



REVIEW

of the dissertation of

Eng. Ivan Atanasov Ilchev

on "**IMPROVING THE OPERATION OF THE HYDROCRACKING
PROCESS OF RESIDUE AT LUKOIL NEFTOCHIM BURGAS** "

presented for obtaining the educational and scientific degree "Doctor" in the
field of 5. Technical Sciences (doctoral program "Chemical Technologies")

by **Assoc. Prof. Chavdar Petrov Chilev**

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The dissertation is presented in 149 pages, includes 42 figures, 28 tables and a bibliography of 154 references.

The research was carried out in the laboratories of the University "Prof. Dr. Asen Zlatarov" and in the laboratories of Lukoil Neftochim Burgas.

The dissertation was discussed and approved for defence by the extended department council of the Department of Industrial Technologies and Management at the University "Prof. Dr. Asen Zlatarov" – Burgas.

On the basis of Article 44 of the current Regulations on the conditions and procedure for acquiring scientific degrees and holding academic positions at the University "Prof. Dr. Asen Zlatarov" - Burgas, in connection with the decision of the Faculty Council of Social Sciences (Protocol №13/10.07.2024) and Report №23911.07.2024 by Prof. Dr. Rumiana Ivanova Panacheva - Dean of the Faculty of Social Sciences, the procedure for the defence of the dissertation thesis in the UNF of the full-time PhD student Ivan Atanasov Ilchev for obtaining the educational and scientific degree "Doctor" in the doctoral program "Technology of natural and synthetic fuels" of the professional field 5.10 "Chemical technologies", field of higher education 5 "Technical sciences" is opened.

The above-mentioned regulations and orders, as well as a review of the documents relating to the announcement, the competition and the development of the topic, show that the legal requirements were followed during the development of the doctoral research.

1. Overview of the dissertation and analysis of the results

The first part of the literature review is devoted to the description of the product bitumen (brief history) and the ways of its production. Detailed attention is paid to the main fractions of compounds in bitumen, namely: oils, resins, asphaltenes and asphaltene acids and their anhydrides. **In relation to this, one of my questions to the doctoral student relates to**

asphaltenes. On page 12, the dissertator mentions that free asphaltenes are solid, non-melting substances of black colour. What does he mean by "non-melting"?

On page 13 the dissertation mentions that in terms of chemical composition bitumen can be divided into two groups, asphaltenes and maltenes. This is immediately followed by the phrase "The four groups...". Could the doctoral student explain which four groups he is referring to?

I have some remarks regarding the figures in this part of the literature review. Namely figures 1 to 7 and tables 1 and 2. The figures seem to be copied from textbooks (not produced by the doctoral candidate) or from the internet. They have not been translated into Bulgarian. While such figures can be used, they should be cited, and the source from which they were taken should be provided; otherwise, there may be claims of copyright infringement.

In describing the basic reactions that take place in the oxidation columns, the equations presented lack labelled charges of the radical and functional groups.

The next part of the literature review is devoted to the description of bitumen oxidation technology. The detailed and accurate description of the influence of various parameters such as temperature, pressure and amount of air supplied on the quality of the resulting final is very impressive. This indicates a profound knowledge of the subject matter on the part of the doctoral candidate and thoroughness in the interpretation of various facts. The key characteristics by which the quality of bitumen is evaluated, such as softening temperature, foaming fracture according to Fraas, etc., and the methods for their experimental determination are presented very accurately and in detail. I have comments on Tables 3 and 4, which are again not produced by the doctoral candidate, and the literature source is not cited

The last part of the literature review is devoted to the characteristics of different bitumen brands. Additionally mentioned is the bitumen assessment standard BDS EN 12591 from 2009 and the National Annex (NA) added in 2017, which is complementary to the work.

The extensive literature review made by the doctoral candidate in the considered scientific field clearly demonstrates that he is well versed with the essence of the research problem and has studied the recent advances in this scientific field, correctly interpreted the scientific information and successfully accomplished the set goals and objectives.

The aim of the dissertation and the tasks for its implementation are clearly and well formulated on page 54. The experimental part includes the materials used, the description of the experiments, and the methods for characterizing the products obtained. Experiments were carried out to establish the possibility of increasing the proportion of unconverted vacuum residue in the H-OIL process for road bitumen production. The effects of variations in the quality of the hydrocracked H-OIL gudron on the feasibility of producing road bitumen from it were experimentally determined. A laboratory and industrial study were conducted on the production of road bitumen from blends of direct distilled and hydrocracked gudron in different ratios. Increasing addition of petroleum residue from hydrocracking of gudron in the production of road and construction bitumen was experimentally studied.

