Waste Biomass to Methanol – Optimisation of the Gasification Agent to Feed Ratio

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Waste biomass

- wood waste from forestry and wood processing industry,
- waste from agriculture and landscape maintenance (maize and cereal straw, rape straw, hay, the remains of vineyards and orchards),
- waste from livestock,
- organic waste from food industry

Pyrolysis

Gas

Tar (Oil)

Char

Product recovery

Liquid fuels

Solid fuels and fertilizers

Methanol

Other Chemicals

Energy recovery

Electricity

Heat

Gasification

Gas (H_2, CO, CO_2, CH_4)

Contaminants (Tar, NH_3, H_2S, HCl)

Ash (Char)

Product recovery

Methanol

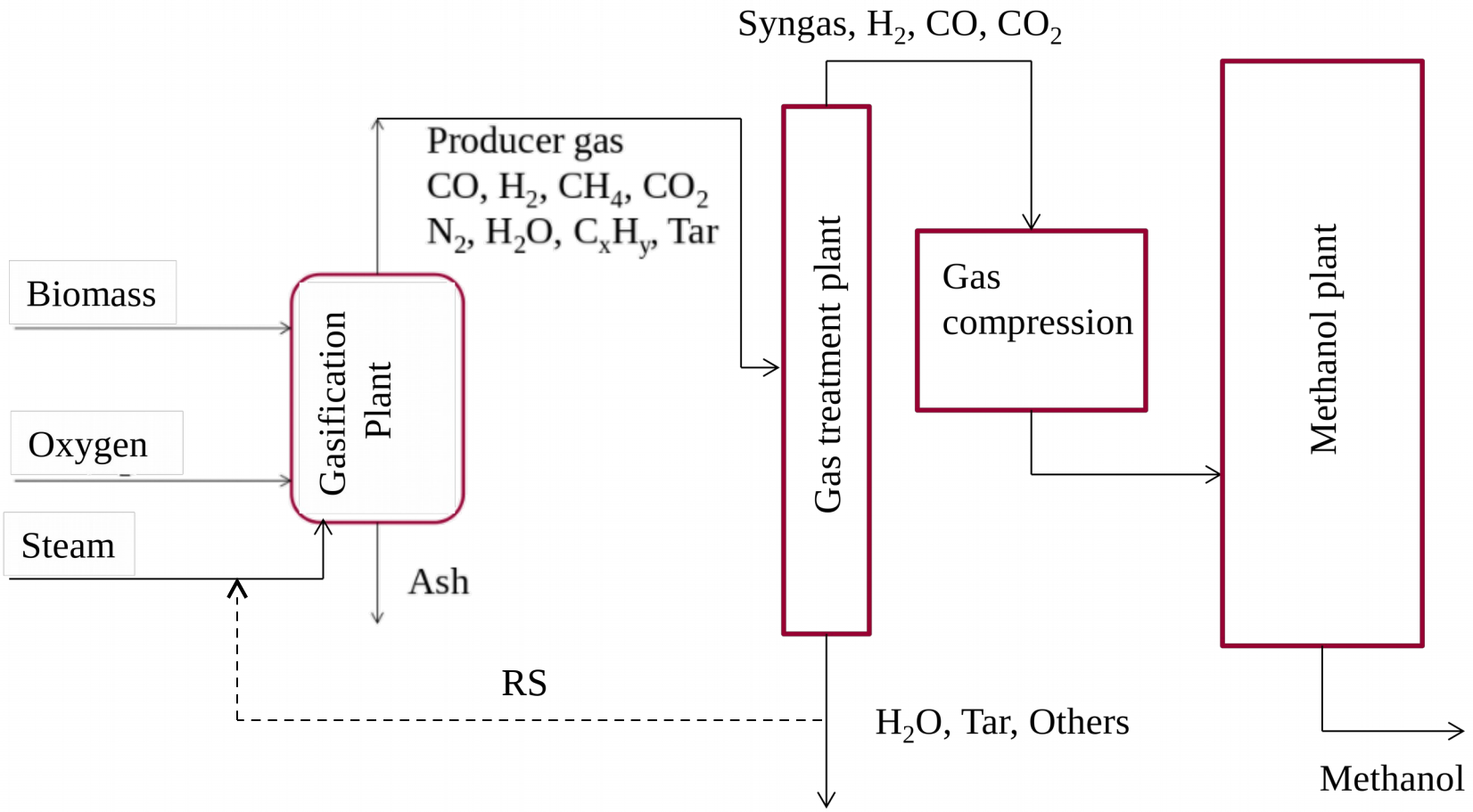
Other Chemicals

Energy recovery

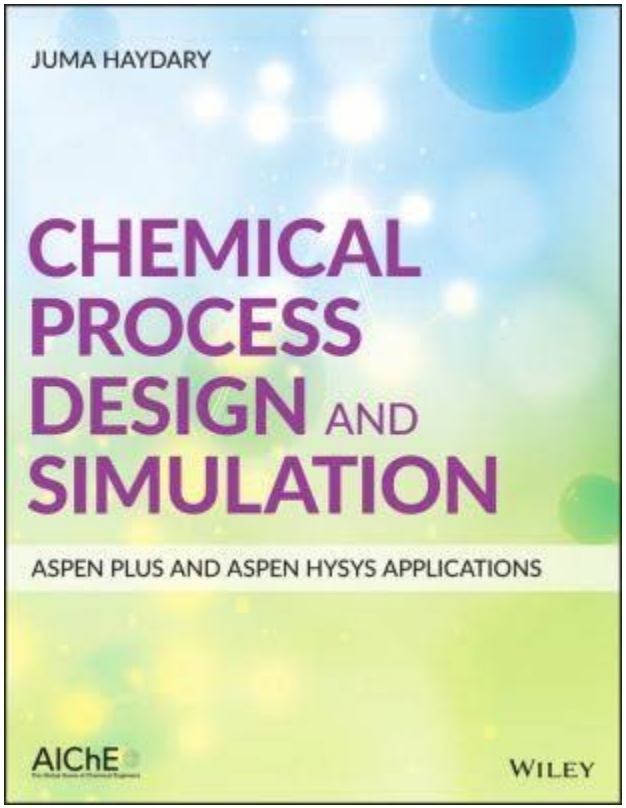
Electricity

Heat

Waste biomass to Methanol



Details of simulation of a complete waste to methanol plant can be found in:



In this work we focus on:
Process efficiency given by:
MBR - Methanol to Biomass Ratio
At variables:
OBR - Oxygen to Biomass Ratio
SBR - Steam to Biomass Ratio
RSBR - Recycled Steam to Biomass Ratio

Biomass Characterization

Weight fraction (wt. %)	Wheat straw	Barley straw	Corn leaves and stalks	Sunflowers	Wood chips
Sample 1	9.238	13.840	15.350	39.092	22.480
Sample 2	14.497	14.499	53.410	12.160	5.430

Biomass	Moisture (wt. %)	Ash (db wt. %)	Ultimate analysis (db wt. %)					HHV (MJ/kg db)
			C	H	N	S	O	
Wheat straw	1.91	4.90	42.80	5.44	0.60	0.00	46.26	16.80
Barley straw	1.94	6.90	49.70	6.90	1.00	0.70	34.80	16.96
Corn leaves and stalks	6.05	2.08	50.88	5.26	0.74	0.19	40.85	16.97
Sunflowers	14.60	7.31	45.38	5.66	0.26	2.22	39.16	14.68
Wood chips	7.04	0.96	52.70	5.34	0.50	0.00	40.50	18.84
Sample 1	8.66	4.80	48.23	5.68	0.52	0.99	39.77	16.48

