

Graphene Nanofluids as a Promising Lubricant and its Sustainability

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ABSTRACT

The engineered nanofluids are the best nanoparticles colloidal suspensions in base fluids which had made attention for the young researchers for the performance enhancement focusing on heat transfer properties. In present scenario, the coolants exhibit the outstanding thermal conductivity with application of nanoparticles. Several attempts had made for this application. When compared to various types of nanofluids graphene nanofluids made a great attention from the world of fluid sciences because of its excellent physical, thermal and mechanical properties. Most of the researchers had developed, prepared, synthesized and, characterised the graphene nanofluids. In this scientific article, the content had been carried out the encroachment of assessment and preparation techniques for the enhancement of graphene nanofluids.

1. Introduction

Actually, Eastman and Choi coined the nanofluids with respect to metallic and non metallic particle suspensions in the host fluids [1]. The primary methods to produce nanofluids [2] for different characteristic utilizations and different derivative based nanofluids [3] are framed by different researchers in past decade. The complete properties of graphene like thermal, physical and mechanical was defined and explained with various investigations using atomic force microscopy [4-6]. The graphene is also used in high energy storage devices [7-9] and in larger wide applications [10-11]. The experimental enhancements can be put forward with the published article on nanofluids in last two decade and shown in figure 1 as graphical representation.

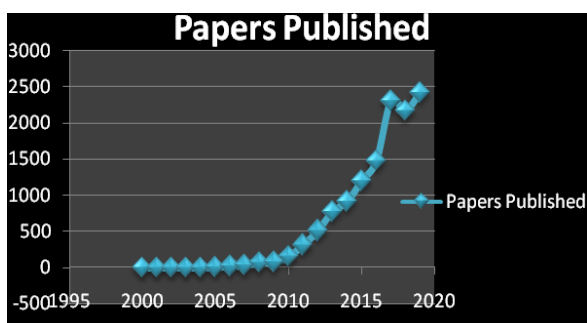


Fig. 1 Papers published on Nanofluids

Graphene attracted too many of the young researchers and scientists in various applications with their area of interests. The graphene Nanofluid is one among the best nanofluids that meant for the properties like longer stability in suspension, easy and well known synthesis and outstanding thermal properties. The synthesis of uni-layered and multi-layered graphene for which majority of research is focused is reduction of single layered graphene oxide, graphite intercalation, aerosol pyrolysis and, chemical vapour deposition on metal surfaces [13-40] and preparation procedures [41-63]

are studied. The preparation techniques of nanofluids play a crucial role in research wing of lubrication [64-71]. There is several synthesis techniques of graphene oxide and reduced graphene oxide with thermally focusing on it [72-134] and mechanisms of stability of nanofluids, graphene nanofluids [135-157] are studied and helped to fill the gaps in the literature. With detailed study from the literature on nanofluids and graphene nanofluids, in the past two decades very few articles are published and less information is available and a graphical representation is shown on papers published on graphene nanofluids in figure 2.

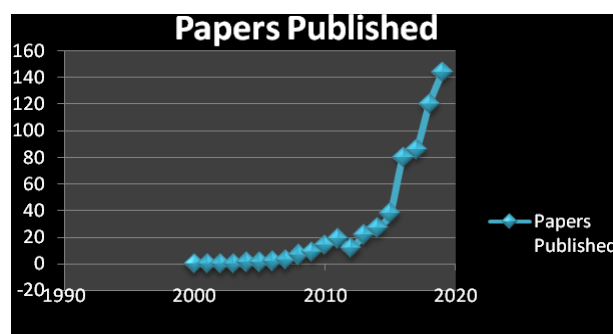


Fig. 2 Papers published on Graphene Nanofluids

2. Why Graphene and Graphene Oxide:

This section includes overview of Graphene and Graphene oxide. It is a 2D material that gradually becoming a new promising lubricant in present scenario and plays a tremendous role in overcoming the wear and friction related failures in moving mechanical systems by giving attention to sustainable developments. Researchers introduced several novel materials for potential growth in this well-known area. Graphene and Graphene oxide acted as solid lubricants and additives for several oils used for lubrication. These are used in solid or liquid forms for overcoming the wear and friction that occurs due to machining operations because of its excellent properties [158-160]. The literature provided different production

techniques of graphene which is an immense deal that affects the properties mechanically, chemically and tribologically. The production of graphene is significantly increased and its synthesis techniques are shown in figure 3. Based on these syntheses, the several studies defined the graphene behaviour at different scales [161-168]. The computational methods are overwhelming it. These studies brought a tremendous change and helped in introducing surface chemistry with modified graphene theories of density functions and different experiments are helped to investigate the properties with a clear study [169]. When compared surprisingly came to know that very less research had been carried in past decades. Chemical modification of graphene is graphene oxide and studies helped in understanding different mechanisms. The

wear and friction properties of graphene and graphene oxide additives in oils summarize and covered the mechanical behaviour of this novel material. The theoretical simulations help in predicting the nature of increasing or decreasing the tribological properties that in turn influences the mechanical properties. There are quite a few promising ways that synthesizes the graphene oxide with different layers based on the preparation and production techniques [170-179]. The type of chemicals and materials used, preparation, synthesis and, characterisation techniques influences this novel material in various applications to determine the mechanical and tribological behaviour of that material after applying this as coolant or an additive in it.

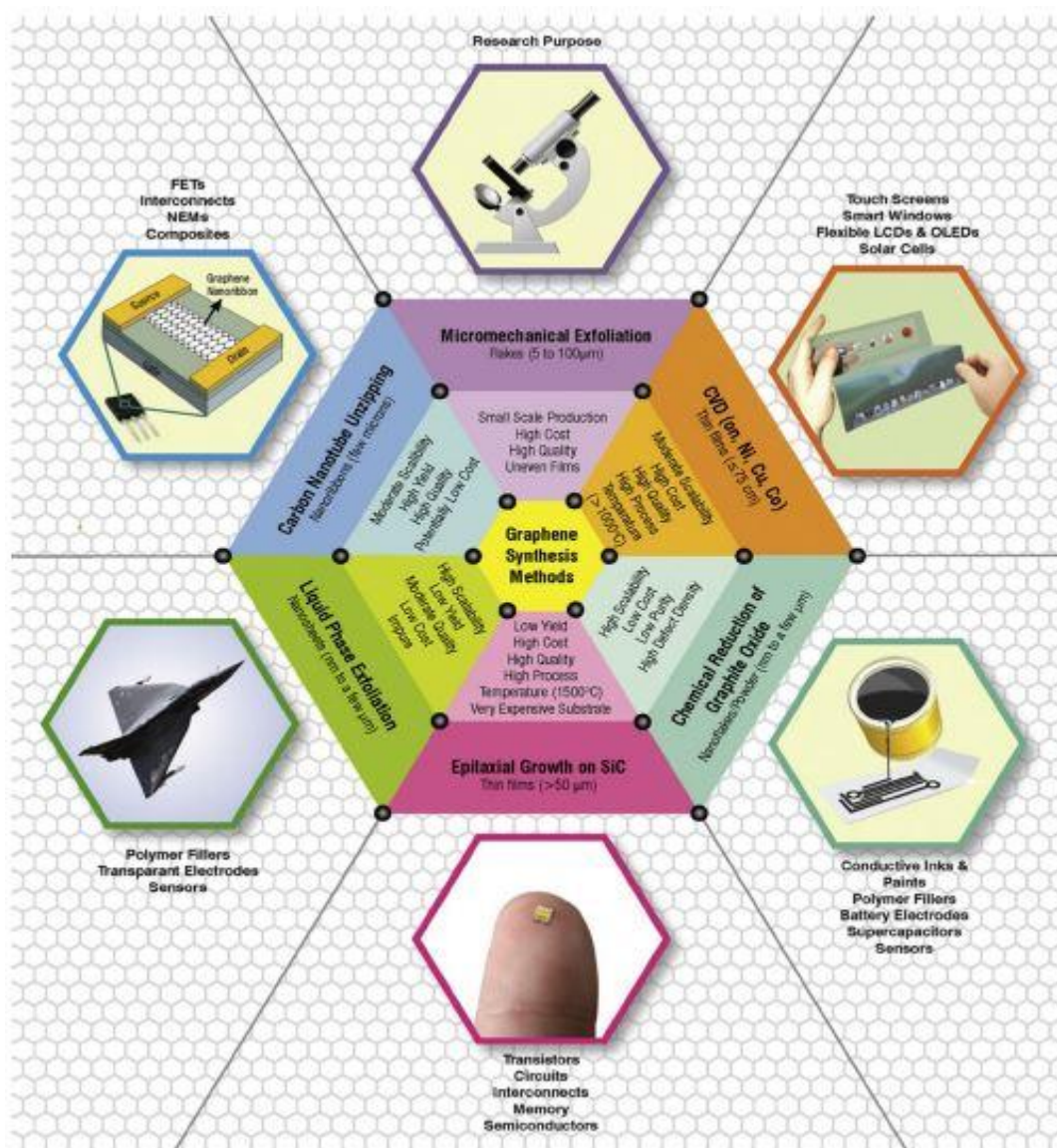


Fig. 3 Techniques of Graphene and Graphene Oxide Synthesis [36]

3. Graphene and Graphene Oxide as Nanofluids / Additives in Nanofluids:

In past decade, the graphene nanoparticles had been widely used in engineering applications which has tremendous advantages over the other with cutting edge in the technology advancement. The studies relating to this section provides the impression in numerical and experimental investigations

regarding. Graphene is the mother of all carbon graphite forms. The all kind of graphene material structures are shown in following figure 4. The stability of the nanofluids depends on the type of surfactant that influences the material surface characteristics and opting the preparation methods either one step or two step methods. The surfactant selection has achieved the greater attention that gradually controls the problems during the mixture with base fluids. The graphene

nanofluids have a prospective feature that enhances all possible properties.

The theoretical and experimental thermal study of graphene nanofluids is a key objective in understanding the

metallurgical behaviour. The lubrication is the key applications of graphene as nanofluids or as an additive in it and only minimal research had done in this glowing area.

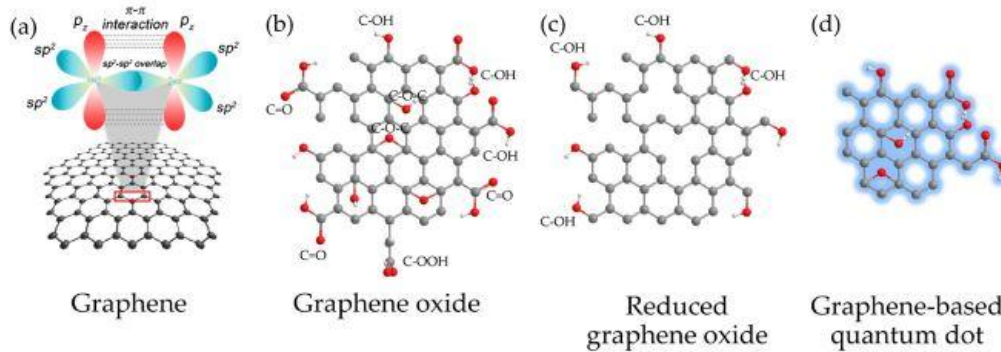


Fig. 4 Graphene Material Structures [180]

The graphene oxide is reduced from graphene by using different functionalities of oxygen is shown in figure 5 and respective procedures for it are shown in figure 6.

