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Thermal energy storage system based on nanoparticle distribution optimisation for enhanced heat transfer

Dear Huo,

Thank you for submitting your manuscript to Journal of Energy Storage.

I have completed my evaluation of your manuscript. The reviewers recommend reconsideration of your manuscript following major revision. I invite you to resubmit your manuscript after addressing the comments below. Please resubmit your revised manuscript by Dec 02 2023 11:59PM.

When revising your manuscript, please consider all issues mentioned in the reviewers' comments carefully: please outline every change made in response to their comments and provide suitable rebuttals for any comments not addressed. Please note that your revised submission may need to be re-reviewed.

To submit your revised manuscript, please log in as an author at https://www.editorialmanager.com/est/, and navigate to the "Submissions Needing Revision" folder.

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Journal of Energy Storage values your contribution and I look forward to receiving your revised manuscript.

Kind regards,

Luisa F. Cabeza

Editor-in-Chief

Journal of Energy Storage

Editor and Reviewer comments:

Reviewer #1: Comments to Author.

1.The novelty of the paper is to be clearly stated.

Reply: Thank you very much for your advice. In this paper, we address the existing study of convective heat transfer with uniformly distributed nanoparticle volume fractions in square cavities, innovatively separating the regions by partitions of negligible thickness and varying the volume fractions in order to achieve a faster melting rate.

2.Major contribution needs to be clarified more. More recent references need to be added. Enrich this article with:- REFERENCES DELETED BY EDITOR –

Reply: Thank you very much for your advice. We have added content about the main contributions at the end of the article, and enriched the article and added more references based on your comments.

Major contribution

Bichen Shen: Methodology, Writing – original draft, Formal analysis.

Liwei Zhang: Validation, Writing – review & editing.

Bingbing Li: Validation, Writing – review & editing.

Yutao Huo: Software, Supervision, Funding acquisition.

3.In the introduction, the author should provide a more comprehensive and detailed explanation of their work, elaborating on the specific objectives, methodology, and significance of their research.

Reply: Thanks for your comment. We have added a fuller and more detailed description of the specific objectives and significance of the work in the introduction.

4.The study needs more references, the language is good, and the style is appropriate.

Reply: Thank you for your affirmation and advice! We have added more references to support this research.

5.The manuscript needs more literature that further explains the nature of the problem.

Reply: Thank you for your advice! We have added more references to explains the nature of the problem.

6.You must add a table of nomenclature and abbreviations.

Reply: Thank you for your sincerely advise. The abbreviated and fully qualified forms of the variables covered in this paper are shown in Table 5 and 6.

7.The Conclusion should summarize the work of the whole paper, rather than simply summarize the results. Furthermore, the advantages and drawbacks of the proposed method should be highlighted. The future works about this subject should be pointed out in the part.

Reply: Thank you for your sincerely advise. We have replaced the previous simpler summary section with one that summarizes the entire paper and presents strengths, weaknesses, and directions for future research.

Reviewer #2: In this paper, authors employed a lattice Boltzmann method to propose a novel thermal storage system with optimized nanoparticle distribution using spacer-separated NEPCM with spacer arrangement. The presented work is purely computational and the results mainly include temperature, liquid fraction, porosity, Nusselt number and other parametric aspects. The paper can be accepted after major revisions:

1.The English language is imperfect, and the manuscript should be corrected by a native speaker all through.

Reply: Thank you for your sincerely advise. We've modified the language and described it by a native speaker.

2.The references quantities should be more, and the 21 references seem not to be sufficient to support the literature research for this work.

Reply: Thank you for your sincerely advise. We have added more references to support this research.

3.In the abstract, I suggest that the author explicitly specify the specific types of "type" instead of using "type1" and "type2". Furthermore, it is strongly recommended that the author summarize in the abstract which distribution type is the optimal choice under identical conditions.

Reply: Thank you for your sincerely advise. I think your suggestion is very good. However, since this article covers a relatively large number of structures, we have included two tables in the article to make the volume fractions corresponding to each type more clear. And based on your suggestions, we summarize in the abstract which allocation type is the best choice under the same conditions.

4.The expression in the paper is very confusing. When distinguishing different cases, sometimes "type" is used, and other times "0011" numbers are used, making the paper appear very unclear and disorganized. Please unify the expression method to make the paper clearer and more organized.