Gasification model assumptions

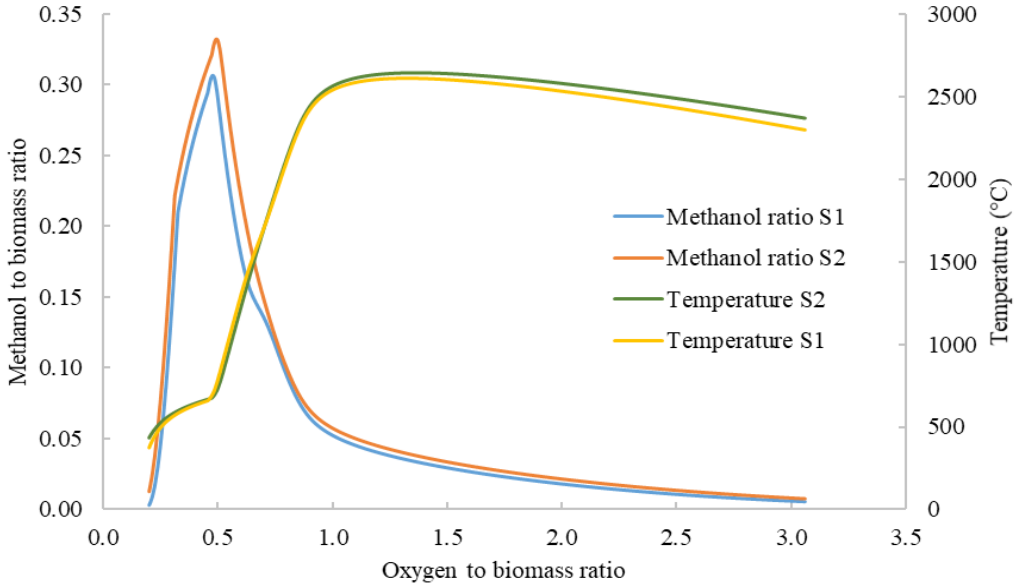
- 100 % conversion of biomass to gases and ash,
- only CO, H_2, CO_2, H_2O, CH_4, NH_3, HCl, H_2S and N_2 are considered as gas components,
- equilibrium gas composition in the gasifier,
- naphthalene as model component for tars,
- tars yield was calculated as a function of temperature inside the gasifier,
- no heat losses from the gasifier and heat exchangers,
- atmospheric pressure inside the gasifier.

Gasification agents

Three different cases were investigated:

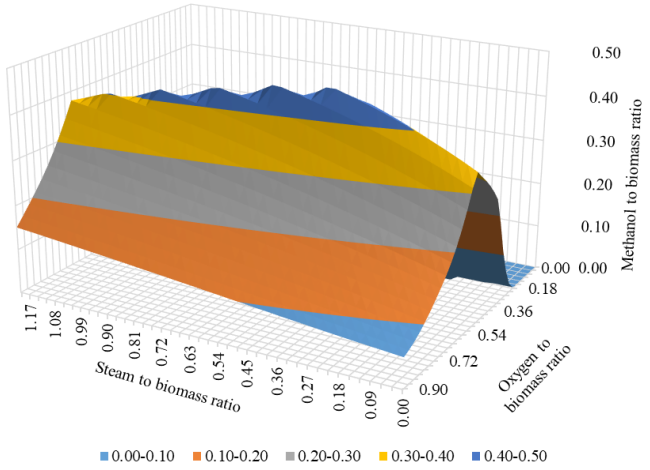
1. Gasification with oxygen only
2. Gasification with oxygen and steam
3. Gasification with oxygen and recycled steam