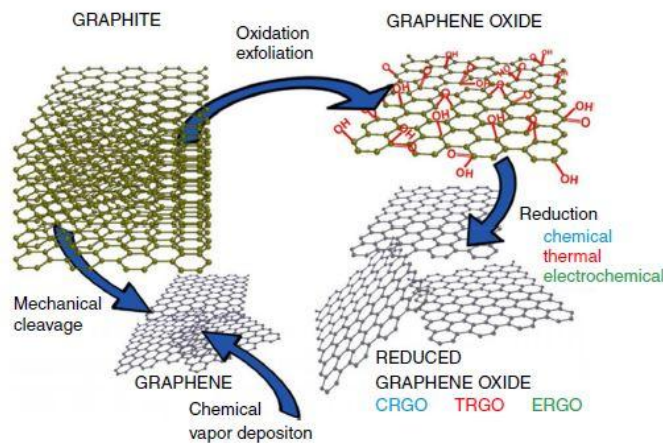


Fig. 5 Oxidation and Reduction of Graphene Oxide [12]

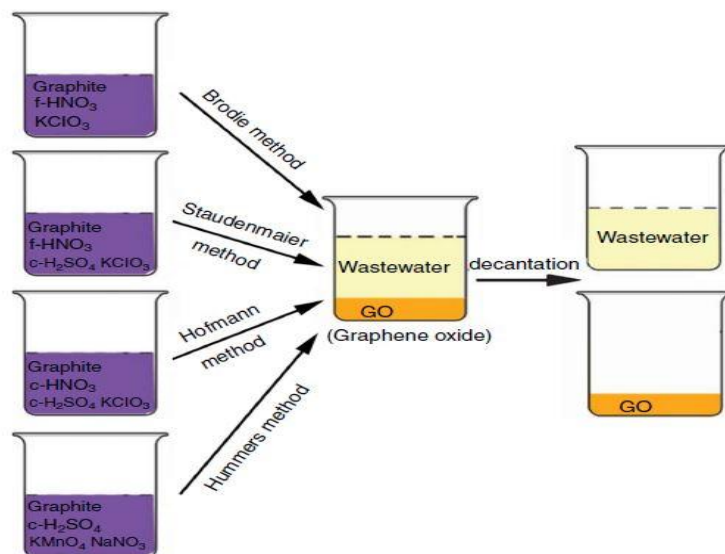


Fig. 6 Preparation Procedures of Graphene Oxide (GO) [41].

There are different preparations methods are considered for the graphene oxide formation. The procedures will be chosen basing on the application.

In recent years, very nominal and remarkable research had done by the researchers and very few articles are

published in this area of graphene nanofluids and Nano-lubricants. The flakes of graphene had been considered for the investigations because of their thermo physical, tribological and mechanical properties. There are several factors that affecting this material in this application of lubrication is one of the key

issues in this recent scenario. The research methodology of nanofluids is shown in figure 7. The GO had excellent advantages over the other such as better stability, protective coatings, not requires any induction periods, outstanding

tribological, mechanical and thermo physical properties. The most important graphene properties are listed in following table 1 [180-198].

Table. 1 Graphene Properties.

Properties	Value
Thermal conductivity	5000 W m ⁻¹ K ⁻¹
Surface area	2600 m ² g ⁻¹
Young's modulus	1 TPa
Fracture strength	130 GPa
Optical transmittance	97.7%
Fermi velocity	300–500 nm
Phase coherence length	3–5 μm

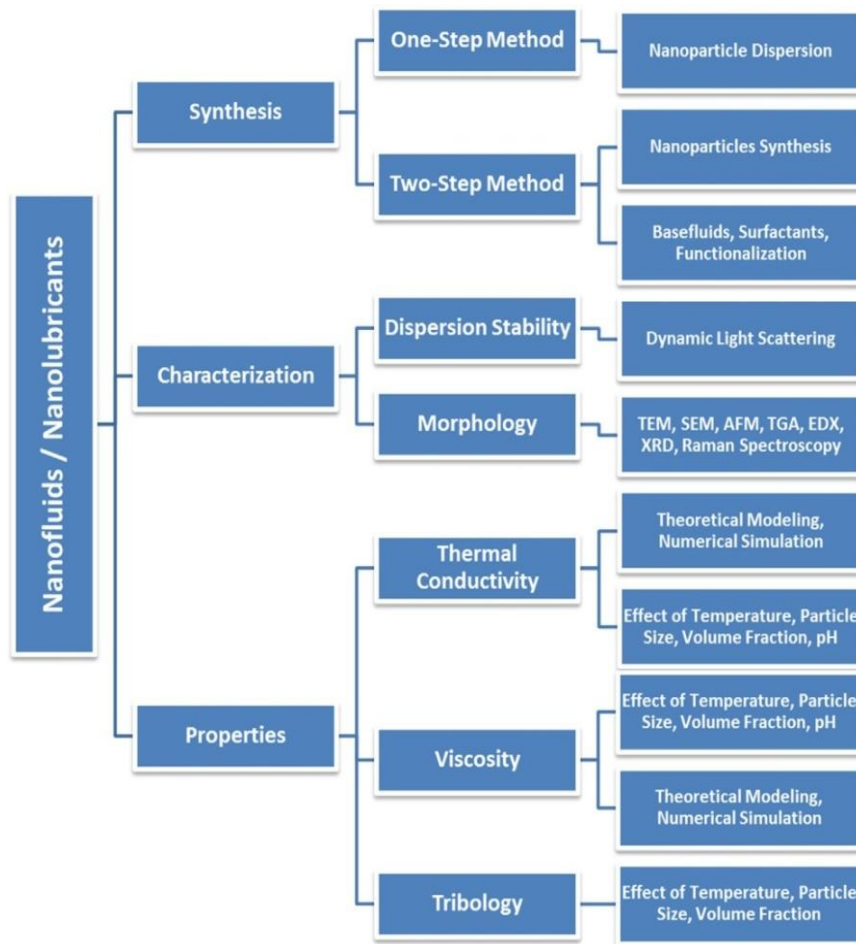


Fig. 7 Research Methodology Algorithm of Nanofluids.

The graphene nanofluids enhance the properties because of their flakes that are formed during the production stage. The surfactant used increases the stability period in the base fluid.

4. GO Nanofluid in Machining Process:

The quality of machined work material depends on the lubrication. Even the life of cutting tool depends on it. The appropriate cutting fluids influence the machining parameters. GO nanofluids is a novel one which targeted the control of temperature effects. The synthesized techniques of GO nanoparticles framed various studies basing on the modified GO. The nanoscience and technology is a competent one which effects every change in every corner of an industry [199].

The surprising deal of graphene had been worked for the enhancement of various properties with application of GO nanofluids which helps in predicting the results of machining process with application of base fluid along with GO as an additive in the base fluids and also sustainable examinations are considered for better understanding of lubricants. Heat transfer properties are enhanced by application of nanofluids and with GO nanofluids, it exhibits the outstanding properties. Out of all machining process, the drilling operation had less research focus in the nanofluids application mainly with the GO nanofluids. It affects the output of drilling parameters and the contact stresses are reduced with application of lubricants which in turn extents the machining efficiency and drill tool life.

Very limited research had done in drilling operation and summary of the published work are framed in the following table 2.

Table. 2 Published Research in Drilling Operation

Drilling Operation	Type of Work Material	Type of Nanoparticles	Base Fluid	Cutting Tool Used
Drilling	Al6061	Nano-diamond	Vegetable Oil	Uncoated Carbide
Drilling	Al6063	Al ₂ O ₃	Soya Bean Oil	HSS Drill Tool
Drilling	Stain. Steel	MoS ₂	Water Sol.	HSS Drill Tool
Drilling	Steel	TiO ₂	Soluble Oil	HSS Drill Tool
Drilling	Ti-6Al-4V	Nano-diamond	Vegetable Oil	Uncoated Carbide
Drilling	Al7075-T6	Nano-diamond	Vegetable Oil	DIXI 1135
Drilling	Aluminum	NF	Vegetable Oil	Uncoated Carbide

5. Ecological Concern of Nanofluids:

The modern world with sharp edge competition provides the crucial factors for the survival of any industrial products of manufacturing with excellent quality and minimum cost. The ultimate function of any cutting fluid is to perform lubrication in machining operations. These fluids play an important role in washing away the chip formations and keeping clean in and around the cutting zone. The cutting fluids must slow down the rust formations on the tool and work material. It also protects the corrosion. The cutting fluid helps in thermal studies of the work material along with better product surface finish and prolongs the life of the cutting tool. These promotions made the cutting fluids as most popular from last 30 decades in machining processes. There are number of fluids are available in the globe. But, water, the first cutting fluid [200] miscible oils are mostly applicable in the industries [201]. The petroleum was first exercised as a cutting fluid after its discovery in America. Later suitable advancements are considered for its developments with applications of industrial chemistry with initiation in the soluble oil inventions. The cutting fluids are selected based on the type of machining process, the tool and, the type of work material. The formulations of cutting fluids became more by depending on the complexity of the cutting processes. The cutting fluids are categorised based on machining processes into straight oils, water soluble oils, synthetic and, semi-synthetic oils. The long-lasting tool-work material interface gives the wear of cutting tool which shows huge impact on product quality. The continuous and excessive usage of tool leads to deformation or permanent failure with chatter formations. The different mechanisms that cause the tool failures are flank, nose, notch and, crater wear.

The Researchers interest is exclusively focused in understanding the study of wear and its minimization. This became an critical issue in machining industries and that particular context, the concept of cutting fluids depicted the attention of researchers from few decades. The effectiveness of cutting fluids [202] with different formulations are kept forward. The friction development and study of shear stress distributions are with respect to tool wear and attention to tribological systems are reported in the literature [203-207]. The study of chip thickness, wear mechanisms, different parameters, vibrations and techniques made researchers to focus in depth for the development of cutting fluids to reduce the tool wear [208-235]. The influence of cutting fluids on machining process is a trending area now a day. There are

conventional methods that reduce the temperatures and friction in machining processes.

Many researchers provided their studies in the literatures about the lubricating effects in machining operations. The factors like chip formations, self welding, friction, corrosion and, high temperature formations helped for the investigation of effective cooling actions [236-239]. There are various researchers proposed different methods of determining cooling actions and their abilities of several cutting fluids and also carried out different experimental investigations with huge focus on emulsions, organic compounds, cutting fluids and, their economical issues [240-266].

