

Principal supervisor's final report on the PhD study

1. PhD candidate
Ing. Pavel Čípek / pavel.cipek@vut.cz
2. Name of PhD programme
Design and Process Engineering (Mechanical Engineering Design)
3. Title of PhD thesis
The Effect of Synovial Fluid Constituents on Friction and Lubrication of Articular Cartilage
4. Principal supervisor
Doc. Ing. Martin Vrbka, Ph.D. / martin.vrbka@vut.cz
5. Co-supervisor
Doc. Ing. David Nečas, Ph.D. / david.necas@vut.cz
6. Stays at other institutions (min. 7 days)
No stays or internships were carried out.
7. Teaching activities
Machine Design – Machine Elements (5KS), Machine Design – Mechanical Drives (6KT), Machine Design Fundamentals (1K), Machine Design (2K).
8. List of main publications
Papers in journals with IF:
ČÍPEK, P.; VRBKA, M.; REBENDA, D.; NEČAS, D.; KŘUPKA, I. Biotribology of Synovial Cartilage: A New Method for Visualization of Lubricating Film and Simultaneous Measurement of the Friction Coefficient. <i>Materials</i> , 2020, 13(9), 1-20. ISSN: 1996-1944.
REBENDA, D.; VRBKA, M.; ČÍPEK, P.; TOROPITSYN, E.; NEČAS, D.; PRAVDA, M.; HARTL, M. On the Dependence of Rheology of Hyaluronic Acid Solutions and Frictional Behavior of Articular Cartilage. <i>Materials</i> , 2020, 13(11), 1-14. ISSN: 1996-1944.
FURMANN, D.; NEČAS, D.; REBENDA, D.; ČÍPEK, P.; VRBKA, M.; KŘUPKA, I.; HARTL, M. The effect of synovial fluid composition, speed and load on frictional behaviour of articular cartilage. <i>Materials</i> , 2020, 13(6), 1-16. ISSN: 1996-1944.



ČÍPEK, P.; VRBKA, M.; REBENDA, D.; NEČAS, D.; KRUPKA, I. Biotribology of Synovial Cartilage: Role of Albumin in Adsorbed Film Formation. *Engineering Science and Technology, an International Journal*, 2022, 34, 101090. ISSN: 22150986

Papers in SCOPUS indexed journals:

ČÍPEK, P.; REBENDA, D.; NEČAS, D.; VRBKA, M.; KRUPKA, I.; HARTL, M. Visualization of Lubrication Film in Model of Synovial Joint. *Tribology in Industry*, 2019, 41(3), 387-393. ISSN: 0354-8996.

9. Assessment of the supervision process

Very good

The supervision process followed the pre-set rules for PhD study. The process was based on one-month main meetings and on-demand discussions with supervisor, co-supervisor and colleagues from Biotribology Research Group. The candidate was always well prepared to discuss the issue of the dissertation including reflection of critical comments. The final PhD thesis and research papers were prepared in time and in sufficient quality. The outputs of PhD thesis have been three research papers. The teaching activities of candidate were focused especially on tutorials of courses of Machine Design – Machine Elements, Machine Design – Mechanical Drives and Machine Design Fundamentals. The candidate attended four international conferences where he presented partial results of his research: Engineering Mechanics in Svratka in Czech Republic, 16th International Conference on Tribology - Serbiatrib in Kragujevac in Serbia, 60th International Conference of Machine Design Departments in Hnanice in Czech Republic and 5th International Conference on BioTribology (online - live and on-demand).

10. Assessment of the candidate's ability to work independently

Very good

The candidate worked independently, based on the discussion with me and my colleagues from the lab and other experts from the field of biotribology, chemistry and orthopaedics. I would like to highlight candidate's efforts in the design and development of a new tribometer that allows for simultaneous measurement of the friction coefficient and visualization of the lubricating film using fluorescence microscopy. The candidate independently designed a methodology of experiments based on the state of the art, performed experiments, and, according to the results analyses, he formulated conclusions. All of the publications, where he is listed as the main author, were prepared by himself. The candidate also supervised three bachelor theses in the field of biotribology and significantly participated in the other research projects of our Biotribological Research Group.

11. Assessment of the contribution that the research makes to knowledge in the field

Good

The PhD thesis is composed from three papers. One paper was published in the journal in Scopus database ("Tribology in Industry") and the other two were published in the journals with impact factor ("Materials" and "Engineering Science and Technology, an International Journal"). However, the candidate has also co-authored two other biotribological publications in the journal with impact factor ("Materials"). The main scientific output of this thesis is the understanding of tribological behaviour of the model synovial joint. For this purpose, a new simulator has been developed to combine coefficient of friction measurement and visualization of lubricated cartilage contact using fluorescence microscopy. The combination of simultaneous measurement of friction and observation of lubricating film in the model of



synovial joint helps to find answers to some of the scientific questions. E.g.: In which lubrication regime does the synovial joint work? How do the different components of synovial fluid (albumin, gamma-globulin, hyaluronic acid, and phospholipids) affect friction and lubrication of cartilage? I believe that the obtained scientific findings will suite the understanding of cartilage lubrication and the better treatment of osteoarthritis by viscosupplementation. The main weaknesses of the PhD thesis are the lack of a deeper analysis of the results and what it means for up-to-date cartilage lubrication (what lubrication regimes are present) and what it means for cartilage wear (only friction and lubrication were discussed). I also find the thesis lacking a better variability of experiments. Only one component (albumin) of the synovial fluid was fluorescently labelled and observed. Why not gamma-globulin or hyaluronic acid? Is it possible to describe the behaviour of synovial fluid on the basis of labelled albumin alone?

12. Other comments

none

13. 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

16. Date and signature

24/03/2022

Please note

- Evaluate categories 9 to 11 using the following scale: unacceptable, acceptable, satisfactory, good, very good, excellent.
- In each category 9 to 11 explain reasons for evaluation using between 100–200 words.
- E-mail the completed form to: Klara.Javorcekova@vut.cz