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CFD Simulation with Modeling on Fuel Cell Thermal Management Using Water Based SiO_2, TIC and SIC Nanofluids

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Abstract: ***Computer codes stand built and practiced on water based SiO_2, TiC and SiC nanofluids. The situation visualizes on fuel cell heat management. It evaluates thermal field/contour besides fuel cell temperature. Ultimately, for all the quoted nanofluids, the fuel cells temperatures remain quite below the critical breakdown value of 356 K. Furthermore, for all the quoted nanofluids, the thermal fields/contours range between fuel cells edges and ambient values. Despite the resemblances in thermal fields/contours, the dissimilarities are in consequence of the deviances in thermophysical properties of enumerated nanomaterials. Besides, fuel cell temperatures of 342 K, 313 K and 322 K are observed with water based SiO_2, TiC and SiC nanofluids, respectively. In addition, the water based TiC nanofluid extracts optimum fuel cell heat management. Because, the water based TiC nanofluid also remains with the smallest resulting fuel cell temperature of 313 K.***

Index Terms: ***Computer Codes, Heat Management, Fuel Cell, SiO_2, TiC and SiC, Nanofluids.***

I. INTRODUCTION

Certainly, the fuel cells are having widespread industrial/domestic applications. However, the fuel cell heat management still remains the toughest ever challenge. A typical fuel cell is demonstrated in figure 1. The natural/atmospheric heat management remains inapt for tremendously high heat generation circumstances. Nevertheless, in the last few decades the abnormal method of heat management or heat removal has compelled the investigators for more exploration in fuel cell heat management.Even so, the nanofluid heat management remains unparalleled. It is because the natural/atmospheric heat management is feeble to support the target. Also, the experimental and CFD researches on solidification remain demonstrated in literature [1-7]. Numerical assessments on heat management over rectangular field also remain presented in texts [8-25]. It is well known that the nanofluid heat management (as opposed to the natural/atmospheric heat management) evades the problems of high heat generations and hereafter, the nanofluid cooling stands as the momentous get-up-and-go of the present assessment. Here, the fuel cell heat management with water based SiO_2, TiC and SiC nanofluids are researched computationally.

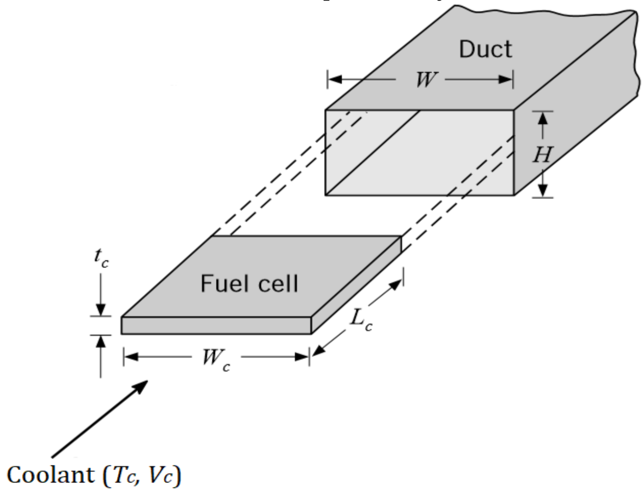

Figure 1. Fuel cell with enclosure

II. REPRESENTATION OF PHYSICAL PROBLEM

Figure 2 highlights the computational domain of fuel cell where top and bottom faces represent heat evolution. Remaining faces represent the ambient conditions. Here, the fuel cell heat management with water based SiO_2, TiC and SiC nanofluids are researched computationally.

Moreover, the thermophysical properties of SiO_2, TiC and SiC nanoparticles and model data of the computational domain are presented in Table 1.

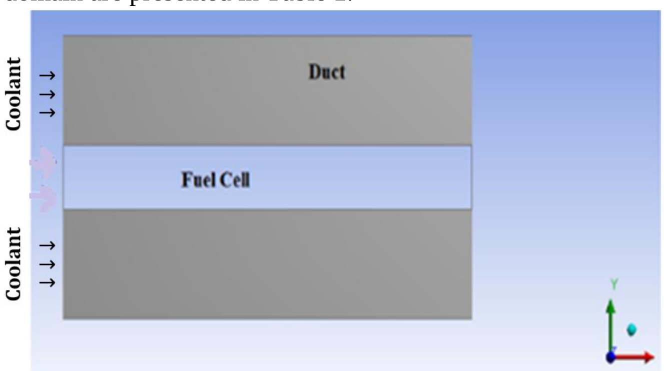

Figure 2. Computational domain

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Table 1. Thermophysical properties and model data.

