6. Application: Mathematical Modelling of Air Heating Solar Collectors with Fuzzy Parameters

6.1. Introduction

In the previous chapter, we developed the results of fuzzy Adomian Decomposition method as an application, we focus on the problem related to green energy. The important use of solar energy is to generate electricity. This application is based on a solar collector that converts radiation into energy. In solar collectors, an air heating plate is covered by glass cover over which sunlight falls, this plate is used to collect solar energy. During this process, many physical factors are involved that affect the efficiency of the collector like Reynolds number, emission and thermal absorption, etc. Based on these pieces of information, the mathematical model of air heating in solar air collector is formulated. The imprecision in estimating these factors and/or initial condition may occur due to the weather condition, which leads us to model such a problem in a fuzzy environment. The mathematical model of heating in solar air collector with fuzzy parameters as given in [67].

Next section explains the mathematical model in crisp as well as fuzzy environment.

6.2. Description of Problem

As shown in Fig. 6.1 [68], [76], solar radiation reaches to absorber plate through the glass cover. It makes air hot in the back plate area and the temp. gradient changes as hot air travel in the back plate area. The mathematical modelling can be represented as follows,

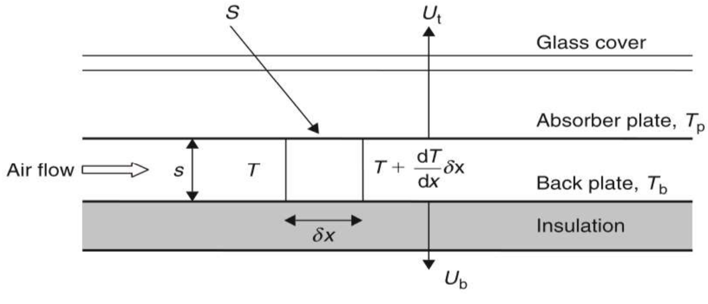

Figure 6.1: Energy balance of absorber plate, backplate and airflow in the solar air collector

From Fig. 6.1, a plate of area $(1\times\, \delta x)$ gives refer [76],

$$S(\delta x) = U_t\left(T_p - T_a\right) + h_{c,p-a}\,(\delta x)\left(T_p - T\right) + h_{r,p-b}\,(\delta x)\left(T_p - T_b\right) \tag{6.1}$$

where, $S = \tau'\alpha' G_t$

An energy balance of the air stream volume $SW\delta x$ gives,

$$\frac{\dot{m}}{W} c_p \dot{T}\;\delta x = h_{c,p-a}\,(\delta x)\left(T_p - T\right) + h_{c,b-a}\,(\delta x)(T_b - T) \tag{6.2}$$

An energy balance on the backplate area $(1\times\, \delta x)$ gives,

$$h_{r,p-a}\,(\delta x)\left(T_p - T_a\right) = h_{c,p-a}\,(\delta x)\left(T_p - T\right) + U_b(\delta x)(T_b - T_a) \tag{6.3}$$

As U_b is very much smaller than U_t, U_L is equivalent to U_t, neglecting U_b and solving equation (6.3), we have,

$$T_b = \frac{h_{r,p-b}\,T_p + h_{c,b-a}\,T}{h_{r,p-b}\; + h_{c,b-a}} \tag{6.4}$$

Now by equations (6.1) and (6.4) and using notation $h = h_{c,b-a}\; + \frac{1}{\frac{1}{h_{c,b-a}} + \frac{1}{h_{r,p-b}}}$, we get

$$T_a(U_L + h) = S + U_l + hT \tag{6.5}$$

Now using all the above equations $c_p = a + bt$ and $F = \frac{h}{h+U_l}$, Refer [76], we have

$$\left(\frac{\dot{m}}{W}\right) a \left(\frac{d\mathrm{T}}{dx}\right) + \left(\frac{\dot{m}}{W}\right) b \left(\frac{d\mathrm{T}}{dx}\right)\mathrm{T}(x) + FU_L\mathrm{T}(x) = F(S + T_aU_L) \text{ with } T(0)$$

where,

$\dot{m}$ is Air mass flow rate (kg/s)

W is the width of collector (m)

a is ambient

b is backplate

F is collector efficiency factor

U_L is overall heat loss coefficient $(W/m^2\;K)$

S is absorbed solar radiation per unit area (W/m^2)

T_a is ambient temperature

For more details, refer [76].

