ENDOREVERSIBLE THERMODYNAMICS

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ABSTRACT

Usually, thermodynamic processes are performed within a finite time interval or with non-vanishing rates. For such processes the classical equilibrium results like the Carnot efficiency as the maximum achievable efficiency no longer apply. Instead a new approach adapted to the non-equilibrium exchanges is required. From an application point of view such an adapted approach is needed to optimize technically relevant thermodynamic processes (which all operate with finite rates). The optimization needs two ingredients: an optimization goal and a description which allows one to quantify the dissipation occurring in the process. While the optimization objective is a matter of choice and might be for instance “maximum power”, an appropriate modelling of the processes occurring in detail is mandatory for a quantitative treatment. Only when the dissipation (or entropy production) can be quantitatively determined, does a quantitative optimization become possible.

Endoreversible Thermodynamics provides a framework, which allows to do that by viewing a system as a network of internally reversible (endoreversible) subsystems exchanging energy in an irreversible fashion. All irreversibilities are confined to the interaction between the subsystems. The concept of ‘endoreversibility’ has proven to be a powerful tool for the construction of models with the desired qualities. A proper modelling of the transport equations between the subsystems allows to quantify the dissipation associated with the energy exchange. The assumption of endoreversibility simplifies the expenditure for the analysis essentially. This concept of ‘endoreversibility’ has been successfully applied to a wide variety of thermodynamic systems and led to remarkable results [1, 2].

An important problem in the analysis of endoreversible systems is how to deal with the time dependence of process variables and parameters, i.e. how the dynamics of a system evolves during a process. This problem has first been investigated in relatively simple models, which lacked the richness in technological detail of sophisticated engine models. However, while it was this approach which made insights into thermodynamic path optimization feasible, endoreversible thermodynamics as a general theory provides a framework to deal with thermodynamical systems *at all levels of detail* and is thus a universal approach also ranging to very elaborate and complex models [3].

Here we will present this modelling approach and show, how the quantitative determination of the entropy production is performed. This approach is adapted to systems consisting of discrete units like reservoirs, engines or reactors, which exchange thermodynamic extensities like volume, mole number or charge in the form of fluxes. This approach can also handle momentum or angular momentum fluxes and can thus seamlessly incorporate mechanical exchange processes. The potential of Endoreversible Thermodynamics becomes apparent in real world thermodynamic optimization problems [4,5].

Keywords: Endoreversible Thermodynamics, Finite-Time Thermodynamics, Quantification of entropy production

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