Nanoparticle Properties	**SiO_2**	**TiC**	**SiC**
Density, ρ (Kg/m^3)	2649	4931	3161
Specific heat, C_P ($J.Kg^{-1}.K^{-1}$)	746	712	675
Thermal conductivity, k (W/m-K)	12	331	491
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		

III. NUMERICAL PRACTICES

Equations of mass, momentum and energy remain presented with equalities 1-4. Linearized form of discretized equations are computed by running computer codes. Usual steps like meshing and initialization stand chosen for running the computer codes. It is intended for getting thermal fields/countours within computational domain presented previously in figure 2.

Continuity:

$$\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}=0 \tag{1}$$

X-momentum:

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

Y-momentum:

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

Energy:

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

Computer codes are developed and exercised with water based SiO_2, TiC and SiC nanofluids. The situation visualizes on fuel cell heat management. Equations of mass, momentum and energy remain computed for the same. Time step chosen in the present computation is 0.0001 s.

IV. RESULTS AND DISCUSSION

Computer codes are generated and implemented on water based SiO_2, TiC and SiC nanofluids. The situation visualizes on fuel cell heat management. It evaluates thermal field/contour besides fuel cell temperature.

Effect of Water-SiO_2 Nanofluid on Fuel Cell Cooling

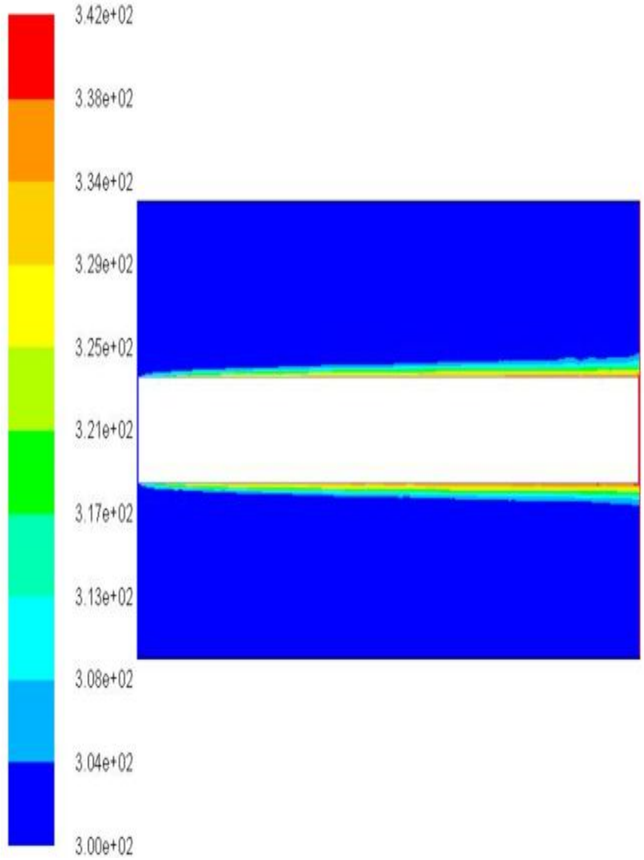

