MARATHA VIDYA PRASARAK SAMAJ'S

KARMAVEER ADV. BABURAO GANPATRAO THAKARE COLLEGE OF ENGINEERING

DEPARTMENT OF MECHANICAL ENGINEERING

Presents

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Institute Vision

To be internationally accredited, Multidisciplinary, and Multi-collaborative institute working on technology enabled platform fostering innovations and patents through state-of-art academic system designed by highly qualified faculty for the development of common masses at large

Institute Mission

To educate and train common masses through undergraduate, post graduate, research programs by inculcating the values for discipline, quality, transparency and foster career and professional development for employment thereby contributing to the development of society

Department Vision

To be the centre for excellence and centre of learning for innovation, incubation and research in the domain of product design, thermal engineering and manufacturing technology thereby path finder for professionalism, entrepreneurship and new knowledge contributing to the common masses.

Department Mission

To educate and train undergraduate and post graduate students in Mechanical Engineering by inculcating the values for discipline, quality and transparency and profession development in the job and self-employment emphasis industry-based practices.

Program Education Objectives (PEO's)

PEO1: To prepare technocrats that can satisfy the need of mechanical and allied industries.

PEO2: To develop critical thinking, problem solving skills, research aptitude and career and professionalism among the students.

PEO3: To improve and expand technical and professional skills of students through effective teaching-learning and industry interaction.

Program Specific Outcomes (PSOs)

PSO1: Ability to design, analysis and problem-solving skills using basic principle of mechanical engineering.

PSO2: Ability to impart technical and professional skills through industry institute interaction

PSO3: Develop practical skills for the benefits of society.

Objectives of Magazine

1. Primary objective of the magazine is to provide a wide platform to the aspiring engineers to showcase their technical knowledge and to explore innovative ideas.
2. This magazine is intended to bring out the hidden literary talents in the students and teachers to inculcate strong technical skills among them.

Investigations on surface modification of journal shaft in three roller motorized system

This investigation focuses on reducing wear in journal bearings of roller mills used in the sugar industry. Roller mills experience high load conditions and abrasive wear during operation, so surface modification techniques were employed to extend the lifespan of the journals, which are critical components of the system. This study demonstrates the effectiveness of electric arc welding in reducing wear on journal bearings in high-load, abrasive environments, offering a potential solution for enhancing the durability of sugar mill roller systems.

Introduction

Abrasive wear occurs when a hard, rough surface slides over a softer one, producing grooves on the latter. It also can be caused by loose, abrasive particles rolling between two sliding surfaces or by particles embedded in one of the opposing surfaces.

Many common machine components such as shafts, bearings, gears and couplings are subjected to abrasive wear. In sugar industry, the roller mill is used for crushing the sugar cane. The roller mill is having rotating shafts and journal bearing working at high load conditions. Thus the roller shaft and bearing are subjected to abrasive wear. As a combine effect of cyclic loading and wear of materials increases stress concentration at the journal and results in its failure. The survey of Indian sugar industry reveals that the average service life of the shaft is around 10 years. During the survey of sugar mill, it was observed that spare shafts are used alternately at the place of failed shafts. Normally, sugar cane mill has been operated during three shifts for a season of 6 to 8 months in a year. Therefore, the journal shafts are used successfully for approximately 5-6 seasons. Also, it was noticed that some of the shafts even failed within one season due to manufacturing defects. To increase the service life of the component requires either design changes or surface modification to minimize the wear. There are various techniques such as metallographic examination of the failed component, material design and optimization, finite element analysis and non destructive test used by various researchers for failure analysis of roll shaft.

Many researchers [1-5] have investigated the wear, friction, lubrication and corrosion behavior of the journal shaft in the sugar industry. They have used different approaches to enhance the service life of the journal and bearing. Also, many researchers have investigated the effect of load on stress concentration, stress measurement and misalignment experimentally and using finite element analysis. It is reported that the estimation of stress in mill roller shaft under different operating conditions using experimental investigations and finite element techniques are in good agreement.

