

## I. IDENTIFICATION DATA

<b>Title:</b>	<b>Fouling in Process Apparatuses</b>
<b>Author:</b>	<b>Bc. Rahul Kumar Gautam</b>
<b>Type of the thesis:</b>	Master thesis (diploma thesis)
<b>Faculty/department:</b>	Faculty of Mechanical Engineering
<b>Department:</b>	Department of Process Engineering
<b>Reviewer:</b>	Ing. Jaromír Štancl, Ph.D.
<b>Reviewer's place of employment:</b>	FME CTU in Prague - Department of Process Engineering

## II. CRITERIA EVALUATION

<b>Thesis assignment</b>	<b>Average</b>
<i>Difficulty evaluation of the thesis assignment.</i>	
<p>The presented work focuses on fouling in process apparatuses, mainly on fouling forming mechanism, effect of fouling on performance of heat exchangers and design of heat exchangers, experimental methods used in this area and fouling modelling. From my point of view, the topic of the presented thesis is a typical engineering task for an engineer. There is available plenty of information to this topic in literature. I see the difficulty of the thesis assignment as average and adequate for a master's degree graduate.</p>	

<b>Fulfilment of thesis's assignment</b>	<b>Fulfilled with greater reservations</b>
<i>Evaluate, whether the proposed final work fulfils the assignment. Comment where appropriate, points of reference that were not fully met, or if the work is extended compared to assignment. If the assignment is also not completely fulfilled, try to assess the importance, impact and possibly cause various deficiencies.</i>	
<p>The task of presented work was to make a literature and patent survey concerning the fouling in process apparatuses. The literature survey should be focused to the description of fouling phenomenon and its influence on the design of industrial apparatuses for chemical, pharmaceutical, food industry... In the next step the work should be focused to the mathematical models of the fouling layer forming and to find suitable models for specific materials, chemicals, foods etc. The next part of literature survey should be the used experimental methods to measure or study the fouling in heat transfer applications (mixing apparatuses, heat exchangers etc.). The last part of the presented work should be the proposal of method to measure and study the fouling in laboratory at the department of process engineering CTU in Prague, where the fouling layer is formed by glauberite – the proposal in form of sketch and short description of the idea how to do it. Most of the goals given by master thesis assignment were fulfilled and discussed in individual chapters (although for some goals it may be somewhat debatable). But the last task – the proposal of the experimental method in form of sketch of the idea or basic description is not solved in the presented work!</p>	

<b>The chosen solution procedure</b>	<b>Correct</b>
<i>Assess whether the student has chosen the correct procedure or method of solution.</i>	
<p>Because all the presented work is mainly literature review, I have no fundamental reservations about the chosen solution procedure. In the presented work I miss some of the author's own contribution to the problem outside of writing the results of literature review.</p>	

<b>Professional level</b>	<b>D – satisfactory</b>
<i>Assess the expertise level of thesis, using knowledge gained from the study of scientific literature, documentation and utilization of data obtained from practice.</i>	
<p>The professional level of the presented thesis is rather weaker. In my opinion, the author of the work has demonstrated the ability to find appropriate and necessary information in available literature. However, in my opinion the engineering work should not consist only in the use of texts obtained from literature, but the engineer should be able to apply the gained knowledge.</p>	

## Formal and language level

C – good

*Assess formal correctness of the thesis and the typographical and linguistic aspects of the thesis.*

The presented thesis contains all the necessary formal requirements. The work is written readily and quite well organized, it is appropriately and logically structured into the chapters. I consider its typographic and graphical level to be on high level. On the other side, the list of used symbols is not complete – it doesn't contain all symbols used in the presented work which worsens orientation in the work.

## Selection of sources, citation correctness and bibliography

E - sufficient

*Comment the student's activity during the acquisition and use of learning materials to solve the thesis. Characterize the selection of sources. Assess whether the student made use of all relevant sources. Verify that adopted information is properly distinguished from student's results and considerations, whether citation forms are corresponding with ethics, whether bibliographic citations are complete and finally whether all citations are in accordance with the practices and standards.*

Author used 27 relevant references in the text of his thesis. Citations in the text and their format listed in the bibliography are in accordance with all the citation practices. However, a lot of citations are missing in some parts of the presented work. It is so difficult to distinguish the author's own thoughts from information taken from literature. Some citations are incorrect.

## Other comments

*Comment the level achieved major results of the final work, e.g. the level of theoretical results, or the functional level of technical solutions, publication outlets, experimental skills, etc.*

From my point of view the author of the presented work has demonstrated the ability to get necessary information to the solved problem from literature. The literature review mainly in chapter 3 and 6 is very good. It is a pity that in the other parts of the work (from chapter 4) the author does not continue in the style used in the introductory parts of the work (chapters 1-3 and 6). The assignment of the work was not entirely satisfied.