The ambient temperature depends on weather and also varies from morning to evening, so taking a range of such values is more realistic than the specific single value over the day of the same. Similarly, the air mass flow rate cannot be stated as a single constant, instead it is a imprecise value around the constant. Due to these reasons, we have proposed the mathematical model of solar air collector involving fuzzy initial temperature and fuzzy rate of mass of airflow. Thus, the fuzzy model is,

$$\left(\left(\frac{\dot{\tilde{m}}}{W}\right)\otimes a\otimes\left(\frac{d\tilde{T}}{dx}\right)\right)\oplus\left(\left(\frac{\dot{\tilde{m}}}{W}\right)\otimes b\otimes\left(\frac{d\tilde{T}}{dx}\right)\otimes\tilde{T}(x)\right)\oplus\left(\tilde{F}\otimes U_L\otimes\tilde{T}(x)\right)$$
$$=\tilde{F}\otimes(S+T_aU_L)\ ;\ \ \tilde{T}(0) \tag{6.6}$$

The parametric form of equation (6.6), is given by using the alpha-cut in chapter 1,

$${}^{\alpha}\dot{\tilde{m}}=[\underline{\dot{m}},\overline{\dot{m}}],\ {}^{\alpha}\tilde{T}=[\underline{T},\overline{T}],\ {}^{\alpha}\tilde{F}=[\underline{F},\overline{F}],$$

$$\left(a\otimes\left[\frac{\underline{\dot{m}}}{W},\frac{\overline{\dot{m}}}{W}\right]\otimes\left[\underline{\dot{T}},\overline{\dot{T}}\right]\right)\oplus\left(b\otimes\left[\frac{\underline{\dot{m}}}{W},\frac{\overline{\dot{m}}}{W}\right]\otimes[\underline{T},\overline{T}]\otimes\left[\underline{\dot{T}},\overline{\dot{T}}\right]\right)\oplus\left(U_L\otimes[\underline{F},\overline{F}]\otimes[\underline{T},\overline{T}]\right) \tag{6.7}$$
$$=[\underline{F},\overline{F}]\otimes(S+T_aU_L)$$

Now, apply FADM in parametric form,

$$\left(a\otimes\left[\underline{\dot{T}},\overline{\dot{T}}\right]\right)\oplus\left(b\otimes[\underline{T},\overline{T}]\otimes\left[\underline{\dot{T}},\overline{\dot{T}}\right]\right) \tag{6.8}$$
$$=\left[\frac{W}{\underline{\dot{m}}},\frac{W}{\overline{\dot{m}}}\right]\otimes\left\{\left([\underline{F},\overline{F}]\otimes(S+T_aU_L)\right)\ominus\left(U_L\otimes[\underline{F},\overline{F}]\otimes[\underline{T},\overline{T}]\right)\right\}$$

where, $\mathbb{L}$ is first order differential operator and $\mathbb{L}^{-1}$ is a fuzzy Integral operator. $\mathbb{L}^{-1}=\int_0^x(\cdot)dx$. Take $\mathbb{L}^{-1}$ on both sides of equation (6.8),

$$\mathbb{L}^{-1}\left\{\left(a\otimes[\mathbb{L}\underline{T},\mathbb{L}\overline{T}]\right)\oplus\left(b\otimes[\underline{T},\overline{T}]\otimes[\mathbb{L}\underline{T},\mathbb{L}\overline{T}]\right)\right\}=\mathbb{L}^{-1}\left(\left[\frac{W}{\underline{\dot{m}}},\frac{W}{\overline{\dot{m}}}\right]\otimes\left\{\left([\underline{F},\overline{F}]\otimes(S+T_aU_L)\right)\ominus\left(U_l\otimes[\underline{F},\overline{F}]\otimes[\underline{T},\overline{T}]\right)\right\}\right)$$

