FORCED CONVECTION HEAT TRANSFER PERFORMANCE OF TiO_2-SiO_2 NANOFLUIDS WITH WIRE COIL INSERTS

KHAMISAH BINTI ABDUL HAMID

Doctor of Philosophy

UNIVERSITI MALAYSIA PAHANG

SUPERVISOR'S DECLARATION

We hereby declare that we have checked this thesis and in our opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Doctor of Philosophy.

____

(Supervisor's Signature)

Full Name : DR. WAN AZMI BIN WAN HAMZAH

Position : ASSOCIATE PROFESSOR

Date :

____

(Co-supervisor's Signature)

Full Name : DR. RIZALMAN BIN MAMAT

Position : PROFESSOR

Date :

STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

____

(Student's Signature)

Full Name : KHAMISAH BINTI ABDUL HAMID

ID Number : PMM16016

Date :

FORCED CONVECTION HEAT TRANSFER PERFORMANCE OF TiO_2-SiO_2 NANOFLUIDS WITH WIRE COIL INSERTS

KHAMISAH BINTI ABDUL HAMID

Thesis submitted in fulfillment of the requirements
for the award of the degree of
Doctor of Philosophy

Faculty of Mechanical Engineering

UNIVERSITI MALAYSIA PAHANG

JANUARY 2019

ACKNOWLEDGEMENTS

In the name of Allah, the Most Merciful and the Most Beneficial. First and foremost, I would like to express my praises to Allah S.W.T with whole-hearted gratefulness for the blessings given so that I can finish my doctoral research study.

There are so many people that helped me complete this research and I wish to express my sincere appreciation and deepest thank you. First, my supervisor; Assoc. Prof. Dr. Wan Azmi bin Wan Hamzah and co-Supervisor; Prof. Dr. Rizalman bin Mamat who gave me this opportunity to work with them and always providing support, continuous encouragement, ideas and knowledge sharing, invaluable guidance, advices and motivation until I finish this project and thesis.

My deepest thank you also goes to my colleagues in Advanced Automotive Liquid Laboratory (A^2LL) who always helped me in completing the experimental work by sharing ideas, experience and knowledge. The continuous support and assistance from my fellow Master and Final Year Project students 2017/2018; Mr. Muhammad Nabil Fikri bin Mohamad and Mr. Adam bin Mohd Bakri who were always helping me day and night.

Last but not least, I am grateful to my beloved family; my late father, Abdul Hamid bin Ismail, my late mother, Mahani binti Abd Samad, and all my siblings who have supported me through financial matters and motivation. Their sacrifice, understanding and patience encouraged me to achieve my dreams. May Allah S.W.T. bless these people always.

Thank you all.

ABSTRAK

Teknik penambahbaikan pemindahan haba melalui kaedah kompaun dengan penggunaan bendalir nano bersama sisipan telah dieksplorasi sejak beberapa tahun yang lalu. Walau bagaimanapun, kajian yang dilakukan pada bendalir nano hibrid dengan memasukkan gegelung wayar adalah terhad. Bendalir nano hibrid adalah cecair pemindahan haba yang lebih baik kerana kelebihannya dari segi kestabilan dan ciri-ciri haba. Gegelung dawai adalah pilihan terbaik antara alat pusaran kerana memberikan peningkatan pemindahan haba maksimum dan penalti geseran minimum kepada sistem. Objektif kajian ini adalah untuk mengkaji ciri-ciri fizikal haba, pemindahan haba dan prestasi hidraulik haba bendalir nano TiO_2-SiO_2 dalam campuran air/EG dengan gegelung dawai. Pada permulaan, bendalir nano TiO_2-SiO_2 disediakan dalam nisbah komposisi yang berbeza iaitu 20:80, 40:60, 50:50, 60:40 dan 80:20 (nisbah TiO_2 kepada SiO_2 dalam peratus isipadu) pada kepekatan isipadu tetap 1.0%. Kemudian, bendalir hibrid nano disediakan pada kepekatan isipadu dalam lingkungan 0.5 hingga 3.0% untuk nisbah komposisi optimum. Kekonduksian haba dan pekali kelikatan bendalir nano diukur menggunakan peralatan makmal analitik, manakala ketumpatan dan haba spesifik diperolehi dengan menggunakan formula campuran yang dianggarkan dengan menggunakan hubungan campuran sedia ada. Ujikaji olakan secara paksaan dilakukan dengan menggunakan peralatan eksperimen yang diubah suai dan dilaksanakan pada nombor Reynolds antara 2,300 hingga 12,000 dan suhu pukal 30 °C. Eksperimen dilaksanakan pada fluks haba yang tetap untuk aliran dalam tiub bersama gegelung dawai pada nisbah pic P/D dari 0.83 hingga 4.17. Model teori pula dibangunkan daripada persamaan kemeresapan pusar van Driest. Penilaian terhadap pekali K dan indeks Prandtl, ζ dijalankan untuk melihat ciri-ciri gelora. Antara lima nisbah komposisi yang berbeza, nisbah pada 20:80 (dinyatakan sebagai R=0.2) diperhatikan sebagai nisbah komposisi yang paling efektif berdasarkan kepada penilaian sifat dan prestasi pemindahan haba. Kekonduksian haba, pekali kelikatan dinamik dan pekali pemindahan haba untuk R=0.2 pada kepekatan isipadu 3.0% meningkat sehingga 22.83%, 68.47% dan 50.99%. Untuk aliran dalam tiub dengan gegelung dawai, peningkatan maksimum dalam pemindahan haba direkodkan sehingga 254.44% pada kepekatan isipadu 2.5% dan nisbah pic 0.83. Pekali geseran tidak banyak meningkat dengan peningkatan kepekatan isipadu untuk aliran dalam tiub tanpa gegelung dawai. Walau bagaimanapun, pekali geseran bendalir nano untuk aliran dalam tiub bersama gegelung dawai meningkat dari 1.88 sehingga 6.38 kali lebih tinggi dari aliran dalam tiub bersama air/EG. Faktor prestasi haba (TPF) bagi bendalir nano untuk aliran dalam tiub bersama gegelung dawai didapati dalam julat 1.3 sehingga 2.06. Pekali pemindahan haba dan pekali geseran bagi bendalir nano meningkat apabila nisbah pic gegelung dawai menurun dari 4.17 kepada 0.83. Bendalir nano TiO_2-SiO_2 pada semua kepekatan isipadu dan nisbah pic gegelung dawai yang berbeza memperoleh nilai TPF yang lebih besar daripada satu. Walau bagaimanapun, kombinasi terbaik bendalir nano bersama gegelung dawai adalah pada kepekatan isipadu 2.5% dan nisbah pic 1.50 dengan nilai TPF sehingga 2.06. Model teori telah disahkan dengan data eksperimen dan berjaya meramal ciri-ciri gelora aliran bendalir nano bersama gegelung dawai. Perbandingan antara anggaran teori dan keputusan eksperimen menunjukkan persetujuan yang baik dan mengesahkan kesahihan model yang dicadangkan. Akhir sekali, adalah digalakkan menggunakan bendalir nano TiO_2-SiO_2 pada nisbah komposisi 20:80 untuk aplikasi dalam pelbagai sistem pemindahan haba dan menyediakan bendalir nano tersebut pada kepekatan isipadu 2.5% bersama nisbah pic gegelung dawai 1.50 untuk prestasi optimum.

ABSTRACT

Heat transfer enhancement technique through compound method has been explored in the past few years with the use of nanofluids and inserts. However, studies on hybrid nanofluids with wire coil inserts are limited in the literature. The hybrid nanofluids provide better heat transfer fluids due to its advantages in stability and thermal properties. The wire coil is the best option among the swirl devices which provides maximum heat transfer enhancement and minimum friction penalty to the system. The objective of the present study is to investigate the thermo-physical properties, heat transfer and thermal hydraulic performance of TiO_2-SiO_2 nanofluids in water/EG mixture with wire coil inserts. Initially, the TiO_2-SiO_2 nanofluids were prepared at different composition ratios of 20:80, 40:60, 50:50, 60:40 and 80:20 (ratio of TiO_2 to SiO_2 in volume percent) for a constant 1.0% volume concentration. Later, the hybrid nanofluids were prepared at different volume concentrations from 0.5 to 3.0% for optimum composition ratio. The thermal conductivity and dynamic viscosity of nanofluids were measured using analytical laboratory equipment, whereas the density and specific heat were estimated using existing mixture relation from literature. The forced convection heat transfer investigation was conducted using the modified experimental setup and undertaken for a wide range of Reynolds number from 2,300 to 12,000 and bulk temperature of 30 °C. The experiment was undertaken at constant heat flux boundary conditions for flow in a tube with wire coil inserts at pitch ratio P/D from 0.83 to 4.17. The theoretical model was developed from van Driest eddy diffusivity equation. The evaluation on coefficient K and Prandtl index, ζ is conducted to observe their turbulent characteristics. Among five composition ratios, the ratio of 20:80 (denoted as R=0.2) was observed to be the most effective composition ratio according to the evaluation of thermo-physical properties and heat transfer performance at different composition ratios. The thermal conductivity, dynamic viscosity and heat transfer coefficient for R=0.2 at 3.0% volume concentration were increased up to 22.83%, 68.47% and 50.99%, respectively. For flow in a tube with wire coil inserts, the heat transfer enhancement was recorded up to 254.44% at 2.5% volume concentration and 0.83 pitch ratio. The friction factor insignificantly increased with the increase of volume concentration for flow in a tube without wire coil inserts. However, the friction factor of nanofluids increased from 1.88 to 6.38 times higher than water/EG in a tube for flow in a tube with wire coil inserts. The thermal performance factor (TPF) for flow of nanofluids over wire coil inserts was obtained in the range of 1.3 to 2.06. The heat transfer performance and friction factor of the nanofluids increased when the wire coil pitch ratio decreased from 4.17 to 0.83. The TPF of the TiO_2-SiO_2 nanofluids at all volume concentrations and different wire coil pitch ratios obtained ratio greater than one. However, the optimum condition for nanofluids with wire coil inserts occurred at 2.5% volume concentration and 1.5 pitch ratio with TPF up to 2.06. The theoretical models were validated with the experimental data and successfully predicted the turbulent characteristics of nanofluids flow with wire coil inserts. The comparison between theoretical estimation and experimental results showed a good agreement hence confirming the validity of the proposed model. Finally, it was recommended to formulate the TiO_2-SiO_2 nanofluids with composition ratio 20:80 for application in various heat transfer systems and prepare the nanofluids at 2.5% volume concentration with 1.50 wire coil pitch ratio for optimum performance.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

