Some Modifications on the text of our paper

TWO DOMINANT ANALYTICAL METHODS FOR THERMAL ANALYSIS OF CONVECTIVE STEP FIN WITH VARIABLE THERMAL CONDUCTIVITY

***Thermal Science,* Vol. 18, 2014, No. 2, pp. 431-442**

by

Mohsen TORABI* * *and Hessameddin YAGHOOBI

Young Researchers and Elite Club, Central Tehran Branch, Islamic Azad University, Tehran, Iran

DOI: 10.2298/TSCI1404437T

As the original manuscript had some similar sentences with some of our previous publications, we have decided to modify the main text of the manuscript in the PDF version. The modifications have been applied within the PDF online version. This printed version is provided for ones who have access to the printable version of the journal and to avoid any confusion. It should be noted that the results and mathematical procedure of the original version are completely correct and this note has nothing to do with the formulations of the main paper.

Modifications

The Introduction of the paper has been changed to the following.

"Extended surfaces are used to augment the rate of heat transfer from the primary surface and its convective, radiative or convective-radiative environment in a large variety of thermal equipment. Fins are extensively used in various industrial applications such as air conditioning, refrigeration, automobile and chemical processing equipment. Krause *et al.* [1] presented a monograph regarding the applications and thermal analyses of fins. They have documented and demonstrated that considering constant thermophysical properties allows scientist to find exact analytical solution for number of cases. It is well-known that existence of large temperature difference within a fin necessitates variable thermal conductivity with temperature. This fact consequently includes one non-linearity within the energy equation of the studied system. From the available published work, about heat transfer in extended surfaces, the following works are of immediate relevance to the present paper. Different configurations of straight fins have been analyzed by Sharqawy and Zubair [2]. They focused on temperature and efficiency within the studied fins and considered both heat and mass transfer mechanisms. The well-known differential transformation method (DTM) was applied to steady-state energy equation within triangular fins with constant properties [3]. In an interesting study, Kundu [4] opted in favor of thermal analysis and optimization of longitudinal and pin fins of uniform thickness. The analytical study was carried out for three conditions: fully wet, partially wet, and fully dry surfaces. Homotopy analysis method (HAM) was also employed by Domairry and Fazeli [5], to tackle

* Corresponding author; e-mail: torabi_mech@yahoo.com

non-linear energy equation in straight fins. They have performed thermal and efficiency analyses with different thermophysical parameters. Considering temperature-dependent thermal conductivity, Arslanturk [6] developed correlation equations for the optimum design of annular fins. Residual minimization technique has been also attracted attention of researchers regarding the analysis of non-linear differential energy equations [7]. Kulkarni and Joglekar [7] used this method to overcome the difficulties within the solution procedure for temperature distribution in a straight convective fin having temperature-dependent thermal conductivity. HAM has been used to derive approximate solutions for the temperature distribution and efficiency of convective fins with simultaneous variation of thermal conductivity and heat transfer coefficient with temperature [8]. Joneidi *et al.* [9] studied an analytical solution of fin efficiency of convective straight fins with temperature-dependent thermal conductivity by the DTM. Variational iteration method (VIM) is another approximate technique which has gained considerable attention in this area. This method can overcome many inherent limitations arising within energy equations such as uncontrollability to the non-zero endpoint boundary conditions. Fouladi *et al.* [10] utilized VIM to solve some examples in the field of heat transfer. Assuming temperature-dependent profile for both thermal conductivity and heat transfer coefficient, Khani and Aziz [11] used HAM to develop an analytical solution for the thermal performance of a straight fin of trapezoidal profile. Ganji *et al.* [12] studied the temperature distribution in an annular fin with temperature dependent thermal conductivity using homotopy perturbation method (HPM). Torabi *et al*. [13] solved the energy equation in the convective-radiative moving fin with variable thermal conductivity using the DTM. They assumed non-zero convection and radiation sink temperature for their analysis.

All of the aforesaid studies are related to fins with constant cross-sectional area or tapered fins. Regarding fins' profile with a step change in cross-sectional area, there are limited studies [14-19]. A pioneering work in this area was done by Aziz [14]. Following his work, Kundu and Das [15] adopted a similar profile for radial fins. Differential quadrature method was used with Malekzadeh *et al.* [16] to optimize convective-radiative flat and step fins. Recently, an annular fin with a step change in thickness was analyzed by Kundu [17]. Both fully and partially wet surface conditions were considered within the analyses. The optimization study was performed and an interesting conclusion was given. It was observed that an annular fin with a step change in thickness is the better choice for the transferring rate of heat in comparison with the concentric-annular disc fin for the same fin volume and identical surface conditions [17]. Kundu and Wongwises [18] applied Adomian decomposition method on the problem of straight find with variable thermal conductivity and heat transfer coefficient.

