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Estimation of Dynamic Viscosity for Cobalt Oxide/Glycol Nano Fluid

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Authors' contributions

This work was carried out in collaboration between both authors. Author SAAE designed the study, wrote the literature, did the laboratory part (preparation, testing) and wrote the first draft of the manuscript. Author MSAE supervised and reviewed of the study. Both authors read and approved the final manuscript.

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ABSTRACT

In this study the effects due to temperature and shear rate on viscosity for Co_3O_4/glycol based Nano fluids at different concentration of metal oxide and different temperatures were experimentally investigated. The structure of the prepared Co_3O_4/glycol nanoparticles was confirmed using XRD (X-Ray Diffraction) technique. All viscosity measurements were conducted using a capillary viscometer, the viscosity experiment were carried out at wide temperatures ranging between 20°C and 80°C to determine their applicability in such range. The viscosity data were collected using a programmable rhemoter. The result showed that the Co_3O_4 glycol exhibit increasing viscosity with increasing nanoparticle loading and decreasing viscosity with increasing temperature.

Keywords: Dynamic viscosity; cobalt oxide; glycol; nanofluid; nanoparticle.

1. INTRODUCTION

Nano fluids are a novel type of fluid created by dispersing nanometer-sized materials (nanoparticles, nanofibers, nanotubes, nanowires, Nano rods, Nano sheet, or droplets) in a base fluid. Nano fluids, in other terms, are nanoscale colloidal solutions that include condensed nanomaterial. They are two-phase systems in which one phase (solid phase) is contained within the other (liquid phase) [1]. Nano fluids have been discovered to have better

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thermophysical properties than base fluids like oil or water, such as thermal conductivity, thermal diffusivity, viscosity, and convective heat transfer coefficients. It has shown to have a wide range of possible applications [2]. One of the significant characteristics that are highly practical in fluid mechanics and heat transfer systems is the dynamic viscosity which highly affects pressure drop and also has an influence on the heat transfer performance. Viscosity of Nano fluid is measured by Viscometer. A particular measuring device called Brookfield programmable viscometer was used for measuring viscosity of some particles Nano fluid, the viscometer drives a spindle immersed in test fluid [3]. When the spindle is rotated, the deflection of the calibrated spring measures the viscous drag of the fluid against the spindle. The viscosity of a liquid is a measurement of its resistance to flow. It is the shear stress to shear rate ratio. When the viscosity remains constant at different shear rates, the liquid is said to be Newtonian; when it varies as a function of shear rate, the liquid is said to be non-Newtonian [4]. Einstein [5] was the first to use the phenomenological hydrodynamic equations to compute the effective viscosity of a suspension of spherical solids, according to Garg, Poudel, Chiesa et al. [6] conducted an experiment to assess the viscosity of copper nanoparticles [7], and they found a significant increase in heat transmission, as well as the fact that friction plays a little role in the application process. Other researchers [8] have determined that the forced convection suffers from a systematic and obvious decrease of natural convective heat transfer, which is dependent on the solution concentration, particle density, and cylinder aspect ratio. Experimental investigation on Al_2O_3 nanofluids using water as base fluid has been studied by various research groups, and they concluded that the heat transfer coefficient in laminar flow [9–11] increases up to 12–15% and in the case of turbulent flow, it ranges up to 8% [12,13]. CNT, CuO, SiO, and TiO_2 nanofluids using water have been investigated [14–16]. CNT nanofluid produced findings that were similar to those of Al_2O_3 nanofluid. Ding et al. [17] came to the conclusion that changing the flow condition and fluid concentration could improve heat transmission. CuO, on the other hand, has been studied for a variety of wall boundary circumstances and has yielded promising results [18].

The objectives of the present paper was to estimate the dynamic viscosity for cobalt oxide/glycol nanofluid, before measuring the dynamic viscosity the prepared nanofluid and its particles was subjected to different tests to confirm its preparation.

2. MATERIALS AND METHODS

The metal oxides nanoparticles was prepared using sol-gel method. Firstly, the sodium alkoxides were prepared and react with metal salt to give metal alkoxide, the second step involve the conversion of alkoxide to metal oxide by heating. Nano fluids was prepared using dispersion methods in which different louds(amount) g/L of the prepared metal oxides is dispersed in to ethylene glycol liquid such as 2, 4, 6, or 5,10 ,…etc

2.1 Preparation of Co_3O_4 Nanoparticle

2.1.1 Chemicals

Potasium hydroxide, Cobalt acetate, Ethylene glycol, Acetone and Ethanol.