$$\mathbb{L}^{-1}\left(b[\mathbb{L}\underline{T},\mathbb{L}\overline{T}]\otimes[\underline{T},\overline{T}]\right)\oplus a\otimes[\underline{T},\overline{T}]$$
$$=a\otimes[\underline{T}_0,\overline{T}_0]\oplus L^{-1}\left(\left[\frac{W}{\underline{\dot{m}}},\frac{W}{\overline{\dot{m}}}\right]\otimes\left\{\left([\underline{F},\overline{F}]\otimes(S+T_aU_L)\right)\ominus\left(U_L\otimes[\underline{F},\overline{F}]\otimes[\underline{T},\overline{T}]\right)\right\}\right) \tag{6.9}$$

Now, we need to decompose this term$[\mathbb{L}\underline{T},\mathbb{L}\overline{T}]\otimes[\underline{T},\overline{T}]$ into Adomian polynomials $[\underline{A}_n,\overline{A}_n]$ as and these polynomials can be obtained by the following formula,

$$[\underline{A}_n,\overline{A}_n]=\left[\frac{1}{n!}\frac{d^n}{d\lambda^n}\left(\underline{N}\sum_{k=0}^{\infty}\underline{T}_k\lambda^k\right),\frac{1}{n!}\frac{d^n}{d\lambda^n}\left(\overline{N}\sum_{k=0}^{\infty}\overline{T}_k\lambda^k\right)\right]$$

where, λ is decomposition factor and ${}^{\alpha}\widetilde{N}(x)$ stands for nonlinear term i.e., $[\mathbb{L}\underline{T}, \mathbb{L}\overline{T}] \otimes [\underline{T}, \overline{T}]$.
Equation (6.9) becomes,

$$\int_0^x \left(\left(\frac{b}{a}\right) \otimes [\underline{A}_{n-1}, \overline{A}_{n-1}] \right) dx \oplus [\underline{T}_n, \overline{T}_n]$$

$$= [\underline{T}_0, \overline{T}_0] \oplus \frac{1}{a} \int_0^x \left(\left[\frac{W}{\underline{\dot{m}}}, \frac{W}{\overline{\dot{m}}}\right] \otimes \left\{ \left([\underline{F}, \overline{F}] \otimes (S + T_a U_L) \right) \right.\right.$$

$$\left.\left. \ominus \left(U_l \otimes [\underline{F}, \overline{F}] \otimes [\underline{T}_{n-1}, \overline{T}_{n-1}] \right) \right\} \right) dx$$

That is,

$$[\underline{T}_n, \overline{T}_n] = [\underline{T}_0, \overline{T}_0] \oplus \frac{1}{a} \int_0^x \left(\left[\frac{W}{\underline{\dot{m}}}, \frac{W}{\overline{\dot{m}}}\right] \otimes \left\{ \left([\underline{F}, \overline{F}] \otimes (S + T_a U_L) \right) \right.\right.$$

$$\left.\left. \ominus \left(U_l \otimes [\underline{F}, \overline{F}] \otimes [\underline{T}_{n-1}, \overline{T}_{n-1}] \right) \right\} \right) dx \qquad (6.10)$$

$$\ominus \int_0^x \left(\left(\frac{b}{a}\right) \otimes [\underline{A}_{n-1}, \overline{A}_{n-1}] \right) dx$$

Now by putting $n = 1,2,3 \ldots$

We have solution of equation (6.5) in convergent series form,

$${}^{\alpha}\tilde{T} = [\underline{T}, \overline{T}] = \left[\sum_{n=0}^{\infty} \underline{T}_n, \sum_{n=0}^{\infty} \overline{T}_n \right] = [\underline{T}_0, \overline{T}_0] \oplus [\underline{T}_1, \overline{T}_1] \oplus [\underline{T}_2, \overline{T}_2] \ldots. \qquad (6.11)$$

