Proceedings of
The First International
Conference on Engineering
Sciences’ Applications, ICESA
24-25 /December/ 2014
First International Conference on Engineering Sciences’ Applications, ICESA

Supported by

- Ministry of Higher Education and Scientific Research
- Imam Hussein Holy Shrine Trust
- Imam Abbas Holy Shrine Trust
- Kerbala Governorate
- Kerbala Governorate Council
- Kerbala Centre for Studies and Researches
- Engineering Consulting Bureau/ University of Kerbala
- The National Group
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Residential Trip Demand Forecasting: A Regression-Based Approach Using Observed Trip Rate Data (Dr. Firas Hasan Alwan Asad)

Effect of Burning by Fire Flame on Some Mechanical Properties of Reactive Powder Concrete (Zainab Sabah Rasoul, Dr. Mohammed Mansour Kadhum)

Pavement Management using Cost-Effective Data Collection Sensors (V. Khalifeh, A. Golroo)

Shear Strengthening Behavior of Light Weight Aggregate Concrete Beams with Near Surface Mounted Using Carbon Fiber Reinforced Polymer Bars (Ali Hameed Naser Al-Mamoori)

Climate Responsive Building Design in Iraqi Environment Context (Ahmed Hasson, Oula S. Hassan)

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Experimental Study of Wave Shape and Frequency of the Power Supply on the Energy Efficiency of Hydrogen Production by Water Electrolysis (Dhafeer M. H. Al-Hasnawi, Haroun A. K. Shahad)

Automated Car Airbag System Using Human Face Detection (Hussain Fadhel Hamdan Jaafar and Qais Kareem Omran Al-Gayem)

New Current-Mode MISO-Type Universal Filter Configurations Using Single FDCCII and Minimum Passive Components (Kasim K Abdalla)

Design of CMOS IR-UWB Transmitter (Hussein Ali Hamza, Dr. Haydar M. Al-Tamimi)

Analysis and Simulation of Force Control Linear Actuator with Spring in Series and its Driving System For Below Knee Amputees (Dhirgaam A. Kadhim)

Comprehensive Design and Implementation of a MPPT Controller for a PV Module Based on dSPACE Microcontroller (Ali J. Mahdi)

Design and Implementation of Hybrid Intelligent Systems Based on FPGA (Dr. Hanan A. R. Akkar)

Wearable Sierpinski Dragon Fractal Patch Antenna for RFID Applications (Ghufran M. Hatem, Ali J. Salim and Jawad K. Ali)

Automatic Digital Modulation Classification Using FFT (Ivan A. Hashim, Jafar Wadi Abdul Sadah and Thamir R. Saeed)

Disturbance Analysis in Wind Power System Connected with 132kV Grid Based on Intelligent Techniques (Dr. Kanaan A. Jalal & Ahmed Najem Abdalameer)
Welcome to 1st ICESA

Welcome to the First International Conference on Engineering Sciences’ Applications (ICESA). Excellences, distinguished delegates, ladies, gentlemen, on behalf of the conference organizing committee, it gives us great pleasure to welcome you all. We are so grateful because you have accepted our invitation to convene this conference here in Kerbala.

The conference programme is organized into paper presentation sessions and exhibition breaks to elucidate the scope of the conference in knowledge exchange between experts in different fields. This event provides a useful networking arena, which enables delegates to make new national and international contacts, bridge the gap between the various parties and help transfer technology from research into practice.

We hope that the present delegates will engage only to fruitful debates in order to make this conference productive and relevant. Conference sessions will be held in the college of engineering, AL-Mudhafein campus. We are extremely fortunate to have speakers and delegates from many countries including (Iran, India, U.K and Malaysia), for them we would like to express our thanks.

The conference committee wishes to express their special thanks to Ministry of Higher Education and Scientific Research, and Kerbala University for their continuous help and support. Sponsoring organizations, especially, Kerbala Center for Studies and Researches/ Imam Hussain Holey Shrine, and Imam Abbas Holey Shrine.

We are aware of the tremendous efforts made by all researchers, reviewers and committees, as the conference covers a wide range of very interesting items relating to engineering theories and applications. We are confident that the First International Conference on Engineering Sciences’ Applications will be a successful one, and all participants will gain purposeful knowledge which will be useful to Iraq, Iran, and other countries especially the Islamic countries.

Professor Dr. Sabah Rasoul Al-Jabiri
Conference Director

Professor Dr. Moneer Hameed Tolephih
President of Kerbala University
Conference Program
Day One: Wednesday 24 Dec 2014

Morning Session
Venue: Imam Al-Hassan (peace be upon him) Hall in Al-Abbas Holy Shrine.
Chairman: Prof. Dr. Riyad H. Al-Anbari /Dean of Building and construction Dept.UOT, Iraq

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<tr>
<td>9:00</td>
<td>Registration</td>
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<tr>
<td>10:00</td>
<td>Conference Opening</td>
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<tr>
<td>10:05-10:10</td>
<td>Holy Quran</td>
</tr>
<tr>
<td>10:10 – 10:20</td>
<td>Welcome by the Conference Director Professor Dr Sabah Rasoul Al-Jabiri</td>
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<tr>
<td>10:20 – 10:30</td>
<td>Welcome by the Conference Supervisor Professor Dr Moneer H.Tolephih</td>
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<tr>
<td>10:30-10:40</td>
<td>Welcome by the Minister of Higher Education and Scientific Research, Dr. Hussein Al-Shehristani</td>
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<tr>
<td>10:40-11:30</td>
<td>Keynote speaker Lecture: Nanotechnology in future Computers (Quantum Computers), Prof. Dr. Mudarr A. Abduasattar, Ministry of Sciences and Technology</td>
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<tr>
<td>11:30-2:00</td>
<td>Prayer and Lunch, Al-Abbas Holy Shrine</td>
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<tr>
<td>2:00-2:30</td>
<td>Movement to the College of Engineering at the Al-Mudhafin Campus</td>
</tr>
<tr>
<td>2:30-2:55</td>
<td>Refreshment and Exhibition</td>
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Afternoon Session2: Civil Engineering Applications
Venue: Hall One, Civil Engineering Department
Chairman : Prof. Dr. Shakir Ahmed Salih/ UOT, Iraq
Register : Assistant Prof. Dr. Laith Sh. Resheed/UOK, Iraq