2.1.2 Methods

The aquas solution was prepared by mixing the calculated amount of KOH (5,61gm 100mmole) and cobalt acetate (7, 08 gm. 4m mole) and stirred for 2 h followed by reflexing for 4 hours. After filtration the residue was washed with distilled water until the solution reach pH 7. The residue calcinated at 45°C for 4h in dry nitrogen, black powder was obtained with 58% yield.

2.2 Preparation of Co_3O_4/Glycol Nanofluid

Specific amount of Co3O4 glycol nanofluids (0,1gm) were dispersed in 40 ml of Glycol and subjected to ultrasonic vibration instrument for about 2h.

Four different concentration of nanofluids were prepared following the above method as shown in Table (1) below:

Table 1. Four different concentration of nanofluids

Sample	Weight of Co_3O_4
Sample 1	0,1
Sample 2	0,2
Sample 3	0,05
Sample 4	0,025

2.3 Viscosity of Co_3O_4/Glycol Nanofluid Measurement

The viscosity and rheological behaviour of nanofluids were obtained by conducting tests under steady state conditions using a Haake RheoStress 1 rotational rhemoter (Thermo Scientific). A cylinders system composed of two concentric cylinders was used. In the gap between the inner cylinder (diameter = 34 mm) and the outer cylinder (diameter = 36.88 mm) the sample was introduced. Before each test, a pre-treatment, in which the samples were submitted to a constant shear stress, was applied to the nanofluids for 30 seconds to ensure similar starting conditions for all the measurements. Used Brookfield DV-III+ Programmable Rhemoter. The Brookfield DV-III+ Programmable Rhemoter measures fluid parameters of Shear Stress and Viscosity at given Shear Rates. The viscosity of a fluid is a measurement of its resistance to flow. The principle of operation of the DV-III+ is to drive a spindle (which is immersed in the test fluid) through a calibrated spring. The spring deflection measures the fluid's viscous drag against the spindle. A rotating transducer is used to measure spring deflection. The measuring range of a DV-III+ (in centipoise) is dictated by the spindle's rotational speed, its size and form, the container in which the spindle is revolving, and the calibrated spring's full scale torque. The CGS or SI systems are used to display all units of measurement.

- Viscosity appears in units of centipoise (shown as “cP”) or milliPascal-seconds (shown as mPa•s) on the DV-III Rhemoter display.
- Shear Stress appears in units of dynes/square centimeter (“D/cm^2”) or Newtons/square meter (“N/m^2”).
- Shear Rate appears in units of reciprocal seconds (“1/S”).
- Torque appears in units of dyne-centimeters or Newton-meters (shown as percent “%” in both cases) on the DV-III Rhemoter display).

3. RESULTS AND DISCUSSION

The Co_3O_4/glycol nanoparticles was characterized by using XRD Diffraction Pattern Graphic in Fig. 1.

The XDR (X-Ray Diffraction) measuring by using EXPLORER, GNR S.r.I, under the condition at room temperature, generator setting 30 mA and40 KV , Cu Kα radiation (K-0.154 nm weave length 1.540598 Å, angle range from 10° - 80° and the XRD(X-Ray Diffraction) peaks were recorded at 2θ in position (2θ= 18,89° , 31,29° , 36,93° , 38,52° , 44,93° , 59,31° and 65,12°). The XRD (X-Ray Diffraction) Fig. 1 is identical to prepared Co_3O_4 nanoparticles. The peak shape and intensity are agreed will with the reported literature.

XRD (X-Ray Diffraction) is used to determine the crystalline structure of nano particles. The X-ray beam is transmitted into the sample and the beam is scattered by the atoms in the path of the X-ray is studied. The scattered X-rays constructively interfere with each other and this interference is calculated using Bragg’s Law or the Debye-Scherrer equation (D= $K\lambda/\beta \cos\theta$) to determine various characteristics of the crystalline, EXPLORER, GNR S.r.I device software calculate the crystal size using Debye-Scherrer.

The average particles size of Co_3O_4 nanoparticles calculated by using Debye_ Scherrer formula:

$$D = K\lambda / (\beta \cos\theta)$$

Where

D is the crystal size (nm)

K is a dimensionless shape factor, with a value close to unity. The shape factor has a typical value of about 0.9

λ is the wave length of the x-ray used for diffraction(n)

β is full width at half maximum (FWHM) of peak.

The average particles size of Co_3O_4 nanoparticles is estimated to be 44, 8 nm.

