Study on Stability of Al_2O_3-Nanoparticles with Different Dispersants

ZHU Dong-sheng, LI Hua, WANG Xian-ju, LI Xin-fan
(The Key Laboratory of Enhanced Heat Transfer & Energy Conservation, College of Chemical and Energy Engineering, South China University of Technology, Guangzhou 510640, China)

Abstract: As us known, nanofluids can enhance heat transfer, and the dispersion and stability of nanofluids are the key factors to enhance heat transfer, so in this paper we mainly discussed the factors which can influence the dispersion of Al_2O_3-nanosuspensions. Through zeta-potential and particle size measurements in Al_2O_3-nanosuspensions, the influence of different PH value and the three different kinds of dispersants (SDBS, CATB and Gum arabic) on the dispersion of Al_2O_3-nanoparticles were discussed. We find that the absolute value of zeta-potential is the biggest and the size of particles is the smallest with SDBS and Gum arabic dispersants when the PH value of nanofluids is about 8, and the absolute value of zeta-potential is the biggest and the size of particles is the smallest with CATB dispersants when the PH value of nanofluids is about 2~3. We also find that nanofluids has a good dispersion when SDBS used as dispersant, which has the biggest absolute value of Zeta-potential and the smallest particle size.

Key words: Al_2O_3-nanoparticle; dispersant; dispersion and stability; zeta-potential; particle size
CLC number: TQ028 Document code: A Article ID: 0529-6579 (2007) S1-0254-02

With the rapid development of nanotechnologies and the increasing energy problem[1-2], the researchers began to apply nanotechnologies to intensify the heat transfer in order to investigate the high efficiency technology in cooling. Nanofluids, produced by dispersing nanoparticles into conventional heat transfer fluids such as water, glycol, or oil, was coined by Choi in 1995 at Argonne National Laboratory of USA[3]. But the nanoparticles is very easily to reunite in water, and the dispersion is very bad. So it is important to control the reuniting of nanoparticles in heat transfer, and it is also a necessary technology in applying nanofluids to heat transfer.

There are nanoparticles, dispersant and solvent in nanofluids. The percent of nanoparticles, electricity quantity and the interactions of nanoparticles, dispersant and solvent will influence the stability of suspensions directly. Fude Nie etc found that the stabilization of the dispersible system will increase by increasing the surface electric charge on particles. Tianming He etc found that nanofluids can get good stable suspension when it was added to a certain kind of dispersant. The above investigations are far away to satisfy the dispersible requirement to enhance the heat transfer. So in this paper, we choose Al_2O_3-nanoparticles to investigate the influences of different PH value and the three different kinds of dispersants (SDBS, CATB and Gum arabic) on the dispersion of system, and we want to find that which PH value and which kinds of dispersants can disperse Al_2O_3-nanosuspensions well.

1 Experimentation

We used mixture method to prepare Al_2O_3-nanosuspensions. In order to get uniformity and good dispersible suspension, we mix Al_2O_3-nanoparticles and water at a certain percent (0.05%), and then add a certain percent dispersant (0.05%) under the condition of supersonic vibration. The ZS Nanos type Malvern nanoparticles analysed apparatus made by Malvern company in England was used to measure Zeta-potential and particle size.

2 Results and Discussion

The Zeta-potential of suspension can reflect the stability of the system[4]. The higher of absolute value of the Zeta-potential, the more opposite ion in diffusion layer, and the less in adsorbed layer, so if the more electric charge in colloidal particle, the thicker of solvent and the more stability of suspension.

The relationship of Zeta-potential and the PH val-

①收稿日期: 2007-01-10
基金项目: 国家自然科学基金资助项目 (20346001); 教育部新世纪优秀人才支持计划项目 (NCET-04-0826)
作者简介: 朱冬生 (1964年生), 男, 教授/博士生导师; 通讯联系人: 李华; E-mail: lihua0415@sohu.com

ue of Al_2O_3-nanosuspension between the dispersants of SDBS, CATB and Gum Arabic is showed in the Fig.1. From the Fig.1, it can be seen that the absolute value of zeta-potetial is the biggest at pH8 with SDBS dispersant. The relationship of particle size and the pH value of Al_2O_3-nanosuspension between the dispersants of SDBS, CATB and Gum arabic is showed in the Fig.2. From the Fig.2, it can be seen that the particle size is the smallest at pH8 with SDBS dispersant and which is about 300 nm. So when pH value is about 8, the absolute value of zeta-potential is the biggest with SDBS dispersant, and the particle size is the smallest, the solution is the most stable.

