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Research Article

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A Simulation Study on Utilizing in Airbus380 fuel Tanks for Thrust and Fuel Efficiency

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Abstract

This paper explores the potential benefits of using nanofluids within the fuel system of an Airbus A380 to enhance engine thrust and reduce fuel consumption. By analyzing the Nusselt and Reynolds numbers, the study aims to understand the heat transfer and fluid dynamics that could lead to more efficient aircraft operation. The integration of nanotechnology in aviation fuel systems represents a promising frontier for improving aircraft performance. the nanoscale as a fluid whose particles are suspended between 1-100 nanometers and permanently in the particle. Adding nanoscale increases heat transfer. In this research used silicon carbide nanofluid (sic nanofluid) with a percentage of (1,2,3,4%) the base fluid (Jet A1) as well as thermal properties including Nusselt number and thermal conductivity coefficient and... It's been studied.

Keywords: Nanofluids, Heat Transfer, Airbus380, Fuel Tank, Reynolds Number

1. Introduction

the Airbus A380, a marvel of modern aviation, requires meticulous engineering to optimize its performance. The fuel management system, a critical component for the aircraft's operation, has been modeled using advanced simulation tools. This report investigates the application of nanofluids in the A380's fuel tank, focusing on the potential for improved heat transfer and fluid flow, which could lead to in engine thrust and decreased fuel consumption. The Airbus A380 is a double-deck, wide-body, four-engine jet airliner which has been in service since 2007. It is one of the largest passenger airliners in the world and has a complex fuel management system designed to optimize its range and efficiency. The integration of nanofluids into this system could potentially lead to improved heat transfer capabilities and reduced fuel consumption. The primary objectives of this study are to simulate the behavior of nanofluids within the fuel tank of an Airbus A380 and to investigate the potential benefits and challenges associated with their use. This includes analyzing the thermal conductivity, viscosity, and stability of nanofluids and their impact on fuel efficiency and aircraft performance. Nano fluids, a term first coined by choi in 1995 n the context of the Airbus A380, the simulation study focuses on the dynamic behavior of the fuel tanks, particularly in response to external forces and internal pressure changes [1]. This analysis is essential for understanding the tank's ability to withstand various flight conditions and potential impacts.Thrust efficiency is a key performance indicator for aircraft, as it directly affects the aircraft's ability to generate lift and thrust. The study also examines the relationship between thrust, weight, and wing loading, which are important factors in aircraft design and performance [2, 3]. Fuel efficiency is not only a matter of aircraft design but also has significant environmental implications. The study considers the impact of design choices on fuel consumption and the resulting carbon emissions, which are of great concern in the aviation industry [4, 5, 6]. The simulation study utilizes finite element models (FEMs) to analyze the behavior of the Airbus A380's fuel tanks and aircraft structures. These models are validated against prototype tests and other relevant data to ensure accuracy nanofluids, a term that suggests a fluid with controllable properties influenced by both the nanoparticles and the base fluid, have been a subject of interest for their potential applications in various industries, including aerospace [7].

These fluids are composed of a base liquid, such as water or ethylene glycol, combined with nanoscale particles, which can enhance the fluid's thermal and hydraulic properties [8]. Thrust in aviation is influenced by various factors, including air density, which affects the mass of airflow and, consequently, the engine's thrust. Understanding these factors is essential for optimizing engine performance and reducing consumption [9]. Nanofluids, when utilized in the fuel tank cooling system, can provide superior cooling performance due to their unique properties. These materials can be modeled and simulated using tools like ANSYS Fluent, allowing for the optimization of fuel tank cooling systems. The A380's fuel management system is already sophisticated, utilizing Model-Based Design for development and simulation [10]. This approach has been instrumental in reducing development time for subsequent aircraft like the A350. The system includes a parameterized plant model of the fuel system, which can be configured for various aircraft, and is supported by hardware-in-the-loop testing [11]. Thermodynamic analysis revealed that the use of nanofluids in the Airbus A380's fuel system could lead to a reduction in fluid friction entropy generation and thermal irreversibility. These reductions suggest that the use of nanofluids could result in a more environmentally friendly and operationally efficient fuel system, with lower emissions and improved fuel economy [12].