The Co_3O_4/glycol Nano fluid was obtained by dispersion of Co_3O_4 Nano particles in glycol. Fig. 2 showed the viscosity of four samples of Co_3O_4/glycol with different concentration in wide shear rate ranging from 1 to 45, it’s clear that the viscosity is fluctuate in low shear rate and when shear rate reaches 20 the viscosity beings stabilize, in shear rate value 25, the viscosity is stable which means that all the four concentration of Co_3O_4/glycol Nano fluids has the same behavior in high shear rate.

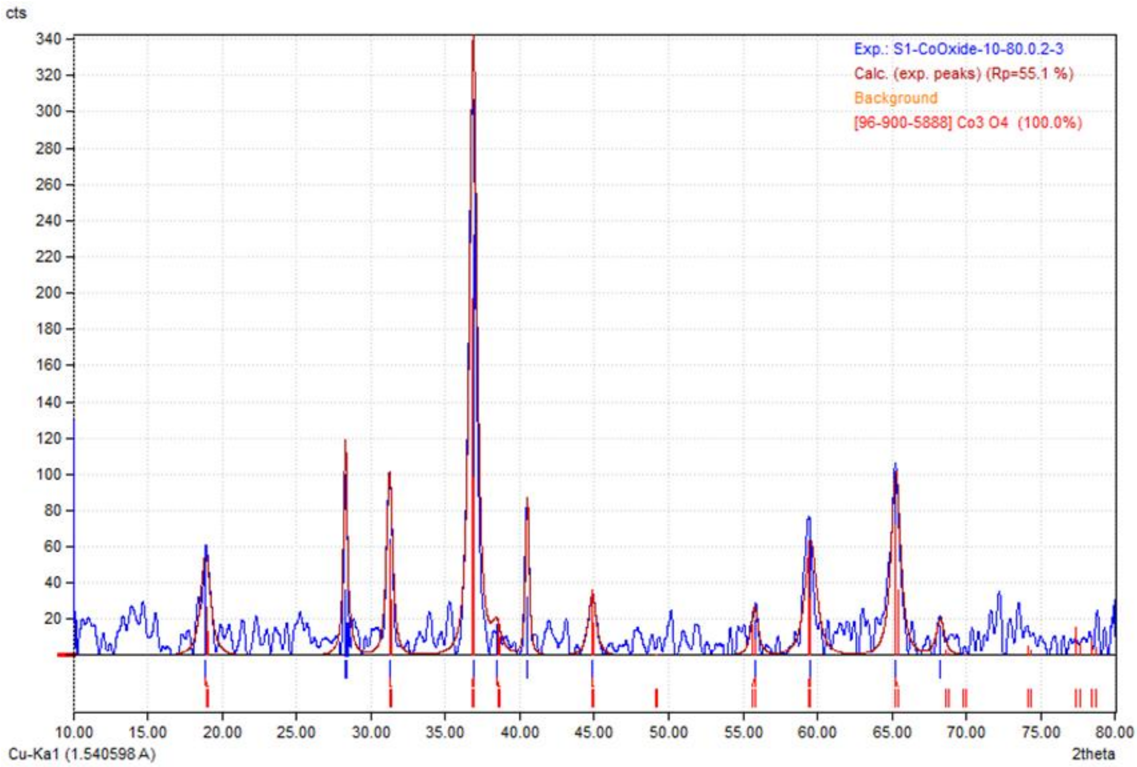

Fig. 1. XRD Diffraction Pattern Graphic of Co_3O_4

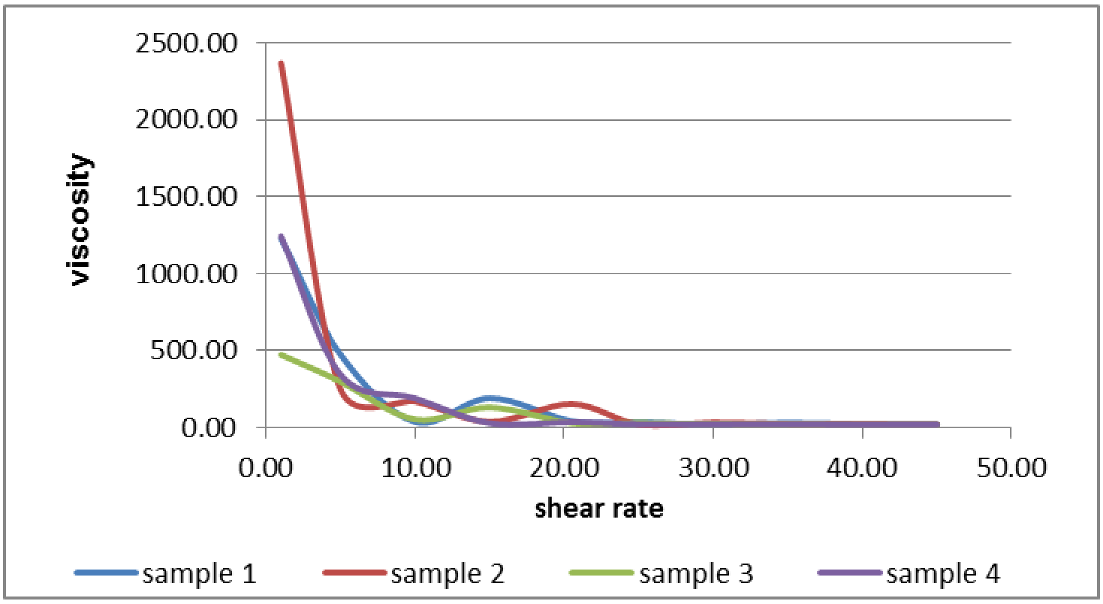

Fig. 2. Viscosity of Co2O3/glycol in multi shear rate

In different condition where the shear rate 40 and heating range between 0 to 80 the Viscosity of Co_3O_4/glycol Nano fluid was also measured, the viscosity was decreased according to increase of temperature and take a value in range 3 to 15.it also showed the concentration effect in viscosity in which sample1 the highest concentration achieves largest viscosity value and sample 4 the lowest concentration recorded less value of viscosity, but sample 3 and sample 4 record same value of viscosity.