A	Final absorbance
A_o	Initial absorbance
$\bar{A}_r$	Absorbance ratio, (A/A_o)
A_s	Surface area
A^+	Constant in van driest expression
α_{nf}	Thermal diffusivity of nanofluids
C_p	Specific heat
$C_{p,bf}$	Specific heat of base fluid
C_{nf}	Specific heat of nanofluids
C_{hnf}	Specific heat of hybrid nanofluids
C_{reg}	Regression of specific heat
$C_{water/EG}$	Specific heat of water/EG
d_P	Diameter of particle
D	Diameter of inner tube
ΔP	Pressure drop
ΔP_{exp}	Experimental pressure drop
ΔT	Temperature difference
ΔV	Volume of base fluid
e	Thickness of wire coil
ε_H	Eddy diffusivity for heat
ε_m	Eddy diffusivity for momentum
η	Thermal performance factor
f	Darcy friction factor
$f_{bf,PT}$	Friction factor of base fluid in plain tube
f_{exp}	Experimental friction factor
f_{Bl}	Blasius friction factor
f_{nf}	Friction factor of nanofluids
$f_{nf,WC}$	Friction factor of nanofluids in wire coil
f_{Pt}	Petukhov friction factor
f_{reg}	Regression of friction factor
f_{th}	Theoretical friction factor

γ	Shear rate
h	Heat transfer coefficient
H	Helical pitch of twisted tape
$\overline{h}_{enhance}$	Average heat transfer enhancement
h_{nf}	Experimental heat transfer coefficient
$H_{water/EG}$	Heat transfer coefficient of water/EG
I	Current
k	Thermal conductivity
k_{bf}	Thermal conductivity of base fluid
k_{nf}	Thermal conductivity of nanofluids
k_{eff}	Effective thermal conductivity, (k_{nf}/k_{bf})
$k_{W/EG}$	Thermal conductivity of water/EG
K	Coefficient in eddy diffusivity equation of van Driest
L	Tube length
L_h	Hydrodynamic entry length
$\dot{m}$	Mass flow rate
μ	Dynamic viscosity
μ_{bf}	Dynamic viscosity of base fluid
μ_{bulk}	Dynamic viscosity in bulk
μ_{nf}	Dynamic viscosity of nanofluids
μ_r	Relative viscosity, (μ_{nf}/μ_{bf})
$\mu_{surface}$	Dynamic viscosity at surface
$\mu_{water/EG}$	Dynamic viscosity of water/EG
N	Number of coil turn
Nu	Nusselt number
Nu_{DB}	Dittus-Boelter Nusselt number
Nu_{exp}	Experimental Nusselt number
Nu_G	Gnielinski Nusselt number
Nu_{nf}	Theoretical Nusselt number
$Nu_{bf,PT}$	Nusselt number of base fluid in plain tube
$Nu_{nf,WC}$	Nusselt number of nanofluids in wire coil
Nu_{reg}	Regression of Nusselt number
Nu_{th}	Theoretical Nusselt number

ω	Weight concentration in percent
P	Pitch in wire coil
Pr	Prandtl number
Pr_{nf}	Prandtl number of nanofluids
ϕ	Volume concentration in percent
ϕ_1	Initial volume concentration
ϕ_2	Final volume concentration
φ	Volume concentration in fraction
φ_{P1}	Volume fraction for particle type 1
φ_{P2}	Volume fraction for particle type 2
Q	Heat input
q	Heat flux
R	Composition ratio
Re	Reynolds number
R^+	Dimensionless radius, $\frac{R}{\nu}\sqrt{\frac{\tau_w}{\rho}}$
ρ	Density
ρ_{bf}	Density of base fluid
ρ_{nf}	Density of nanofluids
ρ_{hnf}	Density of hybrid nanofluids
ρ_p	Density of particle
ρ_{p1}	Density of particle type 1
ρ_{p2}	Density of particle type 2
$\rho_{W/EG}$	Density of water/EG
s	Separation distance
t	Time
T	Temperature
T_b	Bulk temperature
T_{bf}	Temperature of base fluid
T_C	Temperature at centre
T_{inlet}	Inlet temperature
T_{outlet}	Outlet temperature
T_s	Surface temperature

T_W	Wall temperature
T^+	Non-dimensional temperature, $\left(\frac{T_W - T}{T_W - T_C}\right)$
τ	Shear stress
τ_w	Wall shear stress
u	Velocity
u^+	Non-dimensional velocity, (u/u^*)
u^*	Shear velocity, $\left(\sqrt{\frac{\tau_w}{\rho}}\right)$
U	Uncertainty
ν	Kinematic viscosity
ν_{nf}	Kinematic viscosity of nanofluids
$\dot{V}$	Volume flow rate
$\dot{V}_{cal}$	Calibrated volume flow rate
V_1	Initial volume
V_2	Final volume
V_t	Input voltage
$\bar{V}$	Average velocity
y	Distance measured normal to the wall
y^+	Dimensionless distance measured normal to the wall, $\left(\frac{yu^*}{\nu}\right)$
ζ	Prandtl index
W	Water
w	Wall

LIST OF ABBREVIATIONS

AD	Average deviation
Ag	Silver
Al_2O_3	Aluminium oxide
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASNSS	Arc-submerged nanoparticle synthesis system
ASTM	American Society for Testing and Materials
BG	Bioglycol
C	Carbon
CCHP	Combine cooling and heating power
CNT	Carbon nanotube
CO_2	Carbon dioxide
Cu	Copper
CuO	Copper oxide
DPHE	Double pipe heat exchanger
EG	Ethylene glycol
EHD	Electro-hydrodynamic
ETSC	Evacuated tube solar collector
FVC	Fractional volume concentration
Fe	Iron
Fe_3O_4	Iron (II, III) oxide
FOM	Figure of merit
GO	Graphene oxide
GPR	Geometrical progression ratio
HCR	Hexagonal conical ring
HE	Heat exchanger
HEG	Hydrogen induced exfoliated graphene or decorated graphene
HVAC	Heating, ventilation and air conditioning
IEEE	Institute of Electrical and Electronics Engineers
MCHS	Microchannel heat sink
MD	Maximum deviation

MEPCM	Microencapsulated phase change material
MgO	Magnesium oxide
MHD	Magneto-hydrodynamic
MSDS	Material safety data sheet
MWCNT	Multi-wall carbon nanotube
NA	Not available
PCM	Phase change material
PEC	Performance evaluation criterion
PEMFC	Proton exchange membrane fuel cell
PG	Propylene glycol
RSM	Response surface methodology
SC-TiO_2	Sulphur-carbon doped TiO_2
SD	Standard deviation
SIMPLE	Semi-implicit method for pressure-link equations
SiO_2	Silicon dioxide
SWCNT	Single-wall carbon nanotube
TEC	Thermo-electrical conductivity
TEM	Transmission electron microscopy
THW	Transient hot wire
TiO_2	Titanium oxide
TPF	Thermal performance factor
TSP	Transition shape parameter
Uv-vis	Ultraviolet visible
VG	Vortex generator
VR	Vortex ring
W	Water
WC	Wire coil
ZnO	Zinc oxide

REFERENCES

Abdolbaqi, M. K., Azmi, W. H., Mamat, R., Sharma, K. V., & Najafi, G. (2016a). Experimental investigation of thermal conductivity and electrical conductivity of bioglycol–water mixture based Al_2O_3 nanofluid. *Applied Thermal Engineering, 102*, 932-941.

Abdolbaqi, M. K., Sidik, N. A. C., Aziz, A., Mamat, R., Azmi, W. H., Yazid, M. N. A. W. M., & Najafi, G. (2016b). An experimental determination of thermal conductivity and viscosity of bioglycol/water based TiO_2 nanofluids. *International Communications in Heat and Mass Transfer, 77*, 22-32.

Abdolbaqi, M. K., Sidik, N. A. C., Rahim, M. F. A., Mamat, R., Azmi, W. H., Yazid, M. N. A. W. M., & Najafi, G. (2016c). Experimental investigation and development of new correlation for thermal conductivity and viscosity of bioglycol/water based SiO_2 nanofluids. *International Communications in Heat and Mass Transfer, 77*(Supplement C), 54-63.

Afrand, M. (2017). Experimental study on thermal conductivity of ethylene glycol containing hybrid nano-additives and development of a new correlation. *Applied Thermal Engineering, 110*, 1111-1119.

Agarwal, D. K., Vaidyanathan, A., & Sunil Kumar, S. (2015). Investigation on convective heat transfer behaviour of kerosene-Al_2O_3 nanofluid. *Applied Thermal Engineering, 84*, 64-73.

Agarwal, R., Verma, K., Agrawal, N. K., Duchaniya, R. K., & Singh, R. (2016). Synthesis, characterization, thermal conductivity and sensitivity of CuO nanofluids. *Applied Thermal Engineering, 102*(Supplement C), 1024-1036.

Ahammed, N., Asirvatham, L. G., & Wongwises, S. (2016). Entropy generation analysis of graphene–alumina hybrid nanofluid in multiport minichannel heat exchanger coupled with thermoelectric cooler. *International Journal of Heat and Mass Transfer, 103*, 1084-1097.

Ahmad, S. H. A., Saidur, R., Mahbubul, I. M., & Al-Sulaiman, F. A. (2017). Optical properties of various nanofluids used in solar collector: A review. *Renewable and Sustainable Energy Reviews, 73*(Supplement C), 1014-1030.

Akbaridoust, F., Rakhsha, M., Abbassi, A., & Saffar Avval, M. (2013). Experimental and numerical investigation of nanofluid heat transfer in helically coiled tubes at constant wall temperature using dispersion model. *International Journal of Heat and Mass Transfer, 58*(1), 480-491.