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| 3:00  | C40 لدراسة تأثير استخدام المضافات على بعض خواص الجص
M.M. هديل خالد عواد، أ.د. ندى مهدي فوزي الجيلاوي |
| 3:15  | C30 THE BEST EXPANSION RATIO FOR CASTELLATED STEEL BEAMS
BASED ON THE UPPER BOUND CRITERION
Mr. Maher K. Abbas, Prof. Dr. Haitham H. Muteb |
| 3:30  | C41 Effect of plastic optical fiber on properties of Translucent Concrete Boards
Prof. Dr. Shakir Ahmed Salih, Assist.Prof.Dr. Hasan Hamodi Joni, Safaa Adnan Mohamed |
| 3:45  | C27 Characterization of cement kiln dust behavior in the sorption of heavy metal
from aqueous solutions
Abbas H. Sulaymon, Ayad A. H. Faisal and Qusey M. Khaliefa |
| 4:00  | C46 Effect of Burning by Fire Flame on Some Mechanical Properties of Reactive Powder Concrete
Zainab Sabah Rasoul, Dr. Mohammed Mansour Kadhum, University of Babylon
- College of Engineering |
| 4:15  | C36 A Proposed Hexagonal – Cylindrical Specimens Relationship of Concrete
Alyaa Hussein Mohammed, Marawan Mohammed Hamid, Marwah Sami Abduljabbar |
| 4:45  | C56 Stability of Foundations due to Under Planning Dewatering Process
Dr. Haider M. Mekkiyah, Abdul Karim M. Abdul Razzak |
| 5:00  | C39 Sun Light (Solar Radiation) Effect on Evaporation and Temperature of Fresh Concrete
Asst. Lect. Mahmoud H. Abdulrazzaq, Prof. Dr. Shakir A. Salih |
### Afternoon Session 3: Civil Engineering Applications

**Venue:** Hall Two, Civil Engineering Department  
**Chairman:** Assistant Prof. Dr. Ali Khodaii/ AmirKabir University, Iran  
**Register:** Dr. Raid R. Al-Muhanna/ UOK, Iraq

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<tr>
<th>Session</th>
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<th>Presenter(s)</th>
<th>Time</th>
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<tbody>
<tr>
<td>C50</td>
<td>Climate Responsive Building Design in Iraqi Environment Context</td>
<td>Ahmed Hassan, Mechanical Engineering Department, College of Engineering, Nahrain University</td>
<td>3:30 – 3:45</td>
</tr>
<tr>
<td>C3</td>
<td>Proposing Transportation Modes for Effective Tourism Management in City of Karbala</td>
<td>Sedigheh Vakilly, Ehsan Ramezani, Gharem Ashtijou, Roozbeh Mohammadi4, Samira Dibaj5</td>
<td>3:45 – 4:00</td>
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<tr>
<td>C35</td>
<td>تأثير درجات الحرارة على المقاومة النوعية للحمأة المنشطة</td>
<td>A.M.D. Widad Dhiab, M.D. Zinab El-Sebaa, M.D. Gharem Ashtijou, Engineer Sadek Ahmed, Engineer Zaki Al-Sheikh</td>
<td>4:00 – 4:15</td>
</tr>
<tr>
<td>C2</td>
<td>Analysis of Thick Square Plates on Two-parameter Elastic Foundation</td>
<td>Riyadh J. Aziz1, Adel A. Al-Azzawi and Tuqa W. Ahmed3</td>
<td>4:15 – 4:30</td>
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<tr>
<td>C31</td>
<td>The Effect of Earthquake Characteristics on Seismically Isolated Buildings of Variable Geometric Configurations with and without Shear Walls</td>
<td>Dr. Haider S. Al-Jubair, Mr. Fareed H. Majeed</td>
<td>4:30 – 4:45</td>
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<tr>
<td>C48</td>
<td>Residential Trip Demand Forecasting: A Regression-Based Approach Using Observed Trip Rate Data</td>
<td>Dr. Firas Hasan Alwan Asad</td>
<td>4:45 – 5:00</td>
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### Afternoon Session 4: Mechanical Engineering Applications

**Venue:** Hall Three, Mechanical Engineering Department  
**Chairman:** Prof. Dr. Mohammad M. Aghdam/ AmirKabir University, Iran  
**Register:** Assistant Prof. Dr. Mohammed h. Abood/ UOK, Iraq

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<tbody>
<tr>
<td>M4</td>
<td>Adsorption of Co2+ and Ni2+ from Aqueous Solution on Different Nano Montmorillonite Types</td>
<td>Hadi Azimi, Majid Hayati-Ashtiani</td>
<td>3:00 – 3:15</td>
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<tr>
<td>M5</td>
<td>Morphological and Structural Characteristics of Swelling and Nonswelling Nanostructured Montmorillonite</td>
<td>Majid Hayati-Ashtiani, Hadi Azimi</td>
<td>3:15 – 3:30</td>
</tr>
<tr>
<td>M10</td>
<td>Numerical Study of Thermal Performance for Solar Heating System</td>
<td>Audai Hussein Al-Abbas</td>
<td>4:00 – 4:15</td>
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<tr>
<td>M44</td>
<td>Three Dimensional Finite Element Analysis of Wire Drawing Process</td>
<td>Dr. Abdul Kareem F. Hassan, Alyaa Sh. Hashim</td>
<td>4:45 – 5:00</td>
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### Afternoon Session 5: Mechanical Engineering Applications

**Venue:** Hall Four, Mechanical Engineering Department  
**Chairman:** Prof. Dr. Arkan k. Ali/ UOT, Iraq  
**Register:** Assistant Prof. Dr. Abdu-karim Al-Hamadani/ UOK, Iraq