6.2.1. Theorem

The solution (6.11) of the system represented by equation (6.6) is a fuzzy solution if, it satisfies the following conditions,

- $\underline{T}_n \leq \overline{T}_n \;\; \forall\, n = 0,1,2,3 \ldots.$
- $\alpha < \beta,\; \underline{T}^{\alpha} \leq \underline{T}^{\beta} \leq \overline{T}^{\beta} \leq \overline{T}^{\beta}$

Proof: In the recurrence relation (6.10), putting $n = 1$ gives,

$$[\underline{T}_1, \overline{T}_1] = \frac{1}{a} \int_0^x \left(\left[\frac{W}{\underline{\dot{m}}}, \frac{W}{\overline{\dot{m}}}\right] \otimes \left\{ \left([\underline{F}, \overline{F}] \otimes (S + T_a U_L) \right) \ominus \left(U_L \otimes [\underline{F}, \overline{F}] \otimes [\underline{T}_0, \overline{T}_0] \right) \right\} \right) dx$$

$$\ominus \int_0^x \left(\left(\frac{b}{a}\right) \otimes [\underline{A}_0, \overline{A}_0] \right) dx$$

where,

$$\left[\underline{T}_0,\overline{T}_0\right]=\left[\underline{T}(0),\overline{T}(0)\right]\oplus\left(\frac{1}{a}\otimes\left[\frac{W}{\underline{\dot{m}}},\frac{W}{\overline{\dot{m}}}\right]\otimes\left[\underline{F},\overline{F}\right]\otimes(S+T_aU_L)x\right)$$

Also, $\left[\underline{A}_0,\overline{A}_0\right]=\left[\min(\underline{T}_0\underline{\dot{T}}_0,\underline{T}_0\,\overline{\dot{T}}_0,\overline{T}_0\,\underline{\dot{T}}_0,\overline{T}_0\overline{\dot{T}}_0)\,,\max(\underline{T}_0\underline{\dot{T}}_0,\underline{T}_0\,\overline{\dot{T}}_0,\overline{T}_0\,\underline{\dot{T}}_0,\overline{T}_0\overline{\dot{T}}_0)\right]$,

Since temperature is positive quantity,

So, $\left[\underline{A}_0,\overline{A}_0\right]=\left[\underline{T}_0\underline{\dot{T}}_0,\overline{T}_0\overline{\dot{T}}_0\right]$

And,

$$\left[\underline{T}_1,\overline{T}_1\right]=\frac{1}{a}\int_0^x\left(\left[\frac{W}{\underline{\dot{m}}},\frac{W}{\overline{\dot{m}}}\right]\otimes\left\{\left(\left[\underline{F},\overline{F}\right]\otimes(S+T_aU_L)\right)\ominus\left(U_L\otimes\left[\underline{F},\overline{F}\right]\otimes\left[\underline{T}_0,\overline{T}_0\right]\right)\right\}\right)dx$$

$$\ominus\int_0^x\left(\left(\frac{b}{a}\right)\otimes\left[\underline{T}_0\underline{\dot{T}}_0,\overline{T}_0\overline{\dot{T}}_0\right]\right)dx$$

$$\left[\underline{T}_1,\overline{T}_1\right]=\frac{1}{a}\int_0^x\left(\left[\frac{W}{\underline{\dot{m}}},\frac{W}{\overline{\dot{m}}}\right]\otimes\left\{\left(\left[\underline{F},\overline{F}\right]\otimes(S+T_aU_L)\right)\right.\right.$$

$$\ominus\left(U_L\right.$$

$$\left.\left.\left.\otimes\left[\underline{F},\overline{F}\right]\otimes\left\{\left[\underline{T}(0),\overline{T}(0)\right]\oplus\left(\frac{1}{a}\otimes\left[\frac{W}{\underline{\dot{m}}},\frac{W}{\overline{\dot{m}}}\right]\otimes\left[\underline{F},\overline{F}\right]\otimes(S+T_aU_L)x\right)\right\}\right)\right\}\right)dx$$