Figure 3. Temperature field with water-SiO_2 nanofluid

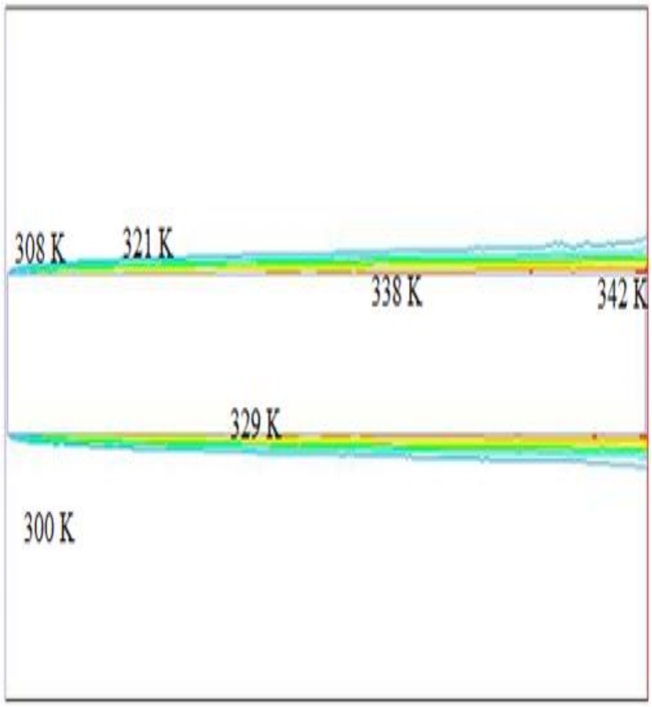

Figure 4. Temperature contour of water-SiO_2 nanofluid

Computer codes are implemented on water based SiO_2 nanofluid. The site visualizes on fuel cell heat management.

This evaluates thermal field/contour and fuel cell temperature.

Figure 3 demonstrates the thermal field only. The follow-on fuel cell temperature is 342 K. It remains quite below the critical breakdown value of 356 K. The thermal field ranges between 342 K at fuel cell edge and ambient 300 K at remotest field location.

Figure 4 demonstrates only the thermal contour. Here too, thermal field ranges between 342 K at fuel cell edge and ambient 300 K at remotest field location.

Effect of Water-TiC Nanofluid on Fuel Cell Cooling

Computer codes are implemented on water based TiC nanofluid. The site visualizes on fuel cell heat management. This evaluates thermal field/contour and fuel cell temperature. Figure 5 demonstrates the thermal field only. The follow-on fuel cell temperature is 313 K. It remains quite below the critical breakdown value of 356 K. The thermal field ranges between 313 K at fuel cell edge and ambient 300 K at remotest field location.

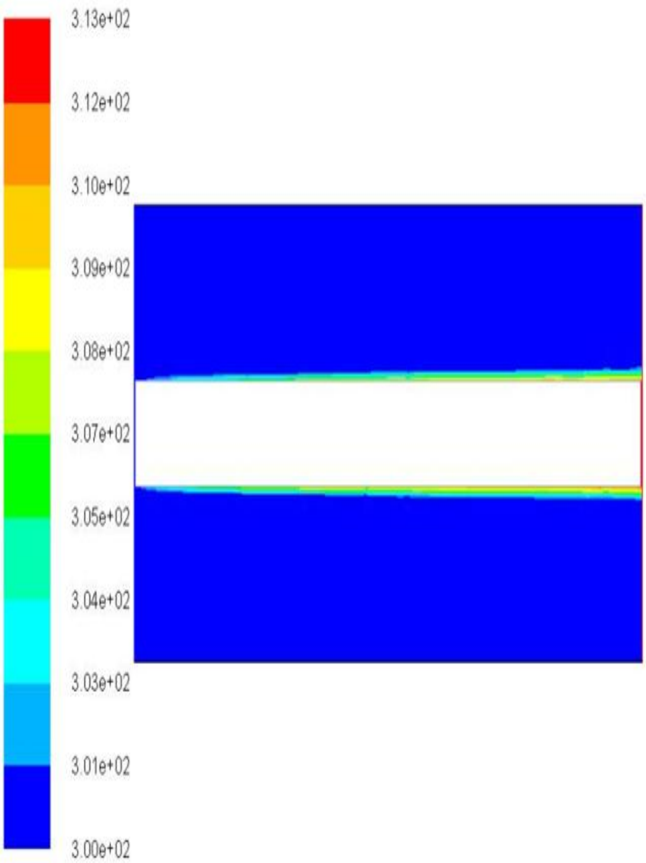

Figure 5. Temperature field with water-TiC nanofluid

Figure 6 demonstrates only the thermal contour. Here too, thermal field ranges between 313 K at fuel cell edge and ambient 300 K at remotest field location.

