Numerical Modeling on Fuel Cell Cooling using Water Based Aluminum Nitride Nanofluid

N. K. Kund

Abstract: *In the trendy research, CFD codes got developed and run with water-AlN nanofluid to predict the thermal concerns of fuel cell. The convective governing equalities of mass, force and drive are computed for predicting the thermal issues of fuel cell. The time step selected throughout the intact computation is 0.0001 s. The soundings affect CFD forecasts of temperature field, temperature contour plus fluid-solid boundary temperature of fuel cell. The fluid-solid boundary temperature of fuel cell is noticed as 320 K. This stands far less than the hazardous limit of 356 K temperature desired for the objective of beating thermal cataclysm of fuel cell. The temperature of water-AlN nanofluid stands peak contiguous to the fuel cell vicinity. Additionally, the temperature of water-AlN nanofluid gently drops with improvement in remoteness from fuel cell. Subsequently, this becomes surrounding temperature in the distant field zone. The corresponding tinted temperature contour stands accessible. In addition, the congruent plot of temperature against distance from fuel cell stays revealed. The development of CFD revelations stand together with the credentials of undertakings.*

Index Terms: *Fuel Cell, Cooling, CFD Codes, Water-AlN Nanofluid.*

I. INTRODUCTION

A signal of thermal dissipations in fuel cell stays established in figure 1. Fuel cell heat dissipation caught numerous routines for illustration. The standard heat dissipation arrayed heretofore for instance, atmospheric convection is inappropriate for extreme thermal flux treatments. Still, in the preceding years the strange way of heat dissipation has compelled the researchers' ubiquitously within the sphere for the humdrum of nanofluid heat control.

Furthermore, the nanofluid thermal dissipation is unequivocally spirited as ambient heat dissipation is poor to deliver the drive. Numerical and experimental reviews on heat spreading over rectangular domain are existent in texts [1-7]. Computational and experimental work with solidification also stand presented [8-20].

Nevertheless of the realities that the nanofluid cooling equivocates the issues about the extreme heat battle as to ambient heat dissipation and hence, the treatment of nanofluid remains the significant drive of the extant exploration. Here,

the heat dissipations of fuel cell through water-AlN nanofluid stay explored numerically.

II. DEMONSTRATION OF PHYSICAL PROBLEM

Figure 2 divulges the physical theme course problem covering a heat generation from fuel cell indicating the top and bottom edges. Rest two edges are signposted through ambient situations. Here, the thermal dissipations from fuel cell is completed over water-AlN nanofluid.

Further, the thermophysical plus model data of AlN nanoparticles are reflected in the existent analysis plus the ambient situation involved in the current course computations, stand agglomerated exceptionally in Table 1.
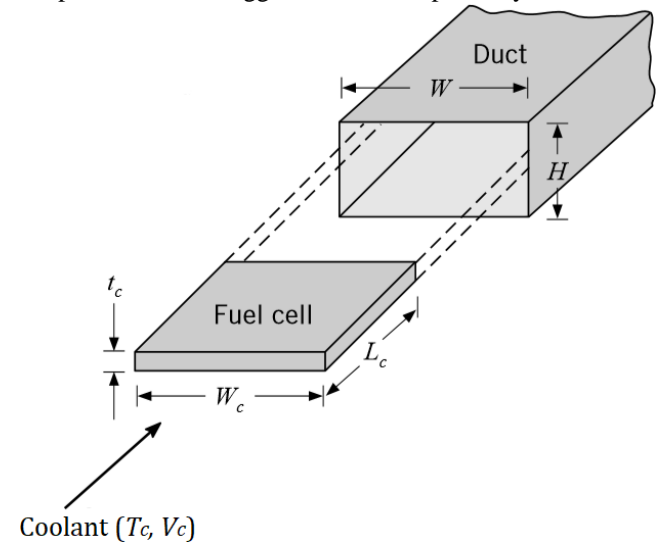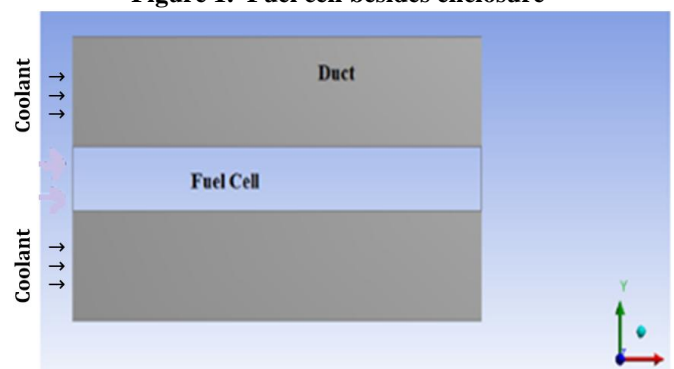

Figure 1. Fuel cell besides enclosure

Figure 2. Computational domain

III. NUMERICAL PROCEDURES

As declared overhead, the figure 2 reveals the CFD worktable aimed at computing the physical topic course.

