List of Figures

Fig, No. **Title** **Page No.**

Fig. 1.1 Schematic presentation of gasification as one of the thermal conversion processes, BTG (2002) as presented in Knoef (2005, p. 13) 2

Fig. 1.2 Difference between 'syngas' and 'product gas' with applications, Boerrigter and Rauch (2005, p. 212) 4

Fig. 1.3 Schematic Layout of Organic Rankine Cycle (ORC) 5

Fig. 1.4 Schematic Layout of Combined Cooling, Heat and Power system 6

Fig. 3.1 Schematic flow sheet for the proposed model used in aspen simulation 25

Fig. 3.2 Plot of syngas (mol/h) vs. gasification temperature (K) for leather waste with constant total mass flow rate but with varying water to biomass ratio 31

Fig. 3.3 Plot of hydrogen gas (mol/h) vs. gasification temperature (K) for with constant total mass flow rate but with varying water to biomass ratio 32

Fig. 3.4 Plot of methane gas (mol/h) vs. gasification temperature (K) for with constant total mass flow rate but with varying water to biomass ratio 32

Fig. 3.5 Plot of Total combustible gases (mol/h) vs. gasification temperature (K) for with constant total mass flow rate but with varying water to biomass ratio 33

Fig. 3.6 Plot of Performance index vs. gasification temperature (K) for with constant total mass flow rate but with varying water to biomass ratio 33

Fig. 3.7 Plot of syngas (mol/h) vs. gasification temperature (K) for Leather waste with constant water to biomass ratio (=0.4) but with varying total mass flow rate 34

Fig. 3.8 Plot of hydrogen gas (mol/h) vs. gasification temperature (K) for Leather waste with constant water to biomass ratio (=0.4) but with varying total mass flow rate 34

Fig. 3.9 Plot of methane gas (mol/h) vs. gasification temperature (K) for Leather waste with constant water to biomass ratio (=0.4) but with varying total mass flow rate 35

Fig. 3.10 Plot of Total combustible gases (mol/h) vs. gasification temperature (K) for Leather waste with constant water to biomass ratio (=0.4) but with varying total mass flow rate 35

Fig. 3.11 Plot of Performance index vs. gasification temperature (K) for Leather waste with constant water to biomass ratio (=0.4) but with varying total mass flow rate 36
Fig. 3.12 Performance Index of all biomasses with total mass flow rate constant and varying water to biomass ratio 36
Fig. 3.13 Number of moles of syngas produced for all biomasses with constant total mass flow rate and varying water to biomass ratio 37
Fig. 3.14 Number of moles of hydrogen produced for all biomasses with constant total mass flow rate and varying water to biomass ratio 37
Fig. 3.15 Methane gas produced for all biomasses with constant total mass flow rate and varying water to biomass ratio 38
Fig. 3.16 Total combustible gases produced for all biomasses with constant total mass flow rate and varying water to biomass ratio 38
Fig. 4.1 Schematic Diagram for Cycle-1 46
Fig. 4.2 Aspen plus flowsheet of cycle-1 47
Fig. 4.3 Schematic Diagram for Cycle-2 50
Fig. 4.4 Aspen plus flowsheet of cycle-2 51
Fig. 4.3 Schematic Diagram of Cycle-3 54
Fig. 4.6 Aspen plus flowsheet of cycle-3 55
Fig. 4.7 Variations of syngas and hydrogen gas yield with gasification temperature for PMSC with constant TMF (160 kg/h) but with varying WBR 68
Fig. 4.8 RE and COP vs. gasification temperature with varying water WBR at a fixed boiler pressure (100 bar) and constant TMF (160 kg/h) for Cycle-1 69
Fig. 4.9PI vs. gasification temperature with varying WBR at a fixed boiler pressure (100 bar) and constant TMF (160 kg/h) for Cycle-1 69
Fig. 4.10 Plot of syngas (mol/h) and hydrogen (mol/h) vs. gasification temperature for PMSC with varying TMF and constant WBR (0.4) 70
Fig. 4.11 Plot of RE and COP vs. gasification temperature for PMSC with varying TMF at a fixed boiler pressure (100 bar) and WBR (0.4) for Cycle-1 70
Fig. 4.12 Plot of PI vs. gasification temperature for PMSC with varying TMF at a fixed boiler pressure (100 bar) and constant WBR (0.4) for Cycle-1 71