Many investigators [11-15] have adopted the fracture mechanics approach to determine the propagation of cracks in the sugar mill shaft materials. This approach has been used to predict the maximum defect size tolerated in a repaired shaft and to find out the inspections duration for non-destructive testing. The present research work is an extension of previous work [16] which was focused on the on the tribological behavior of sugar mill roller shaft material. It has been seen that initiation of cracks is due to the tribological phenomenon at the sliding interface. In the present work the wear behavior of journal and bearing at different operating conditions is carried out using three roller motorized system. Additionally, the surface modification technique namely, electric arc welding is used to reduce the wear journal shaft. Further, the SEM examination is carried out to understand the material removal mechanism due to wear at different conditions.

EXPERIMENTAL PROCEDURE AND DATA ANALYSIS

2.1 Three roller motorized system

 The top roller is powered by a 3 HP electric motor running at 1440 rpm, which is connected to a gearbox with a 1:30 gear ratio. This reduction in speed provides the necessary torque for crushing the sugarcane.

 The two lower rollers are driven by the top roller through an equal-sized spur gear arrangement. This ensures synchronized movement of all rollers.

 Power to the system is regulated via a control panel, which also provides real-time feedback from the monitoring instruments, particularly bearing temperature.

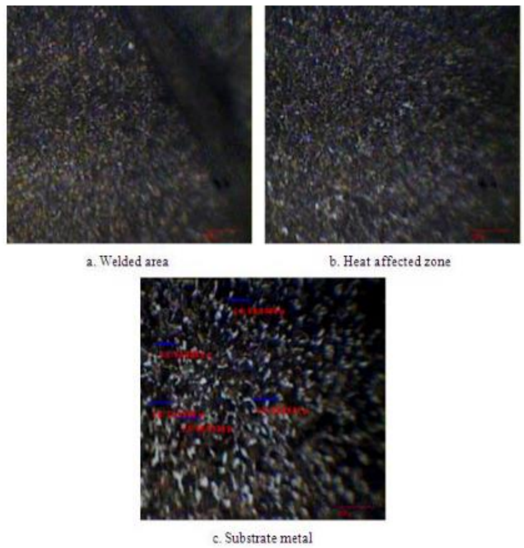
 The lubrication system maintains the required oil pressure within the journal bearings, helping to prevent overheating and reduce wear caused by friction under high load conditions.

Fig. 1: Experimental set up of three roller motorized system

2.2 Materials Used

The journal shaft in the study is made from EN8 steel, a medium-carbon steel known for its good tensile strength and machinability. This shaft is fitted into a phosphorous bronze journal bearing, which provides a low-friction interface between the rotating shaft and the bearing under high load conditions.

2.3 Metallographic analysis of welding Deposit



The samples were polished and etching was performed to reveal the microstructure. The microstructures of the welded area, heat affected zone and substrate material were examined by using metallurgical microscope (Make: Vardhan, Model Number: INBT-2).

The journal shaft on which the welding deposition was carried out by electrode 'A' was cut in cross direction and the sample was polished. Further the etching was performed and the microstructure of the welding material.deposited on the base metal is presented in above Fig.

2.4 Wear test methodology

1. Test Conditions

Untreated shafts (EN8) were tested in both lubricated and contaminated conditions.

Modified shafts (welded layers) were tested in contaminated lubricating oil conditions. The lubricant oil was intentionally contaminated with sugarcane juice, bagasse fine powder, and water droplets to simulate harsh operational environments in a sugar mill. Fresh lubricating oil (SM85) was used for the lubricated condition tests.

2. Operating Parameters:

The three-roller motorized system was operated continuously for 6 hours at a load of 14.43 kN with an oil feed pressure of 50 kg/cm². The system speed was maintained at 48 rpm, corresponding to a surface speed of 113.1 mm/sec, with a bearing pressure of 7.20 N/mm². Tests were conducted under ambient temperatures of 30-35°C and 40-60% relative humidity.