Environmental accountability is a crucial concern with the disposal of wastes. A huge number of companies are paying for its cleanness over the globe or imposing fines by regulatory agencies of respective countries. The lubricating design of mist generation plays a critical role in applying the cutting fluid as a lubricant in machining operations which is indirectly associated with labours health problems. The environmental issues with concentration on disposals of the wastes, and, workers health, various internal problems are also considered for better formulations of the cutting fluids [267-277]. The study of microbial contamination also having critical impacts and influences the machining parameters with application of cutting fluids [278-282]. The mists of cutting fluids are generated through atomization with size distribution and mist rate depending on coolant type and machining type. The literature identified the mist mechanisms of evaporation–condensation and atomization with estimation of fluid amount in the nozzles that was considered during experimentation [283-288]. The disposal of cutting fluids is one of environmental and economical impact in the manufacturing process that must be controlled in the process of dumping. The disposal problems of various cutting fluids are controlled with their best formulations and helped the present researchers to think more and to provide the effective and excellent cutting fluids [289-298].

The major part of research had been framed to examine with effective investigation of cutting fluid effects in machining process, work material and, their environment.

6. Conclusion and Outlook:

In this review article, the preparation, synthesis and, characterization of nanofluids is studied. The published articles of nanofluids and GO nanofluids are represented in graphical form with giving attention to past two decades. The GO

nanofluids are covered with each and every corner of this novel material including the mechanisms of stability. It is considered because of simple and economical benefits when compared with other materials. The investigations of several properties are considered for the enhancement of material properties with nanofluids applications as a lubricant. The theoretical models are required and must develop for the explanation of the experimental data. The impact of nanofluids in machining process is considered with additional focus in drilling operations. When coming to ecological section, the upshot of research provides the techniques of nanofluids minimum quantity lubrication had to develop for succeeding in most of the machining processes and to overcome the drawbacks of respective machining parameters. The environmental issues

can be overcome with effective utilization of nanofluids, mostly GO nanofluids.

There are numerous challenges in nanofluids that are in the literature but given attention to graphene nanofluids.

- Agglomeration of Nanofluids
- Economical issues of Nanofluids
- Stability at High Temperature Zones
- Stability for large period in base fluids
- Effects of Thermophysical Properties
- Morphological Effects
- Physical Phenomenon of Materials that are considered
- Utilization of Surfactants, GO Composites
- Heteroatoms and Functionalizations of GO

References

- [1]. Choi SUS, Eastman JA. Enhancing thermal conductivity of fluids with nanoparticles. ASME Int Mech Eng Congr Expo. 1995;66:99–105.
- [2]. Mehrali M, Sadeghinezhad E, Latibari ST, Kazi SN, Mehrali M, Bin MN, et al. Investigation of thermal conductivity and rheological properties of nanofluids containing graphene nanoplatelets. Nanoscale Res Lett. 2014;9:15.
- [3]. Arshad A, Jabbar M, Yan Y, Reay D. A review on graphene based nanofluids: preparation, characterization and applications. J Mol Liq. 2019;279:444–84
- [4]. Taghioskoufi M. Trends in graphene research. Mater Today. 2009;12:34–7.
- [5]. Huang X, Qi X, Boey F, Zhang H. Graphene-based composites. Chem Soc Rev. 2012;41:666–86.
- [6]. Suk JW, Piner RD, An J, Ruoff RS. Mechanical properties of monolayer graphene oxide. ACS Nano. 2010;4:6557–64.
- [7]. Kim H, Park K-Y, Hong J, Kang K. All-graphene-battery: bridging the gap between supercapacitors and lithium ion batteries. Sci Rep. 2015;4:5278.
- [8]. Bakandritsos A, Jakubec P, Pykal M, Otyepka M. Covalently functionalized graphene as a supercapacitor electrode material. FlatChem. 2019;13:25–33.
- [9]. Ma W, Zhang D. Multifunctional structural supercapacitor based on graphene and magnesium phosphate cement. J Compos Mater. 2019;53:719–30.
- [10]. Ruhl G, Wittmann S, Koenig M, Neumaier D. The integration of graphene into microelectronic devices. Beilstein J Nanotechnol. 2017;8:1056–64.
- [11]. Rogers JA. Making graphene for macroelectronics. Nat Nanotechnol. 2008;3:254–5.
- [12]. Rowley-Neale SJ, Randviir EP, Dena ASA, Banks CE. An overview of recent applications of reduced graphene oxide as a basis of electroanalytical sensing platforms. Appl Mater Today. 2017;10:218–26.
- [13]. Sadeghinezhad E, Mehrali M, Saidur R, Mehrali M, Tahan Latibari S, Akhiani AR, et al. A comprehensive review on graphene nanofluids: recent research, development and applications. Energy Convers Manag. 2016;111:466–87.
- [14]. Mattevi C, Kim H, Chhowalla M. A review of chemical vapour deposition of graphene on copper. J Mater Chem. 2011;21:3324–34.
- [15]. Sun J, Nam Y, Lindvall N, Cole MT, Teo KBK, Woo Park Y, et al. Growth mechanism of graphene on platinum: Surface catalysis and carbon segregation. Appl Phys Lett. 2014;104:152107.
- [16]. Wintterlin J, Bocquet M. Surface science graphene on metal surfaces. Surf Sci. 2009;603:1841–52.
- [17]. Batzill M. The surface science of graphene: metal interfaces, CVD synthesis, nanoribbons, chemical modifications, and defects. Surf Sci Rep. 2012;67:83–115.
- [18]. Novoselov KS, Geim AK, Morozov SV, Jiang D, Zhang Y, Dubonos SV, et al. Electric field effect in atomically thin carbon films. Science. 2004;306:666–9.
- [19]. Edwards RS, Coleman KS. Graphene synthesis: relationship to applications. Nanoscale. 2013;5:38–51.
- [20]. Hiura H, Ebbesen TW, Fujita J, Tanigaki K, Takada T. Role of sp^3 defect structures in graphite and carbon nanotubes. Nature. 1994;367:148–51.
- [21]. Ebbesen TW, Hiura H. Graphene in 3-dimensions: towards graphite origami. Adv Mater. 1995;7:582–6.
- [22]. Bernhardt T, Kaiser B, Rademann K. Formation of superperiodic patterns on highly oriented pyrolytic graphite by manipulation of nanosized graphite sheets with the STM tip. Surf Sci. 1998;408:86–94.
- [23]. Lu X, Yu M, Huang H, Ruoff RS. Tailoring graphite with the goal of achieving single sheets. Nanotechnology. 1999;10:269–72.
- [24]. Roy H-V, Kallinger C, Marsen B, Sattler K. Manipulation of graphitic sheets using a tunneling microscope. J Appl Phys. 1998;83:4695–9.
- [25]. Ci L, Song L, Jariwala D, Elías AL, Gao W, Terrones M, et al. Graphene shape control by multistage cutting and transfer. Adv Mater. 2009;21:4487–91.
- [26]. Liang X, Chang ASP, Zhang Y, Harteneck BD, Choo H, Olynick DL, et al. Electrostatic force assisted exfoliation of prepatterned few-layer graphenes into device sites. Nano Lett. 2009;9:467–72.
- [27]. Yi M, Shen Z. A review on mechanical exfoliation for scalable production of graphene. J Mater Chem. 2013;00:1–3.
- [28]. Sharma S, Mathur RB, Dhakate S, Borah M, Dahiya M, Dhakate SR. Few layer graphene derived from wet ball milling of expanded graphite and few layer graphene based polymer composite. Mater Focus. 2014;3:300–9.
- [29]. León V, Quintana M, Herrero MA, Fierro JLG, de la Hoz A, Prato M, et al. Few-layer graphenes from ball-milling of graphite with melamine.