### III. FINAL EVALUATION, QUESTIONS FOR THESIS DEFENSE AND PROPOSAL OF CLASSIFICATION

*Summarize aspects of the thesis that most influenced your final evaluation.*

The presented work (in the range of 66 pages of text, 19 figures, 4 tables and 0 appendices) is practically literature review and focuses on fouling in process apparatuses. The introduction part of the thesis was focused on explanation of the fouling phenomena (chapter 1) and continues with description of the types of fouling in process apparatuses (chapter 2). Chapter 3 literature review of the fouling phenomenon, its effect on design of heat transfer, pressure drop, presents the effect of fluid velocity etc. The quality of the literature review presented in chapter 3 is very high and professional. Chapter 4 focuses on fouling in design of process apparatus. It summarises the effect of fouling on heat transfer and pressure drop. Chapter 5 contains the description of mechanism of the fouling process. Chapter 6 presents literature review of several experimental methods how to measure or study the fouling formation on heat transfer area. Chapter 6 is also very nicely written and, in my opinion, is the greatest benefit of this work. The task of chapter 7 was to present the mathematical models of the fouling creation. There is mentioned only very general model and some factors that affect the incidence of the fouling. It is a pity that this chapter does not follow the original task of finding suitable mathematical models of fouling formation in the case of processing a variety of materials (chemicals, foods etc.). Many such models can be found in literature (especially for crude oil processing or for milk fouling). It could be a huge benefit of this work. The last chapter contains the conclusions of the presented work.

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Author used 27 relevant references in the text of his thesis. Citations in the text and their format listed in the bibliography are in accordance with all the citation practices. However, some citations are missing in some parts of the presented work. It is so difficult to distinguish the author's own thoughts from information taken from literature. Some citations are incorrect.

The professional level of the presented thesis is rather weaker. In my opinion, the author of the work has clearly demonstrated the ability to find appropriate and necessary information in available literature. However, in my opinion the engineering work should not consist only in the use of texts obtained from literature, but the engineer should be able to apply the gained knowledge. The literature review mainly in chapter 3 and 6 is very good. It is a pity that in the other parts of the work (from chapter 4) the author does not continue in the style used in the introductory parts of the work (chapters 1-3). The assignment of the work was not entirely satisfied. Most of the goals given by master thesis assignment were fulfilled and discussed in individual chapters (although for some goals it may be somewhat debatable). But the last task – the proposal of the experimental method in form of sketch of the idea or basic description is not in the presented work!

Although I find the presented work to be weaker, the presented work has its benefit mainly in the field of summarisation of the experimental methods to study fouling formation and in the overall overview of the problem of fouling phenomena. Despite the mentioned problems of the work (missing citations, missing the proposal of the experimental setup...) I recommend the presented diploma thesis for the defense.

#### Comments to the work:

- Page 7 – Caption to the figure 2 – missing citation (source of the figure)
- Page 8 – Caption to the figure 3 – missing citation (source of the figure)
- Page 8-10 – chapter 2.3, 2.4 and 2.5 – missing citations (source of the information)
- Page 9 – Caption to the figure 4 – missing citation (source of the figure)
- Page 10-11 – Caption to the figure 5, 6 and 7 – missing citations (sources of the figures)
- Page 14 – “In Fig. one of result...” – missing the reference to the figure 9
- Page 17 – “Change in overall heat transfer coefficient is some function of” of what?
- Page 17 – 18 – citations missing
- Page 20 – formula 6 is not correct
- Page 23 – citation missing – especially the values of  $f$  in formulas 22 and 23, same page 24, formulas 28 and 29
- Page 25-35 practically whole chapter 5 - missing citations (sources of the information)
- Pages 52-57 missing citations (sources of the presented information)
- Page 56 – table 3 – incorrect citation – presented table is not from reference 24!
- Page 58 - Caption to the figure 19 – missing citation (source of the figure)
- Page 65 – list of symbols is not complete. List does not contain all used symbols

Other minor comments are highlighted in the printed thesis.

## Questions for thesis defense:

- There are mentioned several types of fouling in chapter 2. What type of fouling can be formed on heat transfer surface during milk thermal treatment?
- Page 21 – formulas 11 – 13 – please explain the presented formulas with description of all parameters used in formulas
- Chapter 5 – there is a lot of text without citations and I can't clearly recognize if these are author's own words or not. Please explain or can you mention the source of presented information?
- Page 43 – "Crude oil and atmospheric residue often contain high molecular weight, non-volatile components with boiling points in excess of 590°C..." The temperature seems to be very high. Please explain.
- Topic for discussion: Can you recommend us how to proceed with the design of the heat exchanger for product processing with a tendency to form fouling on heat transfer surface (e.g. Milk, crude oil or other selected product) - what to focus on mainly? Which factors can play a crucial role (e.g. the material of the heat transfer surface, the velocity of the processed media, used temperatures...)

Due to the quality of the submitted diploma thesis, problems with citations and to the fact that the thesis assignment was not fulfilled I evaluate the work by the grade:

**D – satisfactory**

Date: 5.2.2018

Signature:



Ing. Jaromír Štancl/ Ph.D.