3. Measurements and Data Collection:

- A torque wrench (PROTOOL PTW-50) with a capacity of 14 Nm–68 Nm was used to apply torque to the fasteners, ensuring consistent loading of the bearing assembly.
- RTD probes were inserted into the bearings to monitor the bearing temperature during operation, and the temperature was recorded every 15 minutes.
- The two-wattmeter method was used to measure power consumption, both under no load and during the sugarcane crushing process. Wattmeter readings were taken every 15 minutes during the crushing process.
- Before assembling the journal shaft into the roller system, the diameter of the shaft was measured at five different locations using a Vernier caliper. This process was repeated after the test to quantify the wear by comparing the shaft diameter before and after testing.

2.5 Results and Discussion

 The untreated journal surface showed the highest wear under contaminated conditions, with significant damage due to three-body abrasion from bagasse particles.

 Journals treated with welding electrodes 'A' and 'B' significantly reduced wear, with the journal treated with electrode 'A' showing superior performance in terms of thickness loss, hardness, and service life improvement.

 The treated journals also showed improved resistance to cracking and plastic deformation, enhancing the overall durability of the sugar mill roller shaft in contaminated operating conditions.

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Fault Diagnosis of Rotating Machinery based on the Minutiae Algorithm

The paper introduces the **Minutiae algorithm**, which is commonly used in image processing for **feature extraction**. In the context of this paper, the algorithm is applied to **frequency domain data** of machinery faults. By converting fault signals into a visual representation (likely through methods like recurrence plots), the minutiae algorithm helps extract key features from these images to classify the faults

Introduction

The use of machine learning techniques like SVM, ANNs, and kNN for fault diagnosis in rotating machinery is indeed an exciting area of research. The various methods, such as FFT of IMFs from Hilbert-Huang Transform and the integration of Genetic Algorithms for parameter optimization, demonstrate how complex systems can benefit from advanced signal processing and optimization approaches. Likewise, deep learning models like CNNs, LSTM, and BLSTM are increasingly valuable for analyzing time-series data, as seen in applications like wind turbine gearbox health monitoring.

The Minutiae algorithm for defect characteristic extraction sounds particularly promising for fault classification, offering high resilience and accuracy. By comparing the extracted features with fault signatures, the algorithm can help identify both the type and severity of faults. It's impressive how these advanced techniques continue to evolve, improving the precision and efficiency of fault diagnosis across various domains.

Methodology

Experimental Setup

 Shaft Specifications: The shaft has a 25 mm diameter and a length of 700 mm, supported by two double-row deep groove ball bearings (SKF1205).

 Rotor Disc: At the midpoint of the bearings, a 130 mm-diameter, 18 mm-thick rotor disc is mounted. The disc has eight evenly distributed 12 mm diameter holes, each with a 45 mm radius, allowing for unbalance to be introduced by adding weight.

 Motor and Drive System: A 1 hp DC motor drives the rotor, with a DC controller regulating its speed. The rotor shaft is connected to the motor shaft using a rigid flange coupling.

Fig: FFT Analyzer

 The use of **multiple fault conditions** and the collection of vibration signals in three directions (Horizontal, Vertical, and Axial) enhances the robustness of the experimental setup.

 The **FFT analysis** helps in identifying characteristic frequency peaks corresponding to different fault types, which can be crucial for developing classification models based on vibration data.

 The **data acquisition parameters** are well-defined, ensuring that the collected signals cover a broad frequency range (10 Hz - 1600 Hz) and are of high enough resolution for effective analysis.