Akilu, S., Baheta, A. T., & Sharma, K. V. (2017). Experimental measurements of thermal conductivity and viscosity of ethylene glycol-based hybrid nanofluid with TiO_2-CuO/C inclusions. *Journal of Molecular Liquids, 246*, 396-405.

Akilu, S., Sharma, K. V., Baheta, A. T., & Mamat, R. (2016). A review of thermophysical properties of water based composite nanofluids. *Renewable and Sustainable Energy Reviews, 66*(Supplement C), 654-678.

Akyürek, E. F., Geliş, K., Şahin, B., & Manay, E. (2018). Experimental analysis for heat transfer of nanofluid with wire coil turbulators in a concentric tube heat exchanger. *Results in Physics, 9*, 376-389.

Alam, T., & Kim, M. H. (2017). Heat transfer enhancement in solar air heater duct with conical protrusion roughness ribs. *Applied Thermal Engineering, 126*, 458-469.

Alam, T., & Kim, M. H. (2018). A comprehensive review on single phase heat transfer enhancement techniques in heat exchanger applications. *Renewable and Sustainable Energy Reviews, 81*, 813-839.

Ali, S., Menanteau, S., Habchi, C., Lemenand, T., & Harion, J. L. (2016). Heat transfer and mixing enhancement by using multiple freely oscillating flexible vortex generators. *Applied Thermal Engineering, 105*, 276-289.

Alian, A. R., & Meguid, S. A. (2017). Molecular dynamics simulations of the effect of waviness and agglomeration of CNTs on interface strength of thermoset nanocomposites. *Physical Chemistry Chemical Physics, 19*(6), 4426-4434.

Andreozzi, A., Manca, O., Nardini, S., & Ricci, D. (2016). Forced convection enhancement in channels with transversal ribs and nanofluids. *Applied Thermal Engineering, 98*(Supplement C), 1044-1053.

Anoop, K., Sadr, R., Yrac, R., & Amani, M. (2016). High-pressure rheology of alumina-silicone oil nanofluids. *Powder Technology, 301*(Supplement C), 1025-1031.

Aparna, Z., Michael, M. M., Pabi, S. K., & Ghosh, S. (2018). Diversity in thermal conductivity of aqueous Al_2O_3- and Ag-nanofluids measured by transient hot-wire and laser flash methods. *Experimental Thermal and Fluid Science, 94*, 231-245.

Aravind, S. S. J., & Ramaprabhu, S. (2013). Graphene–multiwalled carbon nanotube-based nanofluids for improved heat dissipation. *Royal Society of Chemistry Advances, 3*(13), 4199-4206.

Asadi, A., Asadi, M., Rezaei, M., Siahmargoi, M., & Asadi, F. (2016). The effect of temperature and solid concentration on dynamic viscosity of MWCNT/MgO (20–80)–SAE50 hybrid nano-lubricant and proposing a new correlation: An experimental study. *International Communications in Heat and Mass Transfer, 78*, 48-53.

Asadi, M., & Asadi, A. (2016). Dynamic viscosity of MWCNT/ZnO–engine oil hybrid nanofluid: An experimental investigation and new correlation in different temperatures and solid concentrations. *International Communications in Heat and Mass Transfer, 76*, 41-45.

ASHRAE Handbook - Fundamentals (SI Edition). (2009). Atlanta: American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

Awais, M., & Bhuiyan, A. A. (2018). Heat transfer enhancement using different types of vortex generators (VGs): A review on experimental and numerical activities. *Thermal Science and Engineering Progress, 5*, 524-545.

Azari, A., & Derakhshandeh, M. (2015). An experimental comparison of convective heat transfer and friction factor of Al_2O_3 nanofluids in a tube with and without butterfly tube inserts. *Journal of the Taiwan Institute of Chemical Engineers, 52*(Supplement C), 31-39.

Azmi, W. H., Sharma, K. V., Sarma, P. K., Mamat, R., & Najafi, G. (2014). Heat transfer and friction factor of water based TiO_2 and SiO_2 nanofluids under turbulent flow in a tube. *International Communications in Heat and Mass Transfer, 59*, 30-38.

Azmi, W. H., Usri, N. A., Mamat, R., Sharma, K. V., & Noor, M. M. (2017). Force convection heat transfer of Al_2O_3 nanofluids for different based ratio of water:ethylene glycol mixture. *Applied Thermal Engineering, 112*, 707-719.

Babita, Sharma, S. K., & Gupta, S. M. (2016). Preparation and evaluation of stable nanofluids for heat transfer application: A review. *Experimental Thermal and Fluid Science, 79*(Supplement C), 202-212.

Baby, T. T., & Sundara, R. (2011a). Surfactant free magnetic nanofluids based on core-shell type nanoparticle decorated multiwalled carbon nanotubes. *Journal of Applied Physics, 110*(6), 064325.

Baby, T. T., & Sundara, R. (2011b). Synthesis and transport properties of metal oxide decorated graphene dispersed nanofluids. *The Journal of Physical Chemistry C, 115*(17), 8527-8533.

Bae, S. J., Kim, S. J., Lee, J. H., Song, I., Kim, N. I., Seo, Y., . . . Park, J. Y. (2014). Degradation pattern prediction of a polymer electrolyte membrane fuel cell stack with series reliability structure via durability data of single cells. *Applied Energy, 131*(Supplement C), 48-55.

Baghbanzadeh, M., Rashidi, A., Rashtchian, D., Lotfi, R., & Amrollahi, A. (2012). Synthesis of spherical silica/multiwall carbon nanotubes hybrid nanostructures and investigation of thermal conductivity of related nanofluids. *Thermochimica Acta, 549*, 87-94.

Bahrami, M., Akbari, M., Karimipour, A., & Afrand, M. (2016). An experimental study on rheological behavior of hybrid nanofluids made of iron and copper oxide in a binary mixture of water and ethylene glycol: Non-Newtonian behavior. *Experimental Thermal and Fluid Science, 79*, 231-237.

Barbés, B., Páramo, R., Blanco, E., Pastoriza Gallego, M. J., Piñeiro, M. M., Legido, J. L., & Casanova, C. (2013). Thermal conductivity and specific heat capacity measurements of Al_2O_3 nanofluids. *Journal of Thermal Analysis and Calorimetry, 111*(2), 1615-1625.

Batmunkh, M., Tanshen, M. R., Nine, M. J., Myekhlai, M., Choi, H., Chung, H., & Jeong, H. (2014). Thermal conductivity of TiO_2 nanoparticles based aqueous nanofluids with an addition of a modified silver particle. *Industrial and Engineering Chemistry Research, 53*(20), 8445-8451.

Beckwith, T. G., Marangoni, R. D., & Lienhard, J. H. (1990). *Mechanical Measurements* (fifth ed.). New York: Addison-Wesley Publishing company.

Behabadi, M. A. A., Shahidi, M., & Aligoodarz, M. R. (2015). An experimental study on heat transfer and pressure drop of MWCNT–water nano-fluid inside horizontal coiled wire inserted tube. *International Communications in Heat and Mass Transfer, 63*(Supplement C), 62-72.

Bhanvase, B. A., Sarode, M. R., Putterwar, L. A., Abdullah, K. A., Deosarkar, M. P., & Sonawane, S. H. (2014). Intensification of convective heat transfer in water/ethylene glycol based nanofluids containing TiO_2 nanoparticles. *Chemical Engineering and Processing: Process Intensification, 82*, 123-131.

Bhattad, A., Sarkar, J., & Ghosh, P. (2018). Discrete phase numerical model and experimental study of hybrid nanofluid heat transfer and pressure drop in plate heat exchanger. *International Communications in Heat and Mass Transfer, 91*, 262-273.

Bisht, V. S., Kumar Patil, A., & Gupta, A. (2018). Review and performance evaluation of roughened solar air heaters. *Renewable and Sustainable Energy Reviews, 81*, 954-977.

Blasius, H. (1913). Das Aehnlichkeitsgesetz bei Reibungsvorgängen in Flüssigkeiten. *Mitteilungen über Forschungsarbeiten auf dem Gebiete des Ingenieurwesens, 131*(0).

Boyaghchi, F. A., Chavoshi, M., & Sabeti, V. (2015). Optimization of a novel combined cooling, heating and power cycle driven by geothermal and solar energies using the water/CuO (copper oxide) nanofluid. *Energy, 91*, 685-699.

Buongiorno, J., Venerus, D. C., Prabhat, N., McKrell, T., Townsend, J., Christianson, R., . . . Zhou, S. Q. (2009). A benchmark study on the thermal conductivity of nanofluids. *Journal of Applied Physics, 106*(9), 094312.

Buonomano, A., Calise, F., Ferruzzi, G., & Palombo, A. (2015). Molten carbonate fuel cell: An experimental analysis of a 1kW system fed by landfill gas. *Applied Energy, 140*(Supplement C), 146-160.

Cebeci, T. (2002). *Convective Heat Transfer*. Long Beach: Horizons Publishing Inc.

Cengel, Y. A., & Ghajar, A. J. (2011). *Heat and Mass Transfer-Fundamental and Applications* (4th Edition in SI Units ed.). New York: McGraw Hill.

Chandrasekar, M., Suresh, S., & Chandra Bose, A. (2010). Experimental studies on heat transfer and friction factor characteristics of Al_2O_3/water nanofluid in a circular pipe under laminar flow with wire coil inserts. *Experimental Thermal and Fluid Science, 34*(2), 122-130.

Chandrasekar, M., Suresh, S., & Senthilkumar, T. (2012). Mechanisms proposed through experimental investigations on thermophysical properties and forced convective heat transfer characteristics of various nanofluids – A review. *Renewable and Sustainable Energy Reviews, 16*(6), 3917-3938.

Charab, A. A., Movahedirad, S., & Norouzbeigi, R. (2017). Thermal conductivity of Al_2O_3+TiO_2/water nanofluid: Model development and experimental validation. *Applied Thermal Engineering, 119*, 42-51.

