

Research stay at Leibniz Universität Hannover (LUH), Institut für Kraftwerkstechnik und Wärmeübertragung (IKW)

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Introduction

First of all, I need to say, that I don't want to concentrate on transport, accommodation and other formal moments. There have been said a lot of kind words to the whole organization of studying process at LUH by another students from St. Petersburg. But I have to highline the great support which was given to me by my institutional coordinator, Nataliya Butych, my supervisor, Martin Günzel, my professor, Roland Scharf, and my friends. At this report I want to focus on the scientific part of LUH and SPbSPU joint research work and my own cultural impressions.

Joint research work

I had a four month research stay at LUH, IKW with research topic "Design and off-design modeling of ORC cycles". The first variant of the research topic, related to thermodynamic modeling of ORC cycles, was changed to consider the different aspects of ORC cycles behavior related to its off-design operating conditions. My research topic was adopted by myself and my supervisor in order to match my PhD thesis theme. I should outline that my working place at University was perfect. I had a new computer with two monitors, so I was able to connect one monitor to my laptop and work in parallel with two computers. It was really comfortable because at my laptop I worked with my program and at stationary computer I had all needed licensed software.

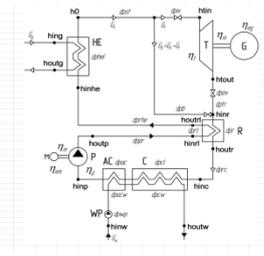
The aim of my research stay was creating and validating of computer program for ORC design and off-design modeling in collaboration with LUH professors and engineers. The REFPROP databases and REFPROP MS Excel



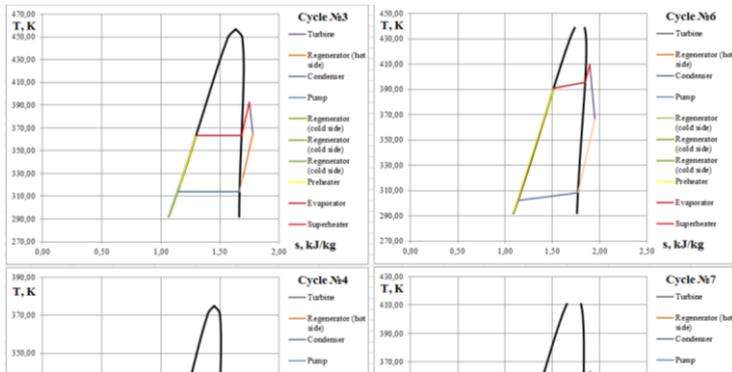
spreadsheets were taken as a basis of this program because I already had an experience in using of these models. At the first stage the different models of turbine efficiency and mass-flow rate calculation were analyzed to establish correct approach of off-design microturbine behavior modeling. The large number of experimental data was analyzed. The Stodola equation was accepted for mass

flow rate calculation. The special microturbine efficiency parabolic equation was provided on the base of large number of experimental data for different types of microturbines. The enthalpy method of the cycle parameters calculations was applied for the calculations of cycle points and parameters.

Pure fluids (single and regenerative cycles)										Mixtures (single and regenerative cycles)									
Working fluids					Working fluids					Working fluids					Working fluids				
Working fluid	η _{max}	η _{opt}	η _{opt}	η _{opt}	Working fluid	η _{max}	η _{opt}	η _{opt}	η _{opt}	Working fluid	η _{max}	η _{opt}	η _{opt}	η _{opt}	Working fluid	η _{max}	η _{opt}	η _{opt}	η _{opt}
CO ₂	0.12	0.12	0.12	0.12	CO ₂	0.12	0.12	0.12	0.12	CO ₂	0.12	0.12	0.12	0.12	CO ₂	0.12	0.12	0.12	0.12
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On the second stage the main algorithms were implemented with VBA software language for calculation of different cycle configurations with different working fluids. The main equations were implemented so that to provide calculations for pure fluids, azeotropic and zeotropic mixtures. The final stage was validating of designed program. There were analyzed more than 14 experimental data sources and results of Epsilon Professional software test simulations;



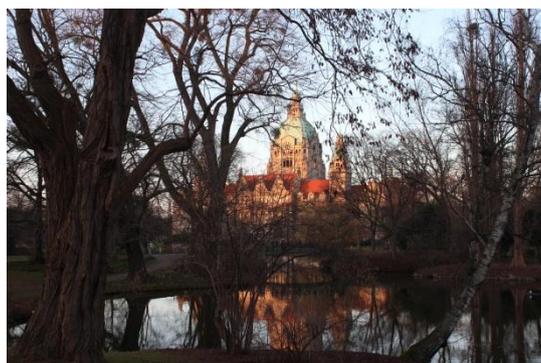
maximum deviation in thermodynamic parameters calculations estimated as less than 10%. However, the error in mass flow rate calculations is in range between 5% and 30% for different cases. The

nature of this mass flow rate equation behavior needs to be established with additional analysis.

During the research period a joint scientific paper was submitted to proceedings of the 3rd International Seminar on ORC Power Systems as the result of my research activity. Moreover, all the needed data for the second joint publication was collected. The abstract of the second joint publication has been accepted to the proceedings of the 12th International Symposium on Experimental and Computational Aerothermodynamics of Internal Flows.

Cultural and language aspects

To say about a cultural aspect of my staying in Germany I have to outline that I have visited many German towns, including Hamburg and Berlin. I had completely positive impressions of German architecture and atmosphere of German towns. Every town, which I have visited, has its own specific atmosphere and I really like it. Unfortunately, I had a real lack of free time, because I tried to learn German language together with my scientific work and improving English language skills. However, I had a chance to see the beauty and uniqueness of Hannover itself. The Old and New Rathaus, Masch See, Herenhäuser Gärten and another sightsees are amazing and very atmospheric.



My hobby is sport (powerlifting). So it was impossible for me not to go to the gym all these four months. I tried to get an appointment to go to the LUH's gym, but I was not a student exactly and it would be too expensive for me. Fortunately, I've found cheaper gym and I'd been going there for all

the period of my staying in Hannover.

To say about my learning German language I have to say that Nataliya Butych gave me a great support in finding of an appropriate Deutsch courses. In parallel with Deutsch courses I learnt German language by myself. As a result, I have A2 language level to the end of my research period. Another thing that I have to highline is a communication with other people at the dormitory and at the University. At the first time it was a real assay for me to communicate with other people in English. It doesn't mean that I had real difficulties with the language, but after living all my life in Russia it was really hard for me to speak in English, think in English and so on. But I have to say that it was a great experience and great opportunity for improving of my language skills which I've realized.

Conclusion

To sum up, my research was very productive and useful for developing of LUH and SPbSPU joint research activity. Two joint scientific publications were accepted to be published in international conferences proceedings. The facilities for further joint research were established. Also it was very useful for me to improve my language skills and learn more about Germany and studying abroad.