To facilitate the CFD forecasts the binding stages such as constructing geometry and purview, meshing and initialization are followed to run the simulation.

Here, the prevailing equalities (as termed below through equalities 1-4) of mass, force and drive beside the edge states are chosen. Linearized equalities are computed through the CFD codes. After the development of computations, CFD codes form the shapes and curls through that numerous graphs stand strained to amalgam the CFD forecasts through the prognoses. With the later dispensation the forecasts are scrupulously explored aimed at receiving profuse insights.

Continuity:

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0 \qquad (1)$$

X-momentum:

$$\rho\left(\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} + v\frac{\partial v}{\partial y}\right) = -\frac{\partial P}{\partial x} + \mu\left(\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2}\right) \quad (2)$$

Y-momentum:

$$\rho\left(\frac{\partial v}{\partial t} + u\frac{\partial v}{\partial x} + v\frac{\partial v}{\partial y}\right) = -\frac{\partial P}{\partial y} + \mu\left(\frac{\partial^2 v}{\partial x^2} + \frac{\partial^2 v}{\partial y^2}\right) + \rho g \quad (3)$$

Energy:

$$\left(\frac{\partial T}{\partial t} + u\frac{\partial T}{\partial x} + v\frac{\partial T}{\partial y}\right) = \alpha\left(\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2}\right) \qquad (4)$$

Table 1. Thermophysical properties and model data.

Nanoparticle Properties	AlN
Density, ρ (Kg/m^3)	3261
Specific heat, C_P (J.Kg^{-1}.K^{-1})	741
Thermal conductivity, k (W/m-K)	286
Model Data	**Values**
Enclosure height (H)	25 mm
Fuel cell length (L$_c$)	51 mm
Thickness of fuel cell (t$_c$)	5 mm
Fuel cell width (W$_c$)	51 mm
Enclosure width (W)	51 mm
Atmospheric temperature	300 K
Fuel cell heat flux	10 W/cm^2
Coolant velocity	8 m/s

In the enduring examination, CFD codes are established and executed with water-AlN nanofluid to visualize the thermal concerns of fuel cell. The convective governing equalities of mass, force and drive are computed for envisaging the thermal issues of fuel cell. The time step selected in the integral iteration is 0.0001 s.

IV. RESULTS AND DISCUSSIONS

CFD codes stand established and executed with water-AlN nanofluid. It envisages the impacts on heat dissipation of fuel cell. The soundings affect CFD forecasts of temperature field, temperature contour plus fluid-solid boundary temperature of fuel cell.

Effect of Water-AlN Nanofluid on Fuel Cell Cooling

To expedite the scouting for the stimulus of water-AlN nanofluid on fuel cell cooling, the contemporaneous corporeal archetype stands computed numerically bearing in mind both thermophysical and model data regarding the standing positions.

Figure 3 discloses the CFD prognosis of temperature field besides the tinted measuring scale screening the temperature values over K. It stands viewed at the documented archetype statuses bearing in mind the water-AlN nanofluid for fuel cell heat dissipation. The fluid-solid boundary temperature of fuel cell is viewed as 320 K. This stands far less than the chancy limit of 356 K temperature wished for the objective of outwitting thermal cataclysm of fuel cell. Tritely, the temperature of water-AlN nanofluid stands peak contiguous to the fuel cell locality. Further, the temperature of water-AlN nanofluid gently drops with improvement in aloofness from fuel cell. Afterwards, this becomes surrounding temperature in the aloof arena precinct.
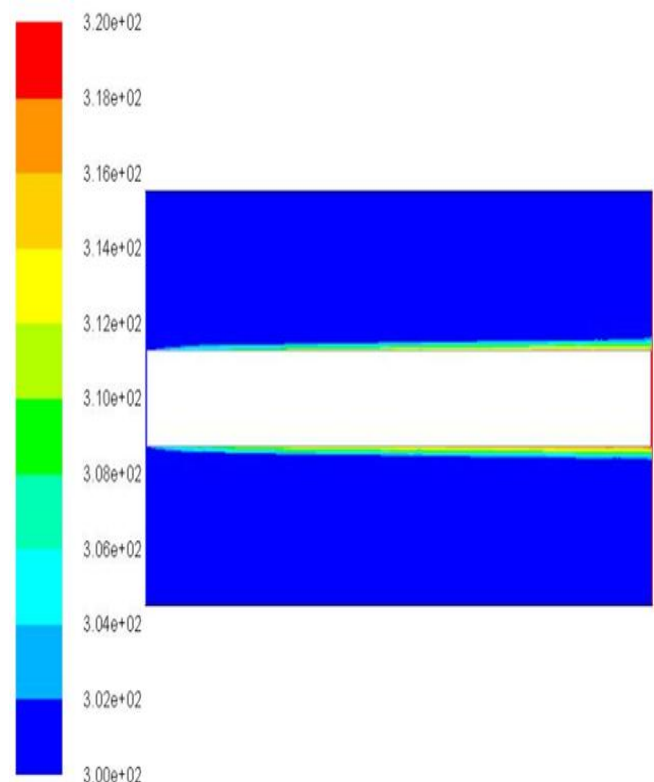