Chen, L., Yu, W., & Xie, H. (2012). Enhanced thermal conductivity of nanofluids containing Ag/MWNT composites. *Powder Technology, 231*, 18-20.

Chingtuaythong, W., Promvonge, P., Thianpong, C., & Pimsarn, M. (2017). Heat transfer characterization in a tubular heat exchanger with V-shaped rings. *Applied Thermal Engineering, 110*, 1164-1171.

Choi, S. U. S. (1995). Enhancing thermal conductivity of fluids with nanoparticles. In D. A. Siginer & H. P. Wang (Eds.), *Developments and Applications of Non-Newtonian Flows* (Vol. FED-vol. 231/MD-Vol. 66, pp. 99–105). New York: American Society of Mechanical Engineers (ASME).

Chougule, S. S., Nirgude, V. V., Gharge, P. D., Mayank, M., & Sahu, S. K. (2016). Heat transfer enhancements of low volume concentration CNT/water nanofluid and wire coil inserts in a circular tube. *Energy Procedia, 90*(Supplement C), 552-558.

Culham, R. (2007). Fluid Properties Calculator. http://www.mhtl.uwaterloo.ca/old/onlinetools/airprop/airprop.html

Daneshipour, M., & Rafee, R. (2017). Nanofluids as the circuit fluids of the geothermal borehole heat exchangers. *International Communications in Heat and Mass Transfer, 81*, 34-41.

Dardan, E., Afrand, M., & Meghdadi Isfahani, A. H. (2016). Effect of suspending hybrid nano-additives on rheological behavior of engine oil and pumping power. *Applied Thermal Engineering, 109*, 524-534.

Dawood, H. K., Mohammed, H. A., Sidik, N. A. C., Munisamy, K. M., & Wahid, M. A. (2015). Forced, natural and mixed-convection heat transfer and fluid flow in annulus: A review. *International Communications in Heat and Mass Transfer, 62*(Supplement C), 45-57.

Dehshali, M. E., Barzanji, S. Z. N., & Fard, A. H. (2018). Pool boiling heat transfer enhancement by twisted-tape fins. *Applied Thermal Engineering, 135*, 170-177.

Deshmukh, P. W., Prabhu, S. V., & Vedula, R. P. (2016). Heat transfer enhancement for laminar flow in tubes using curved delta wing vortex generator inserts. *Applied Thermal Engineering, 106*, 1415-1426.

Devireddy, S., Mekala, C. S. R., & Veeredhi, V. R. (2016). Improving the cooling performance of automobile radiator with ethylene glycol water based TiO_2 nanofluids. *International Communications in Heat and Mass Transfer, 78*, 121-126.

Dittus, F. W., & Boelter, L. M. K. (1930). Heat transfer in automobile radiators of the tubular type (Vol. 2, pp. 443–461): University of California Publications on Engineering 2.

Duangthongsuk, W., & Wongwises, S. (2010). An experimental study on the heat transfer performance and pressure drop of TiO_2-water nanofluids flowing under a turbulent flow regime. *International Journal of Heat and Mass Transfer, 53*(1-3), 334-344.

Esfe, M. H., Afrand, M., Rostamian, S. H., & Toghraie, D. (2017a). Examination of rheological behavior of MWCNTs/ZnO-SAE40 hybrid nano-lubricants under various temperatures and solid volume fractions. *Experimental Thermal and Fluid Science, 80*, 384-390.

Esfe, M. H., Alirezaie, A., & Rejvani, M. (2017b). An applicable study on the thermal conductivity of SWCNT-MgO hybrid nanofluid and price-performance analysis for energy management. *Applied Thermal Engineering, 111*, 1202-1210.

Esfe, M. H., Karimipour, A., Yan, W. M., Akbari, M., Safaei, M. R., & Dahari, M. (2015a). Experimental study on thermal conductivity of ethylene glycol based nanofluids containing Al_2O_3 nanoparticles. *International Journal of Heat and Mass Transfer, 88*(Supplement C), 728-734.

Esfe, M. H., Wongwises, S., Naderi, A., Asadi, A., Safaei, M. R., Rostamian, H., . . . Karimipour, A. (2015b). Thermal conductivity of Cu/TiO_2–water/EG hybrid nanofluid: Experimental data and modeling using artificial neural network and correlation. *International Communications in Heat and Mass Transfer, 66*, 100-104.

Esparza, D. M., & Rojas, E. S. (2011). Numerical simulations of the laminar flow in pipes with wire coil inserts. *Computers & Fluids, 44*(1), 169-177.

Faghri, A., Zhang, Y., & Howell, J. R. (2010). *Advanced Heat and Mass Transfer*. Columbia, MO: Global Digital Press.

Faizal, M., Bouazza, A., & Singh, R. M. (2016). Heat transfer enhancement of geothermal energy piles. *Renewable and Sustainable Energy Reviews, 57*, 16-33.

Fal, J., Barylyak, A., Besaha, K., Bobitski, Y. V., Cholewa, M., Zawlik, I., . . . Żyła, G. (2016). Experimental investigation of electrical conductivity and permittivity of SC-TiO_2 -EG nanofluids. *Nanoscale Research Letters, 11*(1), 375.

Feng, Z., Luo, X., Guo, F., Li, H., & Zhang, J. (2017). Numerical investigation on laminar flow and heat transfer in rectangular microchannel heat sink with wire coil inserts. *Applied Thermal Engineering, 116*(Supplement C), 597-609.

Ganvir, R. B., Walke, P. V., & Kriplani, V. M. (2017). Heat transfer characteristics in nanofluid-A review. *Renewable and Sustainable Energy Reviews, 75*, 451-460.

García, A., Vicente, P. G., & Viedma, A. (2005). Experimental study of heat transfer enhancement with wire coil inserts in laminar-transition-turbulent regimes at different Prandtl numbers. *International Journal of Heat and Mass Transfer, 48*(21), 4640-4651.

García, J. P., García, A., Martín, R. H., & Solano, J. P. (2018). Experimental correlations on critical Reynolds numbers and friction factor in tubes with wire-coil inserts in laminar, transitional and low turbulent flow regimes. *Experimental Thermal and Fluid Science, 91*, 64-79.

Garg, J., Poudel, B., Chiesa, M., Gordon, J. B., Ma, J. J., Wang, J. B., . . . Chen, G. (2008). Enhanced thermal conductivity and viscosity of copper nanoparticles in ethylene glycol nanofluid. *Journal of Applied Physics, 103*(7), 074301-074306.

Ghasemi, S., & Karimipour, A. (2018). Experimental investigation of the effects of temperature and mass fraction on the dynamic viscosity of CuO-paraffin nanofluid. *Applied Thermal Engineering, 128*(Supplement C), 189-197.

Ghosh, M. M., Ghosh, S., & Pabi, S. K. (2013). Effects of particle shape and fluid temperature on heat-transfer characteristics of nanofluids. *Journal of Materials Engineering and Performance, 22*(6), 1525-1529.

Gnielinski, V. (1976). New equations for heat and mass transfer in turbulent pipe and channel flow. *International Chemical Engineering, 16*, 359-368.

Goudarzi, K., & Jamali, H. (2017). Heat transfer enhancement of Al_2O_3-EG nanofluid in a car radiator with wire coil inserts. *Applied Thermal Engineering, 118*, 510-517.

Guo, W., Li, G., Zheng, Y., & Dong, C. (2018a). Measurement of the thermal conductivity of SiO_2 nanofluids with an optimized transient hot wire method. *Thermochimica Acta, 661*, 84-97.

Guo, Y., Zhang, T., Zhang, D., & Wang, Q. (2018b). Experimental investigation of thermal and electrical conductivity of silicon oxide nanofluids in ethylene glycol/water mixture. *International Journal of Heat and Mass Transfer, 117*(Supplement C), 280-286.

Gupta, M., Singh, V., Kumar, S., Kumar, S., Dilbaghi, N., & Said, Z. (2018). Up to date review on the synthesis and thermophysical properties of hybrid nanofluids. *Journal of Cleaner Production, 190*, 169-192.

Habibzadeh, S., Beydokhti, A. K., Khodadadi, A. A., Mortazavi, Y., Omanovic, S., & Niassar, M. S. (2010). Stability and thermal conductivity of nanofluids of tin dioxide synthesized via microwave-induced combustion route. *Chemical Engineering Journal, 156*(2), 471-478.

Hajjar, Z., Rashidi, A. m., & Ghozatloo, A. (2014). Enhanced thermal conductivities of graphene oxide nanofluids. *International Communications in Heat and Mass Transfer, 57*(0), 128-131.

Hamzah, M. H., Sidik, N. A. C., Ken, T. L., Mamat, R., & Najafi, G. (2017). Factors affecting the performance of hybrid nanofluids: A comprehensive review. *International Journal of Heat and Mass Transfer, 115*, 630-646.

Hamzah, W. A. W. (2015). *Heat Transfer Augmentation of Water Based TiO_2 and SiO_2 nanofluids in a Tube with Twisted Tape.* (PhD Unpublished doctoral dissertation), Universiti Malaysia Pahang, Pekan, Malaysia.

Han, D., He, W. F., & Asif, F. Z. (2017). Experimental study of heat transfer enhancement using nanofluid in double tube heat exchanger. *Energy Procedia, 142*, 2547-2553.

Harandi, S. S., Karimipour, A., Afrand, M., Akbari, M., & D'Orazio, A. (2016). An experimental study on thermal conductivity of *f*-MWCNTs–Fe_3O_4/EG hybrid nanofluid: Effects of temperature and concentration. *International Communications in Heat and Mass Transfer, 76*, 171-177.

Hatami, N., Kazemnejad Banari, A., Malekzadeh, A., & Pouranfard, A. R. (2017). The effect of magnetic field on nanofluids heat transfer through a uniformly heated horizontal tube. *Physics Letters A, 381*(5), 510-515.

He, Y., Liu, L., Li, P., & Ma, L. (2018). Experimental study on heat transfer enhancement characteristics of tube with cross hollow twisted tape inserts. *Applied Thermal Engineering, 131*, 743-749.

