes, there's stuff like friction and thickness that cause energy to be lost. For example, when something is moving and stops, it loses its energy as heat to its surroundings. Or, if something's spinning in a liquid and slows down because of the liquid's thickness, it loses energy as heat, and the liquid gains internal energy.

These effects that cause energy loss are always around, and while we can reduce them, we can't completely get rid of them. That's why most of the processes we see can't be undone – they're one-way changes.

A thermodynamic process, like when something changes from state i to state f, is considered reversible if we can make it go back exactly as it was before. Both the system and its surroundings should end up in their original states, and nothing else in the universe should change. But, this is kind of an ideal and perfect idea. In reality, a process can only be reversible if it's very slow and careful (quasi-static), where the system and surroundings are always in balance, and there are no energy-wasting effects. For example, when an ideal gas slowly expands at the same temperature with a piston that moves very smoothly, it's a reversible process.

Why do we care so much about reversibility in thermodynamics? Well, one big thing in thermodynamics is how good we can turn heat into useful work. The Second Law of Thermodynamics says we can't have a perfect heat engine that's 100% efficient. But, we want to know what's the best efficiency we can get for a heat engine that works between two heat sources at different temperatures, T1 and T2.

It turns out that a heat engine using these idealized, reversible processes can get the highest possible efficiency. Any other engines that deal with some irreversibility (like most real-world engines) will have an efficiency lower than this best limit.