REVIEW
THESIS OPPONENT

I. IDENTIFICATION DATA

Title of thesis:	**CFD simulation of heat transfer in an agitated vessel with a pitched six-blade turbine impeller**
Author:	**Gokul Sai Namburi**
Thesis type:	Diploma
Faculty/department:	Faculty of Mechanical Engineering
Department:	Department of Process Engineering
Opponent:	Ing. Stanislav Solnař
Opponent affiliation:	Department of Process Engineering

II. EVALUATION OF THE PARTICULAR CRITERIA

Assignment — **average**

I consider the assignment as average difficult. It is the numerical task of the heat transfer in a well-known geometry – an agitated vessel with a standard axial impeller, flat bottom and four baffles in the basic configuration. The task was extended by another geometry by shifting the agitator distance from the bottom of the vessel. For these geometrical configurations, there is a lot of information available in the literature, both in the field of numerical simulation and in the field of experimental measurement.

I consider the assignment as average difficult.

Fulfilling the assignment — **fulfilled wiht major qualifications**

The assignment as such (to create a CFD model and calculate the heat transfer coefficient on the bottom and wall of the vessel) has been met. Student found some sources of information in the literature that deal with the heat transfer in the agitated vessel, and create a CFD model. However, the diploma thesis shows many shortcomings, see below.

Student has completed the diploma thesis assignment, but there are shortcomings.

Selected solution procedure — **Partly suitable**

Student has searched for some sources in the literature that deal with heat transfer in the agitated vessel. From the literature, it can be deduced that the correlation relations for Nusselt's number can expect the geometric constant C in the order of tenths and the exponent of the Reynolds number about 2/3. Without any analysis of the problem, student prepared the computational mesh with moving reference frame technique. Information about meshing is practically useless, and there are only data on the number of elements that the mesh has created. For some reason, the network was changed for h/d=1 and h/d=1/3 geometries. The network was rougher for these two geometries, and the number of elements had fallen by about 500,000 elements.

There is no grid independence study (GCI) at work, so it is not possible to judge whether the network was appropriate and fine enough. There is no information on the quality and fineness of the mesh at the walls and at the bottom of the vessel, which are critical for this task (here the heat transfer is calculated). The quality and smoothness of the mesh in these areas directly affects the calculated results.

Student deal with this task in a non-stationary way, but did not pass the time step independence study (again, we do not know if his time step is fine enough for this simulation). The solver setting is described very strictly, and unfortunately, its computational model in not included on the CD, so it is quite impossible to judge the suitability of the setting.

Student (again without analysis) chose a turbulent flow model of k-omega SST, which is suitable for this task. However, this model and its launch is closely related to the size of the mesh cell, which we do not know much about.

The time of the calculation was set based on the homogenization time.

The solution of this work is not entirely appropriate.

Professional level — **E - sufficient**

Professional level of the presented work is at a very bad level. There is a lot of information about agitated vessels in the work, but the individual work of the student is described very strictly. From the calculated results, student prepared correlation relationships (according to the practice in the literature), which did not correspond to the literature data, and so the sentence “results are relatively fine with experimental data” seems very bold. The calculated confidence intervals are in the order of hundreds of percent, their information value is therefore questionable.

Professional level of this thesis is bad.

Formal and language level, scope of work **F - failed**

In the presented work there are very, very many formal, language and typographical errors. List of found (and not yet found) errors is impossible in terms of quantity. Primarily:
Variables are written in italics, otherwise it makes reading difficult. Variables such as Re and Nu are written vertically.
One character is used in the text for several meanings, while reading it is very confusing.
The nomenclature is incomplete and shows mistakes.
We write personal names with a capital letter (chapman -> Chapman).
Many errors and mistakes in dashes, dots at the end of sentences, and also in spaces.
The language used is very bad.
Overall, the work is very blurred.

Formal and language level of this thesis is insufficient.

Source Selection, Correct Quotation **F - failed**

There are about 25 literature sources used in this work (especially articles in magazines, books) of which some are ineligible! I do not consider “Project – I course CVUT (2016)” as a suitable quote.
The list of literature is not written consistently, it contains both formal and typographical errors. Some names are not written correctly.
It is very difficult to recognize in the text whether the information is obtained from the literature source or is inherent.
Only a few information and pictures are quoted in the text. Many of the information that is evidently from the literature is not quoted.