2 Fuel Tank of Airbus380

Fuel is primarily stored in the wings of the A380, with additional tanks in the horizontal stabilizer. The distribution system is designed to ensure efficient fuel supply to the engines and auxiliary power unit (APU), with tank pumps and a crossfeed system for engine isolation. The fuel is also utilized to operate actuators and cool electrical generators, showcasing the multifaceted role of the fuel system.The A380's fuel system comprises various components, including surge tanks that act as part of the fuel vent system, and manual refueling points on the wings. The system is equipped with gauges and sensors to monitor fuel levels, and the fuel is pressurized to prevent boiling and vacuum formation during flight. The control panel allows for pre-setting fuel levels during refueling, with automatic valves controlling the fuel flow.Refueling the A380 involves a controlled process where the outer tanks are filled first, followed by the inner and center tanks. Safety measures include a control panel for the operator to manage the refueling and prevent overfilling. In case of a pump failure, the fuel can be drawn from the tanks through suction valves, requiring a descent to a lower altitude to avoid fuel boiling. To ensure reliability, the fuel system features redundant tank pumps for each tank, powered by the main electrical system. In the event of an APU pump failure, the wing tank pumps can be activated to supply fuel. The system's design minimizes the risk of operational disruptions due to mechanical issues [13]. Figure1, illustrate schematic fuel tank of A380.

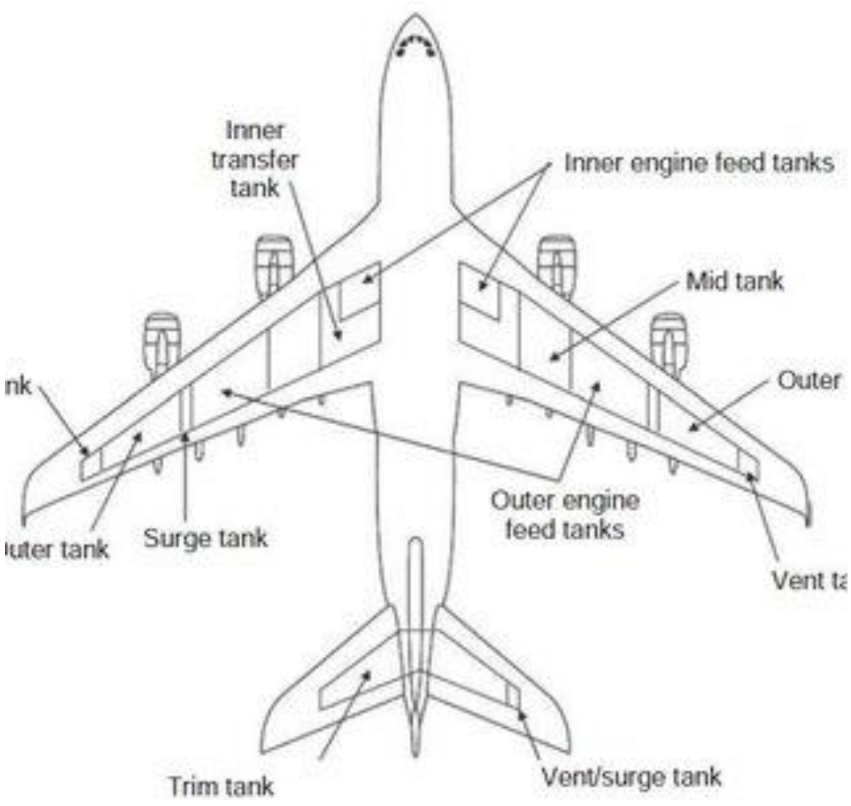

Figure 1: schematic of fuel tank

Classification of Nanofluid

In, nanoscale classification is determined by four factors: preparation, stability, thermophysical properties, and heat transfer. Nanoscale is categorized into metal nanoscale and non-metal nanoscale [14, 15]. In, Eastman et al. studied nanostructures at atomic and micro-scale levels, observing increased thermal conductivity, temperature- dependent effects, and heat flux. Critical metallic nanoparticles typically contain Fe, Si, Ni, Zn, Al, Cu, Au, Ti, and Ag, while non-metallic nanoparticles consist of aluminum oxide (Al_2O_3), copper oxide (CuO), and silicon carbide (TiO_2, ZnO, SiC). Additionally, metal semiconductors like TiO_2, carbon nanotubes including DWCNT, SWCNT, and MWCNT, and composite materials like polymer shell composites are considered nanoparticle nuclei as depicted in Figure2.

