Wind turbine main-bearing lubrication - Part 1: An introductory review of elastohydrodynamic lubrication theory

Response to reviewer 2

Dear reviewer,

First, we would like to thank you for the considerable effort you have put into assessing our manuscript and suggesting improvements. We will make sure the updated manuscript includes the suggestions you have made.

A detailed response is now provided. We include your comments below in **blue**, followed by our responses in **black**.

The submitted paper gives an overview of the current state of elastohydrodynamic lubrication theory, focusing on simplified descriptions for reaching a wider readership. The authors are encouraged to add further figures in order to support the overarching goal of reaching a wider (non-expert) readership. The complex processes taking place in an EHL contact (e.g. starvation) can be illustrated using existing images. In the current version the reader is challenged to use his power of imagination.
We agree that the paper would benefit from more figures illustrating the various described effects. We will include these in the revised manuscript.

While the depth of the explanations is nicely balanced, the review leaves most of the chapters open. Please consider adding clearer recommendations for the aimed readership.
Since this is part 1 of a two part paper, much of the discussion specific to the main-bearing in wind turbines is handled in part 2. This is where some of this discussion takes place. However, when revising the paper, we will try and include some clear recommendations to the intended audience here as well.

Furthermore, multiple equations are given without proper citation. Therefore, the authors should assess if all references had been included.
We will check to ensure relevant references for all equations are included.

Furthermore, the title is misleading. The overview does not clearly explain the applicability or the relevance of the individual approaches for the case “main-bearing”. In the reviewer’s opinion the title should be changed or the relevance of each approach (including the validity range) for main-bearing applications should be addressed.
Again, this relates to the fact that this is a two-part paper. This arrangement was agreed with the journal editors prior to submission, but, we will consider whether recommendations can be added to this first part to help bridge the gap between the two.

Please consider also following points:

Introduction

• Could the authors please give an overview of other EHL-Reviews (e.g. doi:10.3390/lubricants8050051) and shortly comment the differences between the reviews and the need for a new one?
Excellent suggestion, yes we will do this.

Surface separation and lubrication regimes

• No further comments

Reynolds equation and the EHL lubrication problem

• No further comments

Approximation in EHL modeling

• The authors state in paragraph 140 that *"the surface geometries close to the contact region roughly approximate a plane surface", p*lease revise. in the reviewer's opinion this chapter should address the use of a reduced *R*, in which the curvature of both contact bodies is consider in order to allow the use of the aforementioned simplification

We will revise as suggested.

Line and point contacts

• It seems that not all variables had been introduced. For example, Equation 15 is given without introducing the ellipse axis first

We will check to make sure all variables are introduced at the appropriate time.

• Please add further information and/or references to the statement in paragraph 180 *"other approaches to these types of equivalence have also been taken in the literature""*

We will add relevant references here.

General characteristics of EHL contacts

• It is commonly known that the film thickness decreases in the area after the PETRUSEVICH-peak. The authors state, furthermore, that this occurs *"in both incompressible and compressible cases".* Could the authors please describe under which boundary conditions incompressible and compressible cases occur?

Compressibility is a characteristic of the lubricant, therefore I am not entirely sure to which boundary conditions you are referring. However, we will consider this point and address it if we are able.

• In the case of compressible cases, the authors described that the film thickness is *"slightly"* reduced and the pressure pike *"dramatically".* Can the authors please quantify the expected decrease? Which case would be the reference case, incompressible behavior?

We will seek to include quantitative numbers to give some indication of relative magnitudes here, likely percentage reductions. Yes, we were using the incompressible case as the reference case.

• Starting at paragraph 230 it becomes unclear whether side-leakage is being consider or not (according to paragraph 215 it is being ignored). Please revise

We will revise as suggested.

• Please consider adding further information to Figure 3, which would support the descriptions found in paragraphs 234 and 235

Excellent suggestion, we will do this!

Dimensionless groupings and film thickness equations

• Please add references to the presented equations

Will do!

• Please revise paragraph 275. It seems a bit misplaced

I am not sure if you are referring to the text-box, or the discussion of the dimensionless parameter in the case of a point contact. We will assess this general section for clarity.

• Paragraph 280: Please try to give a clearer recommendation for the intended Readership

I believe this refers to the discussion of optimal dimensionless groupings. I am not sure what recommendation might be given here. Dimensionless groupings are, in general, determined by which film thickness equations is being used. We will consider what might be suggested here though (maybe just that!).

• Please give further information regarding the validation strategy and validity range (e.g. oil types) of the reduced analysis given in equations 23 through 25. It is unclear how far this simplified approach can be used in real life applications.

Excellent suggestion, will do!

Accuracy of film thickness equations

• Paragraph 350: The authors states that according to WEEHLER "*the current analytical equations must be considered as providing qualitative, rather than truly quantitative estimates of the film thickness* ". Could the authors please comment this statement? There are multiple publications (including in-situ film thickness measurements) that show that the analytical approach can give good results for a wide range of contact conditions, in particular if the oil properties are well known

This is a good point. I guess the main point to make is that while good results can be obtained in some cases (especially when oil properties are known), in any given applications the quality of results will likely not be known, and so results should be treated as qualitative. This is especially true if oil properties are not well known. We will revise to improve this discussion.

Surface roughness interactions

• On paragraph 425 the authors state that when *"roughness increases, hmin increases.."*. Could the authors comment on this? As described in the first chapters, the commonly used calculation methods for the film thickness do not consider the surface roughness. How does an increase in the surface roughness improves the film build-up?

We will revise to try and better describe the interactions here.

• On paragraph 435 state that equations 32 and 33 are valid for lambda > 0.5. Please comment on how lambda (especially *h*min) was calculated

Will do!

Starvation

• Paragraph 360: There exist methods to determine the meniscus distance, see:
- Nogi 2015 (https://doi.org/10.1115/1.4030203)
- Fischer 2021a (10.1016/j.triboint.2021.106858)
- Fischer 2021b (http://dx.doi.org/10.1088/1757-899X/1097/1/012007)
- Chen 2022 (https://doi.org/10.1063/5.0068707)

• Paragraph 370 *"film reductions due to starvation depends on bearing operating parameters, especially speed"*: In the reviewer´s opinion further effects (e.g. viscosity and available Oil volume) also play an important role (see for example Fischer 2021b - http://dx.doi.org/10.1088/1757-899X/1097/1/012007)

Thank you for pointing out this discrepancy. We will improve this section using the literature you suggest here.

Grease Lubrication

• Paragraph 475: I couldn't find the relationship h<cD in Kanazawa 2017. Please specify if this was published or if this is the author´s interpretation

We will update the paper to make this point clear.

• Paragraph 485 *"Contact replenishment occurs in grease lubricated bearings, but as a strictly local phenomenon":* In the reviewer's opinion this section is quite one-sided (only citing CEN and LUGT). Multiple authors have made significant contributions in this field in the last 50 years. Please consider citing: CANN, ASTRÖM, GONCALVES, FISCHER, POLL, KUHN, HUANG.

This is a fair point. We will try and provide a more rounded overview of grease results and key contributors, including the authors you suggest.

Discussion

• No further comments. Please consider the points above

Conclusion

• In the reviewer´s opinion the conclusion is not a conclusion at all

We will revise the conclusion.

Best regards,

Edward Hart
(on behalf of co-authors)