Original Research Article

Estimation of Dynamic Viscosity for Cobalt Oxide/Glycol Nano fluid

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 technique. All viscosity measurements were conducted using a capillary viscometer, the viscosity experiment were carried out at wide temperatures ranging between 20C° and 80C° to determine their applicability in such range. The viscosity data were collected using a programmable rheometer. 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 new class of fluids engineered by dispersing nanometer-sized materials (nanoparticles, Nano fibers, nanotubes, nanowires, Nano rods, Nano sheet, or droplets) in base fluids. In other words, Nano fluids are Nano scale colloidal suspensions containing condensed nanomaterial. They are two-phase systems with one phase (solid phase) in another (liquid phase) [1]. Nano fluids have been found to possess enhanced thermo physical properties such as thermal conductivity, thermal diffusivity, viscosity, and convective heat transfer coefficients compared to those of base fluids like oil or water. It has demonstrated great potential applications in many fields [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 viscous drag of the fluid against the spindle is measured by the deflection of the calibrated spring. Viscosity is measure of the tendency of a liquid to resist flow. It is the ratio of the shear stress to shear rate. When the viscosity is constant at different values of shear rate, the liquid is known as Newtonian while that varies as a function of shear rate then the liquid is known as non-Newtonian [4]. Einstein [5] was the first to calculate the effective viscosity of a suspension of spherical solids using the phenomenological hydrodynamic equations, Garg, Poudel, Chiesa etal. [6] conducted an experiment to test the viscosity of copper nanoparticles [7], great enhancement of heat transfer was observed, and also they reported that the friction factor has a very meager part in the application process. Other scholars [8] have concluded that a systematic and definite deterioration of the natural convective heat transfer occurs for the forced convection reliant on the solution concentration, the particle density, and the aspect ratio of the cylinder. 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]. Among these, CNT nanofluid produced similar results to that of Al_2O_3 nanofluid. Ding et al [17] have concluded that the enhancement of heat transfer could be

obtained by varying the flow condition and the fluid concentration. Alternatively, CuO has been investigated for several wall boundary conditions, and it has reached good 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. MATERIAL 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	Volume of glycol
Sample 1	0,1	40 ml
Sample 2	0,2	40 ml
Sample 3	0,05	40 ml
Sample 4	0,025	40 ml

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 rheometer (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 Rheometer measures fluid parameters of Shear Stress and Viscosity at given Shear Rates. Viscosity is a measure of a fluid's 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 viscous drag of the fluid against the spindle is measured by the spring deflection. Spring deflection is measured with a rotary transducer. The measuring range of a DV-III+ (in centipoise) is determined by the rotational speed of the spindle, the size and shape of the spindle, the container the spindle is rotating in, and the full scale torque of the calibrated spring. All units of measurement are displayed according to either the CGS system or the SI system.

1. Viscosity appears in units of centipoise (shown as "cP") or milliPascal-seconds (shown as mPa•s) on the DV-III Rheometer display.

2. Shear Stress appears in units of dynes/square centimeter ("D/cm2") or Newtons/square meter ("N/m2").
3. Shear Rate appears in units of reciprocal seconds ("1/SEC").

4. Torque appears in units of dyne-centimeters or Newton-meters (shown as percent “%” in both cases) on the DV-III Rheometer display)

This item is set up a cone and plate device however note does not include a cone or spindles, a spare cup is included though

3. RESULTS AND DISCUSSION

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

The XDR 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 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 fig (1) is identical to prepared Co3O4 nanoparticles. The peak shape and intensity are agreed will with the reported literature [1].)