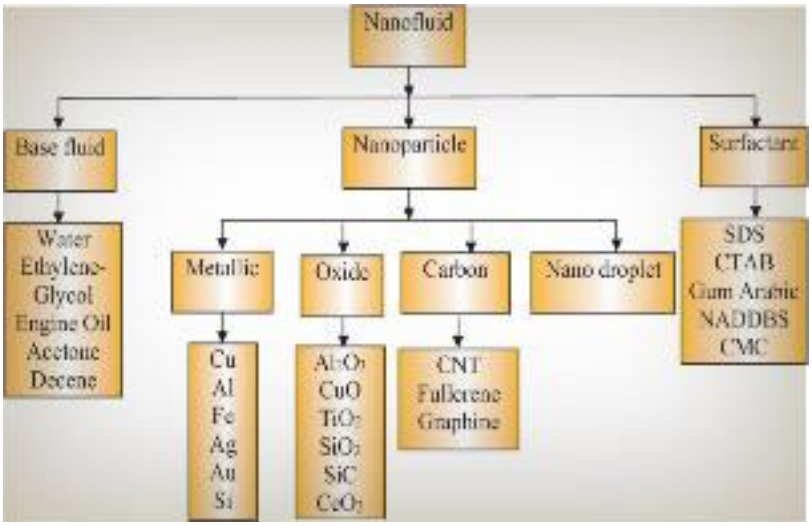

Figure 2: classification of nanofluid

4. Problem Formulation

dead Reynolds is the ratio of inertial forces to adhesive force. The Reynolds number is a dimensionless number utilized in the Classification of Fluid Systems, particularly when viscosity plays a crucial role in regulating the velocity or flow pattern of the fluid. This number helps in distinguishing between calm and turbulent flows; a Reynolds number less than or equal to 2100 signifies a calm flow, while a number greater than or equal to 2100 indicates turbulence. Reynolds number, initially introduced by Reynolds in 1883 to characterize the fluid transfer properties of particles moving within a fluid, holds significant importance.

$$LC = V\,body/A\,surface \quad (1)$$

The Nusselt number is a measure of the rate of heat transfer from displacement to conductive heat transfer. A Nusselt number close to 1 signifies that the conductive heat transfer and displacement are closely related. On the other hand, Nusselt numbers greater than 1 indicate a higher level of displacement heat transfer. The Nusselt number can be defined as the ratio of displacement heat transfer to thermal conductivity.

$$NU=hL/k \quad (2)$$

is defined as the characteristic length in this context. Consequently, when a specific quantity of Nusselt is present, the rise in thermal conductivity aligns with the increase in the heat transfer coefficient. In all the available correlations, if Nusselt is employed as a function of the Reynolds number, the outcomes suggest that:

$$h=k\,Nu/L \quad (3)$$

The value of h rises as k and the Nusselt number increase.

5. Methodology

Geometric figure was done with solidwor ks software and analysis was done by ansys-fluent and explain more about methodology in Figure3&4