B. The Minutiae Algorithm

he Minutiae algorithm, when adapted to machinery fault diagnosis, serves as a powerful tool for analyzing machine performance data and identifying faults in real-time, enabling predictive maintenance. Here's a breakdown of the methodology and how it integrates with graph-based analysis and image processing techniques:

Minutiae Algorithm for Fault Diagnosis:

Steps of the Fault Diagnostic System:

1. Represent the Mechanical System as a Graph:

   ○ The mechanical system is modeled as a graph, where each node represents a component (e.g., gears, bearings), and each edge represents interactions or connections between components. This representation helps visualize the system's structure and its potential failure points.

2. Define the Rotating Faults to Be Detected:

   ○ Common rotating machinery faults include misaligned gears, bearing failures, unbalanced loads, or irregular vibrations. These faults can be defined as patterns in the graph that correspond to specific behaviors or anomalies in the system's performance.

3. Extract Features from the Graph:

   ○ Graph analysis techniques are used to extract features that describe the graph's structure and behavior. Features such as:

- Node degree: How many connections a node has.
- Betweenness centrality: The importance of a node based on its position in the graph.
- Clustering coefficient: Measures how connected a node's neighbors are.

o These features capture various aspects of the system's structure and dynamics, which are critical for fault detection.

4. Application of the Minutiae Algorithm:

o The Minutiae algorithm compares the extracted features from the graph at different time points to identify subtle, unique features that indicate faults. These "minutiae" (small, distinctive features) serve as indicators of abnormalities in the system that may be too small or subtle for traditional methods to detect.

5. Train a Machine Learning Model:

o The identified features from the graph are used as inputs to train a machine learning model (e.g., SVM, neural networks). The model is trained on labeled data, which includes examples of both normal and faulty system states.

o Once trained, the model can automatically detect faults in new, unseen data, providing predictive maintenance insights based on real-time sensor data.

Results and Discussion

The results of the experiment demonstrate the effectiveness and high performance of the proposed fault diagnosis system using Minutiae algorithms for rotating machinery. The classification accuracy for the different fault types provides compelling evidence of the system's ability to accurately identify and diagnose faults in machinery.

The **Minutiae algorithm**-based fault diagnosis system is highly effective in detecting and classifying faults in rotating machinery, with **exceptional accuracy** across multiple fault types. The high classification performance and ability to detect subtle fault features make the system a strong candidate for real-world applications in **predictive maintenance**. By enabling early detection of faults, the system helps reduce **downtime**, **maintenance costs**, and the likelihood of catastrophic equipment failures. This makes it a valuable tool for ensuring the **reliability** and **efficiency** of critical machinery in industrial settings.

Conclusion

he Minutiae algorithm-based fault diagnosis system using image recognition represents a powerful and adaptable solution for rotating machinery monitoring. By leveraging automatic image feature extraction and interest point identification, the system can accurately classify faults while maintaining robustness and generalization across different machine types and fault scenarios. This approach enhances the reliability and efficiency of predictive maintenance systems, providing a proactive solution to machinery health monitoring, reducing operational disruptions, and minimizing maintenance costs.

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A comprehensive review on passive heat transfer augmentation techniques for pipe heat exchangers

This paper provides a **comprehensive review** of passive heat transfer augmentation techniques, which are crucial for enhancing the efficiency and performance of thermal systems. The review covers a wide range of techniques that rely on the **intrinsic properties** of working fluids and **geometrical configurations** to improve heat transfer, without the need for external energy input.

Introduction

1. **Active Methods**

Active methods rely on external power input to improve heat transfer. These techniques require mechanical, electrical, or other forms of energy to induce enhancements. Common active methods include:

- Surface Vibration: Vibrating surfaces can disturb the boundary layer, promoting mixing and increasing heat transfer.
- Fluid Vibration: Applying external vibrations to the fluid can disrupt the thermal boundary layer and enhance heat transfer.
- Electrostatic Fields: Electromagnetic forces can manipulate the flow of charged particles in the fluid, increasing turbulence and heat transfer.
- Mechanical Aids: Devices such as fans or pumps can be used to increase fluid movement and heat transfer.
- Suction or Injection: Introducing additional fluids (e.g., air or another liquid) can improve heat exchange by disturbing flow and enhancing mixing.
- Jet Impingement: Directing fluid jets onto a heated surface can significantly increase heat transfer by enhancing local turbulence and fluid mixing.