- Chem Commun. 2011;47:10936.
- [30]. Lin T, Tang Y, Wang Y, Bi H, Liu Z, Huang F, et al. Scotch-tape- like exfoliation of graphite assisted with elemental sulfur and graphene–sulfur composites for high-performance lithium-sulfur batteries. *Energy Environ Sci.* 2013;6:1283.
- [31]. Del Rio-Castillo AE, Merino C, Díez-Barra E, Vázquez E. Selective suspension of single layer graphene mechanochemically exfoliated from carbon nanofibres. *Nano Res.* 2014;7:963–72.
- [32]. Hernandez Y, Nicolosi V, Lotya M, Blighe FM, Sun Z, De S, et al. High-yield production of graphene by liquid-phase exfoliation of graphite. *Nat Nanotechnol.* 2008;3:563–8.
- [33]. Jayasena B, Subbiah S. A novel mechanical cleavage method for synthesizing few-layer graphenes. *Nanoscale Res Lett.* 2011;6:95.
- [34]. Parvez K, Li R, Puniredd SR, Hernandez Y, Hinkel F, Wang S, et al. Electrochemically exfoliated graphene as solution-processable, highly conductive electrodes for organic electronics. *ACS Nano.* 2013;7:3598–606.
- [35]. Lu J, Yang J, Wang J, Lim A, Wang S, Loh KP. One-pot synthesis of fluorescent carbon nanoribbons, nanoparticles, and graphene by the exfoliation of graphite in ionic liquids. *ACS Nano.* 2009;3:2367–75.
- [36]. Mittal G, Dhand V, Rhee KY, Park S-J, Lee WR. A review on carbon nanotubes and graphene as fillers in reinforced polymer nanocomposites. *J Ind Eng Chem.* 2015;21:11–25.
- [37]. Choucair M, Thordarson P, Stride JA. Gram-scale production of graphene based on solvothermal synthesis and sonication. *Nat Nanotechnol.* 2009;4:30–3.
- [38]. Biswal M, Banerjee A, Deo M, Ogale S. From dead leaves to high energy density supercapacitors. *Energy Environ Sci.* 2013;6:1249.
- [39]. Zhan D, Sun L, Ni ZH, Liu L, Fan XF, Wang Y, et al. FeCl₃-based few-layer graphene intercalation compounds: single linear dispersion electronic band structure and strong charge transfer doping. *Adv Funct Mater.* 2010;20:3504–9.
- [40]. Lee H, Kang J, Cho MS, Choi J-B, Lee Y. MnO₂/graphene composite electrodes for supercapacitors: the effect of graphene intercalation on capacitance. *J Mater Chem.* 2011;21:18215.
- [41]. Marcano DC, Kosynkin DV, Berlin JM, Sinitskii A, Sun Z, Slesarev A, et al. Improved synthesis of graphene oxide. *ACS Nano.* 2010;4:4806–14.
- [42]. Brodie BC. On the atomic weight of graphite. *Philos Trans R Soc Lond.* 1859;149:249–59.
- [43]. Poh HL, San F. Nanoscale graphenes prepared by Staudenmaier, Hofmann and Hummers methods with consequent thermal exfoliation exhibit very different electrochemical. *Nanoscale.* 2012;4:3515–22.
- [44]. Hofmann U, Holst R. Über die Säurenatur und die Methylierung von Graphitoxyd. *Berichte der Dtsch Chem Gesellschaft (A B Ser).* 1939;72:754–71.
- [45]. Hofmann U, König E. Untersuchungen über Graphitoxyd. *Zeitschrift für Anorg und Allg Chem.* 1937;234:311–36.
- [46]. Hummers WS, Offeman RE. Preparation of graphitic oxide. *J Am Chem Soc.* 1958;80:1339.
- [47]. Shende RC, Ramaprabhu S. Application of few-layered reduced graphene oxide nanofluid as a working fluid for direct absorption solar collectors. *J Nanosci Nanotechnol.* 2017;17:1233–9.
- [48]. Akhavan-Zanjani H, Saffar-Avval M, Mansourkiaei M, Sharif F, Ahadi M. Experimental investigation of laminar forced convective heat transfer of graphene–water nanofluid inside a circular tube. *Int J Therm Sci.* 2016;100:316–23.
- [49]. Askari S, Lotfi R, Rashidi AM, Koolivand H, Koolivand-Salooki M. Rheological and thermophysical properties of ultra-stable kerosene-based Fe₃O₄/graphene nanofluids for energy conservation. *Energy Convers Manag.* 2016;128:134–44.
- [50]. Mehrali M, Sadeghinezhad E, Akhiani AR, Tahan Latibari S, Talebian S, Dolatshahi-Pirouz A, et al. An ecofriendly graphene-based nanofluid for heat transfer applications. *J Clean Prod.* 2016;137:555–66.
- [51]. Zhang C, Zhang L, Xu H, Wang D, Ye B. Investigation of flow boiling performance and the resulting surface deposition of graphene oxide nanofluid in microchannels. *Exp Therm Fluid Sci.* 2017;86:1–10.
- [52]. Esfahani MR, Languri EM. Exergy analysis of a shell-and-tube heat exchanger using graphene oxide nanofluids. *Exp Therm Fluid Sci.* 2017;83:100–6.
- [53]. Marcano DC, Kosynkin DV, Berlin JM, Sinitskii A, Sun Z, Slesarev A, et al. Improved synthesis of graphene oxide. *ACS Nano.* 2010;4:4806–14.
- [54]. Chin WL, Hashim U, Liu WW, Noriman NZ, Hidayah NMS. Effect on variation of KMnO₄ amount for production of graphene oxide (GO). *Adv Mater Res.* 2015;1133:476–80.
- [55]. Shen J, Hu Y, Shi M, Lu X, Qin C, Li C, et al. Fast and facile preparation of graphene oxide and reduced graphene oxide nanoplatelets. *Chem Mater.* 2009;21:3514–20.
- [56]. Dreyer DR, Park S, Bielawski CW, Ruoff RS. The chemistry of graphene oxide. *Chem Soc Rev.* 2010;39:228–40.
- [57]. Esmaeili-Faraj SH, Nasr Esfahany M. Absorption of hydrogen sulfide and carbon dioxide in water based nanofluids. *Ind Eng Chem Res.* 2016;55:4682–90.
- [58]. Anin Vincely D, Natarajan E. Experimental investigation of the solar FPC performance using graphene oxide nanofluid under forced circulation. *Energy Convers Manag.* 2016;117:1–11.
- [59]. Luo D, Wang F, Zhu J, Cao F, Liu Y, Li X, et al. Nanofluid of graphene-based amphiphilic Janus nanosheets for tertiary or enhanced oil recovery: high performance at low concentration. *Proc Natl Acad Sci.* 2016;113:7711–6.
- [60]. Esfahani MR, Languri EM, Nunna MR. Effect of particle size and viscosity on thermal conductivity enhancement of graphene oxide nanofluid. *Int Commun Heat Mass Transf.* 2016;76:308–15.
- [61]. Kim KM, Bang IC. Effects of graphene oxide nanofluids on heat pipe performance and capillary limits. *Int J Therm Sci.* 2016;100:346–56.
- [62]. Mirzaei M, Azimi A. Heat transfer and pressure drop characteristics of graphene oxide/water nanofluid in a circular tube fitted with wire coil insert. *Exp Heat Transf.* 2016;29:173–87.
- [63]. Mehrali M, Sadeghinezhad E, Rosen MA, Akhiani AR, Tahan Latibari S, Mehrali M, et al. Experimental investigation of thermophysical properties, entropy generation and convective heat transfer for a nitrogen-doped graphene nanofluid in a laminar flow regime. *Adv Powder Technol.* 2016;27:717–27.
- [64]. Yu W, Xie H, Bao D. Enhanced thermal conductivities of nanofluids containing graphene oxide nanosheets. *Nanotechnology.* 2009;21:055705.
- [65]. Jia L, Chen Y, Lei S, Mo S, Luo X, Shao X. External electromagnetic field-aided freezing of CMC-modified graphene/water nanofluid. *Appl Energy.* 2016;162:1670–7.

- [67]. Tharayil T, Asirvatham LG, Ravindran V, Wongwises S. Thermal performance of miniature loop heat pipe with graphene-water nanofluid. *Int J Heat Mass Transf.* 2016;93:957–68.
- [68]. Sarsam WS, Amiri A, Kazi SN, Badarudin A. Stability and thermophysical properties of non-covalently functionalized graphene nanoplatelets nanofluids. *Energy Convers Manag.* 2016;116:101–11.
- [69]. Sathishkumar A, Kumaresan V, Velraj R. Solidification characteristics of water based graphene nanofluid PCM in a spherical capsule for cool thermal energy storage applications. *Int J Refrig.* 2016;66:73–83.
- [70]. Khosrojerdi S, Vakili M, Yahyaei M, Kalhor K. Thermal conductivity modeling of graphene nanoplatelets/deionized water nanofluid by MLP neural network and theoretical modeling using experimental results. *Int Commun Heat Mass Transf.* 2016;74:11–7.
- [71]. Selvam C, Balaji T, Mohan Lal D, Harish S. Convective heat transfer coefficient and pressure drop of water–ethylene glycol mixture with graphene nanoplatelets. *Exp Therm Fluid Sci.* 2017;80:67–76.
- [72]. Abd Elhafez SE, Abo-Zahhad EM, El-Shazly AH, Elkady MF. Experimental investigate of heat transfer for graphene/ water nanofluid in micro heat exchanger. *AIP Conf Proc.* 2017;1814:020014.
- [73]. Park SD, Lee SW, Kang S, Kim SM, Bang IC. Pool boiling CHF enhancement by graphene-oxide nanofluid under nuclear coolant chemical environments. *Nucl Eng Des.* 2012;252:184–91.
- [74]. Park SD, Bang IC. Flow boiling CHF enhancement in an external reactor vessel cooling (ERVC) channel using graphene oxide nanofluid. *Nucl Eng Des.* 2013;265:310–8.
- [75]. Dhar P, Sen Gupta S, Chakraborty S, Pattamatta A, Das SK. The role of percolation and sheet dynamics during heat conduction in poly-dispersed graphene nanofluids. *Appl Phys Lett.* 2013;102:163114.
- [76]. Ghozatloo A, Shariaty-Niasar M, Rashidi AM. Preparation of nanofluids from functionalized graphene by new alkaline method and study on the thermal conductivity and stability. *Int Commun Heat Mass Transf.* 2013;42:89–94.
- [77]. Kole M, Dey TK. Investigation of thermal conductivity, viscosity, and electrical conductivity of graphene based nanofluids. *J Appl Phys.* 2013;113:084307.
- [78]. Theres Baby T, Sundara R. Synthesis of silver nanoparticle decorated multiwalled carbon nanotubes-graphene mixture and its heat transfer studies in nanofluid. *AIP Adv.* 2013;3:012111.
- [79]. Akhavan-Zanjani H, Saffar-Avval M, Mansourkiaei M, Ahadi M, Sharif F. Turbulent convective heat transfer and pressure drop of graphene–water nanofluid flowing inside a horizontal circular tube. *J Dispers Sci Technol.* 2014;35:1230–40.
- [80]. Zhang L, Yu Z, Li D, Fan L, Zhu Y, Hong R, et al. Enhanced critical heat flux during quenching of extremely dilute aqueous colloidal suspensions with graphene oxide nanosheets. *J Heat Transfer.* 2013;135:054502.
- [81]. Liu J, Wang F, Zhang L, Fang X, Zhang Z. Thermodynamic properties and thermal stability of ionic liquid-based nanofluids containing graphene as advanced heat transfer fluids for medium-to-high-temperature applications. *Renew Energy.* 2014;63:519–23.
- [82]. Park SD, Bang IC. Experimental study of a universal CHF enhancement mechanism in nanofluids using hydrodynamic instability. *Int J Heat Mass Transf.* 2014;70:844–50.
- [83]. Liu K, Chen S, Luo Y, Jia D, Gao H, Hu G, et al. Noncovalently functionalized pristine graphene/metal nanoparticle hybrid for conductive composites. *Compos Sci Technol.* 2014;94:1–7.
- [84]. Park SS, Kim NJ. Influence of the oxidation treatment and the average particle diameter of graphene for thermal conductivity enhancement. *J Ind Eng Chem.* 2014;20:1911–5.
- [85]. Li P, Zheng Y, Wu Y, Qu P, Yang R, Zhang A. Nanoscale ionic graphene material with liquid-like behavior in the absence of solvent. *Appl Surf Sci.* 2014;314:983–90.
- [86]. Mehrali M, Sadeghinezhad E, Tahan Latibari S, Mehrali M, Togun H, Zubir MNM, et al. Preparation, characterization, viscosity, and thermal conductivity of nitrogen-doped graphene aqueous nanofluids. *J Mater Sci.* 2014;49:7156–71.
- [87]. Hajjar Z, Rashidi AM, Ghozatloo A. Enhanced thermal conductivities of graphene oxide nanofluids. *Int Commun Heat Mass Transf.* 2014;57:128–31.
- [88]. Esmaeili Faraj SH, Nasr Esfahany M, Jafari-Asl M, Etesami N. Hydrogen sulfide bubble absorption enhancement in water-based nanofluids. *Ind Eng Chem Res.* 2014;53:16851–8.
- [89]. Li X, Chen Y, Mo S, Jia L, Shao X. Effect of surface modification on the stability and thermal conductivity of water-based SiO₂-coated graphene nanofluid. *Thermochim Acta.* 2014;595:6–10.
- [90]. Hadadian M, Goharshadi EK, Youssefi A. Electrical conductivity, thermal conductivity, and rheological properties of graphene oxide-based nanofluids. *J Nanoparticle Res.* 2014;16:2788.
- [91]. Zubir MNM, Badarudin A, Kazi SN, Huang NM, Misran M, Sadeghinezhad E, et al. Experimental investigation on the use of reduced graphene oxide and its hybrid complexes in improving closed conduit turbulent forced convective heat transfer. *Exp Therm Fluid Sci.* 2015;66:290–303.
- [92]. Liu J, Ye Z, Zhang L, Fang X, Zhang Z. A combined numerical and experimental study on graphene/ionic liquid nanofluid based direct absorption solar collector. *Sol Energy Mater Sol Cells.* 2015;136:177–86.
- [93]. Kazi SN, Badarudin A, Zubir MNM, Ming HN, Misran M, Sadeghinezhad E, et al. Investigation on the use of graphene oxide as novel surfactant to stabilize weakly charged graphene nanoplatelets. *Nanoscale Res Lett.* 2015;10:212.
- [94]. Mohd Zubir MN, Badarudin A, Kazi SN, Huang NM, Misran M, Sadeghinezhad E, et al. Highly dispersed reduced graphene oxide and its hybrid complexes as effective additives for improving thermophysical property of heat transfer fluid. *Int J Heat Mass Transf.* 2015;87:284–94.
- [95]. Asirvatham LG, Wongwises S, Babu J. Heat transfer performance of a glass thermosyphon using graphene–acetone nanofluid. *J Heat Transfer.* 2015;137:111502.
- [96]. Mahmudul Haque AKM, Kwon S, Kim J, Noh J, Huh S, Chung H, et al. An experimental study on thermal characteristics of nanofluid with graphene and multi-wall carbon nanotubes. *J Cent South Univ.* 2015;22:3202–10.
- [97]. Li Tong W, Ong W-J, Chai S-P, Tan MK, Mun Hung Y. Enhanced evaporation strength through fast water permeation in graphene-oxide deposition. *Sci Rep.* 2015;5:11896.
- [98]. Fan L-W, Li J-Q, Li D-Y, Zhang L, Yu Z-T, Cen K-F. The effect of concentration on transient pool boiling heat transfer of graphene-based aqueous nanofluids. *Int J Therm Sci.* 2015;91:83–95.
- [99]. Park S-S, Kim YH, Jeon YH, Hyun MT, Kim N-J. Effects of spray-deposited oxidized multi-wall carbon nanotubes and graphene on pool-boiling critical heat flux enhancement. *J Ind Eng Chem.* 2015;24:276–83.
- [100]. Khosrojerdi S, Vakili M, Yahyaei M, Kalhor K. Thermal conductivity modeling of graphene nanoplatelets/deionized water nanofluid by