Figure 3. Temperature field with water-AlN nanofluid

The equivalent tinted temperature contour stands accessible in figure 4 onwards. Besides, the harmonizing graph of temperature against distance from fuel cell stands revealed in figure 5. Tritely, the development of CFD elucidations stand along the structures of prospects.
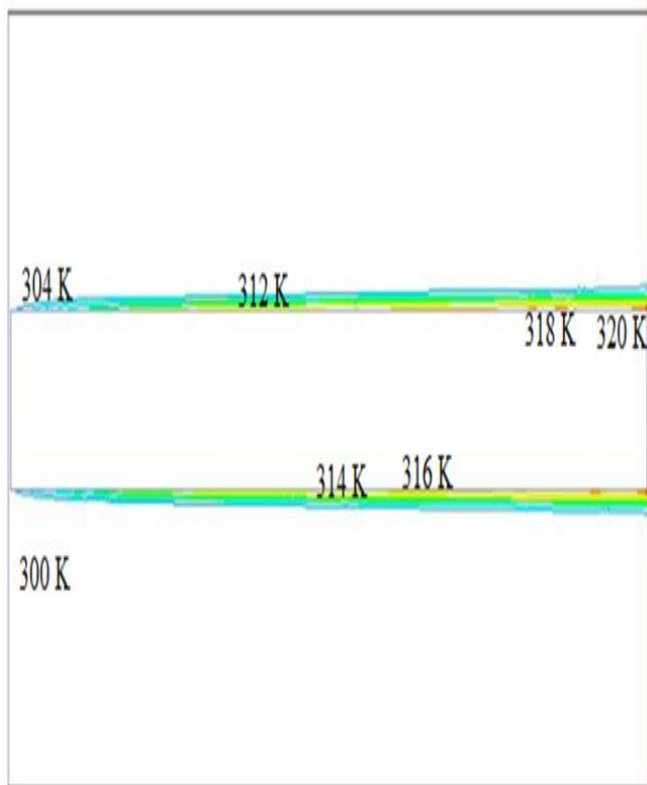
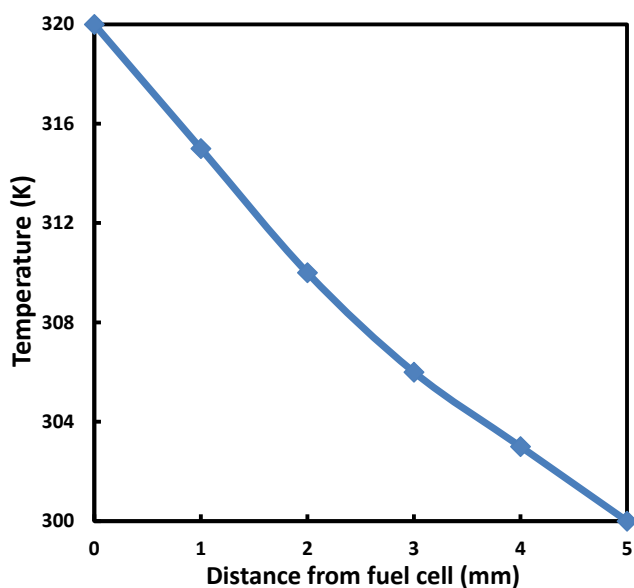**Figure 4. Temperature contour with water-AlN nanofluid**

Figure 5. Temperature vs. distance from fuel cell

V. CONCLUSION

In the fashionable investigation, CFD programmes got developed and executed with water-AlN nanofluid to envision the thermal concerns of fuel cell. The convective governing equalities of mass, force and drive are computed for predicting the thermal issues of fuel cell. The time step selected throughout the intact computation is 0.0001 s. The soundings affect CFD forecasts of temperature field, temperature contour plus fluid-solid boundary temperature of fuel cell. The fluid-solid boundary temperature of fuel cell is noticed as 320 K. This stands far less than the hazardous limit of 356 K temperature desired for the objective of beating thermal cataclysm of fuel cell. The temperature of water-AlN

nanofluid stands peak contiguous to the fuel cell vicinity. Additionally, the temperature of water-AlN nanofluid gently drops with improvement in remoteness from fuel cell. Subsequently, this becomes surrounding temperature in the distant field zone. The corresponding tinted temperature contour stands accessible. In addition, the congruent plot of temperature against distance from fuel cell stands publicized. The establishment of CFD revelations stay alongside the backgrounds of promises.

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Dr. N. K. Kund has obtained both M.Tech. & Ph.D. in Mechanical Engineering from Indian Institute of Science Bangalore. He has also obtained B.Tech.(Hons) in Mechanical Engineering from IGIT Sarang, Utkal University Bhubaneswar. He has published several research papers in international journals and also guided many research scholars, besides, wide teaching and research experience. He is presently working as Associate Professor in the Department of Production Engineering, VSSUT Burla (A Government Technical University).