These methods typically require external power and may lead to higher operational costs due to increased energy consumption.

2. **Passive Methods**

Passive methods, on the other hand, do not require any external power input. They work by modifying the flow conditions or the surface characteristics of heat transfer devices. Common passive methods include:

(1) Treated Surfaces

Surface modifications can significantly improve heat transfer by changing the surface texture or coating. These changes can be continuous or discontinuous and are particularly useful for boiling and condensation applications.

(2) Rough Surfaces

Surface roughness enhances heat transfer by increasing turbulence in the flow. This is commonly used in single-phase flows and does not necessarily increase the surface area but disrupts the boundary layer, promoting convective heat transfer.

(3) Extended Surfaces (Fins)

Fins and extended surfaces increase the surface area available for heat exchange. Additionally, the presence of these surfaces disturbs the flow field, which can further enhance heat transfer. This method is widely used in heat exchangers and cooling systems.

(4) Displaced Enhancement Devices

These devices are designed to move fluid from the heated or cooled surface to the core of the flow. This mixing action can improve heat transfer by increasing fluid contact with the surface and promoting more uniform temperature distributions. These are especially effective in confined forced convection systems.

(5) Swirl Flow Devices

Swirl flow devices, such as twisted tapes and helical screw tapes, generate secondary flows (swirl) that enhance turbulence in the fluid. These devices are effective in both single-phase and two-phase heat exchangers, as they promote more efficient mixing and better thermal contact.

(6) Coiled Tubes

Coiled tubes create secondary flows and vortices, which can promote higher heat transfer rates in single-phase flows. Coiled tube designs are particularly useful in compact heat exchangers where space is limited but enhanced heat transfer is required.

(7) Surface Tension Devices

These devices are designed to improve boiling and condensation processes by altering the surface properties, such as wicking or grooving, which can enhance phase change heat transfer. These are mainly used in applications involving phase transformation, such as in refrigeration or heat exchangers dealing with refrigerants.

(8) Additives for Liquids and Gases

Inserting additives (solid particles, trace soluble chemicals, or gas bubbles) into liquids or gases can improve heat transfer. For example, solid particles or gas bubbles reduce the surface tension in liquids, enhancing boiling heat transfer. In gaseous flows, adding suspended particles can reduce friction and increase the effective surface area for heat transfer.

3. Compound Methods

Compound methods involve combining two or more passive or active methods to leverage the advantages of different mechanisms. By integrating multiple techniques, compound methods aim to optimize heat transfer enhancement while minimizing the negative effects, such as pressure drop or energy consumption. Examples of compound methods include:

- **Rough Surface with Twisted Tapes**: Combining surface roughness (which increases turbulence) with twisted tapes (which generate swirl flow) can maximize the benefits of both methods.
- **Rough Surface with Fluid Vibration**: The combination of a rough surface and fluid vibration can lead to enhanced mixing and improved heat transfer.
- **Coiled Inserts with Twisted Tapes**: Coiling tubes to induce secondary flows and pairing them with twisted tapes to promote additional turbulence can create highly efficient heat transfer systems.

Passive Techniques

2.1 Twisted Tape Inserts:

Twisted tape inserts are widely used for enhancing heat transfer in tube flow systems. These inserts, made from metallic strips twisted into various shapes and configurations, enhance the heat transfer performance with relatively low pressure drop. The enhancement in heat transfer is achieved by increasing turbulence in the flow, which disrupts the boundary layer near the tube wall. Important parameters that affect performance include: **Pitch:** Distance between two twists along the axis of the tape. **Twist ratio:** Ratio of pitch to the inner diameter of the tube. Various studies are cited that investigate different modifications to twisted tapes, such as perforated tapes, V-cut tapes, and tapes with surface modifications.