$$\ominus\int_0^x\left(\left(\frac{b}{a}\right)\otimes\left[\underline{T}_0\underline{\dot{T}}_0,\overline{T}_0\overline{\dot{T}}_0\right]\right)dx$$

$$\left[\underline{T}_1,\overline{T}_1\right]=\frac{1}{a}\int_0^x\left(\left[\frac{W}{\underline{\dot{m}}},\frac{W}{\overline{\dot{m}}}\right]\otimes\left\{\left(\left[\underline{F},\overline{F}\right]\otimes(S+T_aU_L)\right)\right.\right.$$

$$\ominus\left(\left\{U_L\otimes\left[\underline{F},\overline{F}\right]\otimes\left[\underline{T}(0),\overline{T}(0)\right]\right\}\oplus\left\{U_L\right.\right.$$

$$\left.\left.\left.\left.\otimes\left[\underline{F},\overline{F}\right]\otimes\left(\frac{1}{a}\otimes\left[\frac{W}{\underline{\dot{m}}},\frac{W}{\overline{\dot{m}}}\right]\otimes\left[\underline{F},\overline{F}\right]\otimes(S+T_aU_L)x\right)\right\}\right)\right\}\right)dx$$

$$\ominus\int_0^x\left(\left(\frac{b}{a}\right)\otimes\left[\underline{T}_0\underline{\dot{T}}_0,\overline{T}_0\overline{\dot{T}}_0\right]\right)dx$$

$$
\begin{aligned}
\left[\underline{T}_1,\overline{T}_1\right] = \frac{1}{a}\otimes\int_0^x\Bigg(&\left[\frac{W}{\underline{\dot{m}}},\frac{W}{\overline{\dot{m}}}\right]\otimes\left(\left[\underline{F},\overline{F}\right]\otimes(S+T_aU_L)\right)\\
&\ominus\left[\frac{W}{\underline{\dot{m}}},\frac{W}{\overline{\dot{m}}}\right]\otimes\Bigg(\left\{U_L\otimes\left[\underline{F},\overline{F}\right]\otimes\left[\underline{T}(0),\overline{T}(0)\right]\right\}\oplus\Bigg\{U_L\\
&\otimes\left[\underline{F},\overline{F}\right]\otimes\left(\frac{1}{a}\otimes\left[\frac{W}{\underline{\dot{m}}},\frac{W}{\overline{\dot{m}}}\right]\otimes\left[\underline{F},\overline{F}\right]\otimes(S+T_aU_L)x\right)\Bigg\}\Bigg)\Bigg)dx\\
&\ominus\int_0^x\left(\left(\frac{b}{a}\right)\otimes\left[\underline{T}_0\underline{\dot{T}}_0,\overline{T}_0\dot{\overline{T}}_0\right]\right)dx
\end{aligned}
$$

$$
\begin{aligned}
\left[\underline{T}_1,\overline{T}_1\right] = \frac{1}{a}\otimes&\left[\frac{W}{\underline{\dot{m}}},\frac{W}{\overline{\dot{m}}}\right]\otimes\left(\left[\underline{F},\overline{F}\right]\otimes(S+T_aU_L)\right)x\\
&\ominus\frac{1}{a}\left\{\left[\frac{W}{\underline{\dot{m}}},\frac{W}{\overline{\dot{m}}}\right]\otimes U_L\otimes\left[\underline{F},\overline{F}\right]\otimes\left[\underline{T}(0),\overline{T}(0)\right]x\right\}\\
&\ominus\frac{1}{a^2}\left\{\left[\frac{W}{\underline{\dot{m}}},\frac{W}{\overline{\dot{m}}}\right]\otimes\left[\frac{W}{\underline{\dot{m}}},\frac{W}{\overline{\dot{m}}}\right]\otimes U_l\otimes\left[\underline{F},\overline{F}\right]\otimes\left[\underline{F},\overline{F}\right]\otimes(S+T_aU_L)\frac{x^2}{2}\right\}\\
&\ominus\int_0^x\left(\left(\frac{b}{a}\right)\otimes\left[\underline{T}_0\underline{\dot{T}}_0,\overline{T}_0\dot{\overline{T}}_0\right]\right)dx
\end{aligned}
$$

