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Editorial

Entropy Generation Results of Convenience But without Purposeful Analysis and Due Comprehension—Guidelines for Authors

Milivoje M. Kostic †

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Academic Editor: Kevin H. Knuth

Department of Mechanical Engineering, Northern Illinois University, DeKalb, IL 60115, USA; kostic@niu.edu
† Thermodynamic Section Editor-in-Chief of *Entropy* Journal.

There is a growing trend in recently-submitted manuscripts and publications to present calculated results of entropy generation, also known as entropy production, as field quantities in a system or device control volume, based on prior calculation of velocity and temperature fields, frequently using CFD numerical methods. On occasions, such results may appear to be very interesting and elaborate intellectual exercises, yet are without purposeful analysis and meaningful objectives, without some discovery or new method, and therefore without due comprehension. Often, such entropy generation results are presented separate from, and without due analysis and correlation with, the related flow and heat transfer results, the latter usually published before. The entropy generation results are often presented "as is", with almost trivial analysis and conclusions, and with little, if any, purpose and objective. Stating the obvious, based on the calculated outcome, where and in what region the entropy generation is maximum and higher, and where it is lower and minimum, is a self-evident observation and does not provide any method for design optimization, and usually no parametric study and results are presented to generate useful data for future analysis and optimization. It appears that such work is performed as a matter of convenience, since the flow and heat transfer results were already performed in related prior work. Therefore, such manuscripts become more opportunistic than purposeful, and thus have little value if any at all. Such results may be easily performed by specialists in CFD, but non-experts in Thermodynamics, and without due comprehension of the meaning of entropy generation as a critical concept of the Second Law of Thermodynamics. It would be similar if CFD results are conveniently performed without due analysis by non-experts in fluid mechanics and heat transfer, just because of the opportunity and availability of powerful computational methods and software.

In some cases, the energy equation used for entropy generation is simplified and does not contain all potentially relevant terms. For example, the energy dissipation term is often neglected for velocity field calculation, but it may be important for the proper entropy generation calculation. Such, and other, simplifications should be explicitly stated and valid justifications provided. Given that validation of the numerical methods is often limited in simpler geometry and prior flow and heat transfer result, and, usually, no specific validation were given for the entropy generation results, the former does not necessarily imply the latter. The validity of entropy generation results have to be justified in addition to, and independently from, the validity of the related flow and heat transfer results. Self-critical analysis of the simplifications and limitations of the methodology and calculation methods should be presented, along with proper uncertainty error analysis and validation of the obtained entropy generation results.

Furthermore, the entropy generation results could and should be correlated with related flow and heat transfer results, and presented together to synergistically enhance the integral analysis, and not be separated and presented as independent and not correlated results. The check-and-balance of the two sets of results could and should be performed. The total integral of entropy generation, due to flow dissipation in the device control volume, presents the loss of mechanical energy of the flow and, thus, could be related with the total pressure loss and the pumping power required to compensate for such dissipative loss. This correlation and agreement with pressure and flow results will be the desired comparison and evaluation of the validity of the correlated results.

However, entropy generation due to temperature differences and heat fluxes represents the loss of the "Carnot's work-potential", and may or may not be important in many flow and heat transfer processes, due to the fact that the heat transfer is, by its nature, a typical irreversible process. Furthermore, if substantial entropy generation is due to extreme non-uniformity of temperature fields, driven by high heat fluxes, the consideration of alternate device design to utilize the Carnot's work potential may be considered if it is feasible and economical.

The entropy generation is not a purpose by itself, but consequence of the flow and heat-and-mass transfer processes, also electro-chemical and other processes if present. It could be valuable in process analysis and optimization if properly and creatively utilized. In the absence of other but the flow and heat transfer processes, the entropy generation is a consequence and a measure of mechanical energy dissipation and the heat transfer, Carnot's work-potential loss. The latter represents the irreversible heat transfer loss, and yes, the heat transfer's "dissipation to itself" to a lower temperature, which may or may not be relevant, depending on if any work is exchanged during such a heat transfer (such as in power producing, heat pump, or refrigeration processes), so that the work dissipation losses could be identified and minimized. In heat exchangers, the entropy generation is increased with increased heat transfer, everything else being the same, so reducing entropy generation due to heat transfer may be undesirable and counterproductive for the device performance if such measure is not utilized for heat to work conversion, but the irreversible loses are merely relocated outside of the device. More generally, the "extrema principles," the minimum and maximum entropy production principles, are elusive and not yet fully understood. In particular, the maximum or minimum entropy generation rate (also known as entropy production rate) do not always correspond to the best performance of thermal devices or systems. The Second Law of Thermodynamics, and the entropy that quantifies its analysis, are sometimes subtle and thus may be confusing and misleading if not fully understood and properly accounted for, to enhance the efficacy of all devices involved in all processes to be optimized.