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<tbody>
<tr>
<td>M16</td>
<td>Robust Control Design of Variable Speed Wind Turbine Under Parametric Uncertainty</td>
<td>Dr. Emad Q. Hussien</td>
<td>3:00 – 3:15</td>
</tr>
<tr>
<td>M30</td>
<td>Cognitive Neural Trajectory Tracking Controller Design for Mobile Robot</td>
<td>Dr. Moafaq Ali Tawfeq, Dr. Ahmed Sabah Al – Araji and Basim Raheem Sadeq</td>
<td>3:15 – 3:30</td>
</tr>
<tr>
<td>M32</td>
<td>Hyperelastic Constitutive Modelling for Fiber-Reinforced Rubber Materials</td>
<td>Assist. Prof. Dr. Mohsin Noori Hamzah, Mahmood Shakir Nima</td>
<td>3:30 – 3:45</td>
</tr>
<tr>
<td>M35</td>
<td>Theoretical and Numerical Study of Natural Frequency Investigation for Orthotropic Unidirectional and Woven Hyper Composite Materials Beam</td>
<td>Dr. Muhannad Al-Waily</td>
<td>3:45 – 4:00</td>
</tr>
<tr>
<td>M29</td>
<td>Drifting Dynamic Characteristics Due to Effect of Heating Load For Aluminum Alloy 7075 T6</td>
<td>Husam A. Kareem, Prof. Dr. Muhsin J. Jweeg, Prof. Dr. Shaker S. Hassan</td>
<td>4:00 – 4:15</td>
</tr>
<tr>
<td>M40</td>
<td>Structural and Morphology studies of nanocomposite materials</td>
<td>Prof. Dr. Fadhil Attiya Chyad, Asst. Prof. Dr. Abd Al-Raheem Kadhem, Asst. Lec. Auday Abd Muhatlif</td>
<td>4:15 – 4:30</td>
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### Afternoon Session 6: Electrical Engineering Applications

**Venue:** Hall Five, Civil Engineering Department  
**Chairman:** Prof. Dr. Asaam M. Abdulbaqi/ UOM, Iraq  
**Register:** Dr. Ali J. Mahdi

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<th>Time</th>
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<tbody>
<tr>
<td>E25</td>
<td>Design and Implementation of Hybrid Intelligent Systems Based on FPGA</td>
<td>Assist. Prof. Dr. Hanan A. R. Akkar</td>
<td>3:15 – 3:30</td>
</tr>
<tr>
<td>E27</td>
<td>Automatic Digital Modulation Classification Using FFT</td>
<td>Ivan A. Hashim, Jafar Wadi Abdul Sadah, Thamir R. Saeed</td>
<td>3:45 – 4:00</td>
</tr>
<tr>
<td>E28</td>
<td>Disturbance Analysis in Wind Power System Connected with National Grid based on Intelligent Techniques</td>
<td>Dr. Kanaan A. Jalal, Ahmed Najem Abdalameer</td>
<td>4:00 – 4:15</td>
</tr>
<tr>
<td>E11</td>
<td>Automated Car Airbag System Using Human Face Detection</td>
<td>Hussain F. H. Jaafar1, and Qais K. O. Al-Gayem</td>
<td>4:15 – 4:30</td>
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</table>
Workshop: Research and Studies to Solve the Infrastructure and Transportation problems of Karbala City
Venue: Madinate Al-Za’arin
Chairman: Assistant Prof. Dr. Mohammed A. Al-Saraj / UOB, Iraq
Register: assistant Prof. Zwhair Al-Jawaheri , UOK, Iraq

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<tr>
<td>7:30-7:55</td>
<td>Registration</td>
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<tr>
<td>8:00</td>
<td>Workshop Opening</td>
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<td>8:00-8:05</td>
<td>Holy Quran</td>
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<tr>
<td>8:05-8:15</td>
<td>Welcome by the Director of Kerbala Center for Studies and Research</td>
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<tr>
<td>8:15-8:30</td>
<td>The high Demand to develop the infrastructure facilities of Karbala City</td>
</tr>
<tr>
<td>8:30-9:30</td>
<td>Discussion</td>
</tr>
<tr>
<td>9:30-9:40</td>
<td>Recommendation and final report</td>
</tr>
<tr>
<td>9:45</td>
<td>Closing the workshop</td>
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Day Two: Thursday 25 Dec 2014
Morning Session7: Civil Engineering Applications
Venue: Hall One, Civil Engineering Department
Chairman: Prof. Dr. Nada M. Fauzi
Register: Dr. Hussein A. Al-Hamami/UOK, Iraq

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<tr>
<td>C43</td>
<td>9:00-9:15</td>
<td>م. د. صبيحة فرحان , م. د. احسان عباس جاسم</td>
</tr>
<tr>
<td>C1</td>
<td>9:15-9:30</td>
<td>Simulating the Impacts of Groundwater Pumping on Dibdibba Aquifer in Karbala Province</td>
</tr>
<tr>
<td>C13</td>
<td>9:30 – 9:45</td>
<td>Hydraulic Characteristics of Flow through Monosized Gravel</td>
</tr>
<tr>
<td>C25</td>
<td>9:45 – 10:00</td>
<td>Estimation of Axle Load Spectra for Mechanistic-Empirical Pavement Design in New Brunswick</td>
</tr>
<tr>
<td>C51</td>
<td>10:00 – 10:15</td>
<td>Development of Predictive Models for the Resilient Modulus of Asphalt Concrete Mixtures</td>
</tr>
<tr>
<td>C37</td>
<td>10:15– 10:30</td>
<td>Clay Brick Waste as Internal Curing Agent in Normal Weight Concrete</td>
</tr>
<tr>
<td>C55</td>
<td>10:30– 10:45</td>
<td>Pavement Management using Cost-Effective Data Collection Sensors</td>
</tr>
<tr>
<td>C49</td>
<td>10:45– 11:00</td>
<td>Experimental study of insulated and non-insulated concrete behavior under the effect of thermal load</td>
</tr>
<tr>
<td>C19</td>
<td>11:00-11:15</td>
<td>Shear Strengthening Behavior of Lightweight Aggregate Concrete Beams with Near Surface Mounted Using Carbon Fiber Reinforced Polymer Bars</td>
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</tbody>
</table>
C17  Analysis of Earthquake Records from Badra and Kirkuk Seismographic Stations
Prof. Dr. Adnan Falih Ali, Majed Ashoor Khalaf
11:15-11:30