2.2 Coiled Wire Inserts:

Coiled wire inserts are another simple yet effective passive heat transfer enhancement method. Coiled wires are inexpensive and easy to install and remove. Their applications include use in boiler preheaters and oil cooling devices. Coiled wires are particularly effective in low Reynolds number regimes, such as laminar flows, where they induce swirl and increase heat transfer without causing excessive pressure drops.

2.2 Swirl Generators:

Swirl generators are passive inserts that create a spiral flow in the fluid. This flow, characterized by a tangential or azimuthal velocity component, enhances heat transfer by increasing turbulence and disrupting the boundary layer near the tube walls. Swirl flows can be classified into: **Continuous swirl flows**: Where the swirl is maintained throughout the length of the tube. **Decaying swirl flows**: Where the swirl gradually diminishes along the length of the tube. The use of swirl generators helps to improve heat transfer by inducing flow patterns that enhance turbulence, leading to a higher convective heat transfer coefficient.

2.3 Conical Rings

 Investigation of Perforated Conical Rings:

- The research performed a numerical investigation to evaluate the flow friction and heat transfer for a heat exchanger tube fitted with perforated conical rings with circular holes.
- The study explored the effects of two main variables: the **diameter ratio of the perforated conical rings** and the **diameter ratio of the holes**.
- The analysis was conducted in the Reynolds number range of 4000 to 14000, and results were predicted using the **RNG k-ε turbulence model**.
- Key parameters studied included:
    - **Average Nusselt number** (a dimensionless measure of heat transfer performance).
    - **Friction factor** (a measure of flow resistance).
    - **Thermal performance factor** (a composite parameter that considers both heat transfer and pressure drop).

 Conical Turbulators in Flat Tube Heat Exchangers:

- The study by Chen et al. focused on the thermohydraulic performance of flat tube

Compound Techniques

The effects of winglet parameters on friction loss and thermal characteristics were examined using air as the working fluid. The investigation was conducted over a Reynolds number range of 5300 to 24000, which covers a broad spectrum of flow conditions, typically indicative of turbulent flow.

Conclusions

Passive heat transfer augmentation techniques offer great potential for improving thermal performance in a wide range of industries. These methods, by utilizing natural phenomena and modifying surfaces or flow conditions, can lead to more efficient, sustainable, and cost-effective thermal management solutions. However, challenges like scalability, material compatibility, and environmental dependencies need to be carefully addressed during design and implementation stages. Future research should focus on refining current techniques, exploring new strategies, and conducting more comprehensive experimental studies to unlock the full potential of passive heat transfer augmentation.

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Design of Solar-Powered Electric Two Wheeler Charging System

Abstract

The project focuses on addressing the growing need for sustainable solutions in the electric vehicle (EV) ecosystem, specifically in the context of India. The idea of creating an India-specific, solar-powered EV charging station aims to bridge the gap between increasing EV demand and the need for clean, renewable energy sources.

Introduction

- The Indian government is actively implementing reforms to electrify the transport sector, aiming to reduce the carbon footprint and promote sustainability.

- EV Growth in India: The Indian EV market is expected to grow at a rate of 44% annually between 2020 and 2027. This rapid growth, however, raises concerns about the ability of existing power infrastructure to handle the increased electricity demand.