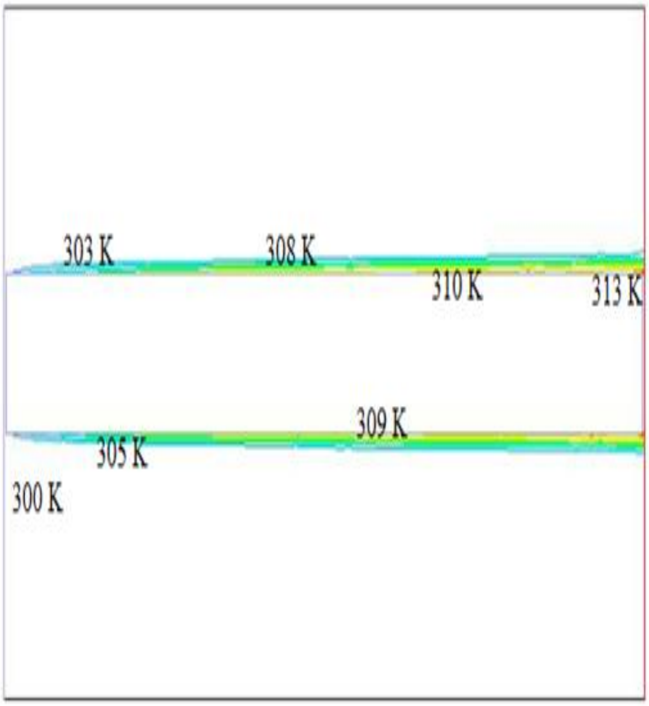

Figure 6. Temperature contour for water-TiC nanofluid

Effect of Water-SiC Nanofluid on Fuel Cell Cooling

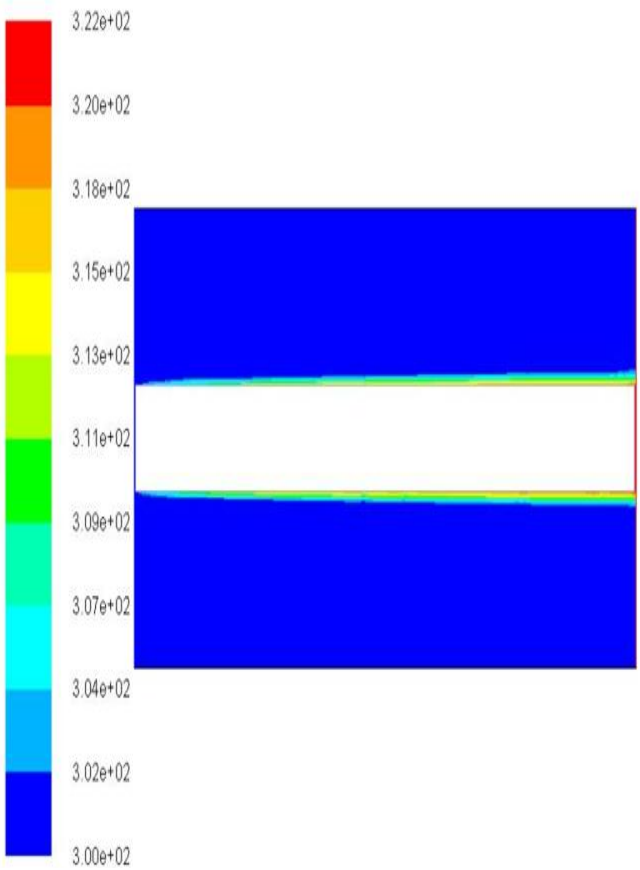

Figure 7. Temperature field with water-SiC nanofluid

Computer codes are implemented on water based SiC nanofluid. The site visualizes on fuel cell heat management. This evaluates thermal field/contour and fuel cell temperature. Figure 7 demonstrates the thermal field only. The follow-on fuel cell temperature is 322 K. It remains quite below the critical breakdown value of 356 K. The thermal field ranges between 322 K at fuel cell edge and ambient 300 K at remotest field location.

Figure 8 demonstrates only the thermal contour. Here too, thermal field ranges between 322 K at fuel cell edge and ambient 300 K at remotest field location.