More comments and ratings

The resulting CFD model is neither academically nor practically useable.

III. TOTAL EVALUATION AND PROPOSAL FOR CLASSIFICATION

The presented thesis is at a very bad level with a number of technical errors and mistakes. Formal and language level are even worse. The text is very complicated to read, the work contains a lot of formal and typographical errors, which are caused by not too much attention of the student.

I evaluate the submitted final thesis with the grade **F - failed**

I have a total of **9 questions** that you should answer during your defense.

Question 1:

On page 2, you write that one of the tasks of you work is a CFD model using the sliding mesh technique, why did you use the MRF method?

Question 2:

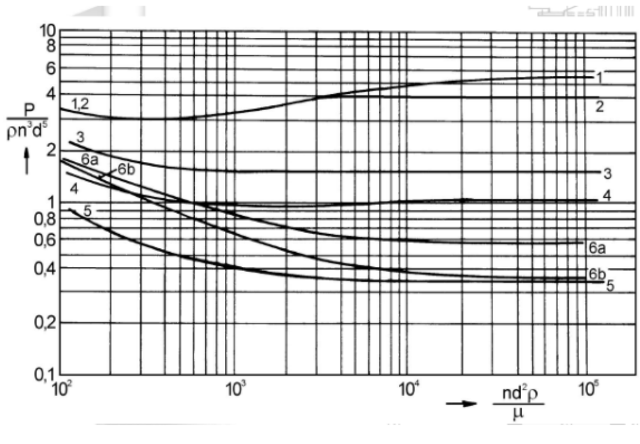
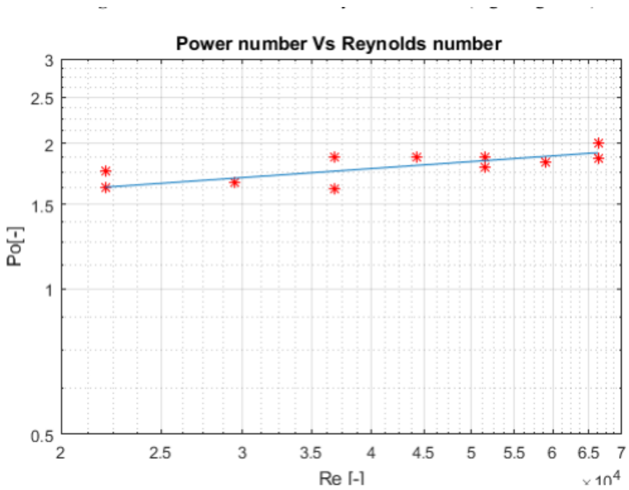
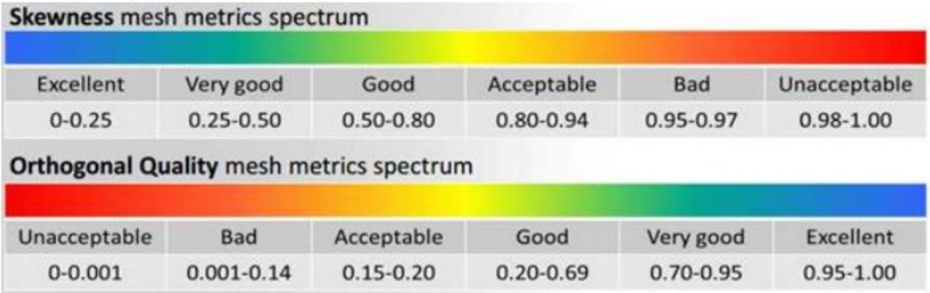


Figure 4.1 Power number vs Reynolds number (log – log scale).



On page 16, you compare the dependency of the power number Po and the Reynolds number Re. Fig. 4.1 shows relatively constant trend of the power number in the range of Re>20,000, but yours is steadily rising. Can you comment this result? What is wrong?