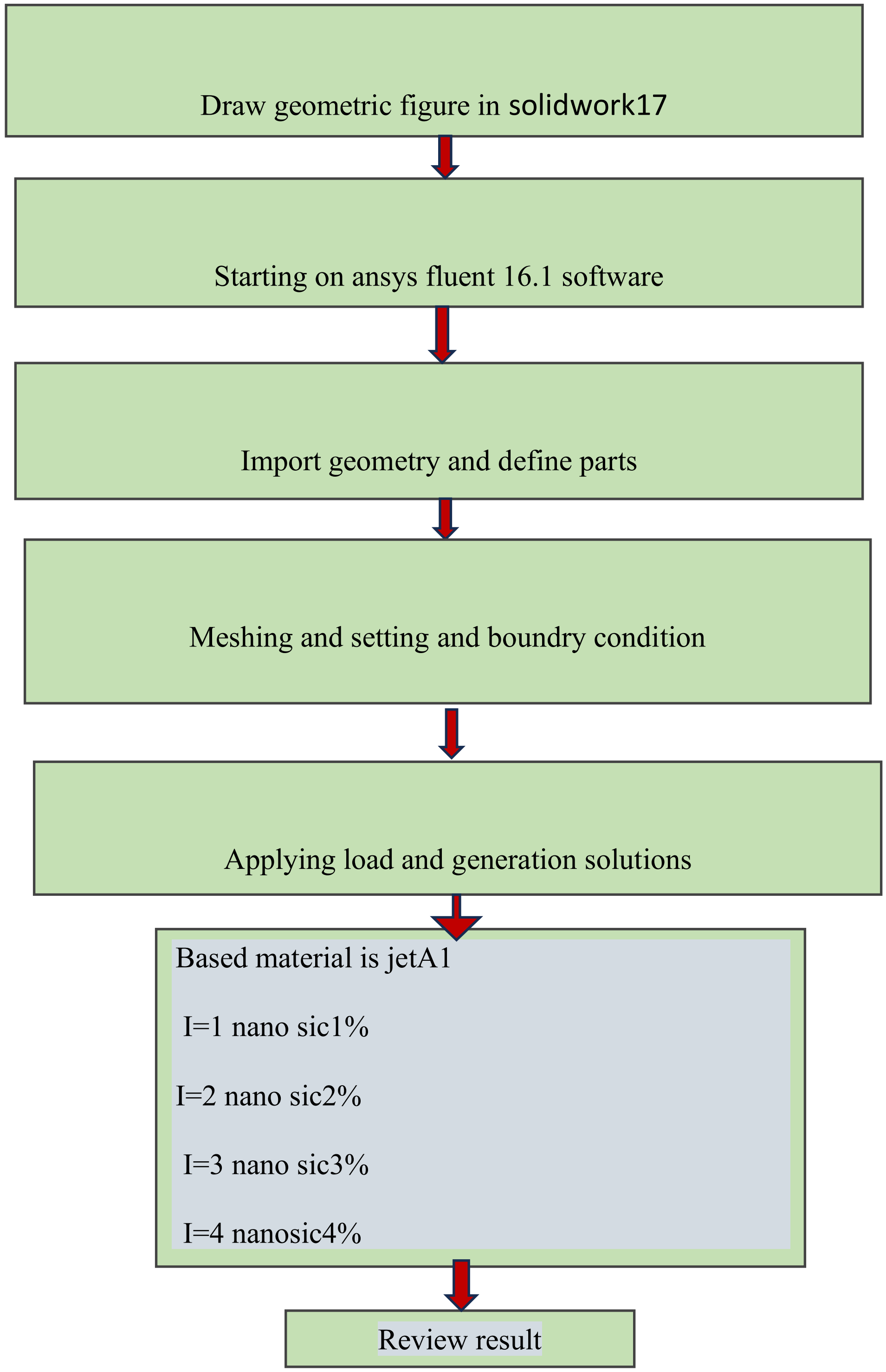

Figure 3: work flow schematic

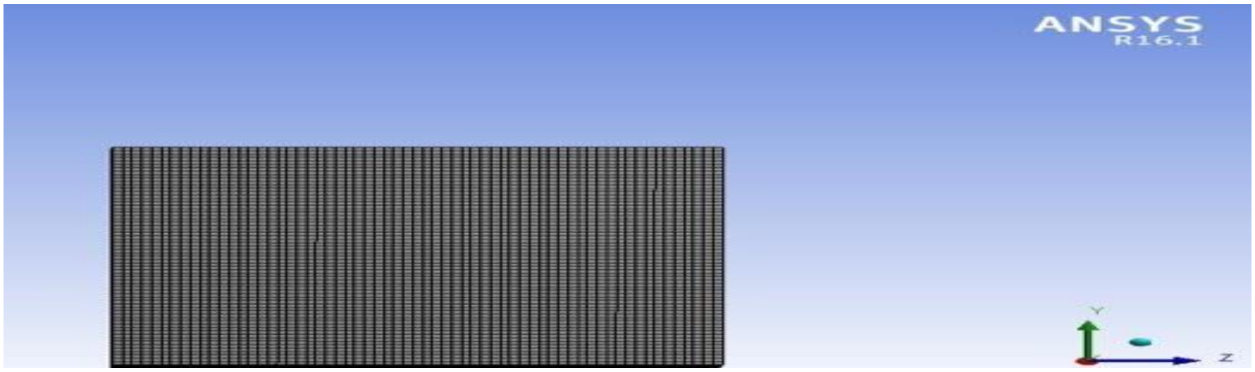

Figure 4: meshing of the computational domain

The temperature data was used to validate the meshing. The temperature was studied in three stages: coarse, medium, and fine meshing. The results are shown in Table 1

Mesh type	Number of elements	T1	T2
Coarse	343.956	303.24	328.13
Medium	6,612,923	303.24	328.15
Fine	1,216,996	303.24	328.15