Reply: Thank you for your sincerely advise. We are very sorry that we overlooked this type and description inconsistency. We have converted references such as "0011" to types, and the types referred to in this paper represent models with different volume fractions in each region, with nanoparticle fractions as shown in the table. The paper become clear and unified!

5. The thickness of the spacer for the boundary condition settings in section 2.2 is nearly 0, and the material of separate plate is NEPCM as well. The impact of the thickness and material of the spacer on the thermal conductivity of NEPCM cannot be ignored.

Reply: Thank you for your sincerely advise. The seperate plate in this paper is not really a seperate plate, but a boundary condition that serves to separate the nanoparticles from the regions inside the square cavity. Therefore, its thickness can be ignored. There is an error in the statement that the material is a phase change material, which we have corrected.

6. The conclusion is not very clear, why compare type2 , type4 to type1 when Ra≥5×103，compare type6 to type1 when Ra≥103? Furthermore, where dose type6 come from?

Reply: Thank you for your sincerely advise. We are very sorry that our previous conclusions were incomplete, we have refined our conclusions to address the previous issues.

7. This paper should add a comparison between the enhanced thermal conductivity of separating the NEPCM by the spacer with the arrangement and with PCM added fins or metal foams discussed in other literature.

Reply: Thank you for your sincerely advise. The suggestion you mentioned is very good, but in this article we are investigating by monitoring the average Nusselt number, that is, comparing the ratio of convective heat transfer to conductive heat transfer. This article is aimed at comparing the enhancement of heat transfer by proper placement of nanoparticles versus uniform placement of nanoparticles, not at studying fins or metal foams. If the fins etc. were to be studied in this paper it would reduce the volume fraction of nanoparticles, which would result in weakening of convective heat transfer, and therefore it is also not studied.

8. All variables within the formulas lack units, and it will be better if the nomenclature is added.

Reply: Thank you for your sincerely advise. We've added a table of variables, which is at the end of the paper. And the units have increased.

9. Type 1 represents the nanoparticles with a uniform distribution, which should serve as the control baseline in the paper. However, the analysis and comparison in the paper seem to have limited involvement with Type 1. Please reorganize the analysis and comparison in the conclusions section, specifically addressing Type 1.

Reply: Thank you for your sincerely advise. We are very sorry that we neglected the comparison of type 1, we have added the comparison of type 1 in the new version. In this paper, for Type 1, which is the case of uniformly distributed computers with all volume fractions of 0.04, the complete melting times have been compared in each study, and the convective heat transfer can be analyzed here, as well as the differences between the arrangements.

10. The three sub-figures in Figure 5 have inconsistent font sizes for their types and all the figures in the text need to be reviewed.

Reply: Thank you for your sincerely advise. We standardized the font sizes of the three subfigures in Figure 5 and double-checked the font sizes of all the images in the text.

11. In the conclusion part, the brief findings of the paper should be given and scientific contributions of the manuscript to the literature should be explained by using precise statements.

Reply: Thank you for your sincerely advise. We have replaced the previous simpler summary section with one that summarizes the entire paper and presents strengths, weaknesses. And it adds to the scientific contribution of this paper to future research.

12. Formatting and text-related issues:

1) There is repeated expression in section 3.1:" Type 2 represents the distribution of 0110. Type 2 represents the distribution of 0101".

2) The expression "Average Nussle number" around equation(28) in the text is confusing, the correct word is "Nusslet" not the "Nussle"！

3) In Figure5, there is an obvious inconsistency in the font size in the diagrams, and the formatting errors should be especially noted.

Reply: Thank you for your sincerely advise. 1) We have already passed the duplicates in Section 3.1 to type representations by full unification. 2)We have changed the full description of the Nusselt number to "Nusselt". 3)The Nusselt number difference in Figure 5 has also been modified. The font size difference of the icons in Figure 5 has also been modified.

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Reviewer #3: Comments to Author.

The authors used the lattice Boltzmann approach to study the effect of Rayleigh number, volume fraction and arrangement on the heat transfer characteristics of composites. The following issues should be revised before the article is accepted for publication

1.Thoroughly check grammar and writing.

Reply: Thank you for your sincerely advise. We've modified the language and thoroughly check grammar and writing .

2. The highlights (No.1) need to be shortend. In addition, one or two specific calculations need to be added to the highlights section.

Reply: Thank you for your sincerely advise. We have shortened the first item in the focus section and add one specific calculation.