- MLP neural network and theoretical modeling using experimental results. *Int Commun Heat Mass Transf.* 2016;74:11–7.
- [101]. Sadeghinezhad E, Mehrali M, Rosen MA, Akhiani AR, Tahan Latibari S, Mehrali M, et al. Experimental investigation of the effect of graphene nanofluids on heat pipe thermal performance. *Appl Therm Eng.* 2016;100:775–87.
- [102]. Iranmanesh S, Mehrali M, Sadeghinezhad E, Ang BC, Ong HC, Esmaeilzadeh A. Evaluation of viscosity and thermal conductivity of graphene nanoplatelets nanofluids through a combined experimental–statistical approach using response surface methodology. *Int Commun Heat Mass Transf.* 2016;79:74–80.
- [103]. Selvam C, Balaji T, Mohan Lal D, Harish S. Convective heat transfer coefficient and pressure drop of water–ethylene glycol mixture with graphene nanoplatelets. *Exp Therm Fluid Sci.* 2017;80:67–76.
- [104]. Abo-Zahhad EM, El-Shazly AH, El-Kady MF. Experimental study of pressure drops across microtube using graphene and magnetic graphene nanofluid. *AIP Conf Proc.* 2017;020015:020015.
- [105]. Abd Elhafez SE, Abo-Zahhad EM, El-Shazly AH, Elkady MF. Experimental investigation of heat transfer for graphene/water nanofluid in micro heat exchanger. *AIP Conf Proc.* 2017;1814:020014.
- [106]. Wang N, Xu G, Li S, Zhang X. Thermal properties and solar collection characteristics of oil-based nanofluids with low graphene concentration. *Energy Procedia.* 2017;105:194–9.
- [107]. Qing SH, Rashmi W, Khalid M, Gupta TCSM, Nabipour M, Hajibeigy MT. Thermal conductivity and electrical properties of hybrid SiO₂-graphene naphthenic mineral oil nanofluid as potential transformer oil. *Mater Res Express.* 2017;4:015504.
- [108]. Mehrali M, Sadeghinezhad E, Akhiani AR, Tahan Latibari S, Metselaar HSC, Kherbeet AS, et al. Heat transfer and entropy generation analysis of hybrid graphene/Fe₃O₄ ferro-nanofluid flow under the influence of a magnetic field. *Powder Technol.* 2017;308:149–57.
- [109]. Su X, Zhang M, Han W, Guo X. Experimental study on the heat transfer performance of an oscillating heat pipe with self-wetting nanofluid. *Int J Heat Mass Transf.* 2016;100:378–85.
- [110]. Yarmand H, Gharekhani S, Shirazi SFS, Goodarzi M, Amiri A, Sarsam WS, et al. Study of synthesis, stability and thermo-physical properties of graphene nanoplatelet/platinum hybrid nanofluid. *Int Commun Heat Mass Transf.* 2016;77:15–21.
- [111]. Selvam C, Lal DM, Harish S. Thermal conductivity enhancement of ethylene glycol and water with graphene nanoplatelets. *Thermochim Acta.* 2016;642:32–8.
- [112]. Ho CY, Yusup S, Soon CV, Arpin MT. Rheological behaviour of graphene nano-sheets in hydrogenated oil-based drilling fluid. *Procedia Eng.* 2016;148:49–56.
- [113]. Kumar V, Tiwari AK, Ghosh SK. Effect of variable spacing on performance of plate heat exchanger using nanofluids. *Energy.* 2016;114:1107–19.
- [114]. Zhang L, Chen L, Liu J, Fang X, Zhang Z. Effect of morphology of carbon nanomaterials on thermo-physical characteristics, optical properties and photo-thermal conversion performance of nanofluids. *Renew Energy.* 2016;99:888–97.
- [115]. Ahammed N, Asirvatham LG, Wongwises S. Entropy generation analysis of graphene–alumina hybrid nanofluid in multiport minichannel heat exchanger coupled with thermoelectric cooler. *Int J Heat Mass Transf.* 2016;103:1084–97.
- [116]. Singh RK, Sharma AK, Dixit AR, Tiwari AK, Pramanik A, Mandal A. Performance evaluation of alumina-graphene hybrid nanocutting fluid in hard turning. *J Clean Prod.* 2017;162:830–45.
- [117]. Kim S, Tserengombo B, Choi SH, Noh J, Huh S, Choi B, et al. Experimental investigation of dispersion characteristics and thermal conductivity of various surfactants on carbon based nanomaterial. *Int Commun Heat Mass Transf.* 2018;91:95–102.
- [118]. Yudong L, Yongkun G, Jiangqing W, Shichao G, Chuangjian S, Quangui P. Nucleation mechanism of nanofluid drops under acoustic levitation. *Appl Therm Eng.* 2018;130:40–8.
- [119]. Imani-Mofrad P, Zeinali Heris S, Shanbedi M. Experimental investigation of the effect of different nanofluids on the thermal performance of a wet cooling tower using a new method for equalization of ambient conditions. *Energy Convers Manag.* 2018;158:23–35.
- [120]. Iranmanesh S, Ong HC, Ang BC, Sadeghinezhad E, Esmaeilzadeh A, Mehrali M. Thermal performance enhancement of an evacuated tube solar collector using graphene nanoplatelets nanofluid. *J Clean Prod.* 2017;162:121–9.
- [121]. Sumanth S, Babu Rao P, Krishna V, Seetharam TR, Seetharamu KN. Effect of carboxyl graphene nanofluid on automobile radiator performance. *Heat Transf Asian Res.* 2018;47:669–83.
- [122]. Verma SK, Tiwari AK, Chauhan DS. Experimental evaluation of flat plate solar collector using nanofluids. *Energy Convers Manag.* 2017;134:103–15.
- [123]. Sadeghinezhad E, Mehrali M, Akhiani AR, Tahan Latibari S, Dolatshahi-Pirouz A, Metselaar HSC, et al. Experimental study on heat transfer augmentation of graphene based ferrofluids in presence of magnetic field. *Appl Therm Eng.* 2017;114:415–27.
- [124]. Chen L, Liu J, Fang X, Zhang Z. Reduced graphene oxide dispersed nanofluids with improved photo-thermal conversion performance for direct absorption solar collectors. *Sol Energy Mater Sol Cells.* 2017;163:125–33.
- [125]. Sadri R, Hosseini M, Kazi SN, Bagheri S, Zubir N, Ahmadi G, et al. A novel, eco-friendly technique for covalent functionalization of graphene nanoplatelets and the potential of their nanofluids for heat transfer applications. *Chem Phys Lett.* 2017;675:92–7.
- [126]. Syam Sundar L, Singh MK, Ferro MC, Sousa ACM. Experimental investigation of the thermal transport properties of graphene oxide/Co₃O₄ hybrid nanofluids. *Int Commun Heat Mass Transf.* 2017;84:1–10.
- [127]. Wang X, Hu Y, Li T, He Y. Experimental investigation of graphene nanofluid and numerical simulation of its natural convection in a square enclosure. *Nanosci Nanotechnol Lett.* 2017;9:640–9.
- [128]. Selvam C, Mohan Lal D, Harish S. Thermal conductivity and specific heat capacity of water–ethylene glycol mixture-based nanofluids with graphene nanoplatelets. *J Therm Anal Calorim.* 2017;129:947–55.
- [129]. Selvam C, Mohan Lal D, Harish S. Enhanced heat transfer performance of an automobile radiator with graphene based suspensions. *Appl Therm Eng.* 2017;123:50–60.
- [130]. Chai YH, Yusup S, Chok VS, Irawan S, Singh JSDB. Thermo-physical properties of graphene nanosheets—hydrogenated oil based nanofluid for drilling fluid improvements. *Appl Therm Eng.* 2017;122:794–805.
- [131]. Zhou Y, Cui X, Weng J, Shi S, Han H, Chen C. Experimental investigation of the heat transfer performance of an oscillating heat pipe with graphene nanofluids. *Powder Technol.* 2018;332:371–80.
- [132]. Liu X, Wang X, Huang J, Cheng G, He Y. Volumetric solar steam generation enhanced by reduced graphene oxide nanofluid. *Appl Energy.* 2018;220:302–12.
- [133]. Ranjbarzadeh R, Karimipour A, Afrand M, Isfahani AHM, Shirneshan A. Empirical analysis of heat transfer and friction factor of water/graphene oxide nanofluid flow in turbulent regime through an isothermal pipe. *Appl Therm Eng.* 2017;126:538–47.