Hekmatipour, F., Akhavan Behabadi, M. A., & Sajadi, B. (2016). Combined free and forced convection heat transfer of the copper oxide-heat transfer oil (CuO-HTO) nanofluid inside horizontal tubes under constant wall temperature. *Applied Thermal Engineering, 100*(Supplement C), 621-627.

Heyhat, M. M., Kowsary, F., Rashidi, A. M., Alem Varzane Esfehani, S., & Amrollahi, A. (2012). Experimental investigation of turbulent flow and convective heat transfer characteristics of alumina water nanofluids in fully developed flow regime. *International Communications in Heat and Mass Transfer, 39*(8), 1272-1278.

Ho, C. J., Chang, C. Y., & Yan, W. M. (2017). An experimental study of forced convection effectiveness of Al_2O_3-water nanofluid flowing in circular tubes. *International Communications in Heat and Mass Transfer, 83*(Supplement C), 23-29.

Ho, C. J., Huang, J. B., Tsai, P. S., & Yang, Y. M. (2010a). Preparation and properties of hybrid water-based suspension of Al_2O_3 nanoparticles and MEPCM particles as functional forced convection fluid. *International Communications in Heat and Mass Transfer, 37*(5), 490-494.

Ho, C. J., Liu, W. K., Chang, Y. S., & Lin, C. C. (2010b). Natural convection heat transfer of alumina-water nanofluid in vertical square enclosures: An experimental study. *International Journal of Thermal Sciences, 49*(8), 1345-1353.

Huang, D., Wu, Z., & Sunden, B. (2016). Effects of hybrid nanofluid mixture in plate heat exchangers. *Experimental Thermal and Fluid Science, 72*, 190-196.

Huminic, G., & Huminic, A. (2018a). The heat transfer performances and entropy generation analysis of hybrid nanofluids in a flattened tube. *International Journal of Heat and Mass Transfer, 119*, 813-827.

Huminic, G., & Huminic, A. (2018b). Hybrid nanofluids for heat transfer applications – A state-of-the-art review. *International Journal of Heat and Mass Transfer, 125*, 82-103.

Hussein, A. K. (2015). Applications of nanotechnology in renewable energies-A comprehensive overview and understanding. *Renewable and Sustainable Energy Reviews, 42*(Supplement C), 460-476.

Hussein, A. M. (2017). Thermal performance and thermal properties of hybrid nanofluid laminar flow in a double pipe heat exchanger. *Experimental Thermal and Fluid Science, 88*, 37-45.

Hwang, Y., Lee, J. K., Lee, C. H., Jung, Y. M., Cheong, S. I., Lee, C. G., . . . Jang, S. P. (2007). Stability and thermal conductivity characteristics of nanofluids. *Thermochimica Acta, 455*(1-2), 70-74.

Ibrahim, T. K., Mohammed, M. N., Kamil Mohammed, M., Najafi, G., Azwadi Che Sidik, N., Basrawi, F., . . . Hoseini, S. S. (2018). Experimental study on the effect of perforations shapes on vertical heated fins performance under forced convection heat transfer. *International Journal of Heat and Mass Transfer, 118*, 832-846.

Islam, M. R., Shabani, B., & Rosengarten, G. (2016). Nanofluids to improve the performance of PEM fuel cell cooling systems: A theoretical approach. *Applied Energy, 178*(Supplement C), 660-671.

Islam, M. R., Shabani, B., & Rosengarten, G. (2017a). Electrical and thermal conductivities of 50/50 water-ethylene glycol based TiO_2 nanofluids to be used as coolants in PEM fuel cells. *Energy Procedia, 110*(Supplement C), 101-108.

Islam, M. R., Shabani, B., Rosengarten, G., & Andrews, J. (2015). The potential of using nanofluids in PEM fuel cell cooling systems: A review. *Renewable and Sustainable Energy Reviews, 48*(Supplement C), 523-539.

Islam, R., Shabani, B., Andrews, J., & Rosengarten, G. (2017b). Experimental investigation of using ZnO nanofluids as coolants in a PEM fuel cell. *International Journal of Hydrogen Energy, 42*(30), 19272-19286.

Jwo, C. S., Jeng, L. Y., Chang, H., & Teng, T. P. (2008). Experimental study on thermal conductivity of lubricant containing nanoparticles. *Reviews on Advanced Materials Science, 18*, 660-666.

Karami, M., Akhavan Behabadi, M. A., Raisee Dehkordi, M., & Delfani, S. (2016). Thermo-optical properties of copper oxide nanofluids for direct absorption of solar radiation. *Solar Energy Materials and Solar Cells, 144*, 136-142.

Karami, M., Bahabadi, M. A. A., Delfani, S., & Ghozatloo, A. (2014). A new application of carbon nanotubes nanofluid as working fluid of low-temperature direct absorption solar collector. *Solar Energy Materials and Solar Cells, 121*(0), 114-118.

Karimi, A., & Afrand, M. (2018). Numerical study on thermal performance of an air-cooled heat exchanger: Effects of hybrid nanofluid, pipe arrangement and cross section. *Energy Conversion and Management*, *164*, 615-628.

Kasaeian, A., Daneshazarian, R., Rezaei, R., Pourfayaz, F., & Kasaeian, G. (2017). Experimental investigation on the thermal behavior of nanofluid direct absorption in a trough collector. *Journal of Cleaner Production, 158*, 276-284.

Kasaeian, A., Eshghi, A. T., & Sameti, M. (2015). A review on the applications of nanofluids in solar energy systems. *Renewable and Sustainable Energy Reviews, 43*(Supplement C), 584-598.

Keklikcioglu, O., & Ozceyhan, V. (2016). Experimental investigation on heat transfer enhancement of a tube with coiled-wire inserts installed with a separation from the tube wall. *International Communications in Heat and Mass Transfer, 78*(Supplement C), 88-94.

Keklikcioglu, O., & Ozceyhan, V. (2017). Entropy generation analysis for a circular tube with equilateral triangle cross sectioned coiled-wire inserts. *Energy, 139*(Supplement C), 65-75.

Keklikcioglu, O., & Ozceyhan, V. (2018). Experimental investigation on heat transfer enhancement in a circular tube with equilateral triangle cross sectioned coiled-wire inserts. *Applied Thermal Engineering, 131*, 686-695.

Khedkar, R. S., Shrivastava, N., Sonawane, S. S., & Wasewar, K. L. (2016). Experimental investigations and theoretical determination of thermal conductivity and viscosity of TiO_2–ethylene glycol nanofluid. *International Communications in Heat and Mass Transfer, 73*(Supplement C), 54-61.

Kumar, B., Srivastava, G. P., Kumar, M., & Patil, A. K. (2018a). A review of heat transfer and fluid flow mechanism in heat exchanger tube with inserts. *Chemical Engineering and Processing: Process Intensification, 123*, 126-137.

Kumar, D. D., & Arasu, A. V. (2018). A comprehensive review of preparation, characterization, properties and stability of hybrid nanofluids. *Renewable and Sustainable Energy Reviews, 81*, 1669-1689.

Kumar, M. S., Vasu, V., & Gopal, A. V. (2016). Thermal conductivity and rheological studies for Cu–Zn hybrid nanofluids with various basefluids. *Journal of the Taiwan Institute of Chemical Engineers, 66*, 321-327.

Kumar, N. T. R., Bhramara, P., Addis, B. M., Sundar, L. S., Singh, M. K., & Sousa, A. C. M. (2017). Heat transfer, friction factor and effectiveness analysis of Fe_3O_4/water nanofluid flow in a double pipe heat exchanger with return bend. *International Communications in Heat and Mass Transfer, 81*, 155-163.

Kumar, N. T. R., Bhramara, P., Kirubeil, A., Syam Sundar, L., Singh, M. K., & Sousa, A. C. M. (2018b). Effect of twisted tape inserts on heat transfer, friction factor of Fe_3O_4 nanofluids flow in a double pipe U-bend heat exchanger. *International Communications in Heat and Mass Transfer, 95*, 53-62.

Kumar, R. S., & Sharma, T. (2018). Stability and rheological properties of nanofluids stabilized by SiO_2 nanoparticles and SiO_2-TiO_2 nanocomposites for oilfield applications. *Colloids and Surfaces A: Physicochemical and Engineering Aspects, 539*, 171-183.

Kumar, V., & Sarkar, J. (2018). Two-phase numerical simulation of hybrid nanofluid heat transfer in minichannel heat sink and experimental validation. *International Communications in Heat and Mass Transfer, 91*, 239-247.

Labib, M. N., Nine, M. J., Afrianto, H., Chung, H., & Jeong, H. (2013). Numerical investigation on effect of base fluids and hybrid nanofluid in forced convective heat transfer. *International Journal of Thermal Sciences, 71*(Supplement C), 163-171.

Lee, B. J., Park, K., Walsh, T., & Xu, L. (2012). Radiative heat transfer analysis in plasmonic nanofluids for direct solar thermal absorption. *Journal of Solar Energy Engineering, 134*(2), 021009.

Lee, J., Lee, H., Baik, Y. J., & Koo, J. (2015). Quantitative analyses of factors affecting thermal conductivity of nanofluids using an improved transient hot-wire method apparatus. *International Journal of Heat and Mass Transfer, 89*, 116-123.

Lee, K., Hwang, Y., Cheong, S., Kwon, L., Kim, S., & Lee, J. (2009). Performance evaluation of nano-lubricants of fullerene nanoparticles in refrigeration mineral oil. *Current Applied Physics, 9*(2, Supplement), e128-e131.

Lee, K. J., Yoon, S. H., & Jang, J. (2007). Carbon nanofibers: A novel nanofiller for nanofluid applications. *Small, 3*(7), 1209–1213.

Li, H., Ha, C. S., & Kim, I. (2009a). Fabrication of carbon nanotube/SiO_2 and carbon nanotube/SiO_2/Ag nanoparticles hybrids by using plasma treatment. *Nanoscale Research Letters, 4*(11), 1384.

Li, H., Wang, L., He, Y., Hu, Y., Zhu, J., & Jiang, B. (2015). Experimental investigation of thermal conductivity and viscosity of ethylene glycol based ZnO nanofluids. *Applied Thermal Engineering, 88*(Supplement C), 363-368.