3. The summary section is not a reproducible description of the results, please change it. Do not include the abbreviation "NEPCM".

Reply: Thank you for your sincerely advise. We modified the abstract differently from the conclusion and removed the abbreviations "NEPCM".

4. Page2, Lines12-13 "and depending on the thermal conduc-tivity of phase change material" inappropriate expression. There are many factors that affect the rate of heat transfer, and the thermal conductivity of PCM is just one of them.

Reply: Thank you for your sincerely advise. We have modified the original description as follows: " Thermal conductivity is the most important evaluation index of TES, and the thermal conductivity of phase change material (PCM) is one of the important factors affecting."

5. The introduction section could be improved with a broader literature review and motivation for the present work. The following Ref can be consulted (doi.org/10.1016/j.ijheatmasstransfer.2023.123904, doi.org/10.1016/j.solener.2022.12.051, doi.org/10.1016/j.solmat.2023.112531, <https://doi.org/10.1016/j.est.2023.109220>).

Reply: Thank you for your sincerely advise. We have taken the introductory section through a broader literature review and the motivation for the current work. We consider these references to be of high research value and have cited them to support the existing work.

6. Page 3, lines 40-41 references required.

Reply: Thank you for your sincerely advise. We have added references on page 3, lines 40-41.

7. "Figure: 1" should be changed to "Figure .1". Please standardize the terms "Figure or Fig", "LB model" or "lattice Boltzmann model" or "LBM" in the text or at the icon. "PCM" or "phase change material". Double-check punctuation in Tables and Figs.

Reply: Thank you for your sincerely advise. We have changed "Figure: 1" to "Figure .1". We have standardized the terms "Figure or Fig" specification, including the unification of the acronyms about "lattice Boltzmann model" and phase change materials we have revised. We also checked the punctuation in the tables and figures.

8. Page 7, line 9, "PCM", "bulk", incorrect quotation marks.

Reply: Thank you for your sincerely advise. We've corrected the incorrect quotation marks on page 7, line 9.

9. Page7 lines 50-53. Page7 lines 50-53. Where are other existing models described? Please provide a description or source.

Reply: Thank you for your sincerely advise. The results obtained from the model in this section are compared with the numerical results of Mencinger. The results show that the model in this section can accurately restore the solid-liquid phase change process and trace the solid-liquid phase change interface.

10. The units in Table 1 are incorrect. All thermal properties are labeled with temperature because thermal properties change with temperature.

Reply: Thank you for your sincerely advise. The variables we study are studied at a reference temperature, which is constant and therefore does not change with temperature transformations.

11. Page 8 "The thickness of seperate plate is nearly 0 and the material of seperate plate is NEPCM as well". Please explain why NEPCM is still used for isolation boards.

Reply: Thank you for your sincerely advise. The seperate plate in this paper is not really a seperate plate, but a boundary condition that serves to separate the nanoparticles from the regions inside the square cavity. Therefore, its thickness can be ignored. There is an error in the statement that the material is a phase change material, which we have corrected.

12. Page 16, line: 10 "ϕ is = 0.04". What kind of expression is this? Page17, line 16 Two commas.

Reply: Thank you for your sincerely advise. The volume fraction representing each of the four regions is 0.04.

13. Fig .3 Provide a temperature color scale. whether the rapid melting of the upper left side and the slow melting of the lower left side in Fig.3 is related to gravity. Why are the standard deviations of only three arrangements discussed in Fig. 4?

Reply: Thank you for your sincerely advise. It is certain that the upper and lower regions on the left side are influenced by gravity, and a clockwise vortex will be generated by the buoyancy force, which will lead to the accumulation of heat in the upper part, and therefore the melting rate in the upper part is faster compared to the lower part, where only the standard deviation of the temperatures of the three arrangements will be considered in this section.

14. Fig. 7: Please standardize the order of pictures. Please standardize "Type" or "0000" in all the Figs. Eq. 31 should change Eq. (31).

Reply: Thank you for your sincerely advise. We are very sorry that we overlooked this type and description inconsistency, we will be "0011" and other numbers are unified into the type of the description, after the revision of the paper to become clear and unified!

15. The figures in Fig 10 are not clear. The X-axis of Fig.10 should be Type, please redraw it.

Reply: Thank you for your sincerely advise. We have redraw the figures in Fig 10 and modify the X-axsi of Fig.10.