Question 3:



Skewness mesh metrics spectrum

Excellent	Very good	Good	Acceptable	Bad	Unacceptable
0-0.25	0.25-0.50	0.50-0.80	0.80-0.94	0.95-0.97	0.98-1.00

Orthogonal Quality mesh metrics spectrum

Unacceptable	Bad	Acceptable	Good	Very good	Excellent
0-0.001	0.001-0.14	0.15-0.20	0.20-0.69	0.70-0.95	0.95-1.00

Quality Measure	Value
Maximum Skewness	0.97
Minimum Orthogonal Quality	0.105089
Maximum Aspect Ratio	4.51293e+02

Table 6.3 Mesh quality measures for generated gird.

On page 37, you provide these mesh quality data. Regarding the skewness your mesh is on the border of Bad/Unacceptable! Can you show a skewness cell histogram and tell how many of these very bad cells do you have in your mesh and where are they?

Question 4:

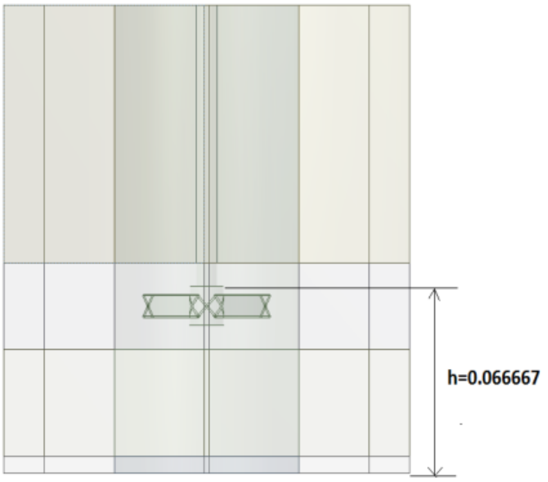


Figure 6. 2 Agitated vessels Off -Bottom clearance with 1, 2/3, 1/3 h = 0.066667 m, h = 0.04444, h= 0.02222m.

Is this picture on page 35 correct?

Question 5:
Can you describe how you generated the mesh? There is no information in your work. How big is the MRF zone? What parameters did you use for meshing? What method did you use for meshing? What about infialition layers?

Question 6:
Can you show the detail of the mesh on the bottom and the wall of the agitated vessel and quantify the Y^+ values for the 900 rpm model case?

Question 7:
Did you do the Grid independence study and time step independence study? If so, please show us the results. If not, how do you know your mesh and your timing is fine?

Question 8:
Your confidence intervals are in hundreds of percent. Can you give any recommendations for reducing them?

Question 9:

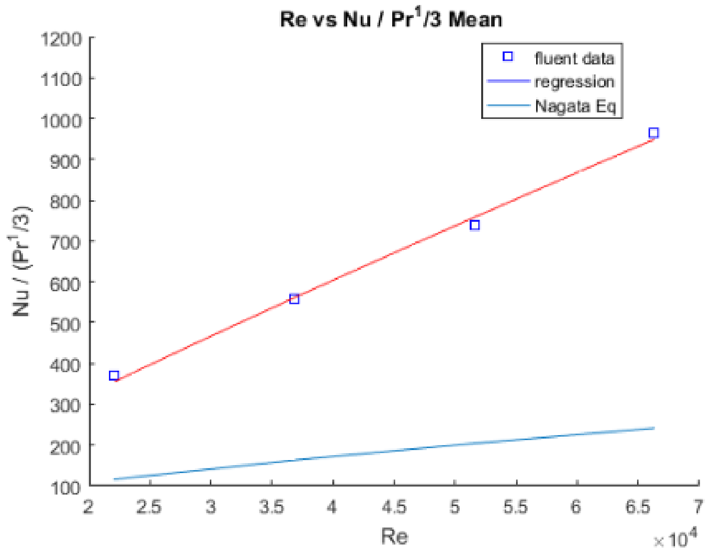


Figure 8.5 Obtained data and fitted correlations compared Nu α (bottom + wall), with the experiment work of Nagata et al. (1972), Off-bottom clearance/d = 1/3.

Can you comment this result? You really find „results are relatively fine with experimental data“ as an answer? What is wrong?

Date: Signature: