

Table of contents

I	Preface	i
II	Zusammenfassung	iii
III	Abstract	v
IV	Nomenclature	x
V	Abbreviations	xv
1	Introduction and Motivation	1
2	Fundamentals of Excavators	3
2.1	History and Basic Structures	3
2.2	Compact Excavators.....	6
2.3	Energy Efficiency of Hydraulic Excavators	6
3	Hydraulic Systems for Excavators	11
3.1	Advantages of Using Hydraulics	11
3.2	Open Center System.....	12
3.2.1	1FP-1V System	12
3.2.2	2FP-2V System	13
3.2.3	Negative and Positive Flow Controls.....	14
3.2.4	2VP-2V System.....	15
3.2.5	Latest OC System.....	17
3.3	Closed Center System	19
3.3.1	Hydro-Mechanical LS System	19
3.3.2	Electro-Hydraulic LS System	22
3.4	Hybrid System.....	23
3.4.1	Recoverable Energy in Hydraulic Excavators	24
3.4.2	Hybrid Excavators.....	28
3.4.3	Energy Storage Devices	31
3.5	New Architectures	33
3.5.1	Displacement Control Systems	34
3.5.2	Transformer Systems.....	35
3.5.3	Individual Metering Systems	36
3.5.4	Digitally Controlled Systems	37
4	New Hydraulic Hybrid System	39
4.1	STEAM	39
4.2	Concepts of the New Hydraulic Hybrid System.....	40

4.2.1	ICE.....	40
4.2.2	Main Pump	42
4.2.3	Auxilliary Components	46
4.2.4	Valve Systems	47
4.2.5	Pressure Rails	52
4.2.6	Accumulators.....	57
4.2.7	Accumulators Charging Circuit	60
4.2.8	Controllability during Saturation	61
4.2.9	Linear Transformer.....	66
5	Simulation Models	67
5.1	Simulation Model for New Hybrid System.....	67
5.1.1	Hydraulic System	67
5.1.2	ICE Modelling.....	69
5.2	Simulation Model for Reference	70
5.3	Parameters	72
5.3.1	New Hybrid System	72
5.3.2	LS System.....	74
5.4	Working Cycles.....	74
5.4.1	JCMAS	75
5.4.2	Calculation of Target Cylinder Strokes for JCMAS Cycles.....	79
5.4.3	Holländer Cycles	83
5.4.4	Measured Test Cycle by IFAS	86
5.5	Structure of Simulation and Operator Model.....	88
6	Simulation Results	90
6.1	JCMAS	90
6.1.1	JCMAS Leveling.....	90
6.1.2	JCMAS Dig and Dump	93
6.2	Holländer Cycles	96
6.2.1	Dig and Dump	96
6.2.2	Trenching.....	99
6.3	IFAS Test Cycles.....	102
6.4	Summry of the Previous Simulation Results.....	105
6.5	Effect of Accumulator Volumes.....	107
6.5.1	JCMAS Cycles	107
6.5.2	Holländer Cycles	111

6.5.3	IFAS Test Cycles	114
6.5.4	Summary of Simulation Results	117
7	Conclusion and Recommendation.....	119
7.1	Conclusion.....	119
7.2	Recommendations for Constant Pressure Systems	121
8	Literature.....	124
9	Appendix.....	133