Entropy generation is a natural phenomenon and taking place everywhere and at all times, without any exception: in closed and open systems, in near-equilibrium and non-equilibrium, in inanimate and animate systems—that is, in all space and time scales. Entropy is only associated and transferred with heat, therefore produced, *i.e.*, generated with heat generation in dissipative, irreversible processes. Even when thermal heat is converted to work in heat engines, the entropy is not destroyed (cannot be converted with heat to something else), but ideally conserved in reversible cycles. Therefore, there is no way to destroy entropy. Entropy may be reduced locally when transferred from a system, but cannot be destroyed by any means, and is always increased within isolated, *i.e.*, all interacting systems, and thus within the universe, due to entropy generation. The overall entropy increase, within all interacting systems, due to entropy generation, should not be confused with local entropy change that could increase or decrease due to entropy transfer.

That is the meaning and spirit of the Second Law of Thermodynamics, that the existing non-equilibrium, *i.e.*, the non-uniform concentrations of mass–energy distribution in space, are forcing, in time, the redistribution of the mass-energy towards common equilibrium at a given scale, when the resulting net-forcing will cease, the latter being the cause-and-effect of the non-equilibrium. This natural tendency or forcing defines directionality and, thus, irreversibility of natural processes—the processes cannot be arbitrarily in any direction opposite the natural forcing. The Second Law provides conditions and limits for process forcing, *i.e.*, the transfer of mass-energy direction and limit. We may, and do, analyze and manage local processes to increase their efficiencies and reduce the impact on the environment; however, we cannot influence the global irreversibility caused by non-equilibrium forcing, including the free expansion of the universe. For example, virtually all energy flow to our planet Earth is the solar thermal radiation (99.98%) at about 5800 K, which is balanced by infrared thermal radiation off the Earth to space at about 290 K, thus producing a global, Earth energy flow irreversibility ratio of $(1 - 290/5800) = 0.95 = 95\%$, *i.e.*, unavoidable Earth energy-flow irreversibility, based on the Earth's outgoing energy radiation average temperature.

It is the Editorial concern in general, in addition to all relevant concerns posed by the reviewers, that a trend to separately present the entropy generation results, without purposeful analysis and correlation with the related flow and heat transfer results, should be discouraged and not accepted without due original contribution, rigor of the analysis, and clear purpose and utility.

Important questions to be posed and answered by the authors, before manuscript submission and in later updates, if any, are:

1. What is the goal and purpose of the submitted manuscript (e.g., discovery of a new concept or a new method, parametric study with optimization, *etc.*)?
2. How specifically, for a heat-exchanger or similar, could the calculated entropy generation results be utilized to optimize and improve heat transfer and/or pumping power for a given flow and/or heat-transfer configuration?
3. Are the entropy generation results correlated with related flow and heat transfer results, and presented together to synergistically enhance the integral analysis and validity of the both sets of results?
4. Are all simplifications and limitations of the methodology and calculation methods presented, as well as a valid uncertainty error analysis and validation of the obtained entropy generation results?
5. Are the objectives achieved, and merit and impact of the research clearly presented, including specific summary in the Abstract and more specifics in the Conclusion section (be specific and avoid general conclusions without relevant facts)?
6. Are all relevant editorial concerns incorporated in the manuscript, and, if available, all relevant reviewers' comments and suggestions as well?

In conclusion, evaluating entropy generation results and presenting them "as-is" without purposeful analysis and, thus, due comprehension by non-entropy experts may be risky, are often useless, and are sometimes misleading. Important and relevant questions should be posed and answered. How the calculated entropy generation results could be utilized to optimize and improve mass-energy processes for a given device configuration? The merit and impact of a manuscript should be clearly presented. Self-critical analysis of the simplifications and limitations of the methodology and calculation methods should be presented, as well as proper uncertainty error analysis and validation of the obtained entropy generation results should be performed and presented. Otherwise, such manuscripts become more opportunistic than purposeful, and, thus, have little value if at all. It appears that some manuscripts are written as a matter of convenience, since the flow and heat transfer results were already published in related prior work.

Conflicts of Interest: The author declares no conflict of interest.