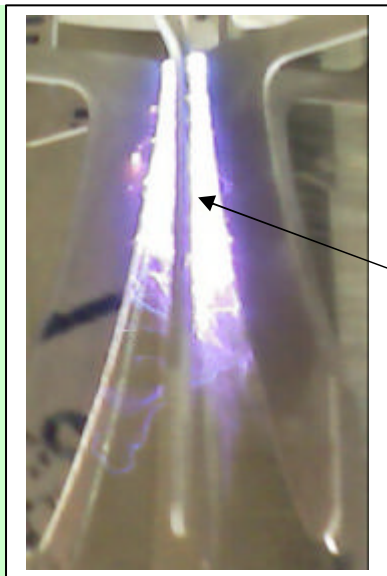


SELECTIVE PARTIAL OXIDATION OF TAR AND OTHER POLLUTANTS IN PRODUCER GASES



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Gasification reappears as a part of renewable energy solution. Any biomass and almost any rubbish can be processed. However the process is problematic and resulting "producer gas" is not enough clean for modern applications. Its main drawback: **presence of residual tars**.

Various methods of gas cleaning have been tested giving "too complicated and expensive" and/or "not sufficient" results. Almost the same strategies of "clean gasification" are applied universally:

- Gasification into as-clean-as-possible producer gas using "modern" high-temperature and/or fluidized bed or other high-tech gasifiers,
- Removal of residual tars and other pollutants using various "filters".

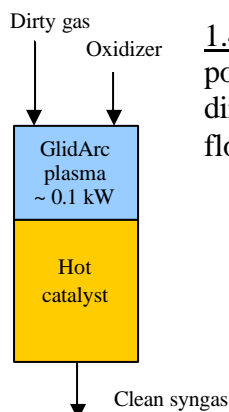
New Concept: an opposite strategy:

- Gasification (or even pyrolysis) into as-dirty-as-possible producer gas** (using a simple low-temperature & low-tech gasifier),
- 2nd-step total conversion of highly abundant tars** into a supplementary amount of very clean synthesis gas ($H_2 + CO$) **using our GlidArc-assisted selective partial oxidation**.

Satisfactory target of step A is only a separation of ashes, minerals, and metals from all other volatile compounds that gives a "dirty" producer gas. The step B deals then separately with all complex molecules converting them totally into H_2 and CO . A particular property of our step B is its selectivity: initial H_2 and/or CO present in dirty gas are not attacked so that more syngas exits our selective Oxidizer. At least 3 vol.% level of cumulated organic Carbon (in any form) is necessary in the "dirty" producer gas.

Experimental

First trials



1.4-L GlidArc-reformer. By controlled mixing of clean syngas and natural gas we get a methane-polluted syngas. The composition of the feed is given below ("In"). Trials were performed at the dirty gas flow rate ~ 23 L(n)/min. An enriched air (28 vol.% O_2) is used as oxidizer at the constant flow rate of 8 L(n)/min. Our test gives the following output ("Out") syngas composition:

Input/output dry syngas composition (vol.%)

	CO_2	C_2H_6	C_3H_8	H_2	N_2+Ar	CH_4	CO
In	5.33	0.30	0.07	46.28	14.15	8.66	25.20
Out	7.43	0.00	0.00	40.68	27.40	0.14	24.06

Based on precise mass balance we obtain 15% more of syngas at the reformer exit. The conversion rate of CH_4 is 98% while the conversions of C_2H_6 and C_3H_8 are total.

2nd trials including steam and hot feed

- Addition of steam and the feed preheat (200°C) to simulate hot (not yet enough) producer gas
- Use of 60% O₂ enriched air.

Input/output wet syngas composition

Test	H ₂ O	vol.% dry						
	g/m ³	CO ₂	C ₂ H ₆	C ₃ H ₈	H ₂	N ₂ +Ar	CH ₄	CO
8 In	222	1.77	2.65	0.53	12.17	4.48	59.22	19.18
Out		25.49	0.00	0.00	36.47	21.94	1.29	14.80
9 In	303	1.77	2.65	0.53	12.17	4.48	59.22	19.18
Out		24.44	0.00	0.00	33.84	21.60	1.18	18.96

Based on precise mass balance we obtain 4-fold increase of the syngas amount. The conversion rate of CH₄ is 98% while the conversions of C₂H₆ and C₃H₈ are total. Moreover, the GlidArc-assisted cleaning of wet producer gas acts also as the "water-shift" of CO into H₂ so that H₂/CO molar ratio improves from initial value of 0.63 up to even 2.5. Such syngas can now be used as feed for Fischer-Tropsch syntheses.

3rd trials including steam and simulated light tar

Dry syngas flow containing (vol.%) 15.7 H₂, 46.3 N₂, 1.6 CH₄, 29.5 CO, and 6.9 CO₂ (H₂/CO = 0.53) is mixed with controlled amounts of water and toluene and preheated to vaporize both liquids. Resulting simulated dirty producer gas enters GlidArc-assisted reformer to which we inject 26 L(n)/min of enriched air (41% O₂):

Input/output data of simulated producer gas

Run	Syngas L(n)/min	H ₂ O	Toluene			H ₂ +CO		H ₂ /CO
		IN	IN	OUT	Destr.	IN	OUT	
		g/m ³ (n)			%	L(n)/min		
8	103	137	115	0.9	98.9	23	22	0.70
9	103	138	115	1.7	97.9	23	20	0.67
10	116	93	92	2.7	96.7	28	23	0.57
15	105	207	115	1.2	98.5	23	21	0.77