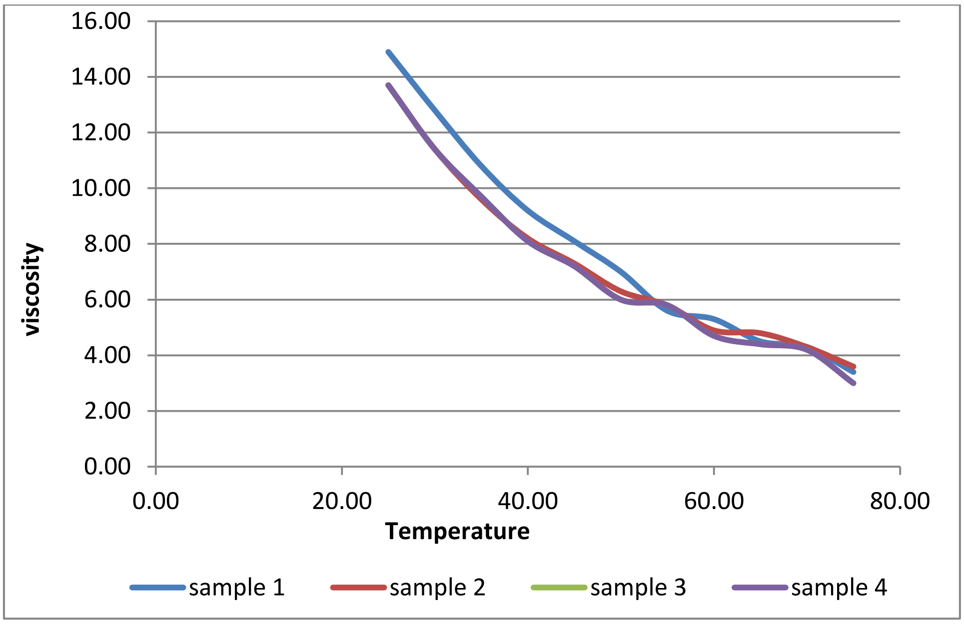

Fig. 3. Viscosity of Co2O3/glycol at different temperature and high shear rate

4. CONCLUSION

The Co_3O_4 Nano fluid was prepared using sol gel method and dispersion of the Co_3O_4 Nano particles via ultrasonic vibration in glycol. The nanoparticle formed confirmed by XRD Diffraction Pattern Graphic and the obtained XRD data for 2θ positions identifies the sample as Co_3O_4 Nano particles, the d-spacing values, lattice constant and cell volume, all confirm the sample to be Co_3O_4 Nano particles. The suitable shear rate to study viscosity behavior of Co_3O_4 Nano fluid was determine by tested the viscosity in wide range of shear rate from 1 to 45 which showed vibrated of viscosity in law shear rate and stabled at shear rate 25. In law shear rate the viscosity was not in harmony behavior, this may be related to the fact that no surfactant or chemical additives were used during Nano fluid preparation. It seems that the enhancement in viscosity does not only depend on the temperature, but also primarily on the volume concentration. The result of viscosity when measured at high shear rate40 and temperature range from 0° to 80° showed decreasing in viscosity by increasing of temperature and increases with increasing of nanoparticles concentration until reaches certain concentration.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Wei Y, Huaqing X. A Review on Nanofluids: Preparation, Stability Mechanisms, and Application. Journal of Nanomaterials. Journal of Nanomaterials. 2012;435873:1-2.
2. Naik MT, Ranga Janardhana G, Vijay Kumar Reddy K, Subba Reddy B. ARPN Journal of Engineering and applied Sciences. 2010;5(6).
3. Suresh S, Venkitaraj KP, Selvakumar P, Chandrasekar M. Synthesis of Al2O3–Cu/water hybridnanofluids using two step method and its thermophysical properties. Colloids Surf A: Physicochem Eng Asp. 2011;388:41–8.
4. Einstein A. Investigations on the theory of the Brownian motions. New York: Dover Publications; 1956.
5. Garg J, Poudel B, Chiesa M, Gordon J, MaJ J, Wang JB, Ren ZF, Kang YT, Ohtani H, Nanda, McKinley J, Chen GHG. Enhanced thermal conductivity and viscosity of copper nanoparticles in ethylene glycolnano fluid. Jappl Phys. 2008;103(7):074301-1–6.
6. Deven Diran DK, Amirtham VA. A review on preparation, characterization, properties and applications of nanofluids, Renewable and Sustainable Energy Reviews. 2016;60: 21–40.
