Chapter 6
Differential Transformation Method

ABSTRACT

In this chapter, a new linearization procedure based on Differential Transformation Method (DTM) will be presented. The procedure begins with solving nonlinear differential equation by DTM. The effectiveness of the procedure is verified using a heat transfer nonlinear equation. The simulation result shows the significance of the proposed technique.

INTRODUCTION

The investigation of convective flow through porous media is mandatory in many thermal engineering applications. Numerous numerical and experimental studies were conducted to provide a deeper understanding of the transport mechanism of the heat transfer inside the porous mediums.

BACKGROUND

Porous media has an extensive use of applications like catalytic and inert packed bed reactors, enhancing drying efficiency, filtering, insulation, lubrication (Kaviany, 1995), stabilization of non-uniform flow (Hasanpour et al., 2011) and enhancing oil and natural gas production. A high thermal conductivity porous substrates are used to enhance forced convection heat transfer in many engineering applications such as reactor cooling, heat exchangers, and solar collectors (Alkam & Al-Nimr, 1999). The concept of using fins made of porous materials is firstly introduced by Kiwan and Al-Nimr (2001) and they introduced Darcy model for analyzing the porous fins for the first time in Refs. (Kiwan, 2007; Kiwan & Zeitoun, 2008). Heat exchanger industries are looking for more compact in and more cost-effective heat exchanger manufacturing techniques which lead the method to use porous fins to enhance heat transfer (Hamdan & Al-Nimr, 2010). The heat-transfer enhancement between two parallel-plate channels was investigated

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by adding porous fin through the channel (Hamdan, Al-Nimr & Alkam, 2000) and by adding porous insert to one side of the duct walls (Alkam, Al—Nimr & Hamdan, 2002). An analytical prediction for performance of porous fins was presented by Kundu and Bhanja (2011). In their work, the influence of some dependent parameters on the performances and optimization conditions was studied for the selection of a design criterion of porous fins. Also it was concluded that a clear difference in results for heat transfer rate at the optimum point is noticed for the different models of predictions and consequently it can be highlighted that the selection of the actual model is necessary for the realistic implementation of the design in concern. Kiwan (2007) investigated the thermal analysis of natural convection porous fins. He used a method based on energy balance and Darcy's model to formulate the heat transfer equations and the thermal performance of porous fins was studied for three types of fins. It was found that the heat transfer rate from porous fin can exceed that of a solid fin. Gorla and Bakier (2011) performed a study on natural convection and radiation in rectangular profile fin. Their results showed that the radiation transfers more heat than a similar model without radiation. Domairry and Fazeli (2009) solved the non-linear straight fin differential equation to evaluate the temperature distribution and fin efficiency. Also temperature distribution for annual fins with temperature-dependent thermal conductivity was studied by Ganji et al. (2011). The analytical approaches like Differential Transformation Method (DTM) is used for solving the scientific and engineering cases.

Ghafoori et al. (2011) used the DTM for solving the nonlinear oscillation equation. Abdel-Halim Hassan (2008) has applied the DTM for different systems of differential equations and he has discussed the convergency of this method in several examples of linear and non-linear systems of differential equations. Joneidi et al. (2009) used DTM for analytical solution of convective straight fins with temperature-dependent thermal conductivity and comparing results with exact and numerical one. Their results reveal the capability, effectiveness, convenience and high accuracy of this method. Rashidi et al. (2010) solved the problem of mixed convection about an inclined flat plate embedded in a porous medium by DTM; they applied the Pade approximant to increase the convergence of the solution. Abbasov and Bahadir (2005) employed DTM to obtain approximate solutions of the linear and non-linear equations related to engineering problems and they showed that the numerical results are in good agreement with the analytical solutions. Balkaya et al. (2009) applied the DTM to analyze the vibration of an elastic beam supported on elastic soil. Borhanifar and Abazari (2011) employed DTM on some PDEs and their coupled versions.

Fins are used to increase the heat transfer of heating system such as, refrigeration, cooling of oil carrying pipe, cooling electric transformers, cooling of computer processor and air conditioning. A review about the extended surfaces and its industrial applications is presented by Kern and Krause (1972). Numerous researches have been done to investigate the heat transfer of the fins.

Group classification of the differential equation of fin has been analyzed using symmetry analysis (Bokhari, Kara & Zaman, 2006; Vaneeva et al., 2008). In another work, Pakdemirli and Sahin (2006) investigated nonlinear equation of fin with general temperature-dependent thermal conductivity. A simple state which the thermal conductivity and heat transfer coefficient are constant, the exact analytical solution is existent. But if a large temperature difference exists within a fin, heat transfer coefficient and thermal conductivity are not constant. Because of this, in general, thermal conductivity and heat transfer coefficient are functions of temperature.

It is clear that obtaining the exact solutions of these nonlinear problems are usually difficult. Because of this, researchers used the numerical techniques and semi-analytical methods such as the perturbation method (PM), homotopy perturbation method (HPM), variational iteration method (VIM), homotopy analysis method (HAM), decomposition method (DM) and differential transform method (DTM).

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