Gasification with only oxygen as gasification agent

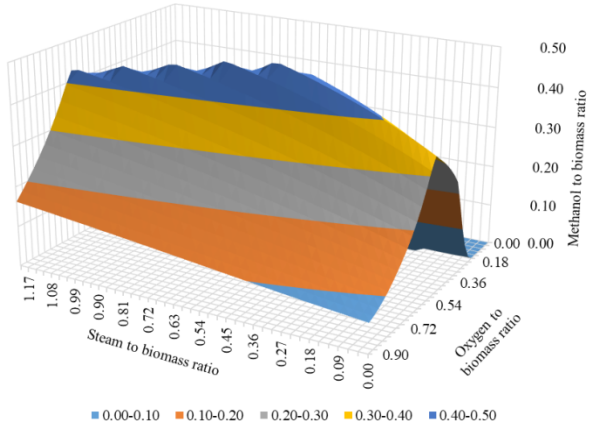


Biomass	MBR status	OBR	SBR	RSBR	Temperature (°C)	MBR
Sample 1	Maximal	0.4780	0	0	701.4	0.3066
Sample 1	At required temperature	0.5230	0	0	903.1	0.2602
Sample 2	Maximal	0.4800	0	0	715.5	0.3323
Sample 2	At required temperature	0.5736	0	0	904.8	0.2902

Gasification with oxygen and steam without steam recycle



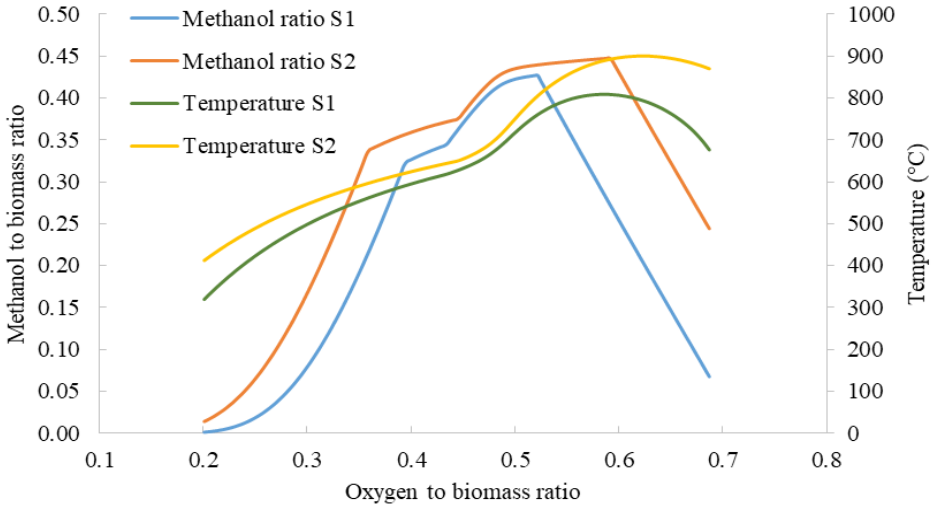
sample 1



sample 2

Biomass	MBR status	OBR	SBR	RSBR	Temperature (°C)	MBR
Sample 1	Maximal	0.4800	0.4201	0	678.9	0.4617
Sample 1	At required temperature	0.5910	1.040	0	900.1	0.4084
Sample 2	Maximal	0.4800	0.5101	0	688.2	0.4927
Sample 2	At required temperature	0.5736	0.8892	0	900.1	0.4265

Gasification with oxygen and recycled steam



Biomass	MBR status	OBR	SBR	RSBR	Temperature (°C)	MBR
Sample 1	Maximal	0.5190	0	0.6097	755.6	0.4269
Sample 1	At required temperature	-	-	-	-	-
Sample 2	Maximal	0.6000	0	1.213	896.3	0.4306
Sample 2	At required temperature	0.6168	0	1.412	900.0	0.3942

Conclusion

- The best methanol to biomass ratio MBR (at required 900 °C) was achieved when OBR was 0.57 , SBR 0.89 and Sample 2 was used. The MBR at these conditions was 0.43.
- The required temperature of 900 °C in the gasifier may not be achived for same biomass types if all recycled steam is used.
- The samples reached different results in every case. It can be stated that lower moisture and higher heating value of biomass led to better methanol to biomass ratio

Thank you for attention