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# A Review on Hybrid Nanofluid

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**Abstract:** This paper aims to review recent progress and application of hybrid nanofluid in machining process. The paper also discussed the preparation method of hybrid nanofluid and nano composite. Few aspects such as the stability of nano hybrid and characterization of hybrid nanofluid enlightened. The prior research on nanofluid shows that hybrid nanoparticle are work more effectively than single (mono) nanoparticle. The hybrid nanofluid are having higher thermal conductivity which affects significantly to machining output response variables.

**Keywords:** Nanoparticle, Hybrid nanofluid, Hybrid nano-composite, Characterization, Preparation method of hybrid nanofluid

## I. INTRODUCTION

In the recent development of the nano technology, the integration of nanoparticle and base fluid i.e. Nanofluid is developed. Choi introduced the concept of nanofluid. The Nanoparticle is coming out from Latin prefix i.e. Nano. It is used to denote  $10^{-9}$ nm part of units. The mixture of nano sized particles and base fluid i.e. coolants, water etc is known as Nanofluid [1]. The thermal conductivity of the nanofluid is depends on numerous factors such as type, shape, size and stability of dispersed nanoparticle, type of base fluid concentration of nanoparticle and fluid temperature. By hybridization of two or more different nanoparticles are increases the thermal conductivity of new composite nanoparticle is formed is knows as hybrid nanoparticle. The nanofluid shows better performance than the conventional fluid. When nanofluid used as heat transfer medium hybrid nanofluid shows better thermal conductivity than the mono. The different types base fluid and hybrid nanoparticle are presented in the study are show in below.

The different type of base fluid is -

- A. Water
- B. Ethylene glycol
- C. Water + ethylene glycol mixture
- D. Vegetable oil
- E. PAO oil
- F. Transformer oil
- G. Naphthenic mineral oil
- H. Paraffin oil
- I. SAE oil
- J. Dia-thermic oil

The various types of hybrid nanoparticle were stated by eminent researchers -

|                    |                                           |                                       |                                       |                                     |
|--------------------|-------------------------------------------|---------------------------------------|---------------------------------------|-------------------------------------|
| Ag/GNPs            | Al <sub>2</sub> O <sub>3</sub> /Cu        | TiO <sub>2</sub> /SiO <sub>2</sub>    | MWCNTs/Si                             | CNTs/Fe <sub>2</sub> O <sub>3</sub> |
| Ag/WO <sub>3</sub> | Al <sub>2</sub> O <sub>3</sub> /CuO       | TiO <sub>2</sub> -CuO/C               | MWCNTs/ZnO                            | Ni/ND                               |
| Ag/Si              | Al <sub>2</sub> O <sub>3</sub> /CNTs      | TiO <sub>2</sub> /Ag                  | MWCNTs/Ag                             | Cu/Zn                               |
| Ag/MgO             | AQI <sub>2</sub> O <sub>3</sub> /Graphene | TiO <sub>2</sub> /CNTs                | MWCNTs/SiO <sub>2</sub>               | GNPs/SiO <sub>2</sub>               |
| Ag/ZnO             | TiO <sub>2</sub> /SiC                     | TiO <sub>2</sub> /MWCNTs              | MWCNTs/Fe <sub>3</sub> O <sub>4</sub> | Co <sub>3</sub> O <sub>4</sub> /ND  |
| Al/Zn              | TiO <sub>2</sub> /Cu                      | MWCNTs/Al <sub>2</sub> O <sub>3</sub> | MWCNTs/MgO                            | GNPs/Pt                             |
| AlN                | TiO <sub>2</sub> /ZnO                     | MWCNTs/GO                             | DWCNTs/ZnO                            | Co <sub>3</sub> O <sub>4</sub> /GO  |

## II. PREPARATION OF HYBRID NANO-COMPOSITE.

There are various types of technique are used to preparation of hybrid nano-composite.

- A. Mechanical alloying
- B. Thermo-chemical
- C. In-situ
- D. Ball milling
- E. Catalytic chemical vapor deposition
- F. Chemical vapor deposition
- G. Spray pyrolysis
- H. Wet chemical
- I. Solvo-thermal
- J. Wet ball milling
- K. Aerosol
- L. Chemical reduction
- M. Hydrogen induced exfoliation

## III. PREPARATION OF NANOFLUID.

The one step and two step are the two method which are generally used in preparation of nanofluid.

### A. One-Step Method.

The one step method is introduced by Eastman et al. It used to reduce the agglomeration of nanoparticles and the process consists of simultaneously mixing along with the dispersion the particle in the fluid. The process of drying storage transportation and dispersion of nanoparticle are avoided. So the agglomeration of nanoparticle is minimized.