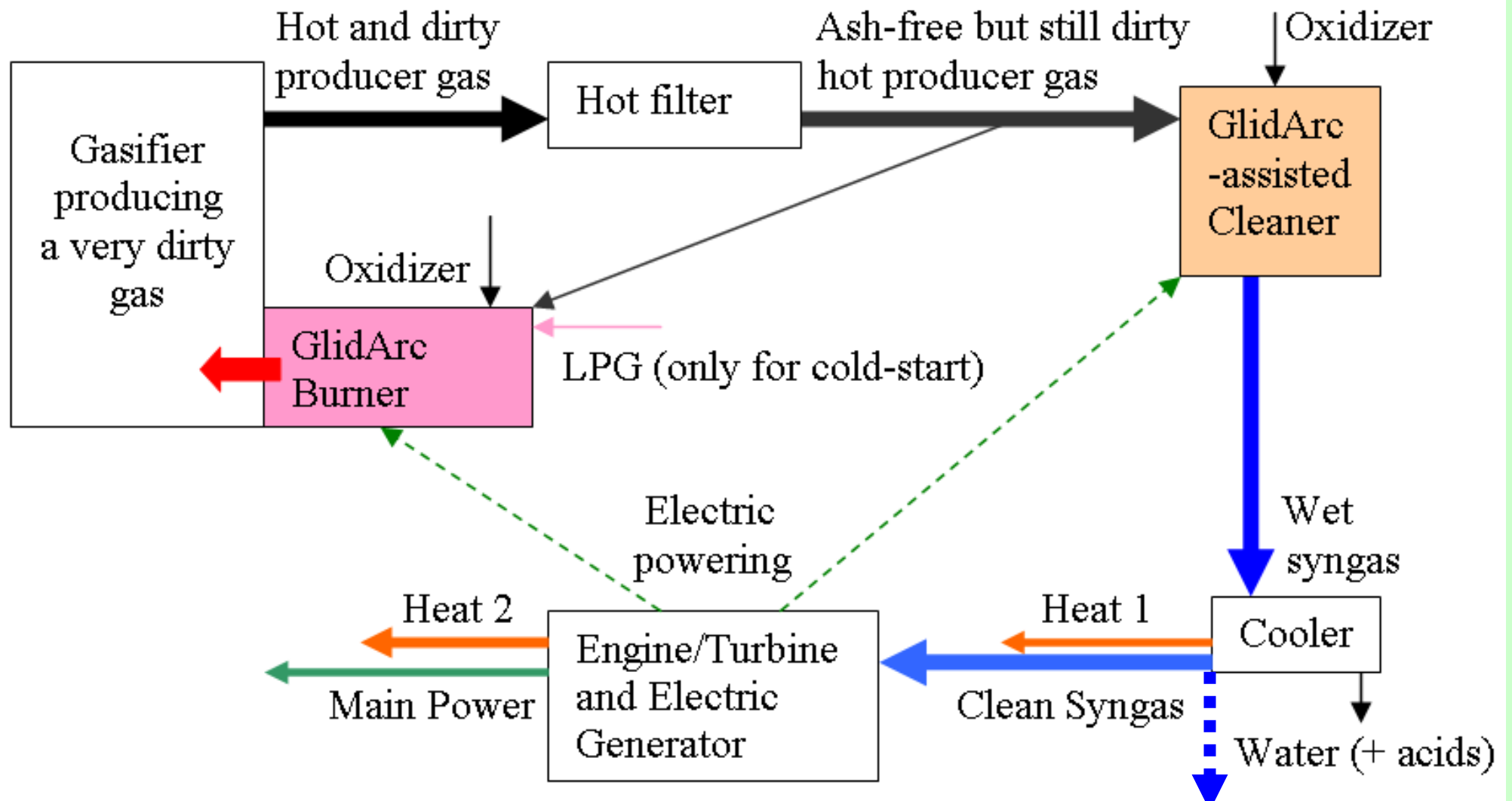
Selective partial oxidation of toluene in the producer gas is confirmed. The Lower Heating Value (LHV) of the syngas content, initially 1.7 kWh/m³(n), slightly lowers to 1.4 kWh/m³(n) which is still acceptable.

Conclusions

Our trials indicate the feasibility of proposed **strategy of rather dirty than clean gasification**. The scale of GlidArc-assisted tests (< 10kW of power of the fuel gas crossing the reformer) was low so that thermal losses of the reformer were quite high. Full-scale series of tests is under preparation, this time using the real dirty producer gas from real gasifier of the waste biomass or coal. There is no upper limit of light tars content in the producer gas as even liquid toluene was successfully and totally converted into the syngas without any soot [1]. There is no limit of producer gas temperature so that the GlidArc cleaner/reformer can use a residual heat of gasification.

References:

1. M. Czernichowski, P. Czernichowski, A. Czernichowski, Non-catalytical reforming of various fuels into syngas, *France - Deutschland Fuel Cell Conference on "Materials, Engineering, Systems, Applications"*, Forbach, 2002, 7pp.
2. A. Czernichowski, M. Czernichowski, Fischer-Tropsch products from compact reactor and high-temperature Iron catalyst, *this Meeting*, paper: 11388 (final number: 91), Division of Fuel Chemistry, Session: Green Chemistry on Fuels of the Future.



Concept of integrated system of dirty gasification followed by hot producer gas reforming/cleaning and Combined Heat & Power generation

Fischer-Tropsch synthesis of very clean liquid fuels [2]