Maximum Entropy Production Rate (MEPR): conditions for existence and non-existence

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Much of the literature on MEPR treats the concept as though it was a law of nature equivalent in status to the second law of thermodynamics. It is of interest therefore to explore systems where the concept of MEPR does not hold. We first trace the development of statements of entropy production rate (EPR) extremum expressions in solid mechanics and chemistry beginning with Onsager\textsuperscript{1}, Biot\textsuperscript{2}, Prigogine and co-workers\textsuperscript{3}, Ziegler\textsuperscript{4} and Ross and co-workers\textsuperscript{5}. Ziegler\textsuperscript{4} analysed work prior to 1962 and showed that the statements of minimum EPR by Onsager and Biot were equivalent to his statement of MEPR. Only the statement of minimum EPR by Prigogine and co-workers\textsuperscript{3} was of a different character. Ross and co-workers\textsuperscript{5} showed that for systems where the thermodynamic flux is a linear function of the thermodynamic force, a non-equilibrium stationary state for the EPR exists. If the thermodynamic flux is a non-linear function of the thermodynamic force then only one stationary state exists for the EPR and that is an equilibrium state defined as a state where the EPR is zero. For the non-linear systems the full Clausius-Duhem relation needs to be solved in order to track the evolution of the EPR; no maximum exists. These statements hold arbitrarily “close” to equilibrium and “far” from equilibrium. Thus for simple uncoupled elasto-plastic mechanical systems a state corresponding to MEPR may exist as proposed by Biot and Ziegler. This is also true for Darcy flow in a porous medium but is not true for non-isothermal chemical diffusion. We give examples of mechanical and thermal systems where the only extremum for EPR is the trivial condition where EPR is zero at equilibrium and the concept of MEPR does not hold.