Now, $\left[\underline{T}_0,\overline{T}_0\right]$ forms proper interval because it depends on these inequalities

$\underline{T}(0)\le\overline{T}(0)$ and $\frac{W}{\underline{\dot{m}}}\underline{F}\,\underline{T}(0)\le\frac{W}{\overline{\dot{m}}}\overline{F}\quad\overline{T}(0)$ and they are satisfied.

Hence, $\underline{T}_1\le\overline{T}_1$ and ${}^{\alpha}\underline{T}_1\le{}^{\alpha}\overline{T}_1$.

Similarly, other intervals are formed based on fuzzy operations of parameters and it is true for $\underline{T}_n\le\overline{T}_n\ \forall\, n=0,1,2,3,\ldots$

Now, put $n=2,3,\ldots$ we get, $\left[\underline{T}_2,\overline{T}_2\right],\left[\underline{T}_3,\overline{T}_3\right],\ldots$ in terms of polynomial in x and we obtain a series solution by putting these values in equation (6.11).

Then by the first Decomposition theorem as defined in KLIR [70], ${}^{\alpha}\tilde{T}$ fuzzy solution of equation (6.11) is obtained that satisfies both conditions.

$$
{}^{\alpha}\tilde{T} = [\underline{T}, \overline{T}] = [\underline{T}(0), \overline{T}(0)] \oplus \Bigg(\frac{1}{a} \otimes \left[\frac{W}{\underline{\dot{m}}}, \frac{W}{\overline{\dot{m}}} \right] \otimes [\underline{F}, \overline{F}] \otimes (S
$$

$$
+ T_a U_L) x \Bigg) \oplus \frac{1}{a} \otimes \left[\frac{W}{\underline{\dot{m}}}, \frac{W}{\overline{\dot{m}}} \right] \otimes \Big([\underline{F}, \overline{F}] \otimes (S + T_a U_L) \Big) x
$$

$$
\ominus \frac{1}{a} \left\{ \left[\frac{W}{\underline{\dot{m}}}, \frac{W}{\overline{\dot{m}}} \right] \otimes U_l \otimes [\underline{F}, \overline{F}] \otimes [\underline{T}(0), \overline{T}(0)] x \right\}
$$

$$
\ominus \frac{1}{a^2} \left\{ \left[\frac{W}{\underline{\dot{m}}}, \frac{W}{\overline{\dot{m}}} \right] \otimes \left[\frac{W}{\underline{\dot{m}}}, \frac{W}{\overline{\dot{m}}} \right] \otimes U_L \otimes [\underline{F}, \overline{F}] \otimes [\underline{F}, \overline{F}] \otimes (S + T_a U_L) \frac{x^2}{2} \right\}
$$

$$
\ominus \int_0^x \left(\left(\frac{b}{a} \right) \otimes \left[\underline{T}_0 \underline{\dot{T}}_0, \overline{T}_0 \dot{\overline{T}}_0 \right] \right) dx \oplus \cdots
$$

The convergence of above series depends on the nature of the nonlinear term. Since, the nonlinear term is Lipschitz continuous as defined in Chapter 5, the solution exists.

6.3. Result and Discussion

For the parametric involved in the mathematical modelling of the phenomenon and the solution we take the values as in [68], [76] as follows,

$a = 980.54,$	$U_L = 6.5,$
$b = 0.083$	$k = 0.029,$
$\mu = 2.05 \times 10^{-5},$	$\tau' \alpha' = 0.90,$
$T(0) = 323,$	$s' = 0.015,$
$W = 1.2,$	$G_t = 890,$
$L = 4,$	$T_a = 293\ K.$
$h_{r,p-b} = 7.395,$	${}^{0^+}\tilde{\dot{m}} = [0.03, 0.08\,],$
${}^{0^+}\tilde{T} = [320, 325],$	

where,

k is Conductivity of the fin $(W/m\ K)$,

τ' is Transmittance,

$\alpha'$is Absorbance,

$s'$is Depth of air flow section (or channel height) (m),

G_t is Solar Radiation (W/m^2),

$h_{r,p-b}$ is Radiative heat transfer coefficient between absorber plate and back plate.