Li, P., Luo, Y., Zhang, D., & Xie, Y. (2018). Flow and heat transfer characteristics and optimization study on the water-cooled microchannel heat sinks with dimple and pin-fin. *International Journal of Heat and Mass Transfer, 119*, 152-162.

Li, Y., Zhou, J. e., Tung, S., Schneider, E., & Xi, S. (2009b). A review on development of nanofluid preparation and characterization. *Powder Technology, 196*(2), 89-101.

Liu, S., & Sakr, M. (2013). A comprehensive review on passive heat transfer enhancements in pipe exchangers. *Renewable and Sustainable Energy Reviews, 19*, 64-81.

Liu, X., Li, C., Cao, X., Yan, C., & Ding, M. (2018). Numerical analysis on enhanced performance of new coaxial cross twisted tapes for laminar convective heat transfer. *International Journal of Heat and Mass Transfer, 121*, 1125-1136.

Maddah, H., Alizadeh, M., Ghasemi, N., & Wan Alwi, S. R. (2014). Experimental study of Al_2O_3/water nanofluid turbulent heat transfer enhancement in the horizontal double pipes fitted with modified twisted tapes. *International Journal of Heat and Mass Transfer, 78*, 1042-1054.

Madhesh, D., Parameshwaran, R., & Kalaiselvam, S. (2014). Experimental investigation on convective heat transfer and rheological characteristics of Cu–TiO_2 hybrid nanofluids. *Experimental Thermal and Fluid Science, 52*, 104-115.

Mahbubul, I. M., Saidur, R., Amalina, M. A., Elcioglu, E. B., & Ozyurt, T. O. (2015). Effective ultrasonication process for better colloidal dispersion of nanofluid. *Ultrasonics Sonochemistry, 26*(0), 361-369.

Mahendran, M., Lee, G. C., Sharma, K. V., Shahrani, A., & Bakar, R. A. (2012). Performance of evacuated tube solar collector using water-based titanium oxide nanofluid. *Journal of Mechanical Engineering and Sciences, 3*, 301-310.

Mahmoudi, M., Tavakoli, M. R., Mirsoleimani, M. A., Gholami, A., & Salimpour, M. R. (2017). Experimental and numerical investigation on forced convection heat transfer and pressure drop in helically coiled pipes using TiO_2/water nanofluid. *International Journal of Refrigeration, 74*(Supplement C), 627-643.

Manglik, R. M. (2003). *Heat Transfer Handbook. Ch. 14: Heat Transfer Enhancement* (A. D. K. Adrian Bejan Ed.). Hoboken, New Jersey: John Wiley & Sons, Inc.

Manna, I. (2009). Synthesis, characterization and application of nanofluid - An overview. *Journal of the Indian Institute of Science, 89*(1), 21-33.

Maradiya, C., Vadher, J., & Agarwal, R. (2018). The heat transfer enhancement techniques and their thermal performance factor. *Beni-Suef University Journal of Basic and Applied Sciences, 7*(1), 1-21.

Mashoofi, N., Pesteei, S. M., Moosavi, A., & Sadighi Dizaji, H. (2017). Fabrication method and thermal-frictional behavior of a tube-in-tube helically coiled heat exchanger which contains turbulator. *Applied Thermal Engineering, 111*, 1008-1015.

Masuda, H., Ebata, A., Teramae, K., & Hishinuma, N. (1993). Alteration of thermal conductivity and viscosity of liquid by dispersing ultra fine particles. *Netsu Bussei, 4*(4), 227–233.

Maxwell, J. C. (1904). *A Treatise on Electricity and Magnetism* (Second edition ed.). Cambridge, U.K.: Oxford University Press.

Megatif, L., Ghozatloo, A., Arimi, A., & Shariati Niasar, M. (2016). Investigation of laminar convective heat transfer of a novel TiO_2–carbon nanotube hybrid water-based nanofluid. *Experimental Heat Transfer, 29*(1), 124-138.

Mikkola, V., Puupponen, S., Granbohm, H., Saari, K., Ala-Nissila, T., & Seppälä, A. (2018). Influence of particle properties on convective heat transfer of nanofluids. *International Journal of Thermal Sciences, 124*, 187-195.

Minakov, A. V., Guzei, D. V., Meshkov, K. N., Popov, I. A., & Shchelchkov, A. V. (2017). Experimental study of turbulent forced convection of nanofluid in channels with cylindrical and spherical hollows. *International Journal of Heat and Mass Transfer, 115*(Part A), 915-925.

Minea, A. A. (2017). Hybrid nanofluids based on Al_2O_3, TiO_2 and SiO_2: Numerical evaluation of different approaches. *International Journal of Heat and Mass Transfer, 104*, 852-860.

Mohamed, W. A. N. W., Talib, S. F. A., Zakaria, I. A., Mamat, A. M. I., & Daud, W. R. W. (2017). Effect of dynamic load on the temperature profiles and cooling response time of a proton exchange membrane fuel cell. *Journal of the Energy Institute*.

Moldoveanu, G. M., Ibanescu, C., Danu, M., & Minea, A. A. (2018). Viscosity estimation of Al_2O_3, SiO_2 nanofluids and their hybrid: An experimental study. *Journal of Molecular Liquids, 253*, 188-196.

Mousavi, S. V., Sheikholeslami, M., Gorji bandpy, M., & Barzegar Gerdroodbary, M. (2016). The influence of magnetic field on heat transfer of magnetic nanofluid in a sinusoidal double pipe heat exchanger. *Chemical Engineering Research and Design, 113*, 112-124.

Mwesigye, A., & Huan, Z. (2015). Thermodynamic analysis and optimization of fully developed turbulent forced convection in a circular tube with water–Al_2O_3 nanofluid. *International Journal of Heat and Mass Transfer, 89*(Supplement C), 694-706.

Nadooshan, A. A. (2017). An experimental correlation approach for predicting thermal conductivity of water-EG based nanofluids of zinc oxide. *Physica E: Low-dimensional Systems and Nanostructures, 87*, 15-19.

Nadooshan, A. A., Eshgarf, H., & Afrand, M. (2018). Measuring the viscosity of Fe_3O_4-MWCNTs/EG hybrid nanofluid for evaluation of thermal efficiency: Newtonian and non-Newtonian behavior. *Journal of Molecular Liquids*.

Naik, B. A. K., & Vinod, A. V. (2018). Heat transfer enhancement using non-Newtonian nanofluids in a shell and helical coil heat exchanger. *Experimental Thermal and Fluid Science, 90*(Supplement C), 132-142.

Naik, M. T., Fahad, S. S., Sundar, L. S., & Singh, M. K. (2014). Comparative study on thermal performance of twisted tape and wire coil inserts in turbulent flow using CuO/water nanofluid. *Experimental Thermal and Fluid Science, 57*, 65-76.

Nemade, K., & Waghuley, S. (2016). A novel approach for enhancement of thermal conductivity of CuO/H_2O based nanofluids. *Applied Thermal Engineering, 95*(Supplement C), 271-274.

Nine, M. J., Batmunkh, M., Kim, J. H., Chung, H. S., & Jeong, H. M. (2012). Investigation of Al_2O_3-MWCNTs hybrid dispersion in water and their thermal characterization. *Journal of Nanoscience and Nanotechnology, 12*(6), 4553-4559.

Nine, M. J., Munkhbayar, B., Rahman, M. S., Chung, H., & Jeong, H. (2013). Highly productive synthesis process of well dispersed Cu_2O and Cu/Cu_2O nanoparticles and its thermal characterization. *Materials Chemistry and Physics, 141*(2), 636-642.

Noghrehabadi, A., Hajidavaloo, E., & Moravej, M. (2016). Experimental investigation of efficiency of square flat-plate solar collector using SiO_2/water nanofluid. *Case Studies in Thermal Engineering, 8*, 378-386.

O'Hanley, H., Buongiorno, J., McKrell, T., & Hu, L. W. (2012). Measurement and model validation of nanofluid specific heat capacity with differential scanning calorimetry. *Advances in Mechanical Engineering, 4*, 181079.

Omidi, M., Farhadi, M., & Jafari, M. (2017). A comprehensive review on double pipe heat exchangers. *Applied Thermal Engineering, 110*, 1075-1090.

Pak, B. C., & Cho, Y. I. (1998). Hydrodynamic and heat transfer study of dispersed fluids with submicron metallic oxide particles. *Experimental Heat Transfer, 11*(2), 151-170.

Panahi, D., & Zamzamian, K. (2017). Heat transfer enhancement of shell-and-coiled tube heat exchanger utilizing helical wire turbulator. *Applied Thermal Engineering, 115*(Supplement C), 607-615.

Petukhov, B. S. (1970). Heat Transfer and Friction in Turbulent Pipe Flow with Variable Physical Properties. In P. H. James & F. I. Thomas (Eds.), *Advances in Heat Transfer* (Vol. Volume 6, pp. 503-564): Elsevier.

Prandtl, L. (1904, August 1904). *On the motion of a fluid with very small viscosity.* Paper presented at the 3rd International Congress of Mathematicians, Heidelberg.

Prasad, P. V. D., Gupta, A. V. S. S. K. S., & Deepak, K. (2015). Investigation of trapezoidal-cut twisted tape insert in a double pipe U-tube heat exchanger using Al_2O_3/water Nanofluid. *Procedia Materials Science, 10*, 50-63.

Promvonge, P., Koolnapadol, N., Pimsarn, M., & Thianpong, C. (2014). Thermal performance enhancement in a heat exchanger tube fitted with inclined vortex rings. *Applied Thermal Engineering, 62*(1), 285-292.

Purohit, N., Purohit, V. A., & Purohit, K. (2016). Assessment of nanofluids for laminar convective heat transfer: A numerical study. *Engineering Science and Technology, an International Journal, 19*(1), 574-586.

Qi, C., Wan, Y. L., Li, C. Y., Han, D. T., & Rao, Z. H. (2017). Experimental and numerical research on the flow and heat transfer characteristics of TiO_2-water nanofluids in a corrugated tube. *International Journal of Heat and Mass Transfer, 115*(Part B), 1072-1084.