- [134]. Hussien AA, Abdullah MZ, Yusop NM, Al-Nimr MA, Atieh MA, Mehrali M. Experiment on forced convective heat transfer enhancement using MWCNTs/GNPs hybrid nanofluid and mini-tube. *Int J Heat Mass Transf.* 2017;115:1121–31.
- [135]. Selvam C, Solaimalai Raja R, Mohan Lal D, Harish S. Overall heat transfer coefficient improvement of an automobile radiator with graphene based suspensions. *Int J Heat Mass Transf.* 2017;115:580–8.
- [136]. Zhou M, Xia G, Li J, Chai L, Zhou L. Analysis of factors influencing thermal conductivity and viscosity in different kinds of surfactant solutions. *Exp Therm Fluid Sci.* 2012;36:22–9.
- [137]. Khosrojerdi S, Lavasani AM, Vakili M. Experimental study of photothermal specifications and stability of graphene oxide nanoplatelets nanofluid as working fluid for low-temperature Direct Absorption Solar Collectors (DASCs). *Sol Energy Mater Sol Cells.* 2017;164:32–9.
- [138]. Ahmadi A, Ganji DD, Jafarkazemi F. Analysis of utilizing graphene nanoplatelets to enhance thermal performance of flat plate solar collectors. *Energy Convers Manag.* 2016;126:1–11.
- [139]. Yarmand H, Gharehkhani S, Ahmadi G, Shirazi SFS, Baradaran S, Montazer E, et al. Graphene nanoplatelets–silver hybrid nanofluids for enhanced heat transfer. *Energy Convers Manag.* 2015;100:419–28.
- [140]. Kulkarni P, Sureshkumar R, Biswas P. Multiscale simulation of irreversible deposition in presence of double layer interactions. *J Colloid Interface Sci.* 2003;260:36–48.
- [141]. Tchalala MR, Anjum DH, Chaieb S. Effect of ionic liquid (emim BF₄) on the dispersion of gold nanoparticles. *J Phys Conf Ser.* 2016;758:012020.
- [142]. Heller W. Effects of macromolecular compounds in disperse systems. *Pure Appl Chem.* 1966;12:249–74.
- [143]. Heller W, Pugh TL. “Steric protection” of hydrophobic colloidal particles by adsorption of flexible macromolecules. *J Chem Phys.* 1954;22:1778.
- [144]. Turkevich J, Stevenson PC, Hillier J. A study of the nucleation and growth processes in the synthesis of colloidal gold. *Discuss Faraday Soc.* 1951;11:55.
- [145]. Turkevich J. Colloidal gold. Part I. *Gold Bull.* 1985;18:86–91.
- [146]. Yu W, Xie H. A review on nanofluids: preparation, stability mechanisms, and applications. *J Nanomater.* 2012;2012:1687–4110.
- [147]. Wei X, Wang L. Particulate synthesis and thermal conductivity of microfluidic copper nanofluids. *Particuology.* 2010;8:262–71.
- [148]. Li J, Cui J, Yang Z, Qiu H, Tang Z, Yang J. Stabilizing graphene layers by intercalating laponite between them. *New Carbon Mater.* 2018;33:19–25.
- [149]. Mahanta NK, Abramson AR. Thermal conductivity of graphene and graphene oxide nanoplatelets. In: 13th Intersoc Conf Therm Thermomechanical Phenom Electron Syst. IEEE; 2012. p. 1–6.
- [150]. Ali HM, Arshad W. Effect of channel angle of pin-fin heat sink on heat transfer performance using water based graphene nanoplatelets nanofluids. *Int J Heat Mass Transf.* 2017;106:465–72.
- [151]. Arshad W, Ali HM. Graphene nanoplatelets nanofluids thermal and hydrodynamic performance on integral fin heat sink. *Int J Heat Mass Transf.* 2017;107:995–1001.
- [152]. Angayarkanni SA, Philip J. Review on thermal properties of nanofluids: recent developments. *Adv Colloid Interface Sci.* 2015;225:146–76.
- [153]. Amiri A, Shanbedi M, Chew BT, Kazi SN, Solangi KH. Toward improved engine performance with crumpled nitrogen-doped graphene based water–ethylene glycol coolant. *Chem Eng J.* 2016;289:583–95.
- [154]. Goodarzi M, Kherbeet AS, Afrand M, Sadeghinezhad E, Mehrali M, Zahedi P, et al. Investigation of heat transfer performance and friction factor of a counter-flow double-pipe heat exchanger using nitrogen-doped, graphene-based nanofluids. *Int Commun Heat Mass Transf.* 2016;76:16–23.
- [155]. Zuber N, Novak. Hydrodynamic aspects of boiling heat transfer (Thesis). Oak Ridge, TN; 1959.
- [156]. Zhang L, Fan L, Yu Z, Cen K. An experimental investigation of transient pool boiling of aqueous nanofluids with graphene oxide nanosheets as characterized by the quenching method. *Int J Heat Mass Transf.* 2014;73:410–4.
- [157]. Rose BAJ, Singh H, Verma N, Tassou S, Suresh S, Anantharaman N, et al. Investigations into nanofluids as direct solar radiation collectors. *Sol Energy.* 2017;147:426–31.
- [158]. K. Holmberg, P. Andersson, A. Erdemir, *Tribol. Int.* 47 (2012) 221–234.
- [159]. A. Erdemir, J.M. Martin, *Superlubricity*, Elsevier, Amsterdam, 2007.
- [160]. A. Erdemir, in: B. Bhushan (Ed.), *Handbook of Modern Tribology*, CRC Press, 2001, pp. 787–818.
- [161]. K.S. Novoselov, et al. *Proc. Natl. Acad. Sci. U.S.A.* 102 (2005) 10451.
- [162]. D. Chen, L. Tang, J. Li, *Chem. Soc. Rev.* 39 (2010) 3157.
- [163]. C. Soldano, A. Mahmood, E. Dujardin, *Carbon* 48 (2010) 2127.
- [164]. M. Lotya, et al. *ACS Nano* 4 (2010) 3155.
- [165]. S. Mohammadi, et al. *Carbon* 52 (2013) 451–463.
- [166]. S.W. Lee, et al. *J. Phys. Chem. Lett.* 3 (2012) 772–777.
- [167]. A.C. Ferrari, et al. *Phys. Rev. Lett.* 97 (2006) 187401.
- [168]. M.H. Rummeli, et al. *Adv. Mater.* 23 (2011) 4471.
- [169]. J. Wang, et al. *Tribol. Lett.* 48 (2012) 255–261.
- [170]. W.S. Hummers Jr. and R. E. Offeman, “Preparation of graphitic oxide,” *Journal of the American Chemical Society*, vol. 80, no. 6, p. 1339, 1958.
- [171]. S. Guo and S. Dong, “Graphene nanosheet: synthesis, molecular engineering, thin film, hybrids, and energy and analytical applications,” *Chemical Society Reviews*, vol. 40, no. 5, pp. 2644–2672, 2011.
- [172]. C. Zhu, S. Guo, Y. Fang, and S. Dong, “Reducing sugar: new functional molecules for the green synthesis of graphene nanosheets,” *ACS Nano*, vol. 4, no. 4, pp. 2429–2437, 2010.
- [173]. H. Jiang, “Chemical preparation of graphene-based nanomaterials and their applications in chemical and biological sensors,” *Small*, vol. 7, no. 17, pp. 2413–2427, 2011.
- [174]. S. Guo and S. Dong, “Graphene nanosheet: synthesis, molecular engineering, thin film, hybrids, and energy and analytical applications,” *Chemical Society Reviews*, vol. 40, no. 5, pp. 2644–2672, 2011.
- [175]. C. N. R. Rao, K. S. Subrahmanyam, H. S. S. Ramakrishna Matte, U. Maitra, K. Moses, and A. Govindaraj, “Graphene: synthesis, functionalization and properties,” *International Journal of Modern Physics B*, vol. 25, no. 30, pp. 4107–4143, 2011.
- [176]. S. D. Perera, R. G. Mariano, K. Vu et al., “Hydrothermal synthesis of graphene-TiO₂ nanotube composites with enhanced photocatalytic activity,” *ACS Catalysis*, vol. 2, no. 6, pp. 949–956, 2012.