Objectives

i. Reduce Carbon Emissions:- Mitigate greenhouse gas emissions and reduce air pollution by utilizing clean solar energy for EV charging, contributing to environmental sustainability.

ii. Enhance Energy Efficiency:- Improve the efficiency of the charging process by utilizing energy storage solutions, allowing for consistent and reliable charging even during non sunny periods.

iii. Expand Charging Infrastructure:- Increase the availability of EV charging points in various locations, such as urban areas, highways, and public parking lots, to ensure convenience for EV owners.

iv. Energy Independence:- Foster energy independence by generating electricity onsite, reducing reliance on non-renewable energy sources and centralized power grids.

v. Cost-Effective Charging:- Offer cost-effective charging options for EV owners, potentially reducing the overall cost of EV ownership compared to traditional gasoline vehicles.

Methodology

1. Procurement of Charging Infrastructure
2. Land Provision
3. Solar Panel Installation

4. Inverter and Battery Installation
5. Charging Infrastructure Setup
6. Safety Measures

Component Details

1. Solar Panels and EV Charging:

- Solar panels, also called photovoltaic (PV) panels, are devices that convert solar radiation into electrical energy. This energy can be used to power homes, businesses, or electric vehicles (EVs).
- EVs, which use direct current (DC) to charge their batteries, can be charged using solar panels, which also produce DC. In this case, inverters may not be necessary unless the charging system requires converting the solar energy into alternating current (AC).

2. Types of Solar Panels:

A. Polycrystalline Solar Panels:

B. Monocrystalline Solar Panels:

C. Thin-film Solar Panels:

3. Battery

4. DC to AC convertor

5. Charging Standard

6. PV Sizing

7. Testing and Commissioning
8. Performance Evaluation
9. Regular Assessment and Improvement

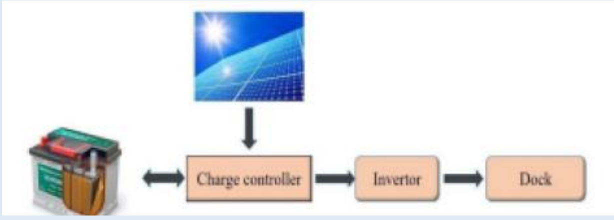

Fig: Block Diagram

CONCLUSION & FUTURE SCOPE

A solar powered two wheeler EV charging station for 1.2 kwhr (48V, 25A) battery of an EV bike is design in this project work and all the components with the design specification are installed and tested for the EV charging of a battery. Thus, this project addresses the growing need for sustainable transportation solution by harnessing solar energy to charge electric vehicle. This innovative initiative addresses the pressing need for clean transportation alternatives in urban areas such as charging system will offer convenient and environment friendly charging option for electric vehicle owners supporting the city transition towards greener and sustainable future.

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Numerical investigation of thermal performance of brine-copper oxide nanofluids using DPM

Abstract

Low thermal conductivity is a major limitation in developing energy-efficient heat transfer fluids for industrial applications. Traditional fluids are less efficient than metals, making heat removal mechanisms less effective. Nanofluids, with suspended ultra-fine particles, can improve heat transfer by suspending metallic nanoparticles in conventional fluids. This approach, particularly in the HVAC industry, can enhance heat transfer. Numerical simulations of brine-based copper oxide nanofluids show a significant enhancement in heat transfer coefficients under laminar and turbulent regimes.

Introduction

Nanofluids are the dispersion of nanoparticles in base fluids that can transmit heat more efficiently than conventional fluids like water, minerals oil, and ethylene glycol. These nanoparticles can be metallic or nonmetallic and have enhanced heat characteristics, such as convective heat transfer coefficient, without significant alterations in physical and chemical properties. Their unique composition and structure make them highly advantageous for various applications, including microelectronics, fuel cells, pharmaceutical processes, hybrid-powered engines, engine cooling/vehicle thermal management, domestic refrigerators, chillers, heat exchangers, grinding, machining, and boiler flue gas temperature reduction.

Brine is a solution formed by dissolving a soluble substance in water, with water used as the secondary refrigerant for temperature applications above its freezing point of 0°C. Ethylene glycol is a colorless, practically odorless, low volatility, low-viscosity, hygroscopic liquid that is commonly used in heat-transfer applications and heating applications that temporarily may not be operated in freezing conditions. It is the most common antifreeze fluid for standard heating and cooling applications.