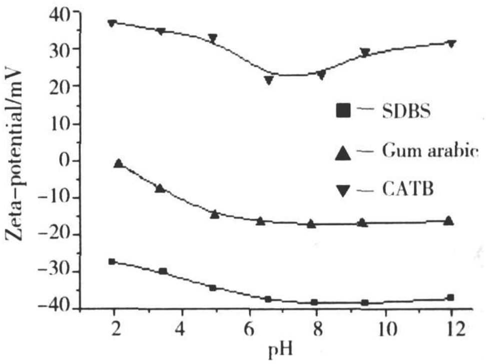

Fig. 1 The relationship of Zeta-potential and pH value of Al_2O_3-nanosuspension between the three dispersants

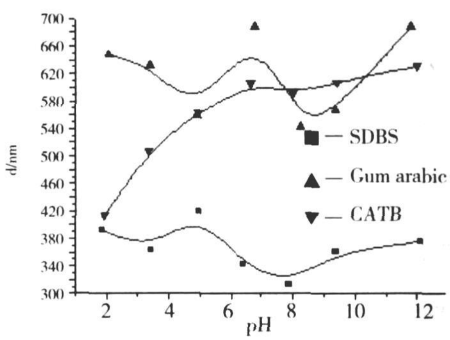

Fig. 2 The relationship of particle size and pH value of Al_2O_3-nanosuspensionbetween the three dispersants

From the experimentation, the average particle size of Al_2O_3-nanoparticles in suspension with SDBS dispersant is about 200 nm which is nearly 5 times of the average particle size of Al_2O_3-nanoparticles. Because we used two-steps method to prepare Al_2O_3-nanosuspension, they reunited at the course of dispersion, moreover the dispersant has certain surface finish effect on the Al_2O_3-nanoparticles, so the particle size of Al_2O_3-nanoparticles increases. Jiwen Fu etc measured the particle size of $BaTiO_3$-nanosuspensions, the particle size is about 580 nm under the best condition of dispersion. These results are consistent with our work.

3 Conclusion

(1) The absolute value of zeta-potential is the biggest when pH value is about 8, and the solution is the most stable.

(2) The absolute value of zeta-potential is the biggest at pH8 with SDBS dispersant, and the particle size is the smallest, the solution is the most stable.

References:

[1] ZHU D S, JIANG X. Enhanced heat transfer investigation on high viscosity fluid in shell-and-tube exchanger [J]. Journal of Chemical Industry and Engineering (China), 2005, 56 (8): 1451－1455.

[2] WU H J, ZHU D S, XIANG L. Research progress on solvothermal synthesis of nanostructured materials [J]. New Chemical Materials, 2005, 23 (8): 1－4.

[3] CHOI S U S. Anomalous thermal conductivity enhancement in nanotube suspensions [J]. Appl Phys Lett, 2001, 79 (14): 2252－2254.

[4] LI Z L, LI J M, HU H T, et al. Influence of ingredients of copper oxide nano-suspension on stability and viscosity of suspension [J]. Thermal Science and Technology, 2005, (2): 157－163.

不同分散剂条件下氧化铜纳米颗粒的稳定性研究

朱冬生，李 华，王先菊，李新芳

(华南理工大学化工与能源学院传热强化与节能教育部重点实验室，广东 广州 510640)

摘 要：纳米流体作为新型传热介质可以提高传热系数，而其分散性和稳定性是影响热传递的主要因素，文章讨论了影响纳米氧化铜分散性的主要因素。通过 Zeta电位和粒径的测定，讨论了 PH值和三种不同的分散剂 (SDBS, CATB, 阿拉伯胶) 对氧化铜纳米流体分散性的影响。发现 PH值在 8左右时，SDBS, 阿拉伯胶做为分散剂时纳米 Al_2O_3 悬浮液的 Zeta电位绝对值较大，粒径较小；在 PH值在 2~3之间时，CATB做为分散剂时 Al_2O_3 纳米悬浮液的 Zeta电位绝对值较大，粒径较小。其中在各个分散剂最佳 PH值范围内，SDBS作为分散剂时，纳米氧化铝悬浮液的 Zeta电位绝对值最大，粒径最小。

关键词：Al_2O_3 纳米颗粒；分散剂；分散稳定；Zeta电位；粒径

中图分类号：TQ028