Table 1: Information about grid independence test

5.1 Boundry Condition

Once the problem grid has been prepared, the next step is to handle the boundary conditions within the Fluent software. In order to successfully solve the problem at hand, it is crucial to define the appropriate boundary conditions in the Fluent software. These conditions can be referenced in Table2. It is important to highlight that the surface-to-surface model is employed for simulating heat transfer through thermal radiation. The equation governing this model and the limitations outlined in the Ansys software guide have been duly considered

Thermal flux	$1000(w/m^2)$
Inlet temperature	$30(c)$
Heat transfer coefficient	$9.89(w/m^2k)$
Speed of ethylene glycole	$30m/s$
Reinolds flow	$10 - 150$

Table 3: Data of pressure Boundry Condition

Convergence testing is a way of varying certain setup parameters to ensure accurate simulation result Convergence testing is a way of varying certain setup parameters to ensure accurate simulation results, Fig. 5 illustrate convergence result.

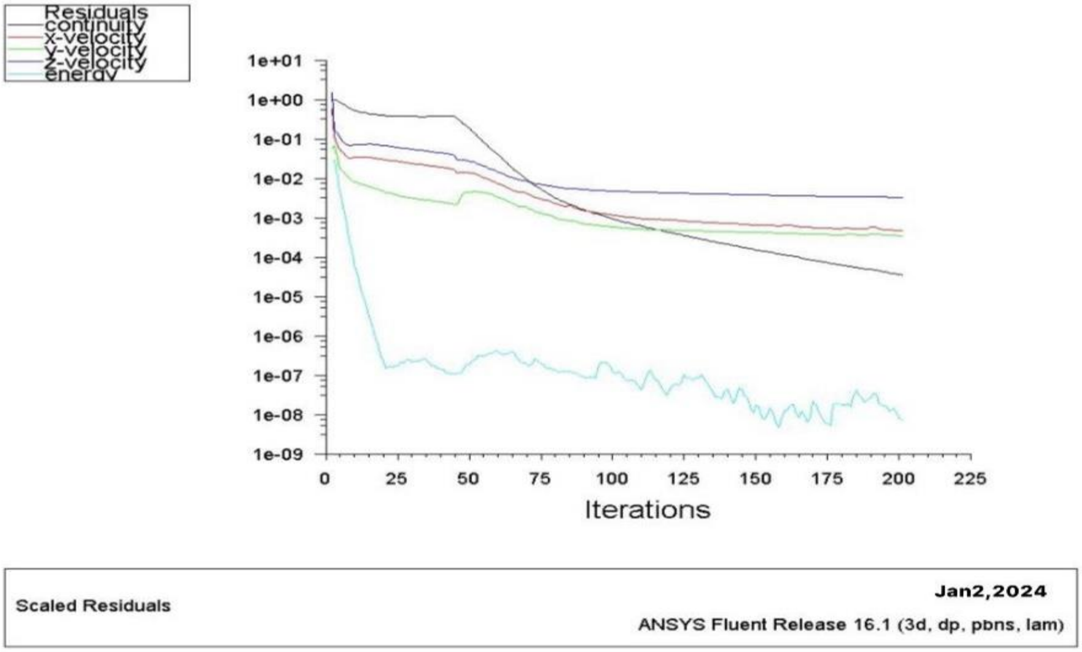

Figure 5: convergence results

6. Result and Discutssion

a. This diagram illustrates the Nusselt number in terms of Reynolds. The base fluid is jet A-1with the nanofluid SiC 1,2,3,4%. The Nusselt number and heat transfer coefficient increase with all volume concentrations of nanofluid.

• b. This Diagram show The result of the conductivity coefficient is presented in terms of temperature. 1, 2, 3, 4% nanofluid along with the base fluid with the volume of 30, 40, 50 nm has been investigated. As the temperature increases, the conductivity heat transfer coefficient increase • c. The result shows the heat transfer rate of 1, 2, 3, 4% nanofluid with base fluid, the heat transfer rate increases with the increase in volume concentration

• d. The heat transfer coefficient of goat is according to Reynolds. Nano silicon car- bide and base fluid jetA-1have been investigated. Increasing the volume concentration of nanofluid results in increasing the heat transfer coefficient. The temperature, Reynolds number and Nusselt number increased, and with the increase of Nusselt number, the heat transfer increased.