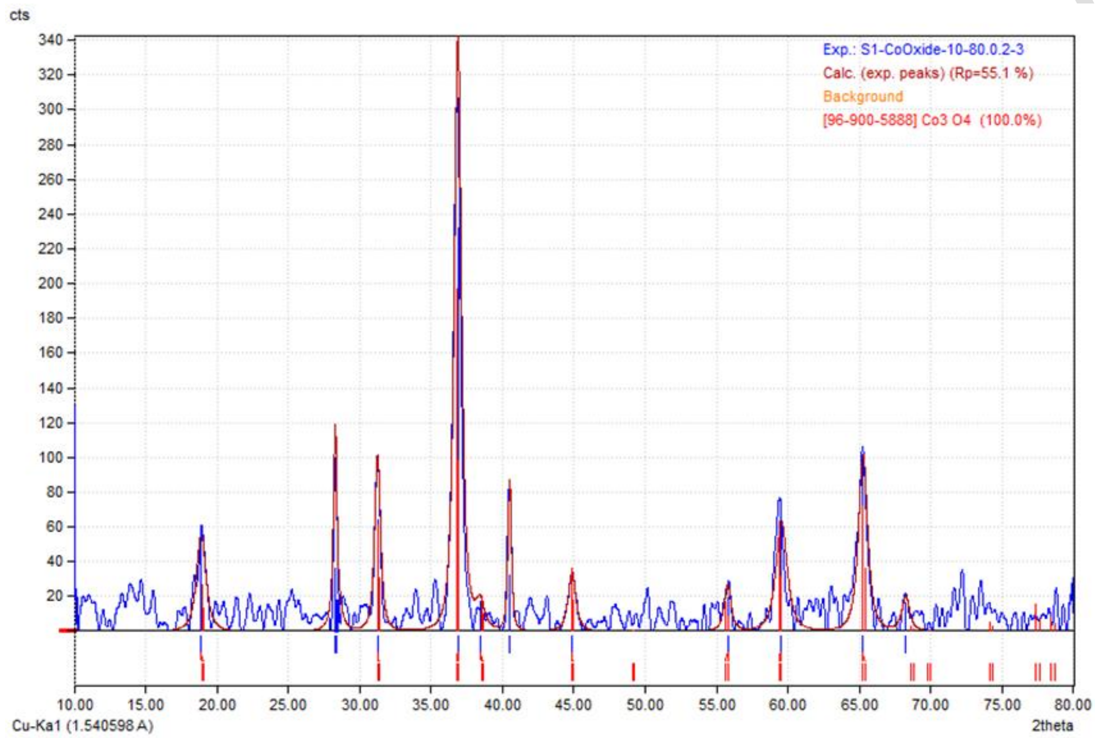

Fig (1). XRD Diffraction Pattern Graphic of Co_3O_4

The average particles size of Co_3O_4 nanoparticles calculated by using Deby_Scherrer formula

D=0.9λ/β cos θ

Where

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

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_2O_3/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_2O_3/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 35, the viscosity is stable which means that all the four concentration of Co_2O_3/glycol Nano fluids has the same behavior in high shear rate.

