INSTITUTE OF MACHINE
AND INDUSTRIAL DESIGN

Faculty of Mechanical Engineering
Brno University of Technology

Principal supervisor's final report on the PhD study

1. PhD candidate
Ing. David Rebenda / david.rebenda@vut.cz
2. Name of PhD programme
Design and Process Engineering (Mechanical Engineering Design)
3. Title of PhD thesis
Effect of Viscosupplementation on Friction of Articular Cartilage

4. Principal supervisor
Doc. Ing. Martin Vrbka, Ph.D. / martin.vrbka@vut.cz
5. Co-supervisor
Ing. David Nečas, Ph.D. / david.necas@vut.cz

6. Stays at other institutions (min. 7 days)
05/2018 – 07/2018 Contipro a.s., Dolní Dobrouč 401, 561 02 Dolní Dobrouč, Czech Republic

7. Teaching activities
Machine Design – Machine Elements (5KS) Machine Design – Mechanical Drives (6KT) Tribology (ZTR)

8. List of main publications
Papers in journals with IF:

TOROPITSYN, E., M. PRAVDA, **D. REBENDA**, I. ŠČIGALKOVÁ, M. VRBKA and V. VELEBNÝ. A Composite device for viscosupplementation treatment resistant to degradation by ROS and hyaluronidase. *Biomacromolecules,* 2021. (Under review)

ČÍPEK, P., M. VRBKA, **D. REBENDA**, D. NEČAS and I. KŘUPKA. Biotribology of Synovial Cartilage: Role of Albumin in Lubricant Film Formating. *Engineering Science and Technology, an International Journal,* 2021. (Under review)

REBENDA, David, Martin VRBKA, David NEČAS, Evgeniy TOROPITSYN, Seido YARIMITSU, Pavel ČÍPEK, Martin PRAVDA and Martin HARTL. Rheological and frictional analysis of viscosupplements towards improved lubrication of human joints. *Tribology International*. 2021, 160. ISSN 0301679X.

REBENDA, David, Martin VRBKA, Pavel ČÍPEK, Evgeniy TOROPITSYN, David NEČAS, Martin PRAVDA and Martin HARTL. On the Dependence of Rheology of Hyaluronic Acid Solutions and Frictional Behavior of Articular Cartilage. *Materials*. 2020, 13(11). ISSN 1996-1944.

LU, Xianjiu, David NEČAS, Qingen MENG, **David REBENDA**, Martin VRBKA, Martin HARTL and Zhongmin JIN. Towards the direct validation of computational lubrication modelling of hip replacements. *Tribology International*. 2020, 146(11). ISSN 0301679X.

ČÍPEK, Pavel, Martin VRBKA, **David REBENDA**, David NEČAS, Ivan KŘUPKA and Martin HARTL. Biotribology of Synovial Cartilage: A New Method for Visualization of Lubricating Film and Simultaneous Measurement of the Friction Coefficient. *Materials*. 2020, 13(9). ISSN 1996-1944.

FURMANN, Denis, David NEČAS, **David REBENDA**, Pavel ČÍPEK, Martin VRBKA, Ivan KŘUPKA and Martin HARTL. The Effect of Synovial Fluid Composition, Speed and Load on Frictional Behaviour of Articular Cartilage. *Materials*. 2020, 13(6). ISSN 1996-1944.

CHOUDHURY, Dipankar, **David REBENDA**, Shinya SASAKI, Pavel HEKRLE, Martin VRBKA and Min ZOU. Enhanced lubricant film formation through micro-dimpled hard-on-hard artificial hip joint: An in-situ observation of dimple shape effects. *Journal of the Mechanical Behavior of Biomedical Materials*. 2018, 2018-05-14, 81, 120-129. ISSN 17516161.

NEČAS, David, Martin VRBKA, **David REBENDA**, Jiří GALLO, Adéla GALANDÁKOVÁ, Lucie WOLFOVÁ, Ivan KŘUPKA and Martin HARTL. In situ observation of lubricant film formation in THR considering real conformity: The effect of model synovial fluid composition. *Tribology International*. 2018, 2018-05-14, 117, 206-216. ISSN 0301679X.

Papers in SCOPUS indexed journals:

RUFAQUA, Risha, Martin VRBKA, Dušan HEMZAL, Dipankar CHOUDHURY, **David REBENDA**, Ivan KŘUPKA and Martin HARTL. Raman analysis of chemisorbed tribofilm for metal-on-polyethylene hip joint prostheses. *Biosurface and Biotribology*. ISSN 2405-4518.

RUFAQUA, Risha, Martin VRBKA, Dušan HEMZAL, Dipankar CHOUDHURY, **David REBENDA**, Ivan KŘUPKA and Martin HARTL. Analysis of Chemisorbed Tribo-Film for Ceramic-on-Ceramic Hip Joint Prostheses by Raman Spectroscopy. *Journal of Functional Biomaterials*. 2021, 12(2). ISSN 2079-4983.

ČÍPEK, Pavel, **David REBENDA**, David NEČAS, Martin VRBKA, Ivan KŘUPKA and Martin HARTL. Visualization of Lubrication Film in Model of Synovial Joint. *Tribology in Industry*. 2019, 41(3), 387-393. ISSN 03548996.

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 Tribology. The candidate attended three 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 and 60th International Conference of Machine Design Departments in Hnanice in Czech Republic. He also contributed with his results to the presentation at the international conference (STLE Annual Meeting and Exhibition in the USA), without his personal participation.

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 the cooperation with Contipro company, where candidate completed a three-month internship and carried out rheological measurements of individual synovial solutions and commercial viscosupplements. 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 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

Very good

The PhD thesis is composed from three papers in the journals with impact factor. Two of them were published in the journal "Materials", and last one was published in the journal "Tribology International". However, the candidate has also co-authored other biotribological publications, namely four publications in journals with impact factor and three in journals in Scopus database. The main scientific output of this thesis is the understanding of tribological and rheological behaviour of the model synovial joint, immediately after hyaluronic acid injection (that is, after viscosupplementation). The combination of tribology and rheology of viscosupplements is an understudied problem and this work helps to find answers to some of the questions. I believe that the obtained scientific findings will suite the future development of viscosupplements for better treatment of osteoarthrosis. The main weaknesses of the PhD thesis are the lack of a deeper analysis of the results and what it means for actual cartilage lubrication (what lubrication regimes are present), what it means for cartilage wear (only friction and rheology were discussed) and what it means in terms of clinical outcomes and how we can improve viscosupplementation. I also find the thesis lacking a better correlation of the results between two presented models of synovial joint - cartilage against glass and PVA hydrogel against glass.

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	[redacted]
27/07/2021	

Please note

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