- [177]. K. Zhou, Y. Zhu, X. Yang, X. Jiang, and C. Li, "Preparation of graphene-TiO₂ composites with enhanced photocatalytic activity," *New Journal of Chemistry*, vol. 35, no. 2, pp. 353–359, 2011.
- [178]. Y. Zhang and C. Pan, "TiO₂/graphene composite from thermal reaction of graphene oxide and its photocatalytic activity in visible light," *Journal of Materials Science*, vol. 46, no. 8, pp. 2622–2626, 2011.
- [179]. J. Shen, M. Shi, B. Yan, H. Ma, N. Li, and M. Ye, "Ionic liquid- assisted one-step hydrothermal synthesis of TiO₂-reduced graphene oxide composites," *Nano Research*, vol. 4, no. 8, pp. 795–806, 2011.
- [180]. P. Suvaranaphaet, S. Pechprasarn, Graphene based materials for biosensors: A Review, *Sensors* 17(10), 2017.
- [181]. Einstein A. Investigations on the theory of the Brownian movement. New York: Dover; 1956.
- [182]. Kitano T, Kataoka T, Shirota T. An empirical equation of the relative viscosity of polymer melts filled with various inorganic fillers. *Rheol Acta* 1981;20 (2):207–9.
- [183]. Batchelor GK. The effect of Brownian motion on the bulk stress in a suspension of spherical particles. *J Fluid Mech* 1977;83(01):97–117.
- [184]. Nielsen LE. Generalized equation for the elastic moduli of composite materials. *J Appl Phys* 1970;41(11):4626–7.
- [185]. Savithiri S, Pattamatta A, Das SK. Scaling analysis for the investigation of slip mechanisms in nanofluids. *Nanoscale Res Lett* 2011;6(1):1–15.
- [186]. Zhmud B, Pasalskiy B. Nanomaterials in lubricants: an industrial perspective on current research. *Lubricants* 2013;1(4):95.
- [187]. Zhang W, et al. Fundamental understanding of the tribological and thermal behavior of Ag–MoS₂ nanoparticle-based multi-component lubricating system. *Wear* 2012;288(0):9–16.
- [188]. Nika DL, Askerov AS, Balandin AA. Anomalous size dependence of the thermal conductivity of graphene ribbons. *Nano Lett* 2012;12(6):3238–44.
- [189]. Jang W, et al. Thickness-dependent thermal conductivity of encased graphene and ultrathin graphite. *Nano Lett* 2010;10(10):3909–13.
- [190]. Chou R, et al. Tribological behavior of polyalphaolefin with the addition of nickel nanoparticles. *Tribol Int* 2010;43(12):2327–32.
- [191]. Hu ZS, et al. Preparation and tribological properties of nanometer magnesium borate as lubricating oil additive. *Wear* 2002;252(5–6):370–4.
- [192]. Wei Z, et al. Tribological properties of oleic acid-modified graphene as lubricant oil additives. *J Phys D: Appl Phys* 2011;44(20):205303.
- [193]. Lin J, Wang L, Chen G. Modification of graphene platelets and their tribological properties as a lubricant additive. *Tribol Lett* 2011;41(1):209–15.
- [194]. Kinoshita H, et al. Tribological properties of monolayer graphene oxide sheets as water-based lubricant additives. *Carbon* 2014;66:720–3.
- [195]. Ou J, Wang J, Liu S, Mu B, Ren J, Wang H, et al. Tribology study of reduced graphene oxide sheets on silicon substrate synthesized via covalent assembly. *Langmuir* 2010;26:15830–6.
- [196]. Miura K, Ishikawa M. C60 Intercalated graphite as nanolubricants. *Materials* 2010;3:4510–7.
- [197]. Shenoy VB, Reddy CD, Ramasubramaniam A, Zhang YW. Edge-stress-induced warping of graphene sheets and nanoribbons. *Phys Rev Lett* 2008;101:245501.
- [198]. Dikin DA, Stankovich S, Zimney EJ, Piner RD, Dommett GHB, Evmenenko G, et al. Preparation and characterization of graphene oxide paper. *Nature* 2007;448:457–60.
- [199]. S.K. Das, S.U. Choi, W. Yu, T. Pradeep, "Nanofluids: science and technology", John Wiley & Sons, 2007
- [200]. Jerry P. Byers, "Metalworking Fluids", 1st Edition, CRC, USA, 1994.
- [201]. Milton C. Shaw, "Metal Cutting Principles", 2nd Edition, Oxford University Press, USA, 2004.
- [202]. M.A. El Baradie, "Cutting Fluids: Part I: Characterisation", *Journal of Materials Processing Technology*, 56, 786-797, 1996.
- [203]. Usui, K and Takeyama, H., "A Photo-Elastic Analysis of Machining Stresses", *Trans. ASME, Journal of Engineering for Industry*, B82, 303-308, 1960.
- [204]. Madhavan, V., Chandrasekhar, S., Farris, T.N., "Direct Observations of the Chip-Tool Interface in the Low Speed Cutting of Pure Metals", *Trans. ASME Journal of Tribology*, 124, 617-626, 2002.
- [205]. Manna A, Bhattacharayya B, "Study on Different Tooling Systems Turning for Effective Machining of Al/SiC-MMC", *Journal of Materials Processing Technology*, 123 (3), 476-482, 2002.
- [206]. "Wear Control Hand Book", ASME Press, 1980.
- [207]. Usui, K and Takeyama, H., "A Photo-Elastic Analysis of Machining Stresses", *Trans. ASME, Journal of Engineering for Industry*, B82, 303-308, 1960.
- [208]. M.C. Shaw, "Dimensional Analysis for Wear Systems", *Wear*, 43, 263–266, 1977.
- [209]. Glass K, and Colbaugh R, "Real-Time Tool Wear Estimation using Cutting Force Measurements", *Proceedings of IEEE International Conference on Robotics and Automation*, 4 (22-28), 3067 - 3072, 1996.
- [210]. D.E. Dimla JR, P.M. Lister and N.J. Leighton, "Neural Network Solutions to the Tool Condition Monitoring Problem in Metal Cutting- A Critical Review of Methods", *Int. Journal of Machine Tools and Manufacture*, 37 (9), 1219-1241, 1997.
- [211]. Y. Koren, and E. Lenz, "Mathematical Model for the Flank Wear while Turning Steel with Carbide Cutting Tools", *Proc. CIRP seminar on Manufacturing Systems, Ljubljana*, 1(2), 127-137, 1972.
- [212]. D.W. Yen and P.K. Wright, "Adaptive Control in Machining-A New Approach Based on the Physical Constraints of Tool Wear Mechanisms", *Trans. ASME Journal of Engineering for Industry*, 105, 56-64, 1988.
- [213]. Y. Koren, "Flank Wear Model of Cutting Tools using Control Theory", *Trans. ASME Journal of Engineering for Industry*, 100, 103-109, 1978.
- [214]. Backer, W.R, Marshall, E.R, and Shaw, M.C, "The Size Effect in Metal Cutting", *Trans AMSE, Journal of Engineering for Industry*, 74, 61-72, 1952.
- [215]. G.F. Micheletti, A. De Fillipi and R. Ippolito, "Tool Wear and Cutting Forces in Turning", *Ann. CIRP*, 16, 353-360, 1968.
- [216]. D.E. Dimla, Sr, "Tool Wear Monitoring using Cutting Force Measurements", *Proceedings of 15th NCMR: Advances in Manufacturing Technology XIII*, University of Bath, 33-37, 6th -8th September, 1999.
- [217]. H. Takeyama, Y. Doi, T. Mitsuoka and H. Sekiguchi, 'Sensors of Tool Life for Optimization of Machining.' *Advances in Mach. Tool Des. Res.*, 1, 191-208, 1967.
- [218]. L.V. Colwell, "Tracking Tool Deterioration by Computer (During Actual Machining)", *Ann. CIRP*, 23(1), 29-30, 1974.
- [219]. J.W. Youn and M.Y. Yang, "A Study on the Relationships between Static/Dynamic Cutting Force Components and Tool Wear", *Journal of Manufacturing Science and Engineering, Transactions of ASME* 123 (2), 196–205, 2001.
- [220]. L.V. Colwell, "Methods for Sensing the Rate of Tool Wear", *Ann. CIRP*, 19(1), 647-651, 1971.

- [221]. W.Y.H. Liew, Y.G. Lu, X. Ding, B.K.A. Ngoi and S. Yuan, "Performance of Uncoated and Coated Carbide Tools in the Ultra-Precision Machining of Stainless Steel", *Tribology Letters*, 17 (4), 851-857, 2004.
- [222]. P. Leskover, J. Grum, "The Metallurgical Aspect of Machining", *Annals of CIRP* 35 (1), 537-550, 1986.
- [223]. A. De Fillipi and R. Ippolito, "Adaptive Control in Turning: Cutting Force and Tool Wear Relationship for Carbides", *Ann. CIRP*, 17, 377-385, 1969.
- [224]. W. König, K. Langhammer and H.U. Schemmel, "Correlation between Resultant Cutting Force Component and Tool Wear", *Ann. CIRP*, 21(1), 19-20, 1972.
- [225]. G. Boothroyd, "Fundamentals of Metal Machining and Machine Tools", McGraw-Hill, New York, 1975.
- [226]. M.C. Shaw, "Temperature in Cutting", *Proceedings of ASME Symposium on Thermal Aspects in Manufacturing*, Chicago, 30, 133-143, 1988.
- [227]. A. De Fillipi and R. Ippolito, "Analysis of Correlation among: Cutting Force Variation (vs. Time), Chip Formation Parameters, Machinability", *Ann. CIRP*, 21(1), 29-30, 1972.
- [228]. C.Y. Jiang, Y.Z. Zhang and H.J. Xu, "In-Process Monitoring of Tool Wear Stage by the Frequency Band-Energy Method", *Ann. CIRP*, 36 (1), 45-48, 1987.
- [229]. H.K. Tonshoff and E. Brinkomeier, "Determination of the Mechanical and Thermal Influences on Machined Surface by Microhardness and Residual Stress Analysis", *Annals of CIRP* 29 (2), 519-532, 1986.
- [230]. S.M. Pandit, "Stochastic Linearization by Data Dependent Systems", *Transactions of ASME, Journal of Engineering for Industry*, 221-226, 1977.
- [231]. M.P. Groover, R.J. Karpovich and E.K. Levy, "A Study of the Relationship between Remote Thermocouple Temperatures and Tool Wear in Machining", *Int. Journal of Production Research*, 25(2), 129-141, 1977.
- [232]. Y. Yao, X.D. Fang and G. Arndt, "On-Line Estimation of Groove Wear in the Minor Cutting Edge for Finish Machining", *Ann. CIRP*, 40 (1), 41-44, 1991.
- [233]. K.J. Trigger and B.T. Chao, "An Analytical Evaluation of Metal Cutting Temperature", *Trans. ASME*, 73, 57-68, 1951.
- [234]. D. Spurgeon and R.A.C. Slater, "In-Process Indication of Surface Roughness Using a Fibre-Optics Transducer", *Proceedings of 15th Int. Machine Tool Design and Research Conference*, Birmingham, 251-257, 1974.
- [235]. V.C. Venkatesh and M. Satchithananda, "A Discussion of Tool Life Criteria and Total Failure Causes", *Ann. CIRP*, 29, 19-22, 1980.
- [236]. J. Rotberg, S. Braun and E. Lenz, "Mechanical Signature Analysis in Interrupted Cutting", *Ann. CIRP*, 36 (1), 249-252, 1987.
- [237]. Chou YK, "Hard Turning of M50 Steel with Different Micro Structures in Continuous and Intermittent Cutting", *Wear*, 255 (22), 1388-1394, 1999.
- [238]. Chiou R.Y, Chen J.S.J, Lu L. and North M.T, "The Effect of an Embedded Heat Pipe in a Cutting Tool on Temperature and Wear", *Proceedings of ASME Conference on Mechanical Engineering*, Washington, DC, 1-8, 2003.
- [239]. V. Sukaylo, A. Kaldos, H.-J. Pieper, V. Bana and M. Sobczyk, "Numerical Simulation of Thermally Induced Workpiece Deformation in Turning when using Various Cutting Fluid Applications", *Journal of Materials Processing Technology*, 167, 408-414, 2005.
- [240]. Ko TL, Kim HS, Chung BG, "Air-Oil Cooling Method for Turning of Hardened Material", *Int Journal of Advanced Manufacturing Technology*, 15 (7), 470-477, 1999.
- [241]. Jen TC, Gutierrez G, Eapen S, Barber G, Zhao H, Szuba PS, Lambataille J, and Manjunathaiah J, "Investigation of Heat Pipe Cooling in Drilling Application: Part 1-Preliminary Numerical Analysis and Verification", *Int Journal of Machine Tools and Manufacture*, 43, 643-652, 2002.
- [242]. A. Cambiella, J.M. Benito and C. Pazos, J. Coca, A. Hernández and J.E. Fernández., "Formulation of Emulsifiable Cutting Fluids and Extreme Pressure Behaviour", *Journal of Materials Processing Technology*, 184 (1-3), 139-145, 2007.
- [243]. L. De Chiffre and W. Belluco, "Correlation of Cutting Fluid Performance in Different Machining Operations", *V CONVEGNO A.I.TE.M., Bari*, 18th -20th September, 7-12, 2001.
- [244]. R. W. Mould, H. B. Silver and R. J. Syrett, "Investigations of the Activity of Cutting Oil Additives II. Organochlorine Containing Compounds", *Wear*, 22 (2), 269-286, 1972.
- [245]. W.F. Sales, G. Guimaraes, A.R. Machado, E.O. Ezugwu, "Cooling Ability of Cutting Fluids and Measurement of the Chip-Tool Interface Temperatures", *Journal of Industrial Lubrication and Tribology*, 54 (2), 57 - 68, 2002.
- [246]. J. M. Vieira, A. R. Machado and E. O. Ezugwu, "Performance of Cutting Fluids During Face Milling of Steels", *Journal of Materials Processing Technology*, 116 (2), 244-251, 2001.
- [247]. Ronaldo Yoshinobu Fuisse, Thiago Valle França, Rodrigo Eduardo Catai, Leonardo Roberto da Silva, Paulo Roberto de Aguiar and Eduardo Carlos Bianchi, "Analysis of the Cutting Fluid Influence on the Deep Grinding Process with a CBN Grinding Wheel", *Materials Research*, 7 (3), 451-457, 2004.
- [248]. O.C. Mendes, R.F. Avila, A.M. Abrao, Pedro Reis, J. Paulo Davim, "The Performance of Cutting Fluids When Machining Aluminium Alloys", *Journal of Industrial Lubrication and Tribology*, 58 (5), 260 - 268, 2006.
- [249]. Gedberg, M.G, Kononov, V.Z and Makarov, V.N, "Properties of a Water-Oil Emulsion used As A Quenching Medium", *Journal of Metal Science and Heat Treatment*, 29 (5), 392-395, 1987.
- [250]. V.A. Soshko, "The Condition of a Metal Surface after Machining with use of Cutting Fluids", *Journal of Materials Science*, 26 (5), 603-604, 1991.
- [251]. D. M. Haan, S. A. Batzer, W. W. Olson and J. W. Sutherland, "An Experimental Study of Cutting Fluid Effects in Drilling", *Journal of Materials Processing Technology*, 71 (2), 305-313, 1997.
- [252]. O. Cakir, M. Kiyak and E. Altan, "Comparison of Gas Applications to Wet and Dry Cuttings in Turning", *Journal of Materials Processing Technology*, 153-154, 35-41, 2004.
- [253]. Tsao C.C, " Study on Tool Life and Surface Roughness in Milling Aluminum Alloys using Sulfurous Boric Acid Ester Cutting Fluids by Taguchi Method", *Proceedings of the 17th Conference CSME, Kaoshiong*, 4, 425-428, 2000.
- [254]. David Chargin, "Cutting Fluid Study for Single Crystal Silicon", Report submitted by Lawrence Livermore National Laboratory, California, 1998.
- [255]. Radoslav Raki, A and Zlata Rakib, "Tribological Aspects of The Choice of Metalworking Fluid in Cutting Processes", *Journal of Materials Processing Technology*, 124 (1-2), 25-31, 2002.
- [256]. Tsao C.C, "An Experiment Study of Hard Coating and Cutting Fluid Effect in Milling Aluminum Alloy", *International Journal of Advanced Manufacturing Technology*, 32 (9-10), 885-891, 2007.

