

Review of Doctoral Thesis

1. PhD candidate
Ing. Jiří Krupka / Jiri.Krupka@vut.cz
2. Name of PhD programme
Design and Process Engineering (Mechanical Engineering Design)
3. Title of PhD thesis
Development of film thickness in elastohydrodynamically lubricated compliant contacts
4. Principal supervisor
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6. Reviewer
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7. Overview of the scope of PhD thesis¹
Very good
The thesis by Mr Jiri Krupka approaches a relatively little researched topic of lubrication of polymeric materials. The objectives of the research are clearly identified and stated in the scientific questions: 1) Will a coherent lubricant film always be formed in compliant contacts, fully separating the rubbing surfaces? 2) What is the effect of the load and entrainment speed on the fluid-film thickness and the contact shape in the compliant contact operated in the TR region of EHL? 3) How the rheological response of the lubricant contributes to the formation of the fluid-film thickness in the TR region of the EHL, considering a different effect in the I-E and P-E modes of the EHL? 4) What is the contribution of the constitutive viscoelastic response of the material in the compliant contacts to the formation of fluid-film thickness and contact shape changes in the TR region of EHL? These are pertinent objectives, and the author pursues them systematically in four research outputs which form the core of the results chapter of the thesis.
8. Significance of the topic and clarity of problem statement
Excellent
The quest for improving efficiency of machinery and other engineering systems and consequently reduce the carbon footprint of industrial activities led to the use of lighter materials in applications which

¹ Overview of the scope of PhD thesis is a short description of objectives of PhD thesis's research and summary of main findings and scientific achievements.

traditionally metals (especially steel) have been used. Polymers appear as good candidates due to their low density, decent mechanical properties and adequate tribological properties. Traditionally these materials have been regarded as suitable for very low speeds and loads applications, where lubrication was not deemed necessary. Increasing the demands of the applications, with other words increasing the load and sliding speed however have shifted this approach and the attention of researchers has started to focus on lubrication of these machine components. The thesis by Mr Krupka comes at the right time to set benchmarks on the most important aspects of the lubrication of polymeric machine components. The problem is clearly identified and followed through.

9. Knowledge of existing literature

Excellent

The literature review forms a consistent part of the thesis. It shows the breadth and depth of author's knowledge in the field of lubrication elastohydrodynamic contacts in general and the soft EHL in particular. The literature review clearly identifies the state of the art in soft elastohydrodynamic lubrication of compliant, (relatively) soft contacts. The references are ample and relevant, encompassing areas of both experimental and theoretical lubrication research, rheology of materials, contact mechanics and characterisation of materials properties. The literature review is superbly arranged and presented, easing the reader into the subject and offering them the platform to understand the new research problem tackled in the thesis.

10. Choice of methods and technical soundness

Excellent

The huge breakthrough in the research of elastohydrodynamic lubrication was no doubt the application of the optical interferometry method at the Tribology Laboratory, Imperial College London, in 1960s. This method confirmed the earlier theoretical approach and open the doors for tremendous research into the understanding of the details of the mechanisms of the lubricant film formation in high-pressure contacts. If for hard EHL, other methods can be used, e.g. electrical capacitance or resistance, it is obvious that these methods are inadequate when one of the contacting bodies are made of a polymer, that is an insulating material. It follows that optical interferometry really is the only method of choice in this case and the author benefited by the wealth of experience and expertise present in the host laboratory. Going through the literature review I eagerly anticipated the chapters describing the experimental methods and I was not disappointed; the author's approach is elegant and comprehensive, as it considers both anticipated arrangements: soft disk/hard ball and the opposite, hard disk and soft ball. This is in my view a sound approach which gives robustness to the experimental results.

11. Quality, originality and significance of the results

Very good

The results are presented in an original format, as a summary of three research papers. This is a proof of the originality of the results, as those papers have passed through the scrutiny and rigour of the journal reviewing process. The results are very clearly presented covering all the scientific questions set by the author. They bring new knowledge to the field proving originality and the same time they are detailed and significant to the chosen field they are applied to. Presenting the results as a summary of the published papers gives the author the opportunity to bring the various topics in one place and offer coherent and comprehensive discussion.



12. Quality of attached papers

Very good

As mentioned in the above section the papers have already went through the scrutiny and rigour of the review process. This is in itself a guarantee of their quality. Each paper addresses a slice of the research programme set in this thesis. They are well-written and arranged, with detailed discussion and pertinent conclusions. The figures are relevant and explanatory and the references appropriate. Each of those papers form one of the pieces of the puzzle which is the whole research programme. They fall well into place, complementing each other to offer an overall response to the research questions asked by the author.

13. Overall assessment, strengths and weaknesses (based upon the above evaluation categories 8–12)

Very good

This is a very good thesis, built on the foundation of three/four research output published in relevant journals/conferences. The thesis is concise and very well written and structured. The description of the method is adequate, with the only negative aspect the lack of details of the calibration method, as I will explain below. The English is excellent, with only very minor corrections needed, which really can be ignored. In my opinion the author followed a superb research programme and set directions of future research in the field. In my opinion the thesis I of high quality and it is a firm foundation of the PhD degree, assuming successful defending during the oral viva.

14. Questions and comments

The research questions are complemented by a number of hypotheses; In my view these are too many. It also looks like some of these hypotheses end with a phrase which is rather a conclusion not a hypothesis (e.g. H1c, H2 and H3a). Hypothesis H3c states: "An increase in the loading frequency of the solid material, referred to as the entrainment speed in the EHL...". This is new to me and I cannot see how loading frequency can be defined and entrainment speed; it is needs clarifications.

-The author presents relevant material properties of the lubricants, underlining the thermal degradation of 5P4E oil up to 450 C; In my view this is not relevant as polymeric gears and other machine components are not meant to work at this temperature.

-Personally I would have liked to see details of the calibration procedure. As this is a PhD thesis it needs to include these details, even if they were presented in the research papers attached to the thesis. In fact the thesis sends the reader to the research papers, where they are send to other, previous research papers.

-I also wanted to see more explanations on the difference between the soft disk/hard ball and hard disk/soft balls experiments. Was the roughness of the balls the only reason why the hard disc/soft balls were not used? Regarding the film thickness of the glass disk/polymer ball: what was the phase change upon reflection at the ball surface? Was this considered? Is it the same for all ball materials?

15. Conclusion

PhD thesis is an independent scientific work that presents a novel solution to a significant problem in the research area and demonstrates the candidate's ability to conduct independent research.

YES



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16. Date and signature

20/03/2024

Please note

- A. Evaluate categories 7 to 13 using the following scale: unacceptable, acceptable, satisfactory, good, very good, excellent. The qualification of 'excellent' should only be given for a PhD Thesis in the top 3% of the research in your field of expertise.
- B. E-mail the completed form to: Klara.Javorceková@vut.cz