A careful assessment of the foregoing literature shows that there is just one paper that investigated a problem of convective step fin analytically [19]. The primary purpose of the present paper is to demonstrate the usefulness of DTM and VIM to solve problem of convective heat transfer from a step fin with temperature dependent thermal conductivity. In recently published paper we extended our analyses on the thermal processes of the fin with *convective-radiative* heat transfer and step change in thickness, using differential transformation method (DTM).* Thermal analysis of step fins is a new application for DTM and VIM which were used for other engineering applications [20-23]. The results to be presented will highlight the effects of the thickness ratio, α,

* Torabi, M., Yaghoobi, H., Kiani, M. R., Thermal Analysis of the Convective Radiative Fin with a Step Change in Thickness and Temperature Dependent Thermal Conductivity, *Journal of Theoretical and Applied Mechanics, 51* (2013), 3, pp. 593-602

dimensionless fin semi thickness, δ, length ratio, λ, thermal conductivity parameter, β, and Biot number, Bi, on the temperature distribution."

The results and discussion for figs. 4-7 have been changed to the following:

"The effect of length ratio parameter, *i. e.*, λ, on the temperature distribution within the fin has been plotted in fig. 4. It is clear from this figure that as λ increases, *i. e.*, as the thin section of the fin increases, the temperature distribution within the thin section of the fin decreases.

For the case of different values for dimensionless fin semi thickness, results of the present analysis are depicted in fig. 5. As δ decreases, the cooling becomes more effective, promoting lower temperatures in the fin. This interesting behavior occurs for both thin and thick sections of the step fin. Physically speaking, the thinner the cross-section of the fin, the easier the heat can transfer from the fin material to the environment, and consequently the lower is the fin temperature. In fig. 6 we have plotted the effect of the thermal conductivity parameter on the temperature distribution within the fin. Results in the figure reveal that as the value of β increases the temperature distribution within both sections increases.

Figure 7 illustrates the effect of Biot number, on the temperature distribution within the fin. Increasing the Biot number makes the convective cooling more effective. Therefore, as the Biot number increases, the cooling effects become more profound, which in turn causes the lowering of temperatures within both sections of the fin."

The Conclusion has been changed to the following.

"The performance analysis of convective step fin with temperature-dependent thermal conductivity is considered. The energy equation within each part, namely thin and thick parts, was considered separately. The two main non-linear energy equations together with the joint boundary condition in the junction and other boundary conditions on base and tip of the fin build a system of ordinary differential equation. Differential transformation method (DTM) and variational iteration method (VIM) were used to analytically solve the non-linear system of equations. As the convection effect, *i. e.*, Biot number, increases, this effect is to lower the fin temperature. Unlikely, as the thermal conductivity of the fin increases, *i. e.*, the parameter β increases, it promotes slower cooling accompanied by higher local fin temperatures. As an important result, it was found that the DTM solution can achieve extremely accurate results when compared with the VIM. This paper proves that the DTM is a powerful analytical technique to handle non-linear energy equations in step fins."

*
* *

Conclusion

The above modifications have been provided for whom which have access to the printable version of the journal. The above modifications have been applied within the PDF online version. These modifications are just regarding the text of the original paper, and have nothing to do with the equations and formulations of the paper. The results and conclusions of the original paper are solid and completely correct.

Subscription

Annual – five issues	188 €/275 $
with air-mail delivery (Europe)	195 €/285 $
with air-mail delivery (overseas)	222 €/321 $
Single issue	40 €/60 $
with air-mail delivery (Europe)	43 €/64 $
with air-mail delivery (overseas)	49 €/69 $
Reprints	
For 10 examples (with air-mail delivery)	50 €/74 $

Subscriptions has to be made in written form on the e-mail address: bakicv@vinca.rs
or via the web site of the journal *Thermal Science* http://thermalscience.vinca.rs/subscription

For domestic subscribers the prices are 188 € (annual), or 40 € per issue, or 45 € for 10 reprints of published paper, in domestic currency, according to the Euro/Din equivalence on the day of payment, on the account 205-39132-62, Društvo termičara Srbije, Beograd.

CIP – Каталогизација у публикацији
Народна библиотека Србије, Београд

621.1

THERMAL Science : International Journal / editor-in-chief Simeon Oka. - Vol. 1, No. 1 (1997)- .-Belgrade : Vinča Institute of Nuclear Sciences, 1997-. - 24 cm

Tromesečno
ISSN 0354-9836 = Thermal science
COBISS.SR-ID 150995207