



NOTAR® - Novel two stage downdraft gasifier for production of clean syngas for industrial applications

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Introduction

Gasification offers an **efficient** way to recover the energy from solid feedstocks by converting them into syngas. However, the amount of **tar in the syngas** of industrial biomass gasification facilities is still a **major concern**, especially in the case of **small scale plants** that cannot afford large syngas cleaning system and associated high operating costs.

In 2004, Xylo watt started the development of its **multi-stage technology** in order to decrease the tar content in the syngas at the outlet of the gasifier. This development led to the design of **NOTAR® gasifier**, an industrial downdraft gasifier that produces a **"Tar Free syngas"**.



Figure 1: The NOTAR® gasifier

The technology developed by Xylo watt has been **demonstrated** at industrial scale on 1MWth units on thousands of operating hours; with NOTAR® gasifiers connected to CHP engines and to thermal processes in the industry.

- Results show **tar content is greatly reduced (< 100 mg/Nm³)**, compared to ~3g/Nm³ for single staged downdraft gasifiers of similar nominal power.
- **Clean syngas** produced with NOTAR® gasifiers is suitable to power **multiple applications**

Applications for syngas	Syngas suitability	Status
CHP (engine)	✓	Industrial solution
Thermal processes in industry	✓	Industrial solution
Chemistry: syngas upgrading	✓	Development

- Production of **clean syngas** has a **strong impact** on plant economics : design of syngas conditioning units, reduced maintenance operations and optimum plant availability.

These consequences are particularly relevant in small and medium power ranges, where heavy syngas treatment cannot be considered for obvious economical reasons.

Experimental Setup

Results presented in this work were obtained on a **industrial 600 kW (LHV) NOTAR® gasifier** installed on an industrial CHP plant in Tournai (**Belgium**). The syngas produced from woodchips is converted into 200 kWe of electricity and 370 kW of heat. Mass and energy balances are implemented on the industrial plant following measurement protocol.



Figure 2: NOTAR® Gasifier powering CHP engine in Belgium

Measurement protocol

- Gasification plant is equipped for autonomous operation with various thermocouples and pressure gauges.
- Gas flows are recorded continuously by measuring pressure drop on diaphragms.
- Syngas composition is continuously analyzed at the outlet of the gas conditioning unit.
- Measurement protocol includes additional manual measurements of solid and liquid mass flows.
- Compositions of solid and liquid samples are analyzed by external laboratories.
- Tar content of the raw producer syngas is measured at the outlet of the gasifier by means of a gravimetric tar probe internally developed [2]

Mass & Energy Balances

Quality of the closure of mass balance (<3%) shows the high reliability of the energy balance and its related conclusions.

	Input (kg/h)	Output (kg/h)
Biomass	183.06	-
Air	279.49	-
Raw syngas	-	464.79
Bottom Ashes	-	8.8
Flying Ashes	-	1.8
TOTAL	462.55	475.39
Closure of mass balance		2.78%

Table 1: Experimental mass balance of industrial gasifier

Dry syngas		
CO	%vol	20.1
H ₂	%vol	19.9
CO ₂	%vol	13.6
CH ₄	%vol	1.7
N ₂	%vol	44.7
LHV	MJ/Nm ³	5.27

Table 2: Syngas composition measured at the outlet of the gas conditioning unit

Average composition of the syngas on is presented in table 2. Syngas is characterized by a low LHV as the gasifier operates with air and combustible gases are diluted by nitrogen. Energy balance of the gasifier are presented in Table 3; they are computed by combining the results of mass balance and sample analysis performed in laboratories

Cold gas efficiency	%	70.7
Hot gas efficiency	%	82.7
Carbon conversion rate	%	90.6

Table 3: Experimental efficiencies of industrial gasifier

The gasifier is characterized by good carbon conversion rate for a downdraft technology (90%). Mass and energy balances show that industrial scale NOTAR® gasifier efficiently converts biomass woodchips into syngas power. Energy loss is mainly due to carbon, in the form of char, leaving the gasifier with the bottom and fly ash.

Tar Content

Tar measurements were performed on the industrial NOTAR® gasifier and on classic downdraft gasifier of similar power, both operating with air and woodchips.

Results show that the design of the NOTAR® gasifier ensures high quality of the syngas, with drastic reduction of tar content when compared to standard downdraft technology.

Test	Gasifier Type	Tar Content (mg/Nm ³)
Test 1.1	Downdraft	2700
Test 1.2	Downdraft	3000
Test 1.3	Downdraft	3300
Test 2.1	NOTAR®	0.75
Test 2.2	NOTAR®	1.9
Test 2.3	NOTAR®	0.46

Table 4: Comparison of tar content of downdraft gasifier with NOTAR® gasifier operating at similar power output

Conclusion

Results obtained on **industrial gasification plants** validate the design of the **NOTAR®** gasifier and its capacity to produce **clean syngas**. Tar content measured with gravimetric tar probe at the outlet of the gasifier can be as low as 1 mg/Nm³.

Production of clean syngas at the outlet of the gasifier offers the opportunity to use **simple and cost effective solutions** for gas conditioning. This is specifically relevant for power plants in the small and medium power ranges. On commercial plants, Xylo watt integrates simple conditioning units composed of heat exchangers and bag filters.

Clean syngas produced by NOTAR® gasification technology **fits the requirement of industrial applications: CHP engines** and **direct firing** of thermal processes. The production of clean syngas is relevant for syngas **upgrading** for a **wide range of applications** such as production of Hydrogen, at different levels of purity.

References

[1] Milhé M, van de Steene L, Haube M, Commandré J-P, Fassinou W-F and Flamant G, Autothermal and allothermal pyrolysis in a continuous fixed bed reactor. J. Anal. Appl. Pyrolysis, 2013. 103: p. 102-111

[2] H. Jeanmart, F. Bourgois, A. Bacq, X. Kuborn., Impact of the pyrolysis quality on the tar concentration in the syngas of a new low-tar gasifier In : Proceedings of the 16th Biomass Conference & Exhibition, Valencia, Spain, 2 - 5 June, 2008