Fig. 4.13 Plot of RE vs. gasification temperature for PMSC with varying boiler pressure at constant TMF (160 kg/h) and WBR (0.4) for Cycle-1 71

Fig. 4.14 Plot of PI vs. gasification temperature for PMSC with varying boiler pressure at constant TMF (160 kg/h) and WBR (0.4) for Cycle-1 72

Fig. 4.15 Refrigeration effect vs. gasification temperature for PMSC with varying refrigerant mass flow rate at fixed boiler pressure (100bar), TMF (160 kg/h) and WBR (0.4) for Cycle-1 72

Fig. 4.16 PI vs. gasification temperature for PMSC with varying refrigerant mass flow rate at a fixed boiler pressure (100 bar), TMF (160 kg/h) and WBR (0.4) for Cycle-1 73

Fig. 4.17 Moles of syngas produced for selected biomass materials with constant total mass flow rate (160 kg/h) and refrigerant flow rate (150 kg/h) at optimum gasification temperature a for all three cycles 73

Fig. 4.18 Refrigerant effect for selected biomass materials at different WBR with constant TMF (160 kg/h) and refrigerant flow rate (150 kg/h)at optimum gasification temperature and boiler pressure (100 bar) for all three cycles 74

Fig. 4.19 COP for selected biomass materials with constant TMF (160 kg/h) and refrigerant flow rate (150 kg/h) at optimum gasification temperature and boiler pressure (100 bar) for all three cycles 75

Fig. 4.20 PI for selected biomass materials with constant TMF (160 kg/h) and refrigerant flow rate (150 kg/h) at optimum gasification temperature and boiler pressure (100 bar) for all three cycles 76

Fig.5.1 Layout of Solar Assisted Gasification System 78

Fig. 5.2 A Solar ORC system integrated with SOEC (co-electrolysis) unit 79

Fig.5.3 SOEC model layout in Aspen Plus 81

Fig. 5.4 Variations of syngas with gasification temperature for PMSC at constant collector area (=10 m^2) but with varying Sunlight hours 85

Fig. 5.5 Variations of Hydrogen gas with gasification temperature for PMSC at constant collector area (=10 m^2) but with varying Sunlight hours 86

Fig. 5.6 Variations of Air required in the gasifier with gasification temperature for PMSC at constant collector area (=10 m^2) but with varying Sunlight hours 87

Fig. 5.7 Variations of syngas with gasification temperature for PMSC at constant sunlight hour (=12 pm) but with varying collector area 87
Fig. 5.8 Variations of Carbon dioxide with gasification temperature for PMSC at constant sunlight hour (=12 pm) but with varying collector area 87
Fig. 5.9 Variations of Syngas with Sunlight hours for PMSC at constant collector area (=30 m^2) but with varying Gasification Temperature 88
Fig. 5.10 Variations of Hydrogen with Sunlight hours for PMSC at constant collector area (=30 m^2) but with varying Gasification Temperature 89
Fig. 5.11 Variations of Carbon Dioxide with Sunlight hours for PMSC at constant collector area (=30 m^2) but with varying Gasification Temperature 89
Fig. 5.12 Variations of Air required in the Gasifier with Sunlight hours for PMSC at constant collector area (=30 m^2) but with varying Gasification Temperature 90
5.13 Plot of Air required in the Gasifier with and without solar collector (or Pre-heat) vs Gasification Temperature 90
Fig. 5.14 Variation of the product gases of the SOEC with sunlight hours at constant Collector area (=30 m^2) 91
Fig. 5.15 Variation of Mole Fraction of the product gases of the SOEC with sunlight hours at constant Collector area (=30 m^2) 91
Fig. 5.16 Variation of the Syngas produced from SOEC with sunlight hours at varying Collector area 92
Fig. 5.17 Variation of the Hydrogen produced from SOEC with sunlight hours at varying Collector area 92
Fig. 5.18 Variation of the Carbon Dioxide produced from SOEC with sunlight hours at varying Collector area 93
Fig. 5.19 Variation of the Performance Index with sunlight hours at constant Collector area (=30 m^2) and fixed optimum gasification temperature
for Cycle-4 and Cycle-6a 94

Fig. 5.20 Variation of the Performance Index with sunlight hours at constant Collector area (=30 m^2) and fixed optimum gasification temperature
for Cycle-5 and Cycle-6b 84