Study on the Movement and Deposition of Particles in Supercritical Water Natural Circulation Based on Grey Correlation Theory

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Summary: The paper is interesting and is relevant in the context of research reactors and deposition movement of particles in natural circulation of SCWR. However, there are incomplete sentences in several parts of the manuscript and some technical queries have been highlighted.

Overall recommendation: The paper should be published subject to revision.

1. General Comment: ‘Four-Generation’ is used in some parts. This needs to be ‘Fourth Generation’ or ‘Generation IV’.
2. General Comment: With regard to SCWR, the research tends to focus on Light Water Reactor concepts or CANDU based concept. Can the authors perhaps explicitly highlight early on in the text/abstract where this research material best fits or perhaps whether it is applicable to both?
3. Nomenclature table is required. Specifically KW should be kW.

Line 80 “ash particles on the heated in a three dimensional” Heated what?

Line 90 “sediment particles in water flow condition” End of sentence? Full stop/period required.

144, I cannot see where on Fig. 3, it explicitly states that the pipe diameters are 8mm. Also can the authors specify if the diameters are inner diameter or outer diameters.

145 “four kinds grids” phrase needs to be amended.

178 modification for the Schiller Naumann’s model in CFX. The authors should explicitly state what terms in eq (4) were modified as a result of running it in CFX?

195 “On the contrary, the smaller…….” Sentence appears incomplete

211-213 ‘M’ not ‘m’ signifies or determines the maximum difference. This also applies to line 213. In addition, the method should determine the max and min values among the ‘n’ values for both j and (k) but (k) is not mentioned. Also authors should use either ‘signifies’ or ‘determines’ in line 211.

224-225 Can the authors provide more information of the “different parameters”?

227 Figure 4 should be Fig. 4.
Fig. 4 “Verificate” should be changed to “check”. Verificate is Italian.

Fig. 5. Can the authors provide the temperature distribution/changes in fluid temperature of the fluid at all sections?

245-248 The authors refer to 2 elbows after the heating section. One elbow exhibiting abrupt declines of velocity near the inner wall and refers to the velocity at the elbow after the heating section (247-248) having higher velocities than other parts of the pipe (1.77m/s). This is elbow two I assume. Clearly, these are two different elbows but the use of the phrase ‘after the heating section’ makes it confusing. Can the authors perhaps label the sections on Figure 5 using numbers and then refer to these numbers when describing the results. The same applies to Figure 7.

268-269 Can the authors provide the correlation between varied particle volume fractions, particle diameter and changes in heating power?

269-270 “The simulation calculation of supercritical water natural circulation is carried out” My assumption is the calculation is carried out when the volume fraction, particle diameter and heating section reaches 700kW. If this is not the case, then I do not see the need for this statement. The same applies to 237-238.

Fig. 7. Include ‘%’ on figure. Furthermore, the pipe sections need to be numerically labelled and referred to in the discussion of the results.

285-288 “However, the density........relatively low” This statement/explanation needs to be amended as it is not understood. What do the authors mean by “following performance”?

299 change “on both sides of the pipe wall” to ‘equidistantly around the pipe wall’ or ‘circumferentially evenly distributed around the pipe wall’

Fig 9. It would be good to see what the effect of the particle distribution and size is on variation in heating power and how much heat is required to maintain the necessary heat transfer effectiveness. The same applies to Fig. 10.

355 – 357 “The reason....following the fluid flow” is this statement correct? The fluid flows upwards. Regardless of the higher density of the particles, the particles will still flow in the direction of the fluid and will overcome the gravity action or to better put it, the fluid flow has to overcome gravity, unless we are referring to the initial flow at inlet to the heating section. If this is the case then I would use ‘initial gravity action’.

359 – 361 ‘Concentrating’ as opposed to “concentratin".
375-377 “The reason is that…… fluid flow” What is responsible for the increase in diameter and subsequently mass, if it is not due to the particle following the fluid? What is the material of the particulate? If the particulate can expand under thermal conditions, then to what extent is this the reason?

377-379 “Meanwhile……deposition phenomenon of particle”. Increase in mass results in increase in gravity but there is increase in fluid flow and increase in thermal conditions along the pipe so the question is what has an over-arching effect on the deposition?

385-386. The conditions for the calculation are not fully explicitly described. If the correlation resolution coefficient is calculated by selecting 0.5, 0.2 and 0.1, then what has influenced the choice of numbers? Furthermore, is the ‘degree of correlation’ the same as the ‘correlation resolution coefficient’? Perhaps it would be useful to use the mathematical symbols in the text and in Fig. 13 to avoid ambiguity.

391-392. What is the sensitivity of varying the heating power on the degree of influence? Furthermore, the type of particulate matter/material would also have some influence on the heating power.

396-418 Can the authors‘ confirm that the heating power, particulate volume fraction and particulate diameter is 1um. Furthermore, can the authors provide some description of the test set up in ref [1], specifically, is it closed loop? What are the actual setup deviation of the simulation from the test results in [1]. My assumptions are that given a early deviation of 300% from 0-40% (almost half of the heating pipe), then this essentially affects the fluid velocity, particle diameter and mass increase and overcoming the effect of gravity. This is significant regardless of the trend. It would have made more sense to perhaps simulate the initial increase from zero of the deposition due to the difficulty caused by the large shear force, in order to bring it in line with the experimental conditions. This should be declared in terms of recommendations for improvement of the modelling conditions.

419-440 How do the results affect how the SCWR concept is designed and analysed in terms of the pipe materials choice and selection and the level of particulate concentration and deposition that could affect this choice and selection? How can reactor operation compensate for normal and safe operation due to the effect of heating? Again varying heating power and effects in terms of degree of correlation needs to be fully understood to know whether higher heating power will increase the degree of correlation.

One final note to consider in the conclusion:
With regards to turbulent models and heat transfer models, have other energy and transport models been assessed in their ability to predict the heat transfer between the fluid and particle, including the near shear wall effect that was experienced within the experimental rig in [1]? What advantages/disadvantages do other models
have in replicating the phenomena? This needs to be commented on/assessed in the paper.