### B. Two Step method.

The two step method is the most commonly used method for preparation of nanofluid. In this method the nanomaterial is first produced as a dry powder then the nanosized powder and the fluid are mixed with the help of different types of instruments i.e. ultrasonic agitation, high shear mixing, ball milling etc. Agitation is a process to put something into motion by shaking or stirring. Ball milling is the type of grinder used to grind and blend material.

## IV. CHARACTERIZATION TECHNIQUES.

Characterization is the techniques which is used to find out the properties of nanofluid. The several types of techniques used to find out the characterization are as follows.

- A. x-ray diffraction
- B. transmission electron microscopy
- C. scanning electron microscopy
- D. field emission scanning electron microscopy
- E. energy dispersive x ray spectrum
- F. Energy dispersive x ray spectroscopy
- G. Fourier transform infrared
- H. Vibrating sample magnetometer
- I. X photoelectron spectroscopy
- J. Energy dispersive spectroscopy

SEM and TEM and XRD are techniques probably every researcher is used to find out the characterization.

- 1) *SEM (Scanning Electron Microscopy)*: A scanning electron microscopy is a type of microscope that produces image of a sample by scanning the surface with a focused beam of electron. The electron interacts with atoms in the sample producing various signals that contains information about the surface topography and composition of the sample.
- 2) *TEM (Transmission Electron Microscopy)*: Transmission electron microscopy which is also called as instrument a transmission electron microscope is a microscopy technique in which a beam of electron is transmitted through a specimen to form an image.

The specimen is most often an ultrathin section less than 100nm thick or a suspension on a grid. An image is formed from the interaction of the electron with the sample as the beam is transmitted through the specimen. The image is then magnified and focused onto an imaging device such as fluorescent screen, a layer of photographic film, as a sensor such as scintillator attach to a charge coupled devices.

- 3) (XRD) *X-Ray Diffraction*: This is a laboratory-based technique commonly used for identification of crystalline materials and analysis of unit cell dimensions. X-ray crystallography (XRC) is a technique used for determining the atomic and molecular structure of a crystal, in which the crystalline structure causes a beam of incident X-rays to diffract into many specific directions. By measuring the angles and intensities of these diffracted beams, a crystallographer can produce a three-dimensional picture of the density of electrons within the crystal. From this electron density, the mean positions of the atoms in the crystal can be determined, as well as their chemical bonds, their crystallographic disorder, and various other information. The method also revealed the structure and function of many biological molecules, including vitamins, drugs, proteins and nucleic acids such as DNA.

The properties which can be determined with the help of characterization techniques are

- a) Thermal conductivity
- b) Viscosity
- c) Density
- d) Specific heat
- e) Size of the particles

## V. STABILITY

Stability of hybrid nanofluid is important. Because the aggregation of nanoparticle causes sedimentation and clotting. Due to which the thermal conductivity of nanofluid leads to decreases. The researchers found that less sedimentation leads to stable nanofluid. The each nanofluid required different stability period of time.

Stability period of different nanofluid in various article are-

| References | Nanofluid                                          | Stability period |
|------------|----------------------------------------------------|------------------|
| [2]        | Al <sub>2</sub> O <sub>3</sub> -MWCNTs/thermal oil | 7 days           |
| [4]        | Sic-TiO <sub>2</sub> /diathermic oil               | 10 days          |
| [3]        | Cu-Zn/vegetable oil                                | 03 days          |
| [5]        | MWCNTs-Fe <sub>2</sub> O <sub>3</sub> /water       | 60 days          |
| [6]        | SiO <sub>2</sub> -graphene/naphthenic mineral oil  | 14 days          |
| [7]        | Cu-TiO <sub>2</sub> /water and EG                  | 07 days          |
| [8]        | Al <sub>2</sub> O <sub>3</sub> -Cu/ethylene glycol | 03 days          |
| [11]       | MWCNTs-ZnO/water and EG                            | 10 days          |
| [10]       | GNPs-Pt/water                                      | 22 days          |
| [9]        | TiO <sub>2</sub> -SiO <sub>2</sub> /water          | 14 days          |

There are four different types of stability measurement methods.

- 1) Zeta potential method
- 2) Spectral absorbance analysis
- 3) Centrifugation method
- 4) Sedimentation method

### A. Stability Enhancement Methods

To avoid agglomeration and sedimentation of nanofluid the stability enhancement method are used. There are three types of stability enhancement method.

- 1) Surfactant addition
- 2) Controlling PH
- 3) Ultrasonication

## VI. CONCLUSIONS

- A. Thermal conductivity of hybrid nanofluid was found to be dependent on type of base fluid.
- B. Studied concluded that water base hybrid nanofluids yielded higher enhancement in thermal conductivity than ethylene glycol.
- C. Size of the particle has the inverse relation with thermal conductivity.
- D. Increase in temperature and concentration had upper limits to enhance thermal conductivity beyond which a decline in thermal conductivity was observed.

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