Rabbani, A., & Rokni, M. (2013). Dynamic characteristics of an automotive fuel cell system for transitory load changes. *Sustainable Energy Technologies and Assessments, 1*(Supplement C), 34-43.

Raja, M., Vijayan, R., Dineshkumar, P., & Venkatesan, M. (2016). Review on nanofluids characterization, heat transfer characteristics and applications. *Renewable and Sustainable Energy Reviews, 64*, 163-173.

Ramachandran, R., Ganesan, K., Rajkumar, M. R., Asirvatham, L. G., & Wongwises, S. (2016). Comparative study of the effect of hybrid nanoparticle on the thermal performance of cylindrical screen mesh heat pipe. *International Communications in Heat and Mass Transfer, 76*, 294-300.

Ranjbarzadeh, R., Meghdadi Isfahani, A. H., Afrand, M., Karimipour, A., & Hojaji, M. (2017). An experimental study on heat transfer and pressure drop of water/graphene oxide nanofluid in a copper tube under air cross-flow: Applicable as a heat exchanger. *Applied Thermal Engineering, 125*(Supplement C), 69-79.

Rashid, F., Dawood, K., & Hashim, A. (2014). Maximizing of solar absorption by (TiO_2-water) nanofluid with glass mixture. *International Journal of Research in Engineering and Technology, 2*, 87-90.

Rathnakumar, P., Iqbal, S. M., Michael, J. J., & Suresh, S. (2018). Study on performance enhancement factors in turbulent flow of CNT/water nanofluid through a tube fitted with helical screw louvered rod inserts. *Chemical Engineering and Processing - Process Intensification, 127*, 103-110.

Ravigururajan, T. S., & Bergles, A. E. (1996). Development and verification of general correlations for pressure drop and heat transfer in single-phase turbulent flow in enhanced tubes. *Experimental Thermal and Fluid Science, 13*(1), 55-70.

Reddy, M. C. S., & Rao, V. V. (2013). Experimental studies on thermal conductivity of blends of ethylene glycol-water-based TiO_2 nanofluids. *International Communications in Heat and Mass Transfer, 46*(0), 31-36.

Reddy, M. C. S., & Rao, V. V. (2014). Experimental investigation of heat transfer coefficient and friction factor of ethylene glycol water based TiO_2 nanofluid in double pipe heat exchanger with and without helical coil inserts. *International Communications in Heat and Mass Transfer, 50*, 68-76.

Ruengpayungsak, K., Wongcharee, K., Thianpong, C., Pimsarn, M., Chuwattanakul, V., & Eiamsa-ard, S. (2017). Heat transfer evaluation of turbulent flows through gear-ring elements. *Applied Thermal Engineering, 123*(Supplement C), 991-1005.

Saeedi, A. H., Akbari, M., & Toghraie, D. (2018). An experimental study on rheological behavior of a nanofluid containing oxide nanoparticle and proposing a new correlation. *Physica E: Low-dimensional Systems and Nanostructures, 99*, 285-293.

Saeedinia, M., Behabadi, M. A. A., & Nasr, M. (2012). Experimental study on heat transfer and pressure drop of nanofluid flow in a horizontal coiled wire inserted tube under constant heat flux. *Experimental Thermal and Fluid Science, 36*(0), 158-168.

Sahel, D., & Benzeguir, R. (2017). Thermal characteristic in solar air heater fitted with plate baffles and heating corrugated surface. *Energy Procedia, 139*, 307-314.

Said, Z., Saidur, R., & Rahim, N. A. (2014). Optical properties of metal oxides based nanofluids. *International Communications in Heat and Mass Transfer, 59*(0), 46-54.

Sajid, M. U., & Ali, H. M. (2018). Thermal conductivity of hybrid nanofluids: A critical review. *International Journal of Heat and Mass Transfer, 126*, 211-234.

San, J. Y., Huang, W. C., & Chen, C. A. (2015). Experimental investigation on heat transfer and fluid friction correlations for circular tubes with coiled-wire inserts. *International Communications in Heat and Mass Transfer, 65*(Supplement C), 8-14.

Sarkar, J., Ghosh, P., & Adil, A. (2015). A review on hybrid nanofluids: Recent research, development and applications. *Renewable and Sustainable Energy Reviews, 43*, 164-177.

Sarma, P. K., Chada, K., Sharma, K. V., Sundar, L. S., Kishore, P. S., & Srinivas, V. (2010). Experimental study to predict momentum and thermal diffusivities from convective heat transfer data of nano fluid with Al_2O_3 dispersion. *International Journal of Heat and Technology*, *28*(1), 123-131.

Sarma, P. K., Subramanyam, T., Kishore, P. S., Rao, V. D., & Kakac, S. (2002). A new method to predict convective heat transfer in a tube with twisted tape inserts for turbulent flow. *International Journal of Thermal Sciences, 41*(10), 955-960.

Sekhar, Y. R., & Sharma, K. V. (2015). Study of viscosity and specific heat capacity characteristics of water-based Al_2O_3 nanofluids at low particle concentrations. *Journal of Experimental Nanoscience, 10*(2), 86-102.

Shabani, B., Andrews, J., & Badwal, S. (2010). Fuel cell heat recovery, electrical load management, and the economics of solar-hydrogen systems. *International Journal of Power and Energy Systems, 30*(4), 256.

Shahsavar, A., & Bahiraei, M. (2017). Experimental investigation and modeling of thermal conductivity and viscosity for non-Newtonian hybrid nanofluid containing coated CNT/Fe_3O_4 nanoparticles. *Powder Technology, 318*(Supplement C), 441-450.

Sharif, M. Z., Azmi, W. H., Redhwan, A. A. M., & Mamat, R. (2016). Investigation of thermal conductivity and viscosity of Al_2O_3/PAG nanolubricant for application in automotive air conditioning system. *International Journal of Refrigeration, 70*, 93-102.

Sharifi, K., Sabeti, M., Rafiei, M., Mohammadi, A. H., & Shirazi, L. (2018). Computational fluid dynamics (CFD) technique to study the effects of helical wire inserts on heat transfer and pressure drop in a double pipe heat exchanger. *Applied Thermal Engineering, 128*, 898-910.

Sharma, S. K., & Kalamkar, V. R. (2017). Experimental and numerical investigation of forced convective heat transfer in solar air heater with thin ribs. *Solar Energy, 147*, 277-291.

Sheikholeslami, M., & Bhatti, M. M. (2017). Forced convection of nanofluid in presence of constant magnetic field considering shape effects of nanoparticles. *International Journal of Heat and Mass Transfer, 111*(Supplement C), 1039-1049.

Sheikholeslami, M., Gorji Bandpy, M., & Ganji, D. D. (2015). Review of heat transfer enhancement methods: Focus on passive methods using swirl flow devices. *Renewable and Sustainable Energy Reviews, 49*, 444-469.

Sheikholeslami, M., Vajravelu, K., & Rashidi, M. M. (2016). Forced convection heat transfer in a semi annulus under the influence of a variable magnetic field. *International Journal of Heat and Mass Transfer, 92*(Supplement C), 339-348.

Shirvan, K. M., Mamourian, M., Mirzakhanlari, S., & Ellahi, R. (2017). Numerical investigation of heat exchanger effectiveness in a double pipe heat exchanger filled with nanofluid: A sensitivity analysis by response surface methodology. *Powder Technology, 313*, 99-111.

Shoghl, S. N., Jamali, J., & Moraveji, M. K. (2016). Electrical conductivity, viscosity, and density of different nanofluids: An experimental study. *Experimental Thermal and Fluid Science, 74*(Supplement C), 339-346.

Sidik, N. A. C., Mahmud Jamil, M., Aziz Japar, W. M. A., & Muhammad Adamu, I. (2017a). A review on preparation methods, stability and applications of hybrid nanofluids. *Renewable and Sustainable Energy Reviews, 80*, 1112-1122.

Sidik, N. A. C., Witri Mohd Yazid, M. N. A., & Mamat, R. (2017b). Recent advancement of nanofluids in engine cooling system. *Renewable and Sustainable Energy Reviews, 75*, 137-144.

Smithberg, E., & Landis, F. (1964). Friction and forced convection heat transfer characteristics in tubes with twisted-tape swirl generators. *Trans. ASME J. Heat Transfer, 86*, 39-49.

Solangi, K. H., Kazi, S. N., Luhur, M. R., Badarudin, A., Amiri, A., Sadri, R., . . . Teng, K. H. (2015). A comprehensive review of thermo-physical properties and convective heat transfer to nanofluids. *Energy, 89*(Supplement C), 1065-1086.

Soltani, O., & Akbari, M. (2016). Effects of temperature and particles concentration on the dynamic viscosity of MgO-MWCNT/ethylene glycol hybrid nanofluid: Experimental study. *Physica E: Low-dimensional Systems and Nanostructures, 84*, 564-570.

Sommers, A. D., & Yerkes, K. L. (2010). Experimental investigation into the convective heat transfer and system-level effects of Al_2O_3-propanol nanofluid. *Journal of Nanoparticle Research, 12*(3), 1003-1014.

Sonawane, S. S., Khedkar, R. S., & Wasewar, K. L. (2015). Effect of sonication time on enhancement of effective thermal conductivity of nano TiO_2–water, ethylene glycol, and paraffin oil nanofluids and models comparisons. *Journal of Experimental Nanoscience, 10*(4), 310-322.

Song, K. W., Liu, S., & Wang, L. B. (2016). Interaction of counter rotating longitudinal vortices and the effect on fluid flow and heat transfer. *International Journal of Heat and Mass Transfer, 93*, 349-360.

Srinivas, T., & Vinod, A. V. (2016). Heat transfer intensification in a shell and helical coil heat exchanger using water-based nanofluids. *Chemical Engineering and Processing: Process Intensification, 102*(Supplement C), 1-8.

Sripattanapipat, S., Tamna, S., Jayranaiwachira, N., & Promvonge, P. (2016). Numerical heat transfer investigation in a heat exchanger tube with hexagonal conical-ring inserts. *Energy Procedia, 100*, 522-525.