In summary, it can be said that this research paper presents new data and evidence that, using Siberian light and Urals oils in a 50/50 ratio, up to 35% of secondary-origin goudron can be incorporated directly into the reactor to produce 50/70 grade road bitumen. This result is a

prerequisite to divert 35% gudron from primary distillation for processing into H-OIL and increase the diesel fraction selection. At the same time, a large amount of the vacuum residue VTB, which is only considered suitable for boiler fuel production, is also recovered.

In spite of the criticisms made, which are largely of a conversational nature, my impression of the PhD student's presentation and interpretation of the results obtained is excellent. I am very impressed by the way the results are presented in the thesis: the experimental results are presented with brief comments to begin with, followed by a more in-depth discussion. This contributes to better visualisation and clarity in the presentation and interpretation of the results. In presenting the discussion, not only are the results reported, but also compared with data from the literature, which shows the excellent analytical approach of the doctoral candidate.

2. Evaluation of the correspondence between the abstract and the dissertation

The abstract has been prepared as required and fully corresponds to the content of the dissertation.

3. Characteristics and evaluation of the contributions in the thesis

The main contributions of the dissertation are:

- Sustained implementation of the heavy vacuum residue treatment (VTB) in road bitumen production in compliance with all production and government standards. This significantly increases H-OIL conversion and improves the operation process of the Hydrocracker plant at the LNCB site.
- Successfully implemented an operation scheme with addition of unoxidized VTB in road bitumen production. Low value VTB semi-finished product without any further processing is added to the commodity road bitumen and increases its yield.
- Successfully implemented an operation scheme with addition of oxidized VTB in road bitumen production. This scheme of operation replaces some of the SRVGO, which instead of going to road bitumen production, goes to produce a much higher value light fuel in the H-OIL plant without disturbing the operating regime of the Bitumen plant.
- Due to the seasonal nature of bitumen product production, a large portion of the experiments were utilized by the production team to prepare the operating mode of the installation before startup. This provided preliminary data, based on the types of crude oil currently being processed at the refinery, regarding which operating scheme would be the most suitable for production and would generate the highest revenue for the company.

Regarding the last contribution mentioned by the doctoral candidate, I do not fully agree that this can be highlighted as a contribution of this thesis. This is in itself a statement about the circumstances of the production of the thesis, but it is not a contribution.

All of the contributions mentioned relate to the application of specific results to the production of LNHB. Although the subject matter of the thesis is itself in this direction, there should be clearly defined scientific contributions relating to the development of the relevant field of science - the petroleum industry. This constitutes a minor flaw in the doctoral candidate's presentation of the contributions in the thesis. The scientific contributions of this dissertation

are related to all the results obtained, findings and interpretations obtained in the treatment and blending of different fractions of petroleum products.

In general, I can define the contributions of the dissertation as scientific and applied: confirmation of known scientific facts and proof of new scientific facts by new means.

4. Opinion about the doctoral candidate's publications on the dissertation topic

The dissertation summarizes results published in five publications in four Bulgarian and one foreign journal. All publications are in journals without IF. Only one of the publications was published in a foreign scientific journal (Petroleum Coal, 62 (1), 2020) with SJR impact rank - quartile Q4. Three of the publications are in the same Bulgarian journal with SJR impact rank - with quartile Q4. **In all publications mentioned so far the doctoral candidate is not the first author, which does not make a good impression**, and puts into question the quantitative contribution of the doctoral candidate to the realization of these publications.

One of the publications in which the doctoral candidate is the sole author was published in a scientific journal not refereed in world databases (SCIENTIFIC ATLAS, 2021, NO 3, ISSN 2738-7518). It is through this (chronologically) last publication that the candidate satisfies the scientometric requirements for the PhD degree, which could be considered a drawback.

Due to the submitted documents for review, the absence of any participation or reporting in scientific forums by the candidate was evident.

In this sense, I consider the publication activity regarding the thesis not very good but sufficient.

In spite of the critical remarks, I confirm that the presented publications meet the requirements of the Regulations on the conditions and procedure for acquiring scientific degrees and holding academic positions at Prof. Dr. Asen Zlatarov University in all scientific metrics, exceeding the minimum national requirements for the acquisition of the degree "Doctor" within the meaning of the Academic Staff Development Act and the Regulations for the Implementation of the Academic Staff Development Act in the Republic of Bulgaria.