μ is Dynamic Viscosity

To calculate efficiency of solar air collector $\tilde{F}$, we estimate $\tilde{R}_e, \tilde{h}$ which depends on $\dot{\tilde{m}}$.
Thus, the support $\tilde{F}$ is obtained as,

$$^{0^+}\tilde{F} = [\underline{F}, \overline{F}] = [0.31841, 1.52773].$$

After applying proposed technique on the illustration, result is given in below Table 6.1.

Table 6.1. Effect on temperature at different distances for fuzzy air mass flow rate (0.03, 0.06,0.08) and fuzzy initial temperature (320,323,325)

T									
x	$m = 0.03$			$m = 0.06$			$m = 0.08$		
0	320	323	325	320	323	325	320	323	325
0.36	325.7179	328.5397	330.4300	323.3371	326.2331	328.1638	322.6321	325.5501	327.4955
0.72	331.0962	333.7505	335.5200	326.5585	329.3541	331.2178	325.1923	328.0305	329.9227
1.08	336.1551	338.6517	340.3160	329.6681	332.3669	334.1660	327.6825	330.4431	332.2835
1.44	340.9135	343.2618	344.8273	332.6701	335.2753	337.0121	330.1046	332.7897	334.5799
1.8	345.3893	347.5981	349.0706	335.5680	338.0829	339.7594	332.4605	335.0722	336.8134
2.16	349.5992	351.6768	353.0619	338.3654	340.7931	342.4116	334.7520	337.2923	338.9858
2.52	353.5591	355.5133	356.8161	341.0659	343.4094	344.9718	336.9808	339.4516	341.0989
2.88	357.2838	359.1220	360.3474	343.6727	345.9350	347.4432	339.1487	341.5520	343.1541
3.24	360.7873	362.5163	363.6689	346.1892	348.3731	349.8290	341.2573	343.5949	345.1533
3.6	364.0828	365.7090	366.7932	348.6185	350.7266	352.1321	343.3083	345.5819	347.0977
3.96	367.1825	368.7121	369.7319	350.9635	352.9986	354.3553	345.3031	347.5146	348.9890

Table 6.1, shows the effect of flowing air mass and initial temperature through the collector on temperature in a fuzzy environment. Changes in air mass flow and initial temperature also affect the efficiency of collector. When we take both initial temperature and rate of change in mass of airflow fuzzy then this phenomenon affects the temperature and efficiency. Fig. 6.2, fig. 6.3 and fig. 6.4 show the effect of fuzzy initial temperature and fuzzy rate of change in mass of airflow, on temperature in the three-dimensional triangular graph.

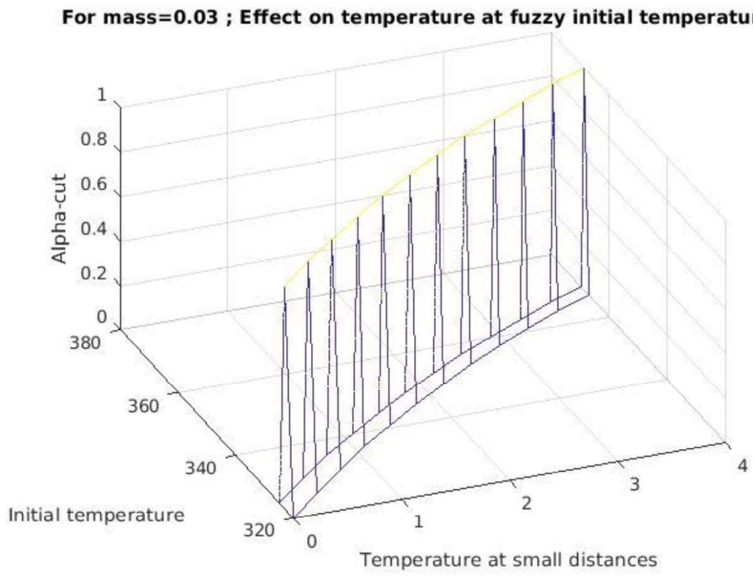

Figure 6.2: Effect on the temperature at different fuzzy initial temperature for mass (0.0300).