C14  ARTIFICIAL NEURAL NETWORKS FOR PREDICTING CHARACTERISTICS OF CIR MIXES AFTER LONG-TERM CURING
Seyed Mahmoud Dibaj, Behrooz Saghafi, Roohollah Noori and Payam Daie
11:30-11:45

Morning Session 8: Mechanical Engineering Applications
Venue: Hall Three, Mechanical Engineering Department
Chairman: Prof. Dr. Abdulhassan Karamallah
Register: Assistant Prof. Dr. Abbas S. Sharif/ UOK, Iraq

M6  Study of Nickel Removal on Raw and Acid-activated Nano-structure Montmorillonite
Zahra Ashouri Mehranjani 1, Mehran Rezaei 2*, Majid Hayati-Ash tiani 3  
9:00 - 9:15

M7  Physicochemical Characterization of Bentonite Clays for Oil Well Drilling Fluids
Masoomeh Bakhshi Mejdar 1, Majid Hayati-Ashtiani 2, Mohammad Reza Mozdian Fard 3  
9:15 – 9:30

M. Muhsen 4, W. Mohammad 5, A. Karamallah 6  
9:30 – 9:45

M42  NUMERICAL INVESTIGATION OF FINNED THERMOSYPHON
Prof. Dr. Karima Esmail Amori, Mohanad Lateef Abdullah  
9:45 – 10:00

M36  Numerical simulation of combined convection of Cu-H2O nanofluid in an inclined lid-driven enclosure with a localized heat source
Ahmed Kadhim Hussein, Sameh E. Ahmed, and Farshid Fathinia  
10:00 – 10:15

M23  The Phases Monitoring System of the Oil Wells
Asst. Prof. Dr. Dhirgham A.H. Al-khafaji, Mustafa A. Kadhim Alkizwini (2)  
10:15 – 10:30

M37  Application of Nanostructured Conducting Polymer Film in Fabrication of Electronic Nose Based on Chemiresistors Array Sensor
Naader Alizadeh*, Mohsen Babaei, Mohammad Sadegh Alizadeh, Ahmad Mani-Varnosfaderani  
10:30 - 10:45

M12  Combined Cycle Plant "The Future Solution for Iraq Electricity Production"
Dr. Raoof M. Radhi  
10:45 - 11:00
**Morning Session**

**9:00 – 9:15**

**Guest Speaker**

**9:15 – 9:30**

**E23** Analysis on Modeling and Simulation Force Control Linear Actuator with Spring in Series and its Driving System For Below Knee Amputees

Dhiraam A. Kadhim

**9:30 – 9:45**

**E7** Experimental Study of Wave Shape and Frequency of the Power Supply on the Energy Efficiency of Hydrogen Production by Water Electrolysis

Dhafer M. H. Al-Hasnawi¹, Haroun A. K. Shahad²

**9:45 – 10:00**

**E24** Comprehensive Design and Implementation of a MPPT Controller for a PV Module based on dSPACE Microcontroller

Ali J. Mahdi

**10:00 – 10:15**

**E13** New Current-Mode MISO-Type Universal Filter Configurations Using Single FDCCII and Minimum passive components

Kasim K Abdalla¹

**10:15 – 10:30**

**E6** Design and Analysis of Environmental monitoring system Using Wireless Sensor Networks

Syed Akhtar Imam¹, Vibhav Kumar Sachan²

**10:30 – 10:45**

**E2** A Proposed Filter for Low Frequency Signals

S. A. Hasan

**10:45 – 11:00**

**E21** Design of CMOS IR-UWB Transmitter

Fadhil Mohammed Al- Hussein Ali Hamza, Dr. Haydar M. Al-Tamimi

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**Register:** Dr. Riadh Mowad/ UOK, Iraq

**Afternoon Session**

**10:00 – 10:15**

**Holy Quran**

2:00-2:05

**Speech of Shaikh Abd Al-Mahdi Al-Karbala’i**

2:05-2:20

**Awards’ Distribution for the selected papers**

2:20-2:40

**Conference Final Report**

2:40-2:50

**Conference closing speech, Prof. Dr. Sabah Rasoul Al-Jabiri**

2:50-3:00
Authors’ CVs

Dr. Haitham Hassan Muteb
B.Sc.-M.Sc.-Ph.D.
- Professor and Consultant Engineer
- With B.Sc.-M.Sc.-and Ph.D. degrees in Civil Engineering.
- having more than 25years’ experience worked on range of projects in different locations,
- Lecturer in Iraqis Universities (Babylon University, University of Technology, Baghdad University and University of Karbala).

Maher Kheder Abbas
Academic Qualification:
- (2012-2014) M.Sc. researcher in civil engineering/structures, university of Babylon.

Safaa Adnan Mohamed
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Marawan Mohammed Hamid  
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Since 2012 when I got my master's degree in engineering and construction materials to the present time I do my teaching at the University of Technology, Department of Building and Construction Engineering, Construction Engineering Branch. The title and my guest Assistant Lecturer.

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2. B.Sc. in Building and construction from the University of Technology. (1984).  
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Masters of Engineering (M.Eng.), Transportation Engineering May 2012  
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Dean of the College of Engineering, 2006-2008, University of Thi-Qar, Iraq.
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Dr. Majid Hayati
assistant professor at University of Kashan, Iran
Graduated in Ph.D at 2010 in Chemical Engineering. Published 8 ISI papers, 6 international conference papers, 1 national conference paper and 2 national patents, Advisor of 1 Ph.D dissertation, supervisor of 4 M.Sc. theses, scientific interests is bentonite clays.

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Place and Data of Birth: Kerbala 1962
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Ghufran M. Hatem
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Ali J. Salim
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Mr. Ivan A. Hashim
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Qais Al-Gayem
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Currently works a cultural counsellor in Iraq's cultural attaché / India. He Has holds a PHD of Engineering Aerodynamic from (JMI) / New Delhi and PGDA from Sikkim Munpal University / India and has held several positions at the University of Babylon.

