

Contents

Abstract	I
Kurzfassung	III
1 Introduction	1
1.1 General remarks	2
2 WP1 – Extending AC²'s ODE-Numerics.....	3
2.1 Terminology and basic relations.....	3
2.2 Preparation of ATHLET and THY to establish a physically consistent coupling within the context of doable numerics	10
2.2.1 Building a Jacobian matrix for the overall system – feasibility con- siderations	10
2.2.2 Derivation of a concept to achieve physical consistency.....	13
2.2.3 Samples for testing the ATHLET-COCOSYS coupling.....	19
2.3 ODE-numerics for single and coupled systems	26
2.3.1 Establishing a feature in NuT to execute certain ODE-methods	27
2.3.2 Building a Jacobian matrix for the overall system – implementation..	42
2.3.3 Adapt control logic in ATHLET and THY	49
2.3.4 Running a test case	58
3 WP2 – Improving NuT and AC² on the Level of Software Engi- neering.....	63
3.1 Reviewing the NuT code regarding the potential for refactoring	63
3.1.1 Software architecture	63
3.1.2 Logging	64
3.1.3 Maintenance	67
3.1.4 CPU affinity	69
3.1.5 Refactoring NuT's documentation	69
3.2 Development and automation of CI processes in GitLab for NuT and AC ²	70
3.2.1 Build techniques.....	70
3.2.2 CI/CD	73
3.2.3 Code analysis in NuT	76
3.2.4 Merge requests workflow	78
3.2.5 Project organisation	82
3.2.6 Improving software development on the level of AC ²	84
3.3 Assessment of the parallel performance of NuT	88

4	WP3 – Reviewing ATHLET’s Steady State Calculation on a Conceptual Level	91
4.1	General objective of the SSC	91
4.2	Procedure of the SSC	91
4.3	Overview of currently used algorithms and thermal-hydraulic models	96
4.3.1	Iteration loops	96
4.3.2	Algorithms for the solution of equation systems.....	100
4.4	Detailed description of relevant algorithms	100
4.4.1	Iteration of enthalpy and mass quality	100
4.4.2	Pressure iteration for TFOs with flowing fluid	108
4.4.3	Pressure iteration for TFOs with stagnant fluid	114
4.4.4	Iteration of the pump rotational speed	116
4.4.5	Iteration of layer temperatures	118
4.5	Comparison of the used methods with state-of-the-art numerical algorithms	128
4.5.1	NuT integration	129
4.6	Suggestions for improvement of the SSC	130
4.6.1	Improvements accomplished within the current project	130
4.6.2	Improvements applicable for the current methodology of the SSC....	131
4.6.3	Improvements that need major modifications of the methodology of the SSC	133
4.6.4	Further suggested modifications	137
5	Conclusions and Outlook	139
	References	143
	Acronyms	149
	List of Figures	151
	List of Tables	154
	List of Codes.....	155
A	Appendix on details of WP1	157
B	Appendix on details of WP3	161