- [257]. Bianchi, E.C, Franzo, C.G, De Aguiar, P.R, and Catai, R.E, "Analysis of the Influence of Infeed Rate and Cutting Fluid on Cylindrical Grinding Processes Using a Conventional Wheel", *Journal of Materials Research*, 7 (3), 385-392, 2004.
- [258]. Salete Martins Alves, A, and Joao Fernando Gomes De Oliveiraa, "Development of New Cutting Fluid for Grinding Process Adjusting Mechanical Performance and Environmental Impact", *Journal of Materials Processing Technology*, 179 (1-3), 185-189, 2006.
- [259]. Radoslav Raki A, and Zlata Raki B, "The Influence of the Metal Working Fluids on Machine Tool Failures", *Wear*, 252 (5-6), 438-444, 2002.
- [260]. Shuh-Bin Wang and Hong-Sen Kou, "Cooling Effectiveness of Cutting Fluid in Creep Feed Grinding", *International Communications in Heat and Mass Transfer*, 24 (6), 771-783, 1997.
- [261]. R. F. Ávila and A. M. Abrão, "The Effect of Cutting Fluids on the Machining of Hardened AISI 4340 Steel", *Journal of Materials Processing Technology*, 119 (1-3), 21-26, 2001.
- [262]. Anselmo Eduardo Diniz, and Ricardo Micaronia, "Influence of the Direction and Flow Rate of the Cutting Fluid on Tool Life in Turning Process of AISI 1045 Steel", *International Journal of Machine Tools and Manufacture*, 47 (2), 247-254, 2007.
- [263]. Baradie, M.A.El, "Cutting Fluids: Part I. Characterization", *Journal of Material Processing Technology*, 56, 786-797, 1996.
- [264]. Motta M.F, and Machado A.R, "Cutting Fluids: Types, Functions, Selection, Application Methods and Maintenance", *Machines and Metals Magazine, Brazil*, 44-56, 1995.
- [265]. Minke, E., "Contribution to the Role of Coolants on Grinding Process and Work Results", *Proceedings of 3rd International Machining and Grinding Conference, Cincinnati, Ohio*, 13-32, 1999.
- [266]. W. Belluco and L. De Chiffre, "Surface Integrity and Part Accuracy in Reaming And Tapping Stainless Steel with New Vegetable Based Cutting Oils", *Tribology International*, 35 (12), 865-870, 2002.
- [267]. W. Belluco and L. De Chiffre, "Performance Evaluation of Vegetable-Based Oils in Drilling Austenitic Stainless Steel", *Journal of Materials Processing Technology*, 148 (2), 171-176, 2004.
- [268]. L.I. Burke, "Automated Identification of Tool Wear States in Machining Processes: An Application of Self-Organising Neural Networks", Ph.D. Thesis, Department Of Industrial Engineering and Operations Research, University of California, Berkeley, USA, 1989.
- [269]. S. Purushothaman and Y.G. Srinivasa, "A Back-Propagation Algorithm applied to Tool Wear Monitoring", *Int. Journal of Machine Tools and Manufacture*, 34 (5), 625-631, 1994.
- [270]. G. S. Hong, M. Rahman and Q. Zhou, "Using Neural Networks for Tool Condition Monitoring based on Wavelet Decomposition", *International Journal of Machine Tools and Manufacturing*, 36 (5), 551-566, 1996.
- [271]. Dimla E. Dimla, Sr, "Application of Perceptron Neural Networks to Tool-State Classification in a Metal-Turning Operation", *Engineering Applications of Artificial Intelligence*, 12, 471-477, 1999.
- [272]. "Cutting Fluid Management in Small Machining Operations", IOWA waste reduction Center, University of Northern IOWA, 1996.
- [273]. "Prevention of Skin Problems when Working with Metal Working Fluids, Safety & Health Assessment & Research for Prevention", Technical Report: 55-7-2001, Washington State Department of Labor and Industries, 2001.
- [274]. Ozel T, Karpat Y, "Predictive Modeling of Surface Roughness and Tool Wear in Hard Turning using Regression and Neural Networks", *International Journal of Machine Tools and Manufacture*, 45, 467-479, 2005.
- [275]. V.A. Soshko, "The Condition of a Metal Surface after Machining with use of Cutting Fluids", *Journal of Materials Science*, 26 (5), 603-604, 1991.
- [276]. D.N. Rao, "Investigations into Tool-Wear Monitoring in Turning", Ph.D-thesis, IIT, Delhi, India, 1991.
- [277]. X. Luo, K. Cheng, R. Holt and X. Liu, "Modeling Flank Wear of Carbide Tool Insert in Metal Cutting", *Wear*, 259 (7-12), 1235-1240, 2005.
- [278]. S. Rangwala, "Machining Process Characterization and Intelligent Tool Condition Monitoring using Acoustic Emission Signal Analysis", Ph.D. Thesis, Mechanical Engineering Department, University of California, Berkeley, USA, 1988.
- [279]. H.W. Rossmoore, "Evaluation Technique for Biodeterioration of Water-Miscible Metalworking Fluids", *Biodeterioration Research Techniques 1*: 227-242, 1976.
- [280]. H.W. Rossmoore, "Microbial Causes of Cutting Fluid Deterioration", *Society of Manufacturing Engineers*, 1974.
- [281]. H.W. Rossmoore, "Antimicrobial Agents for Water-based Metalworking Fluids", *Journal of Occupational Medicine*, 23 (4), 247-254, April 1981.
- [282]. ASTM Standard D 3946-92(1997), "Test Method for Evaluating Bacterial Resistance of Water-Dilutable Metal Working Fluids", *ASTM Book of Standards*, 05.02, Petroleum Products and Lubricants, ASTM International, Philadelphia, Pennsylvania, 2003.
- [283]. Chazal P M, "Pollution of Modern Metalworking Fluids Containing Biocides by Pathogenic Bacteria in France- Reexamination of Chemical Treatments Accuracy", *European Journal of Epidemiology*, 11(1), 1-7, 1995.
- [284]. Inger Mattsby-Baltzer, Michael Sandin, Britta Ahlstrom, Stig Allenmark, Margareta Edebo, Enevold Falsen, Karsten Pedersen, Nils Rodin, Richard A. Thompson, and Lars Edebo, "Microbial Growth and Accumulation in Industrial Metal-Working Fluids", *Journal of Applied and Environmental Microbiology*, 2681-2689, 1989.
- [285]. Y. Yue, Olson WW and Sutherland JW, "Cutting Fluid Mist Formation via Atomization Mechanisms", *Proceedings of Symposium on Design for Manufacturing and Assembly, ASME bound volume-DE*, 89, 37-46, 1996.
- [286]. Y. Yue, J. Sun, K. L. Gunter, D. J. Michalek and J. W. Sutherland, "Character and Behavior of Mist Generated by Application of Cutting Fluid to a Rotating Cylindrical Workpiece, Part 1: Model Development", *Journal of Manufacturing Science and Engineering*, 126, 417-425, 2004.
- [287]. J. Sun, Y. Yue, K. L. Gunter, D. J. Michalek and J. W. Sutherland, "Character and Behavior of Mist Generated by Application of Cutting Fluid to a Rotating Cylindrical Workpiece, Part 2: Experimental Validation", *Journal of Manufacturing Science and Engineering*, 126, 426-434, 2004.
- [288]. A. Noorul Haq and T. Tamizharasan, "Investigation of The Effects of Cooling in Hard Turning Operations", *The International Journal of Advanced Manufacturing Technology*, 30 (9-10), 808-816, 2006.
- [289]. Jeffrey B. Dahmus and Timothy G. Gutowski, "An Environmental Analysis of Machining", *Proceedings of IMECHE 2004, 2004 ASME International Mechanical Engineering Congress and RD&D Expo, Anaheim, California USA*, 13-19, November 2004.
- [290]. ASTM Standard D1401-02, "Test Method for Water Separability of Petroleum Oils and Synthetic Fluids", *ASTM Book of Standards*, 05.01, Petroleum products and lubricants, ASTM International, Philadelphia, Pennsylvania, 2005.
- [291]. ASTM Standard C177-04, "Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by means of The Guarded-Hot-Plate Apparatus", *ASTM Book of Standards*, 04.06, Construction, thermal insulation, environmental acoustics, ASTM International, Philadelphia, Pennsylvania, 2005.
- [292]. ASTM Standard D0445-04E01, "Test Method for Kinematic Viscosity of Transparent and Opaque Liquids", *ASTM Book of Standards*,

- 05.01, Petroleum products and lubricants, ASTM International, Philadelphia, Pennsylvania, 2005.
- [293]. Raynor, Peter C., Kim, Seung Won, and Bhattacharya, Mrinal, "Mist Generation from Metalworking Fluids Formulated Using Vegetable Oils", *Annals of Occupational Hygiene*, 49(4):283-293, 2005.
- [294]. "Waste Treatment Processes, Methods and Tests for Disposal of Cutting Fluids", Cincinnati Milacron Co., 1978.
- [295]. Shane Y. Hong, "Economical and Ecological Cryogenic Machining", *Journal of Manufacturing Science and Engineering*, 123, 331-338, 2001.
- [296]. Junyan Liu, Rongdi Han, Yongfeng Sun, "Research on Experiments and Action Mechanism with Water Vapor as Coolant and Lubricant in Green Cutting", *International Journal of Machine Tools & Manufacture*, 45, 687-694, 2005.
- [297]. Baradie, M.A.El, "Cutting fluids: Part II. Recycling and Clean Machining", *Journal of Material Processing Technology*, 56, 798-806, 1996.
- [298]. "Shop Guide to Reduce the Waste of Metalworking Fluids", Institute of Advanced Manufacturing Sciences and Waste Reduction and Technology Transfer Foundation, 1996.