Discussion: "Performance and Optimization Analysis for Fins of Straight Taper with Simultaneous Heat and Mass Transfer" (Kundu, B., and Das, P. K., 2004, ASME J. Heat Transfer, 126, pp. 862–868)

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In this paper the authors employed a new rather unorthodox approach, and unusual parameterization entirely different from that existing in the literature, to obtain their results. In their abstract, the authors claim to have obtained the performance prediction, i.e., the efficiency and effectiveness, of wet fins, for tapered longitudinal, spines and radial fins. Their lengthy explanation for the obvious differences between wet and dry fins is unnecessary. They further assert to have derived a generalized criterion (what is the meaning of generalized?) for the optimization of the three types of fins they analyze. The authors describe the fins as tapered, shown in their Fig. 1, however the expressions of their profiles such as $y/y_b=f(X,\lambda)$ is missing. Also, their keywords refer to dehumidification and heat exchanger that are not used in the manuscript. Moreover, what is conspicuously missing in this paper is the exact description of the mathematical problem they solve. The authors abruptly start with a differential (Eq. (1)), without any boundary conditions, or any other comments such symmetry, etc. In fact this paper lacks the mathematical perspicuousness and rigor required in any such endeavor.

The following comments are addressed to specific sections of the manuscript.

Nomenclature

We begin with the authors' Nomenclature because it contains several errors, thus making the reading of this manuscript extremely difficult. The Nomenclature is a mirror of the symbols found in the text, which is used to explain their meanings to the reader who frequently needs to consult it.

(i) The authors assume the following linear temperature variation of the specific humidity:

$$\omega = b_1 + b_2 T \tag{1}$$

Considering the values of ω to be specified at the temperatures T_t and T_b, we obtain the following values for of the above constants:

$$b_2 = (\omega_t - \omega_b)/(T_t - T_b), \quad b_1 = \omega_b - b_2 \times T_b \tag{2}$$

The authors' expression for b_1 is incorrect and unless this is a typographical error, this mistake is propagated in their results, although the incautious reader may tempted to ask, are both temperatures, T_b and T_t, that are used in Eq. (2) of this Discussion specified?

(ii) I think $\mathrm{Bi}_t=h_t y_b/k$ should have been $\mathrm{Bi}_t=h_t y_t/k$, although h_t is never defined.

(iii) The authors assert "f, g to be functions defined by Eq. (18) and Eq. (19) respectively." However, Eq. (18) defines the dimensionless volume U, whereas $f(\mathrm{Bi},\psi)$ is defined by Eq. (19), and $g(\mathrm{Bi},\psi)$ by Eq. (20).

(iv) The symbol h_m, which appears in the last term on the left-side of the authors' Eq. (1), has never been defined. Also, the dimensions of q, the actual heat transfer rate, for longitudinal fins should be expressed in watts per meter.

(v) The correct definition of q_e is: "the heat transfer from the base of the fin, with the same heat transfer coefficient in its absence." The assumption for the ideal heat dissipation q_i is: "the entire fin is maintained at the base temperature."

(vi) Q is defined by Eq. (11) not Eq. (10), Q_e by Eq. (16) not Eq. (15), Q_i by Eq. (14) not Eq. (13), and U by Eq. (18) not Eq. (17).

(vii) The parameter Z_0 is recognized as the one which used by Gardner [1] to plot his efficiency graphs and is expressed as the product of the aspect number L/y_b and the $\sqrt{\mathrm{Bi}}$. The quotient L/y_b is always referred in the literature as aspect number, however, the authors' ψ is the reciprocal, but still defined as the aspect number. As shown in Refs. [2,3] the authors' parameters $Z_0^2=\mathrm{Bi}/\psi^2$ and Bi have physical significances.

(viii) Normally, the solutions should be able to handle any values of the parameter $0\leq\lambda\leq 1$, hence the parameters Z_1, Z_2, and α that, are divided by (1-λ), cannot be used unless they are redefined.

(ix) The authors created a huge aggregate of dimensionless parameters, whereas only a few appearing in their results. The principal parameters that are used by the authors in their result are: Z_0, Bi, and λ; however, the temperature is independent of Bi.

Formulation of Mathematical Model

(i) In this section the authors make the following statements: *(1) at any point, the temperature over the fin cross section is assumed to be constant and (2) the transport processes can be rendered one-dimensional (1D) as is conventionally done for dry fins*. The authors should be reminded that, in mathematical analyses nothing is conventionally done, but it must be based on certain fundamental principles. In this case, there are certain conditions, known as simplified assumptions, described in Ref. [1], that must be met, in order to allow using the 1D conduction model. For example here, the restrictive condition for using the 1D approach is the small values of the Biot number (of the order of 0.01). As shown in Refs. [2,3], when one employs the 1D approach, the simplified assumptions, insulated tip and the length of arc idealization are valid. Thus the expression $\sqrt{1+(dy/dx)^2}$ can be eliminated, and the tip boundary condition should be modified accordingly.

(ii) There in no explanation as to why the authors introduce the radius r_i in Eq. (1), which for longitudinal fins and spines is zero, and in radial fins the coordinate x varies from 0 to r_i, instead of $r_i\leq x\leq r_t$, which is universally used. In this case an important new parameter is introduced namely the ratio parameter r_t/r_i. For example, what is the value of this parameter in the results plotted in the original Fig. 4?

(iii) Now, in any mathematical equation involving symbols with dimensions, like those in Eq. (1), one should always first check if it is dimensionally correct. For longitudinal fins, the dimensions of the left-side and the first right-side terms are kelvin per meter whereas the dimensions of the last term h_{fg} are watts per square meter, with similar contradictions appearing in the other cases. I believe the authors neglected to divide this term with the thermal conductivity k.

(iv) The authors assert that have employed the Chilton Colburn analogy and some algebraic manipulations to derive their Eq. (2). However, the temperature becomes now a function of $Y=y/y_b$ instead of $X=x/L$. This is indeed a very puzzling operation for mainly two reasons. First, according to the authors' earlier statement the temperature along this direction is constant. In the other hand, how could the profiles of the fins, which are $y/y_b=f(X)$, possibly influence the results?

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Results and Discussion

At the beginning of this section the authors engage in a long and unnecessary explanation for the self-evident conceptions, of what is meant by dry fins and their performance. Then they present a few graphs, which in the abstract claim to be design curves, while they only refer to one specific case. I am indeed puzzled how these plots were contracted using those formidable equations ((4)–(20)), with all these dimensionless variables, which as was pointed out earlier, they contain several mistakes? What are exactly the differences between efficiencies and effectiveness with the authors' over-all counterparts? I believe that their results are incorrect despite the agreement with previous work shown in the original Fig. 2. Moreover, the variation of the effectiveness versus Z_0 in their Fig. 4 physically does not make sense. For example, when the value of $Z_0=0$ (absence of the fin), by definition, the effectiveness value is equal to 1 instead of the authors' 20. To help the authors revise their paper certain additional references are given here.

I regret to say, that due to space limitations of the journal I cannot describe the correct formulation of the problem that the authors should solve.

References

[1] Gardner, K. A., 1945, "Efficiency of Extended Surfaces," Trans. ASME, **67**, pp. 621–631.

[2] Razelos, P., 2002, "A Critical Review of Extended Surface Heat Transfer," Heat Transfer Eng., **24**(6), pp. 11–28.

[3] Razelos, P., 2005, "A New Approach of Extended Surface Heat Transfer," *Proceedings of IMECE2005*, Paper 83057, Orlando, FL.