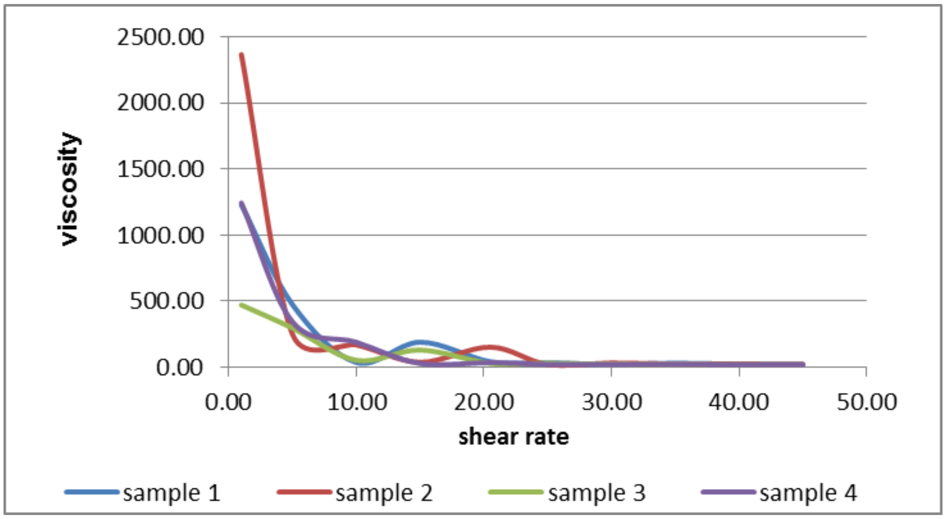

Fig (2). Viscosity of Co2O3/glycol in multi shear rate

In different condition where the shear rate 40 and heating range between 0 to 80 the Viscosity of Co2O3/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 sampl1 the highest concentration achieves largest viscosity value and sample4 the lowest concentration recorded less value of viscosity, but sample3 and sample4 record same value of viscosity.

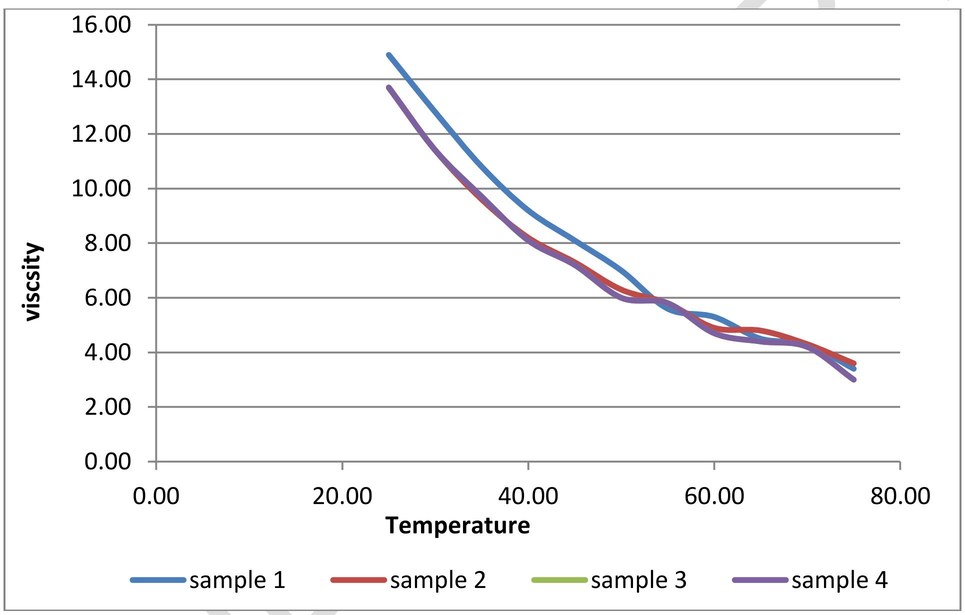

Fig (3). Viscosity of Co2O3/glycol at different temperature and high shear rate

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 rate30 and temperature range from 20° to 80° showed decreasing in viscosity by increasing of temperature and increases with increasing of nanoparticles concentration until reaches certain concentration.

5. REFERENCE

1. Wei Y and Huaqing X. A Review on Nanofluids: Preparation, Stability Mechanisms, and Application. Journal of Nanomaterials. Journal of Nanomaterials.2012: 435873:1-2.

2- Naik M.T., Ranga Janardhana G. , Vijay Kumar Reddy K., Subba Reddy B.,ARPN Journal of Engineering and applied sciences,2010, 5(6),.

3-SureshS,Venkitaraj KP,Selvakumar P,Chandrasekar M. Synthesis of Al2O3– Cu/water hybridnanofluids using two step method and its thermophysical properties. Colloids Surf A: PhysicochemEngAsp 2011; 388:41–8.

4- Einstein A. Investigations on the theory of the Brownian motions. New York: Dover Publications; 1956.

4- Garg J,Poudel B,Chiesa M,Gordon J, MaJ J,Wang JB, Ren ZF,Kang YT, Ohtani H, Nanda,McKinley J,ChenGH.G.Enhanced thermal conductivity and viscosity ofcopper nanoparticles in ethyleneglycolnanofluid. Jappl Phys 2008; 103(7):074301-1–6.

6- Deven diran D.K.,.Amirtham V.A, 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