It should be noted that [8] was a great help in professionally doing the simulations

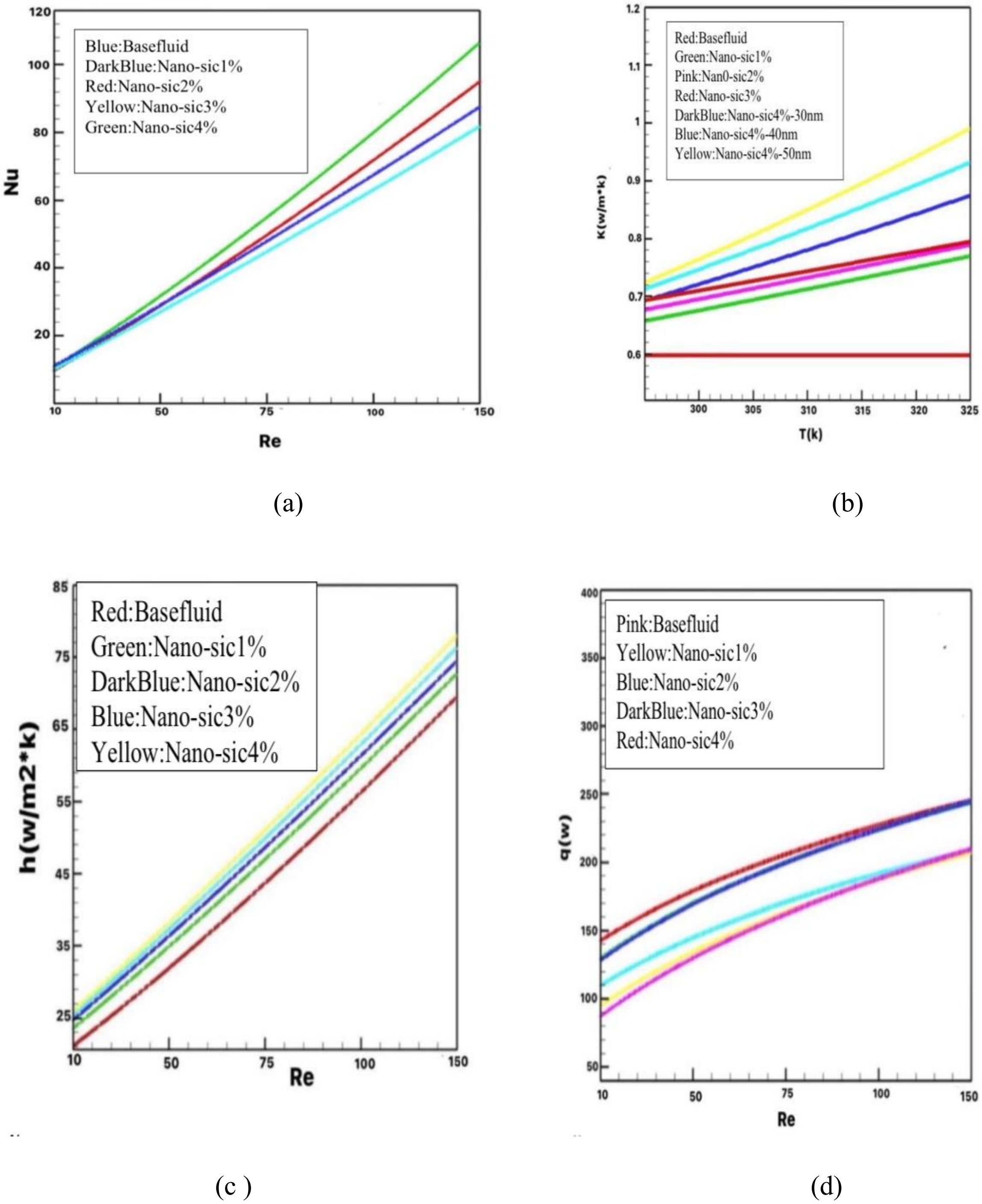

Figure 6: nanofluid result

7. Conclusion

As outlined above the simulation and investigation of nanofluids in the fuel tank of the Airbus A380 present an exciting frontier in aviation technology. The potential for improved thermal management, fuel efficiency, and emissions reduction aligns with the industry's goals of sustainability and performance. As research progresses, it will be essential to address the technical and economic challenges to fully realize the benefits of nanofluids in commercial aviation.The simulation has been done, nanofluids increase heat transfer, with increasing Reynolds number, Nusselt increases, with increasing Reynolds number, heat transfer coefficient and conductive heat transfer coefficient increase, and with increasing volume of nanofluid concentration, heat transfer also increases and this issue leads to increase thrust engine , decrease fuel consumption and increase safety [17, 18].

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