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Dr. Amjad H. Khalil Albayati is assistant professor in the civil engineering department of Baghdad University. He awarded a Ph.D in the highway and pavement engineering in 2006 from Baghdad University. he was the head of civil engineering department – engineering college – University of Baghdad for the period (2006-2007) also (jan 2014-jun2014).
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Dhirgaam Abdul Rahym Kadhim


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-Bsc. : Baghdad University/ College of Engineering/1997
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Dr. Ali Jafer Mahdi

Dr. Ali Jafer Mahdi Is currently a Head of Department and a Lecturer in Power Electronics & Electrical Machines at the Electrical & Electronic Engineering Department at Kerbala University. He has joined as a Lecturer at Kerbala University in October 2004. Prior to that, he was a Power & Machines Lecturer (November 1998 - August 2003) at the High Institute of Electrical Engineering, Sirte – Libya. Dr. Mahdi has received his Ph.D. from the University of Liverpool - UK focusing on Power Electronics Converters (PEC), Controlling of Wind Turbine Generator Systems (WTGS) and Photovoltaic Power Systems (PVPS).
Dr. Syed Akhtar Imam
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   عنوان الرسالة " العلاقة بين استعمالات الأرض ومنظومة النقل الحضري "
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Numerical Simulation of Combined Convection of Cu-H_2O Nanofluid in an Inclined Lid-Driven Enclosure with a Localized Heat Source
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ABSTRACT
A numerical simulation of the combined convection flow in a rectangular inclined lid-driven enclosure filled with copper-water nanofluid has been performed. The upper and the lower walls are maintained at a cold temperature and the upper wall moves from left to right with uniform lid-driven velocity. A localized heat source is embedded on a region of the enclosure left sidewall, the right one is considered thermally insulated together with the remaining regions of the left sidewall. The effects of the governing parameters such as solid volume fraction, Richardson number, enclosure inclination angle and heat source effect are investigated. The results explain that the local Nusselt number decreases as the inclination angle and solid volume fraction increase. Comparisons with another published results are performed and a good agreements are found.

Keywords- combined convection, enclosure, laminar flow, localized heat source, nanofluid

1. Introduction
Nanofluids are a new kind of heat transfer fluids containing a small quantity of nano-sized particles (usually less than 100 nm) that are uniformly suspended in a liquid. They have received more attention as a new generation of heat transfer fluids in building heating, heat exchangers and automotive cooling applications, because of their excellent thermal performance. Various advantages of nanofluids applications include: heat transfer system size reduction, micro channel cooling and miniaturization of systems [1-2]. Various numerical and experimental studies on nanofluids in a lid-driven square or rectangular enclosures have been studied in the literature [3-10]. Kakac and Pramanjaroenki [11] presented an excellent review of convective heat transfer enhancement with nanofluids. Moreover, Mahmoudi et al. [12] studied numerically mixed convection flow and temperature fields in a vented square cavity subjected to an external copper-water nanofluid. The effects of solid volume fraction on the hydrodynamic and thermal characteristics had been investigated. Talebi et al. [13] investigated numerically mixed convection flows in a lid-driven square cavity utilizing copper–water nanofluid. They showed that at a given Reynolds number and Rayleigh number, solid concentration had a positive effect on heat transfer enhancement. Abu-Nada and
Chamkha [14] solved numerically the steady laminar mixed convection of a nanofluid made up of water and Al$_2$O$_3$ in a lid-driven inclined square enclosure.

It was found that the heat transfer mechanisms inside the cavity were strongly dependent on the Richardson number. Ghasemi and Aminossadati [15] numerically studied the mixed convection in a lid-driven triangular enclosure filled with a water–Al$_2$O$_3$ nanofluid. The results showed that the addition of Al$_2$O$_3$ nanoparticles enhanced the heat transfer rate for all values of Richardson number and for each direction of the sliding wall motion. Shahi et al. [16] executed a numerical investigation of mixed convection flows through a copper–water nanofluid in a square cavity with inlet and outlet ports. The results indicated that an increase in solid concentration caused to increase in the average Nusselt number at the heat source surface and a decrease in the average bulk temperature. A literature review indicates that the papers related with the combined convection in a lid-driven inclined enclosure subjected to a localized heat source using a nanofluid concept are very limited. However, the present paper can be considered as a continuous part of our first published paper deals with this subject (Hussein et al. [17]).

2. Mathematical Analysis

2.1 Problem geometry and the governing equations.

Fig.1 shows a schematic diagram of a two-dimensional inclined rectangular enclosure of height (H) and width (w). The fluid inside is a copper-water nanofluid. The nanofluid is assumed incompressible and the flow is assumed to be Newtonian, laminar and steady. It is assumed that the base fluid (i.e. water) and the nanoparticles are in thermal equilibrium state. The enclosure aspect ratio is represented by (A = w / H). The parameters B, D and Gr are considered fixed during the calculation at the values 0.4, 0.5 and 100 respectively. The solid volume fractions, (φ) have been varied from 0 % to 10 % with an increment of 5% while the enclosure inclination angle (Φ) is varied as 0°, 30°, 60° and 90° respectively. The Reynolds number is taken as (1≤ Re ≤100). The thermo-physical properties of the water and copper nanoparticles are given in Table 1. The upper and lower walls are kept to be cooled and the upper wall moves from left to right with uniform lid-driven velocity ($U_p$). The thermo-physical properties of both the base fluid and nanofluid are assumed to be constant except for the density variation, which is modeled using Boussinesq model. The dimensionless governing equations for the laminar and steady state mixed convection in terms of the stream function-vorticity formulation are given by Hussein et al. [17]:

$$
\frac{\partial^2 \Psi}{\partial X^2} + \frac{\partial^2 \Psi}{\partial Y^2} = -\omega
$$

$$
\frac{\partial}{\partial X} \left( \frac{\partial \Psi}{\partial Y} \right) - \frac{\partial}{\partial Y} \left( \frac{\partial \Psi}{\partial X} \right) = \frac{1}{\text{Re}} \frac{1}{(1-\phi)^{2.5} \left( (1-\phi) + \phi \frac{\rho_{nf}}{\rho_f} \right)} \left( \frac{\partial^2 \Omega}{\partial X^2} + \frac{\partial^2 \Omega}{\partial Y^2} \right)
$$
\[ + R\tau (\phi (\frac{\beta_{nf}}{\beta_f}) + (1 - \phi)) \left( \frac{\partial \theta}{\partial X} \cos \Phi - \frac{\partial \theta}{\partial Y} \sin \Phi \right) \]  

\[ \frac{\partial}{\partial X} (\theta \frac{\partial \Psi}{\partial Y}) - \frac{\partial}{\partial Y} (\theta \frac{\partial \Psi}{\partial X}) = \frac{1}{Re \cdot Pr} \frac{k_{nf}}{k_f} \left( \frac{\rho c_p}{\nu} \right)_{nf} \left( \frac{\partial^2 \theta}{\partial X^2} + \frac{\partial^2 \theta}{\partial Y^2} \right) \]  