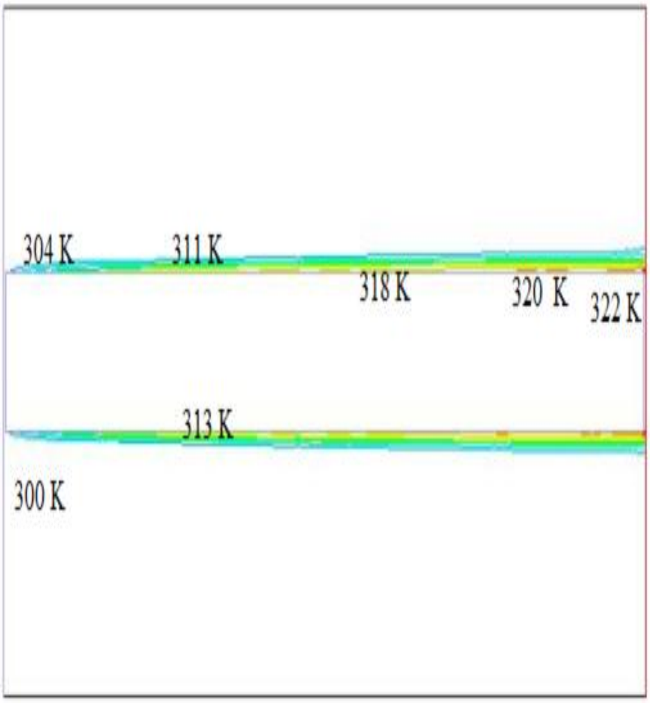

Figure 8. Temperature contour for water-SiC nanofluid

Table 2 restates the follow-on fuel cells temperatures of water based SiO_2, TiC and SiC nanofluids. Despite the resemblances in thermal fields/contours, the dissimilarities are in consequence of the deviances in thermophysical properties of nanomaterials enumerated in table 1.

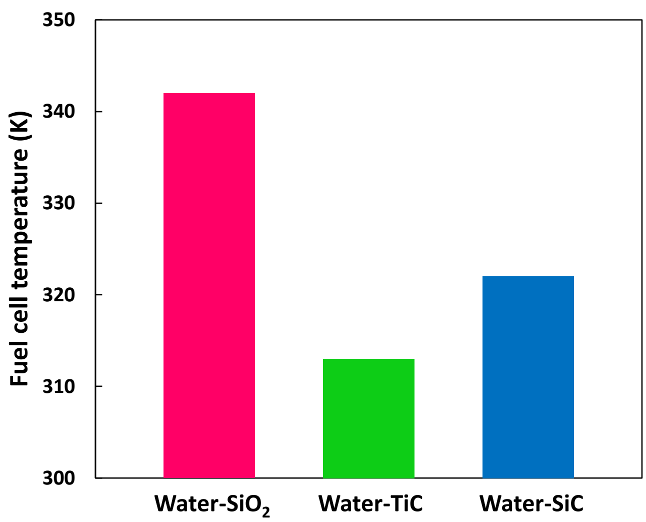

Figure 9. Fuel cell temperature vs. nanofluid

Figure 9 also presents the histogram of fuel cell temperature alongside nanofluid. Further, the water based TiC nanofluid extracts optimum fuel cell heat management. Because, the water based TiC nanofluid corresponds to the minimum follow-on fuel cell temperature of 313 K as well.

Table 2. Summary of Fuel cell temperatures with nanofluids.

Nanofluid	Fuel Cell Temperature (K)
Water-SiO_2	342
Water-TiC	313
Water-SiC	322

V. CONCLUSION

Computer codes are developed and applied on water based SiO_2, TiC and SiC nanofluids. The situation visualizes on fuel cell heat management. It evaluates thermal field/contour besides fuel cell temperature. Ultimately, for all the quoted nanofluids, the fuel cells temperatures remain quite below the critical breakdown value of 356 K. Furthermore, for all the quoted nanofluids, the thermal fields/contours range between fuel cells edges and ambient values. Despite the resemblances in thermal fields/contours, the dissimilarities are in consequence of the deviances in thermophysical properties of enumerated nanomaterials. Besides, fuel cell temperatures of 342 K, 313 K and 322 K are observed with water based SiO_2, TiC and SiC nanofluids, respectively. In addition, the water based TiC nanofluid extracts optimum fuel cell heat management. Because, the water based TiC nanofluid also corresponds to the lowest stimulating fuel cell temperature of 313 K.

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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).