Czech Technical University in Prague, Faculty of Mechanical Engineering
Department of Process Engineering

Review of Master Thesis

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Title: **CFD simulation of heat transfer in an agitated vessel with a draft tube**

Specialization: (N2301) Mechanical Engineering
Field of study: (3909T012) Process Engineering

This thesis is focused on CFD model of the heat transfer in the agitated vesel with impeller located in the draft tube. Several simulations were performed in this work and the results were compared with the literature.

Comments (C) and mistakes (M)

(C) Page 0 (Annotation Czech) – Should be read again with the Czech native speaker
(M) Page 2 (above) – PhD. → Ph.D.
(M) Page 8 (above) – $\mathrm{m}^2/ \rightarrow \mathrm{m}^2/\mathrm{s}$
(C) Page 8 (above) – There is no c in equations (21) and (22)
(M) Page 8 (above) – use SI units, mm → m
(C) Page 8 (middle) – height of the tank → height of the water is more accurate
(M) Page 8 (middle) – rotational speed of the speed → impeller? RPM → 1/s
(M) Page 8 (middle) – Nu, Re and Pr usually not in italics
(M) Page 11 (middle) – uncompressible → incompressible, Newtonians fluids → Newtionian fluids
(M) Page 11 (below) – uncompressible → incompressible
(M) Page 14 (below) – variables in the text should be in italics
(M) Page 14 (below) – if Y^+ is defined as follows, it will not be dimensionless
(M) Page 18 eq. (16) – $\mathrm{CGI_i} \rightarrow \mathrm{GCI_i}$
(C) Page 19 (middle) – Reynolds number is defined by (17) with characteristic diameter of the draft tube but in the text is the diameter of the impeller, it's confusing
(C) Page 19 (middle) – I miss the reference
(C) Page 20 (below) – Petera et al., measured ... is that a reference? Maybe they have measured local values of Nusselt number but in the text is correlation mentioned
(M) Page 21 (middle) – I miss the location of the impeller (impeller height)
(M) Page 21 (below) – example the scripts → example of the scripts
(M) Page 26 (above) – $99.8.2\ \mathrm{kg/m^3} \rightarrow 998.2\,\mathrm{kg/m^3}$
(C) Page 26 (middle) – I miss the definiton of the mean Nusselt number. Numbers in the Table 2 do not match either the arithmetic or the geometric mean
(C) Page 27 (above) – constant c can not go negative
(M) Page 30 (middle) – Dittus-Bolter → Dittus-Boelter
(C) Page 32 (above) – ... where r is the radio of the ... → radius?
(C) Page 32 Fig. 10 – Figure shows that the value of Nusselt number in $r/d = 0$ and in the case of $\mathrm{Re} = 30000$ is smaller then in the case of $\mathrm{Re} = 18500$ and $\mathrm{Re} = 24600$, that is weird
(M) Page 34 (middle) – $\mathrm{w/m^2K} \rightarrow \mathrm{W/m^2K}$ (2x)

(M) – I did not find these variables in Notations ($S, p, \vec{g}, T, \vec{\vec{\tau}}, \vec{\vec{\Delta}}, \dot{Q}^{(\mathrm{g})}, R_{\mathrm{i,j}}, \mu_{\mathrm{T}}, \delta_{\mathrm{i,j}}, u^+, u_{\mathrm{T}}, \tau_{\mathrm{wall}}, Y, Y^+, \Phi_{1,2,3}, \Phi_{\mathrm{ext}}, s, \epsilon_{32,21}, r_{32,21}, N_{1,2,3}, G_W, G_U, w, A, r/d, h/d, y, t, q, S, V, T_W, T_{\mathrm{ref}}$)
(C) – Author did not use a consistent reference system

Overall assessment
In the introduction, author defined the task and described the basic principles used in CFD modeling and, on the basis of recommendations, selected appropriate methods for computing this task. Author also defined the magnitude and the way the different procedures will be compared.

In the next chapter author defined the basic quantities (Re, Nu ...) and introduced the correlations found in the literature, although I do not see a correlation for the flow in the pipe suitable for this application. There is a lot of work to describe the heat transfer in this configuration, or heat transfer in agitated vessels, which might be more suitable for this case.

The largest part of the work is focused on model description and individual calculation settings. However, it is not possible to repeat the job because some of the settings in FLUENT are missing. The boundary conditions are not sufficiently described. Mesh quality was presented with only one parameter (Orthogonal quality) and number of elements. Author has verified the correct network size backwards (with Y^+). A simulation study was performed on the time step, but the results are inconsistent, then the time step with the least computational difficulty was selected.

The calculated Nusselt number values were presented in the form of correlation and also as local values in relation to the coordinate. Correlations were surprising by the unusually high Re power values, and then processed again with a fixed exponent that was outside the confidence interval. Local values were plotted but their tendency is not clear. The final temperature after the calculation was compared with the analytical calculation and corresponds very well.

The conclusion of the thesis is devoted to reasonable recommendations for further simulations.

English used was simple and understandable, the work was not difficult to read.

I found many mistakes and typos in the text.

Evaluation: satisfactory (D)

Questions

- On the page 33, you have written that higher Nusselt number values (for higher impeller speed and in the y/H close to 0) are caused by the swirl effect. I don't agree with that. Could you prove your statement? Try to plot the velocity vectors in this area and compare the radial and rotational parts of velocity.
- Can you explain why you compared your data with the correlation for fluid flow in the tube?

Prague, 19.6.2018 Ing. Stanislav Solnař

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