These dimensionless governing equations have been obtained by employing the following non-dimensional variables as listed below:

\[ X = \frac{x}{H} \quad Y = \frac{y}{H} \quad U = \frac{U}{p} \quad V = \frac{V}{U} \quad \Omega = \frac{\omega}{U \cdot \rho / H} \quad \Psi = \frac{\psi}{U \cdot \rho / H} \]

\[ \theta = \frac{T - T_c}{\Delta T} \quad \Delta T = \frac{gH}{k_f} \quad Gr = \frac{g \beta \Delta T H^3}{\nu_f^2} \quad Pr = \frac{\nu_f}{\alpha_f} \quad Ri = \frac{Gr}{Re^2} \quad Re = \frac{U \cdot H}{\nu_f} \]  

The non-dimensional boundary conditions are given by:

The bottom wall of the cavity is maintained at constant cold temperature:
at \( Y = 0 \) and \( 0 \leq X \leq 1 \) \( \theta = 0 \), \( U = V = 0 \) \( (5) \)

The top wall of the cavity is maintained at constant cold temperature and moves from left to right with uniform lid-driven velocity:
at \( Y = 1 \) and \( 0 \leq X \leq 1 \) \( \theta = 0 \), \( U = 1 \), \( V = 0 \) \( (6) \)

The lower part of the left vertical inclined side wall of the cavity is considered adiabatic:
at \( X = 0 \) and \( 0 \leq Y < (D - 0.5B) \), \( U = V = 0 \), \( \frac{\partial \theta}{\partial X} = 0 \) \( (7) \)

The heat source part of the left vertical inclined side wall of the cavity is considered as:
at \( X = 0 \) and \( (D - 0.5B) \leq Y \leq (D + 0.5B) \), \( U = V = 0 \), \( \frac{\partial \theta}{\partial X} = \frac{k_f}{k_{nf}} \) \( (8) \)

The upper part of the left vertical inclined side wall of the cavity is considered adiabatic:
at \( X = 0 \) and \( (D + 0.5B) \leq Y \leq 1 \), \( U = V = 0 \), \( \frac{\partial \theta}{\partial X} = 0 \) \( (9) \)
The right vertical side wall of the cavity is considered adiabatic:

at \( X = 1 \) and \( 0 \leq Y \leq 1 \), \( U = V = 0 \), \( \frac{\partial \theta}{\partial X} = 0 \) \hspace{1cm} (10)

2.2 Local and average Nusselt number along the heat source surface

The local and average Nusselt numbers along the heat source surface can be written as Hussein et al. [17]:

\[
\text{Nu}_s (Y) = \frac{1}{\theta_s (Y)} \hspace{1cm} \text{(11)}
\]

\[
\text{Nu}_m = \frac{1}{B} \int_{D-0.5B}^{D+0.5B} \text{Nu}_s (Y)dY \hspace{1cm} \text{(12)}
\]

where, \( \theta_s (Y) \) is the dimensionless local temperature along the heat source

3. Numerical Scheme and Verification

Because of the non-linear interactions among the equations (1–3), solution for these equations with the boundary conditions (5–8) can be obtained numerically using finite difference method. During each axial step, the numerical evaluation is iterated until the relative errors of \( U, V \) and \( \theta \) at sequential iterations are less or equal \( (10^{-6}) \). In order to choose the suitable grid for these calculations, an accuracy test using five sets of grids: \( 31 \times 31, 41 \times 41, 61 \times 61, 81 \times 81, 101 \times 101 \) is made. This test is clearly shown in Table 2. A \( (61 \times 61) \) uniform grid is found to meet the requirements of both the grid independency study and the computational time limits. The numerical method is found to be suitable and gives results that are very close to the numerical results obtained by Aminossadatia and Ghasemi [5] and Mansour et al. [18] and with using the copper-water nanofluid. Table 3 shows a good agreement is reached between the present results and the results obtained by Aminossadatia and Ghasemi [5] and an excellent agreement between the present results and the results obtained by Mansour et al. [18]. These comparisons give confidence in the numerical results to be reported subsequently.