Subhedar, D. G., Ramani, B. M., & Gupta, A. (2018). Experimental investigation of heat transfer potential of Al_2O_3/water-mono ethylene glycol nanofluids as a car radiator coolant. *Case Studies in Thermal Engineering, 11*, 26-34.

Subramaniyan, A. L., Priya, S. L., & Ilangovan, R. (2015). Energy harvesting through optical properties of TiO_2 and C-TiO_2 nanofluid for direct absorption solar collectors. *International Journal of Renewable Energy Research, 5*(2), 542-547.

Suganthi, K. S., & Rajan, K. S. (2017). Metal oxide nanofluids: Review of formulation, thermo-physical properties, mechanisms, and heat transfer performance. *Renewable and Sustainable Energy Reviews, 76*(Supplement C), 226-255.

Sui, D., Langåker, V. H., & Yu, Z. (2017). Investigation of thermophysical properties of nanofluids for application in geothermal energy. *Energy Procedia, 105*, 5055-5060.

Sundar, L. S., Bhramara, P., Ravi Kumar, N. T., Singh, M. K., & Sousa, A. C. M. (2017a). Experimental heat transfer, friction factor and effectiveness analysis of Fe_3O_4 nanofluid flow in a horizontal plain tube with return bend and wire coil inserts. *International Journal of Heat and Mass Transfer, 109*(Supplement C), 440-453.

Sundar, L. S., Sharma, K. V., Singh, M. K., & Sousa, A. C. M. (2017b). Hybrid nanofluids preparation, thermal properties, heat transfer and friction factor–A review. *Renewable and Sustainable Energy Reviews, 68, Part 1*, 185-198.

Sundar, L. S., Singh, M. K., & Sousa, A. C. M. (2013). Thermal conductivity of ethylene glycol and water mixture based Fe_3O_4 nanofluid. *International Communications in Heat and Mass Transfer, 49*(0), 17-24.

Sundar, L. S., Singh, M. K., & Sousa, A. C. M. (2018). Turbulent heat transfer and friction factor of nanodiamond-nickel hybrid nanofluids flow in a tube: An experimental study. *International Journal of Heat and Mass Transfer, 117*, 223-234.

Sundar, L. S., Venkata Ramana, E., Graça, M. P. F., Singh, M. K., & Sousa, A. C. M. (2016). Nanodiamond-Fe_3O_4 nanofluids: Preparation and measurement of viscosity, electrical and thermal conductivities. *International Communications in Heat and Mass Transfer, 73*, 62-74.

Suresh, S., Venkitaraj, K. P., Selvakumar, P., & Chandrasekar, M. (2011). Synthesis of Al_2O_3–Cu/water hybrid nanofluids using two step method and its thermo physical properties. *Colloids Surfaces A, 388*(1–3), 41-48.

Takabi, B., & Salehi, S. (2014). Augmentation of the heat transfer performance of a sinusoidal corrugated enclosure by employing hybrid nanofluid. *Advances in Mechanical Engineering, 6*, 147059.

Talib, S. F. A., Azmi, W. H., Zakaria, I., Mohamed, W. A. N. W., Mamat, A. M. I., Ismail, H., & Daud, W. R. W. (2015). Thermophysical properties of silicon dioxide (SiO_2) in ethylene glycol/water mixture for proton exchange membrane fuel cell cooling application. *Energy Procedia, 79*(Supplement C), 366-371.

Teng, T. P., Hung, Y. H., Teng, T. C., Mo, H. E., & Hsu, H. G. (2010). The effect of alumina/water nanofluid particle size on thermal conductivity. *Applied Thermal Engineering, 30*(14–15), 2213-2218.

Tijani, A. S., & Sudirman, A. S. (2018). Thermo-physical properties and heat transfer characteristics of water/anti-freezing and Al_2O_3/CuO based nanofluid as a coolant for car radiator. *International Journal of Heat and Mass Transfer, 118*, 48-57.

Toghraie, D., Alempour, S. M., & Afrand, M. (2016a). Experimental determination of viscosity of water based magnetite nanofluid for application in heating and cooling systems. *Journal of Magnetism and Magnetic Materials, 417*, 243-248.

Toghraie, D., Chaharsoghi, V. A., & Afrand, M. (2016b). Measurement of thermal conductivity of ZnO–TiO_2/EG hybrid nanofluid. *Journal of Thermal Analysis and Calorimetry*, *125*(1), 527-535.

Usri, N. A. (2016). *Investigation of Forced Convection Heat Transfer for Al_2O_3 Nanofluids in Different Base Mixture*. (Master Unpublished master's thesis), Universiti Malaysia Pahang Pekan, Malaysia.

Vajjha, R. S., & Das, D. K. (2009). Specific heat measurement of three nanofluids and development of new correlations. *Journal of Heat Transfer, 131*(7), 071601-071607.

Vajjha, R. S., Das, D. K., & Kulkarni, D. P. (2010). Development of new correlations for convective heat transfer and friction factor in turbulent regime for nanofluids. *International Journal of Heat and Mass Transfer*, *53*(21-22), 4607-4618.

van Driest, E. R. (1956). On turbulent flow near a wall. *Journal of the Aeronautical Sciences, 23*(11), 1007-1011.

Varun, Garg, M. O., Nautiyal, H., Khurana, S., & Shukla, M. K. (2016). Heat transfer augmentation using twisted tape inserts: A review. *Renewable and Sustainable Energy Reviews, 63*, 193-225.

Viscopedia. Retrieved on 16 Jan 2017, from http://www.viscopedia.com/methods/measuring-principles/

Wang, L., & Sundén, B. (2002). Performance comparison of some tube inserts. *International Communications in Heat and Mass Transfer, 29*(1), 45-56.

Wang, Y., Al-Saaidi, H. A. I., Kong, M., & Alvarado, J. L. (2018). Thermophysical performance of graphene based aqueous nanofluids. *International Journal of Heat and Mass Transfer, 119*, 408-417.

Webb, R. L. (1981). Performance evaluation criteria for use of enhanced heat transfer surfaces in heat exchanger design. *International Journal of Heat and Mass Transfer, 24*(4), 715-726.

Yan, S., Wang, F., Shi, Z., & Tian, R. (2017). Heat transfer property of SiO_2/water nanofluid flow inside solar collector vacuum tubes. *Applied Thermal Engineering, 118*, 385-391.

Yang, C., Peng, K., Nakayama, A., & Qiu, T. (2016). Forced convective transport of alumina–water nanofluid in micro-channels subject to constant heat flux. *Chemical Engineering Science, 152*(Supplement C), 311-322.

Yang, C., Wu, X., Zheng, Y., & Qiu, T. (2017). Heat transfer performance assessment of hybrid nanofluids in a parallel channel under identical pumping power. *Chemical Engineering Science, 168*, 67-77.

Yarmand, H., Gharehkhani, S., Shirazi, S. F. S., Goodarzi, M., Amiri, A., Sarsam, W. S., . . . Kazi, S. N. (2016). Study of synthesis, stability and thermo-physical properties of graphene nanoplatelet/platinum hybrid nanofluid. *International Communications in Heat and Mass Transfer, 77*, 15-21.

Yasinskiy, A., Navas, J., Aguilar, T., Alcántara, R., Gallardo, J. J., Coronilla, A. S., . . . Lorenzo, C. F. (2018). Dramatically enhanced thermal properties for TiO_2-based nanofluids for being used as heat transfer fluids in concentrating solar power plants. *Renewable Energy, 119*, 809-819.

Yiamsawasd, T., Dalkilic, A. S., & Wongwises, S. (2012). Measurement of specific heat of nanofluids. *Current Nanoscience, 8*(6), 939-944.

Yiamsawasd, T., Mahian, O., Dalkilic, A. S., Kaewnai, S., & Wongwises, S. (2013). Experimental studies on the viscosity of TiO_2 and Al_2O_3 nanoparticles suspended in a mixture of ethylene glycol and water for high temperature applications. *Applied Energy, 111*, 40-45.

Yu, W., & Xie, H. (2012). A review on nanofluids: preparation, stability mechanisms, and applications. *Journal of Nanomaterials, 2012*, 1.

Zakaria, I., Azmi, W. H., Mamat, A. M. I., Mamat, R., Saidur, R., Abu Talib, S. F., & Mohamed, W. A. N. W. (2016). Thermal analysis of Al_2O_3–water ethylene glycol mixture nanofluid for single PEM fuel cell cooling plate: An experimental study. *International Journal of Hydrogen Energy, 41*(9), 5096-5112.

Zakaria, I., Azmi, W. H., Mohamed, W. A. N. W., Mamat, R., & Najafi, G. (2015a). Experimental Investigation of thermal conductivity and electrical conductivity of Al_2O_3 nanofluid in water - ethylene glycol mixture for proton exchange membrane fuel cell application. *International Communications in Heat and Mass Transfer, 61*(Supplement C), 61-68.

Zakaria, I., Mohamed, W. A. N. W., Mamat, A. M. I., Saidur, R., Azmi, W. H., Mamat, R., & Talib, S. F. A. (2015b). Experimental investigation of Al_2O_3 - water ethylene glycol mixture nanofluid thermal behaviour in a single cooling plate for PEM fuel cell application. *Energy Procedia, 79*(Supplement C), 252-258.

Zhang, C., Wang, D., Ren, K., Han, Y., Zhu, Y., Peng, X., . . . Zhang, X. (2016). A comparative review of self-rotating and stationary twisted tape inserts in heat exchanger. *Renewable and Sustainable Energy Reviews, 53*, 433-449.

Zheng, L., Xie, Y., & Zhang, D. (2017). Numerical investigation on heat transfer performance and flow characteristics in circular tubes with dimpled twisted tapes using Al_2O_3-water nanofluid. *International Journal of Heat and Mass Transfer, 111*(Supplement C), 962-981.

Zhou, S. Q., & Ni, R. (2008). Measurement of the specific heat capacity of water-based Al_2O_3 nanofluid. *Applied Physics Letters, 92*(9), 093123.

Żyła, G., & Fal, J. (2017). Viscosity, thermal and electrical conductivity of silicon dioxide–ethylene glycol transparent nanofluids: An experimental studies. *Thermochimica Acta, 650*, 106-113.