1.1. Problem statement

To validate brine-based Copper oxide, Zinc dioxide, Titanium oxide nanofluid for heat transfer enhancement using CFD software (ANSYS FLUENT)

1.3 Objective of Work

- To develop and validate the numerical model.
- To perform numerical simulation of laminar and turbulent forced convection heat transfer in an internal flow situation.
- To perform numerical analysis of brine based CuO, ZnO and TiO_2 nanofluid for HVAC applications.

Numerical Procedure

Computational fluid dynamics (CFD) is a numerical method used to solve and analyze fluid flow problems. It involves three components: the pre-processor, solver, and post-processor. The preprocessor processes input data, while the solver solves the flow equations. The post-processor interprets the solution in graphs, plots, and charts. FLUENT is used for both the solver and post-processor, with Microsoft Excel used for graphs and charts. The segregated solver in FLUENT provides three algorithms for pressure-velocity coupling: SIMPLE, SIMPLEC, and PISO. SIMPLE is chosen for all simulations due to its simplicity and consistency.

Numerical Model

1. Single Phase Model

The single-phase model of nanofluid uses differential equations to predict its properties, which depend on the volume fraction of particles, the properties of the base fluid, and the solid particles. The properties of nanofluid are temperature-dependent, and the model uses the Standard K epsilon Turbulence Model to address the fluctuating quantities in the velocity field. The model is derived from the exact equation but uses physical reasoning to obtain the transport equation for k.

In conclusion, the single-phase model of nanofluid uses differential equations to predict its properties, but there are no universal correlations that can accurately predict these properties for any combination of independent variables.

2. Numerical Grid

This investigation involves a 2.67 m long copper pipe with an inner diameter of 0.006 m and outer diameter of 0.008 m. The pipe is subjected to a constant wall temperature of 373 K and axial velocity and temperature profile for the inlet section. A two-dimensional (2D) axisymmetric geometry with a fine mesh near the tube wall is considered. The mesh has nodes and elements of 325801 and 320400.

Numerical Investigation

The numerical model is validated using water as a base fluid, with properties such as density, specific heat, thermal conductivity, dynamic viscosity, and outlet temperature. The simulation is performed at various Reynolds numbers (300,600,900,1200,1500,1800) to determine the velocities and outlet temperature. The heat transfer coefficient (h) and Nusselt number (Nu) are calculated using the numerical method and theoretical values. The average Nusselt number is 2.73, while the analytical solution has a value of 3.66. The numerical model's setup is considered acceptable, and these settings are used for subsequent simulations. The comparison shows a 25% deviation in the Nusselt number values.

5.1 Conclusion

In this study, a numerical investigation is carried out on the heat transfer performance and thermophysical properties characterizations of CuO nanofluids in the elongated pipe. Brine (30%EG/70 %DW) and Brine based CuO nanofluid are selected and their properties such as Heat Transfer Coefficient (h) and Nusselt Number with respect to their Reynolds number are examined. The major conclusions that can be drawn from this study are as follows:

• Considerable enhancement in heat transfer coefficient is found by adding nanoparticles to the base fluid.

• A good enhancement in heat transfer coefficient of the brine based nanofluids is found and heat transfer coefficient increased with the increase of the particles' concentrations. The maximum enhancement in Nusselt number is found about 45 % for brine (30 %EG/70 %DW) based nanofluid at 0.5 vol% loading of CuO nanoparticles.

5.2 Future Scope

• Different Metal Oxides instead of Copper Oxide such as titanium oxide, silicon dioxide, etc. can be used for investigation.

• Different concentration for ethylene glycol and water can be used for investigation.

• Different percentages of volume fractions of nanoparticles can be utilized for investigation so as to obtain more enhanced heat transfer coefficient.

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EDITORIAL TEAM