4. Results and Discussion

The streamlines (on the left) and isotherms (on the right) in the enclosure for the water-copper nanofluid are shown in Figs. (2–5) for various inclination angles, solid volume fractions and Richardson numbers. It can be seen from Fig. 2 that, the fluid moves from the inclined left sidewall where the heat source exists towards the right side one and as a result forms a clockwise single circular vortex with \( \psi_{\text{min,nf}} = -0.1032864 \) and \( \psi_{\text{min,f}} = -0.1024746 \) at \( \varphi =0\% \) and \( \varphi =10\% \) when the Richardson number (\( \text{Ri} = 0.05 \)) . When the solid volume fraction increases, the circulation
intensity decreases as a result of small energy transport through the flow related with the low movement of the nanoparticles. The high quantities of nanoparticles volume fraction cause a significant increase in the fluid viscosity and as a result causes the velocity to be decrease. From the other hand, when the Richardson number increases from Ri = 0.05 and 10 to Ri = 100, the effect of buoyancy forces becomes more dominant which causes the circulation vortex to become more stronger and extends deeply inside the inclined cavity. While, when the Richardson number is low, the effect of the lid-driven is dominant and the streamlines are greatly concentrated to each other. In this case the flow is driven by the forced convection mechanism. Moreover, for low values of Richardson number (Ri = 0.05), the existence of the heat source has no clear effect on the streamlines. Also, it can be observed that the isotherms are accumulated adjacent to some part in the left inclined sidewall of the enclosure where the heat source exists. Furthermore, it can be noticed, that as the Richardson number increases from Ri = 0.05 and 10 to Ri = 100, the isotherms begin to distribute uniformly parallel to the cold top and bottom walls and approximately take the horizontal shape in the center of the inclined enclosure indicating that convection is the dominant mechanism for heat transfer in the cavity. While, the distribution of the isotherms are considered random and confuse inside the inclined enclosure when the Richardson number is low. Moreover, it can be observed from the figure that the temperature distribution for both base fluid and nano fluid increase with increasing the Richardson number and their maximum values increase from \( \theta_{\text{max,of}} = 0.2308517, \theta_{\text{max,f}} = 0.2867012 \) when \( \text{Ri} = 0.05 \) to \( \theta_{\text{max,of}} = 0.4185633, \theta_{\text{max,f}} = 0.5444783 \) when \( \text{Ri} = 100 \). This behavior is due to the strong effect of convection when the Richardson number increases. From the other side, the addition of nanofluid to the base fluid leads to reduce the temperature distribution and this reduction increases as the solid volume fraction range increases. Since as the solid volume fraction increases, less heat is transferred into the system and thus the temperature of the entire enclosure decreases. Also, Figs.2 and 3 illustrate the effect of the enclosure inclination angle on the streamlines and isotherms contour when the enclosure inclination angles are taken as 30° and 90° respectively. It can be observed that as the inclination angle increases, the vortex exhibits more clear extension inside the inclined cavity and occupies most of the cavity zone. When the inclination angle reaches to 90°, the vortex begins to separate into two rotating vortices and rotates with a slow rate. From the other hand, no important effect of increasing the enclosure inclination angle can be noticed on the isotherms contour. Fig. 4 explains the profiles of the local Nusselt number along the heat source with the variations of the inclination angle when the Richardson number (Ri = 10), \( A=2 \) and \( \phi = 10 \% \). It can be observed that as the inclination angle increases, the local Nusselt number along the heat source decreases due to the reduced value of velocity. This is due to the weak effect of natural convection heat transfer due to slight effect of buoyancy force while the forced convection heat transfer contribution is significant. Therefore, the cavity inclination angle can be used as a control parameter for fluid flow and heat transfer. Fig.5 demonstrates the profiles of the local Nusselt number along the heat source with the variations of the Richardson number when the enclosure inclination angle (Φ) is 30° and aspect ratio (A = 2). The local Nusselt number along the heat source decreases with addition of nanoparticles (\( \phi = 10 \% \)) compared with base fluid (\( \phi = 0 \% \)). This is due to the increase of the thermal boundary layer
thickness, since it increases rapidly with increasing the volume fraction of nanoparticles. This rapid increase causes to reduce the velocity which leads as a result to reduce the thermal energy transport through the fluid. Therefore, the temperature gradient at the heat source position has a slight effect and causes a reduction in the local Nusselt number values.

5. Conclusions

The following conclusions can be drawn from the results of the present work.

1. The existence of a heat source at the inclined left sidewall of the enclosure causes the vortex to extend vertically.

2. Increasing the solid volume fraction decreases the circulation intensity of the flow and reduces the stream function values.

3. The circulation vortex size increases and extends to the central region of the enclosure when the Richardson number increases.

4. When the Richardson number increases, the isotherms are accumulated near the heat source position and it changes their shape from the random and irregular distribution to approximately uniform distribution.

5. By adding the nanofluid to the base fluid, a clear reduction in the temperature distribution can be detected.

6. The local Nusselt number along the heat source decreases as the enclosure inclination angle increases and the opposite is valid.

7. The local Nusselt number along the heat source decreases with addition of nanoparticles compared with base fluid.

8. No significant effect is noticed in the isotherms when the enclosure inclination angle increases.

References


**Nomenclature**

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<tbody>
<tr>
<td>A</td>
<td>The enclosure aspect ratio which is represented by A = w / H</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>Dimensionless length of the heat source (b / H)</td>
<td></td>
</tr>
<tr>
<td>c_p</td>
<td>Specific heat at constant pressure</td>
<td>J / kg. °C</td>
</tr>
<tr>
<td>D</td>
<td>Dimensionless distance of heat source from the bottom wall (d / H)</td>
<td></td>
</tr>
<tr>
<td>Gr</td>
<td>Grashof number</td>
<td></td>
</tr>
<tr>
<td>g</td>
<td>Gravitational acceleration</td>
<td>m/s²</td>
</tr>
<tr>
<td>H</td>
<td>Height of the enclosure</td>
<td>m</td>
</tr>
<tr>
<td>k</td>
<td>Thermal conductivity</td>
<td>W / m. °C</td>
</tr>
<tr>
<td>Nu_av</td>
<td>Average Nusselt number</td>
<td></td>
</tr>
<tr>
<td>Nu_s</td>
<td>Local Nusselt number</td>
<td></td>
</tr>
<tr>
<td>Pr</td>
<td>Prandtl number</td>
<td></td>
</tr>
<tr>
<td>q</td>
<td>Heat generation per unit area</td>
<td>W/m²</td>
</tr>
<tr>
<td>Re</td>
<td>Reynolds number</td>
<td></td>
</tr>
<tr>
<td>Ri</td>
<td>Richardson number</td>
<td></td>
</tr>
<tr>
<td>T</td>
<td>Temperature</td>
<td>°C</td>
</tr>
<tr>
<td>U</td>
<td>Dimensionless velocity component in x-direction</td>
<td></td>
</tr>
<tr>
<td>U_p</td>
<td>Uniform lid-driven velocity of the moving top wall</td>
<td>m/s</td>
</tr>
<tr>
<td>u</td>
<td>Velocity component in x-direction</td>
<td>m/s</td>
</tr>
<tr>
<td>V</td>
<td>Dimensionless velocity component in y-direction</td>
<td></td>
</tr>
<tr>
<td>v</td>
<td>Velocity component in y-direction</td>
<td>m/s</td>
</tr>
<tr>
<td>w</td>
<td>Width of the enclosure</td>
<td>m</td>
</tr>
<tr>
<td>X</td>
<td>Dimensionless Coordinate in horizontal direction</td>
<td></td>
</tr>
<tr>
<td>x</td>
<td>Cartesian coordinate in horizontal direction</td>
<td>m</td>
</tr>
<tr>
<td>Y</td>
<td>Dimensionless Coordinate in vertical direction</td>
<td></td>
</tr>
<tr>
<td>y</td>
<td>Cartesian coordinate in vertical direction</td>
<td>m</td>
</tr>
</tbody>
</table>