5. Critical notes and comments

In addition to the issues raised in section 1, I have the following questions for the doctoral candidate, which are mainly of a conversational nature:

What does the unit of measurement (*l/h/kg*) refer to regarding air velocity, as described in Table 11?

On page 69 the doctoral candidate mentions the concept of "straight distillation". What does he mean by this term?

On p. 71 the sulfoxide index is commented on. I quote "*...As can be seen from the data in Table 12, the sulphoxide index for the straight-desylate vacuum residue (SRVGO) and the SRVGO and VTB mixtures increases after 6 hours of oxidation, while after 12 hours its value decreases again. The sulfoxide index value for VTB sample 1 and VTB sample 2 increased continuously during oxidation with air.*", end of quote. How would the doctoral candidate comment on these results for the sulfoxide index, i.e. it increases and then decreases again, why?

The results presented in Figure 29. show that the addition of acrylic polypropylene showed, as correctly noted, a significant improvement at the highest concentrations of 8%. How could one explain the deterioration (increase of the softening temperature of VTB) at 0.5% added ACP?

The meaning of the phrase "residual vacuum conversion" remains unclear to me. On page 89 the doctoral candidate uses the expression "...at a residual vacuum conversion of 58%.". Could the doctoral candidate explain what conversion of residual vacuum means?

On page 97 the author has presented the following statements, quote, "...These data support the conclusion made earlier that the addition of sulfur affects the increase in softening point and the decrease in the increase in softening point after the RTFOT test. They also reveal that the sulphur treatment has no effect on the softening point rise and on the softening point fall after the RTFOT test.", end of quote. These are two sentences contradicting each other. Would the doctoral candidate please explain what he means?

The addition of sulphur to the bits is investigated in several places in the thesis, and in almost all cases the sulphur improves the characteristics of the resulting products. The negative finding in this respect is that the treatment of bitumen with sulphur is accompanied by the release of H_2S , which requires special care for safe separation. In the opinion of the doctoral candidate, could a technical solution to this problem not be considered? For example, is it not possible to add sulphur in confined spaces and to capture the hydrogen sulphide by purification?

I would like to draw attention to the poor quality of some of the figures, 13 to 17 are of very poor quality.

The mentioned remarks in no way diminish from my overall good impression of the thesis. The analytical and critical review of the dissertation by Eng. Ilchev demonstrates developed analytical and critical thinking, competence, diverse knowledge, and skills in a rapidly evolving field of study.

6. Conclusion

The analysis of the presented results shows that the research is mainly of scientific and applied nature and is entirely in the bounds of professional field 5 "Technical Sciences". The research is topical and the obtained results enrich the mentioned scientific field with new knowledge. Moreover, the results of the research, with their applied orientation, can help solve existing technological problems of the Lukoil Neftohim refinery. From the above statement it can be concluded that Eng. Ilchev has successfully fulfilled the planned tasks, has in-depth theoretical knowledge, has mastered various methods for characterization of products of the oil refining industry. Within the dissertation thesis was carried out sufficient in quantity and quality experimental work, which reveals the potential for future development of Eng. Ilchev, as well as for practical application of the obtained results. Undoubtedly, the experimental work, the analyses and part of the interpretation of the results in the dissertation are the personal work of the PhD student and were done under the guidance of his supervisor. The results presented in the thesis are distinguished by novelty, scientific and applied contributions and offer technological solutions to overcome problems associated with the use of low-value products in the production of road bitumen in compliance with all production and government standards.

In spite of the critical remarks and recommendations, the thesis of Eng. Ivan Atanasov Ilchev meets the requirements in terms of volume, scientific content, contributions, and number of

publications as set forth by of the Law for the Development of Academic Staff in the Republic of Bulgaria and the Regulations for the Conditions and Procedure for Acquisition of Scientific Degrees and for Holding Academic Positions at the University Prof. Dr. Asen Zlatarov - Burgas. **All this gives me a reason to express my positive opinion and to recommend the members of the academic jury to support the award of the educational and scientific degree "Doctor" to Eng. Ivan Atanasov Ilchev in the professional field 5. Technical Sciences (Doctoral Programme "Chemical Technologies").**

Assoc. Prof. Chavdar Chirlev

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