7. Putra N, Roetzel W, Das SK. Natural convection of nano-fluids. Heat and Mass Transfer. 2003;39:775-784.

8. Yang Y, Zhang ZG, Grulke EA, Anderson WB, Wu G. Heat transfer properties of nanoparticle-in-fluid dispersions (nano-fluids) in laminar flow. International Journal of Heat and Mass Transfer. 2005;48:1107-1116.
9. Chun BH, Kang HU, Kim SH. Effect of alumina nanoparticles in the fluid on heat transfer in double-pipe heat exchanger system. Korean Journal of Chemical Engineering. 2008; 25:966-971.
10. Chandrasekar M, Suresh S, Chandra BA. Experimental studies on heat transfer and friction factor characteristics of Al2O3/water nanofluid in a circular pipe under laminar flow with wire coil inserts. Experimental Thermal and Fluid Science. 2010; 24:122-130.
11. Suresh S, Venkitaraj KP, Selvakumar P. Comparative study on thermal performance of helical screw tape inserts in laminar flow using Al2O3 water and CuO/water nano-fluids. Superlattices and Microstructures. 2011; 49:608-622.
12. Zamzamian A, Oskouie SN, Doosthoseini A, Joneidi A, Pazouki M. Experimental investigation of forced convective heat transfer coefficient in nano-fluids of Al2O3/EG and CuO/EG in a double pipe and plate heat exchangers under turbulent flow. Experimental Thermal and Fluid Science. 2011;35: 495-502.
13. Corcione M, Cianfrini M, QuintinoA. Heat transfer of nano-fluids in turbulent pipe flow. International Journal of Thermal Sciences. 2012; 56:58-69.
14. He Y, Jin Y, Chen H, Ding Y, Cang D, Lu H. Heat transfer and flow behavior of aqueous suspensions of TiO2 nanoparticles (nano-fluids) flowing upward through a vertical pipe. International Journal of Heat and Mass Transfer. 2007; 50:2272-2281.
15. Yu W, France DM, Smith DS, Singh D, Timofeeva EV, Routbort JL. Heat transfer to a silicon carbide/water nano fluid. International Journal of Heat and Mass Transfer. 2009; 52:3606-3612.
16. Anoop KB, Sundararajan T, Das SK. Effect of particle size on the convective heat transfer in nano-fluid in the developing region. International Journal of Heat and Mass Transfer. 2009;52: 2189-2195.
17. Ding Y, Alias H, Wen D, Williams RA. Heat transfer of aqueous suspensions of carbon nanotubes (CNT nano-fluids). International Journal of Heat and Mass Transfer. 2006;49:240-250.
18. Witharana S, Palabiyik I, Musina Z, Ding Y. Stability of glycol nanofluids— The theory and experiment. Powder Technology. 2013; 239:72-77.

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