**Greek Symbols**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>α</td>
<td>Thermal diffusivity</td>
<td>m²/s</td>
</tr>
<tr>
<td>β</td>
<td>Coefficient of thermal expansion</td>
<td>K⁻¹</td>
</tr>
<tr>
<td>θ</td>
<td>Dimensionless temperature</td>
<td></td>
</tr>
</tbody>
</table>
**Nomenclature Continued**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Definition</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>ΔT ΔT</td>
<td>Reference temperature difference</td>
<td></td>
</tr>
<tr>
<td>Ψ</td>
<td>Dimensional stream function</td>
<td>m²/s</td>
</tr>
<tr>
<td>Ψ′ Ψ′</td>
<td>Dimensionless stream function</td>
<td></td>
</tr>
<tr>
<td>ω</td>
<td>Dimensional vorticity</td>
<td>1/sec</td>
</tr>
<tr>
<td>Ω</td>
<td>Dimensionless vorticity</td>
<td></td>
</tr>
<tr>
<td>Φ Φ</td>
<td>Enclosure inclination angle</td>
<td>degree</td>
</tr>
<tr>
<td>φ</td>
<td>Volume fraction of nanofluid</td>
<td></td>
</tr>
<tr>
<td>ν</td>
<td>Kinematic viscosity of the fluid</td>
<td>m²/s</td>
</tr>
<tr>
<td>ρ</td>
<td>Density</td>
<td>kg/m³</td>
</tr>
</tbody>
</table>

**Subscripts**

- **c**: Cold
- **f**: Fluid
- **nf**: Nano fluid particle
- **s**: Heat source surface
Fic. 1 schematic of the enclosure

Table 1 Thermo-physical measured properties of water and copper nanoparticles

( Hussein et al. [17]).

<table>
<thead>
<tr>
<th>Property</th>
<th>Pure water</th>
<th>Copper (Cu)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\rho (\text{kgm}^{-3})$</td>
<td>997.1</td>
<td>8933</td>
</tr>
<tr>
<td>$C_p (\text{Jkg}^{-1}\text{K}^{-1})$</td>
<td>4179</td>
<td>385</td>
</tr>
<tr>
<td>$k (\text{Wm}^{-1}\text{K}^{-1})$</td>
<td>0.613</td>
<td>401</td>
</tr>
<tr>
<td>$\beta (\text{K}^{-1})$</td>
<td>$21 \times 10^{-5}$</td>
<td>$1.67 \times 10^{-5}$</td>
</tr>
</tbody>
</table>
Table 2 Grid independency study for Cu-water nanofluid ($A = 1, B = 0.4, D = 0.5$
$Ri = 1, \phi = 0^0, \varphi = 10\%$)

<table>
<thead>
<tr>
<th>Grid</th>
<th>$\psi_{max}$</th>
<th>$Nu_{av}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>31x31</td>
<td>-0.1019090</td>
<td>7.097252</td>
</tr>
<tr>
<td>41x41</td>
<td>-0.1018446</td>
<td>7.115013</td>
</tr>
<tr>
<td>61x61</td>
<td>-0.1017011</td>
<td>7.140493</td>
</tr>
<tr>
<td>81x81</td>
<td>-0.1015776</td>
<td>7.140493</td>
</tr>
<tr>
<td>101x101</td>
<td>-0.1013410</td>
<td>7.140493</td>
</tr>
</tbody>
</table>

Table 3 Comparisons of $Nu_{av}$ for Cu-water nanofluid with another published works
($\varphi = 10\%, B = 0.4, D = 0.5, Ra = 10^3$).

<table>
<thead>
<tr>
<th>Work</th>
<th>$Nu_{av}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mansour et al. [18]</td>
<td>5.459225</td>
</tr>
<tr>
<td>Present study</td>
<td>5.459225</td>
</tr>
</tbody>
</table>
\[ \psi_{\min, nf} = -0.1032725, \psi_{\min, f} = -0.1024538. \]
\[ \theta_{\max, nf} = 0.2318571, \theta_{\max, f} = 0.2895406. \]

\[ \psi_{\min, nf} = -0.1028613, \psi_{\min, f} = -0.0998961. \]
\[ \theta_{\max, nf} = 0.3988945, \theta_{\max, f} = 0.518526. \]

\[ \psi_{\min, nf} = -0.1027432, \psi_{\min, f} = -0.1070041 \]
\[ \theta_{\max, nf} = 0.4205886, \theta_{\max, f} = 0.5522865. \]

Fig. 2 streamlines and isotherms contours for various values for Cu-water nanofluid at \( \varphi = 0\% \) (solid), \( \varphi = 10\% \) (dash) and \( \phi = \pi/6 \). Increasing from top towards bottom.
ψ_{min,nf} = -0.1031985, \psi_{min,f} = -0.1023384.
θ_{max,nf} = 0.2354761, \theta_{max,f} = 0.2982305

ψ_{min,nf} = -0.0973557, \psi_{min,f} = -0.095029
ψ_{max,nf} = 0, \psi_{max,f} = 2.51E - 005
θ_{max,nf} = 0.4056342, \theta_{max,f} = 0.5312343.

ψ_{min,nf} = -0.0877071, \psi_{min,f} = -0.0787396.
ψ_{max,nf} = 0.0017282, \psi_{max,f} = 0.0159315.
θ_{max,nf} = 0.4234517, \theta_{max,f} = 0.5638728.

Fig. 3 streamlines and isotherms contours for various Ri = 0.05, 10, 100 values for Cu-water nanofluid at ϕ = 0% (solid), ϕ = 10% (dash) and ϕ = π / 2 . Increasing from top towards bottom.
Fig. 4 profiles of the local Nusselt number along the heat source with the variations of the inclination angle.

Fig. 5. profiles of the local Nusselt number along the heat source for variations of Richardson number.
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Sciences’ Applications, ICESA
24-25 December / 2014