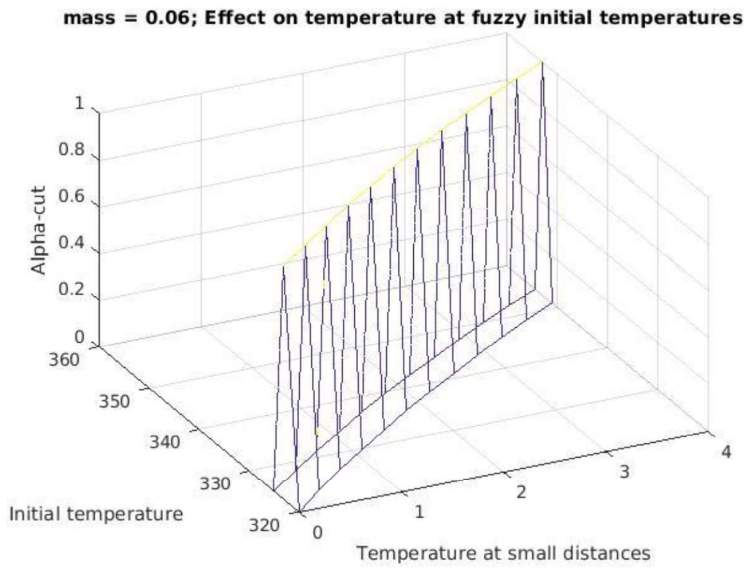

Figure 6.3: Effect on the temperature at different fuzzy initial temperature for mass (0.0600)

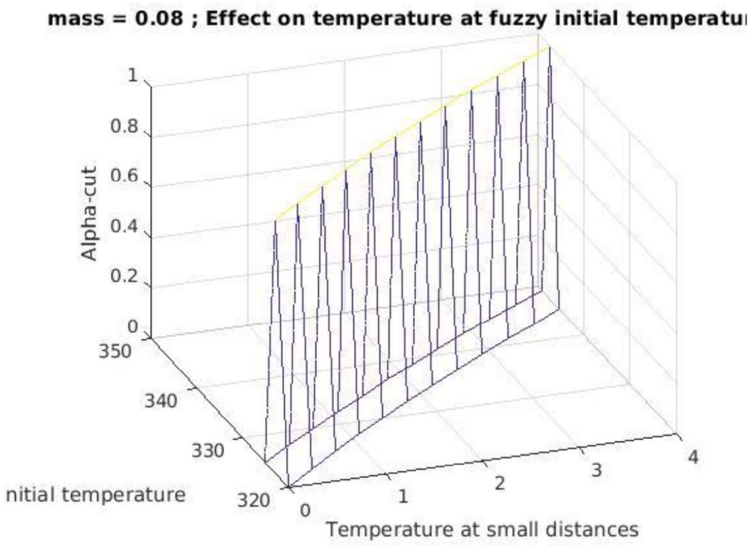

Figure 6.4: Effect on the temperature at different fuzzy initial temperatures for mass (0.0800)

Following points can be observed from the figures,

- The temperature of airflow decreases as rate of change in mass of airflow increases.
- The temperature of airflow increases as the initial temperature increases.

6.4. Conclusion

In this chapter, we have discussed how the temperature of air collector behaves in the fuzzy environment. After the modelling is done, the solution is obtained using fuzzy Adomian Decomposition method in the parametric form. Finally, the graphs are obtained depicts how the temperature in air collector varies with respect to the rate of change of mass of airflow and with respect to the initial condition.