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Investigating the Effect of Producer Gas in Pipelines of Downdraft Gasifier

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Abstract. With energy demand and for promoting the energy supply to remote areas the fuel from biomass initiative is carried. Gasification technology is an efficient conversion technique for biomass resources to energy. The production of producer gas by gasification are used for various applications including electricity generation. Utilization of the Producer gas for applications involves the flow of gas through pipes from reactor to applications. During the flow, the producer gas is subjected to wet scrubbers and passes through various filters for gas clean-up. The pipelines suffer corrosion due to moisture deposits and chemical components in the Producer gas. In this paper, the influence of producer gas to the inner surface of pipelines in downdraft gasifiers is investigated. The inlet pipe exhibits reduction ranging 68 to 72 HRB in the hardness comparing to the outlet pipe ranging 77 to 78 HRB from the coarse filters

Introduction

Biomass implies organic matter formed from plants by converting plant material through photosynthesis. Extracting energy from biomass can be achieved by various techniques. For implicational requirement the fuel derived from biomass can be in liquid form or gaseous form. Moisture content, calorific value, alkali metal content, cellulose /lignin ratio are some properties to considered for choosing biomass for appropriate application [1]. Gasifier based on the Producer gas extraction design are categorized as downdraft, updraft and cross draft gasifier. Downdraft gasifiers are simple to formulate and conduct gasification process in smaller scale. However, design plays a significant role in performance, aside from biomass materials properties and its process parameters. Design modification towards feeding systems and air supply through multi stage has shown promising performance [2]. Downdraft gasifiers with multi-integrated gas cleaner systems are been emphasized to carry out Producer gas cleaning. With optimizing the parameters such as air fuel ratio, the system produces clean and efficient Producer gas. The incorporation of multi-integrated gas cleaner has resulted in significant amount of tar reduction [3]. In African countries the usage of gasifier stoves was not significant because of cost barriers and lower thermal efficiencies. Design modifications to gasifier stoves to inverted downdraft gasifier stove has shown promising results in terms of efficiency [4]. Different models were being proposed for bettering the insight about the gasification process. Kinetics, thermodynamic equilibrium and artificial neural network models are the being mostly employed in evaluating the outcome of the process [5]. Producer gas cleaning operation in coal-based gasification process seems to be efficient in terms of dry rather than in wet or semi wet cleaning process. By introducing aluminosilicate and carbonates converts chlorides into alkyl chlorides and calcium oxide additions leads to removal of Sulphur traces [6]. Technologies for Producer gas cleaning has evolved its course with objective of attaining better efficiency. The usage of candle filters shown better performance however limitations of material properties have effect in it [7]. During the coal-based gasification process, the combination of partial pressure with reduced oxygen and high temperature resulted in corrosion of the gasifier components. Material selection based on kinetic data indicates choosing materials with chromium elements has better resistance against sulfidation [8]. The objective of the experiment to analyze the influence of producer gas on the pipelines of downdraft gasifier.

Materials and Methods

The downdraft gasifier of capacity 200kw is feed with energy crops biomass for Producer gas production. During the gasification process the air is introduced over the oxidation zone and Producer gas is extracted from the bottom. The extracted Producer gas is at higher temperature and contains dust and fly ash particles, for gas conditioning the Producer gas is passed through wet scrubbers and then through series of filters. The gas entering the filters has moisture content in them due to scrubbing operation. The moisture in Producer gas initiates the corrosion in the pipelines and filters. The filters contain wood chips in fine form to filter out the particles suspended in the Producer gas. Fig 1 shows the schematic arrangement of Producer gas production in downdraft gasifier.

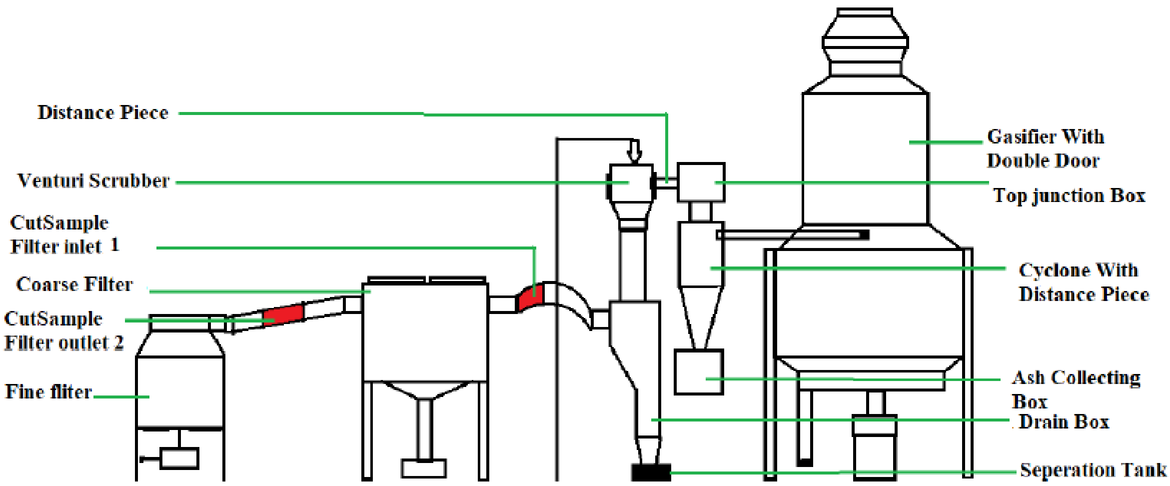

Fig 1. Schematic of Gasification Process for Producer gas Generation

The austenitic stainless steel used for pipeline fabrication is tested for chemical composition before the Producer gas extraction by using optical emission spectroscopy.

Table 1. Chemical composition of As Received Material

	Element	C	Si	Mn	P	S	Cr	Ni	Cu
As Received	Weight %	0.078	0.478	10.25	0.060	0.007	14.67	0.250	1.364

The temperature of Producer gas on extraction is high on exiting the gasifier. After passing the Producer gas through the wet scrubber, the temperature is reduced. The inlet pipeline which supplies the Producer gas to the filters and the outlet pipeline from the filters are been investigated for property changes.

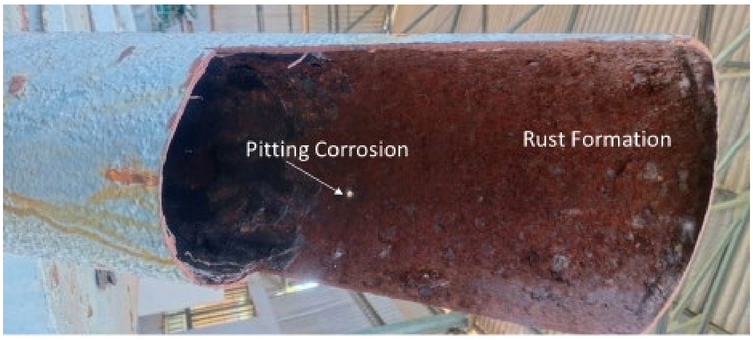

Fig 2. Corroded Pipeline

Fig 2 shows the rust formation inside the pipelines carrying the producer gas. The formation of pitting pores is also visible in the pipelines as producer gas environment breaks the spots in the pipeline.

Result and Analysis

Microstructure

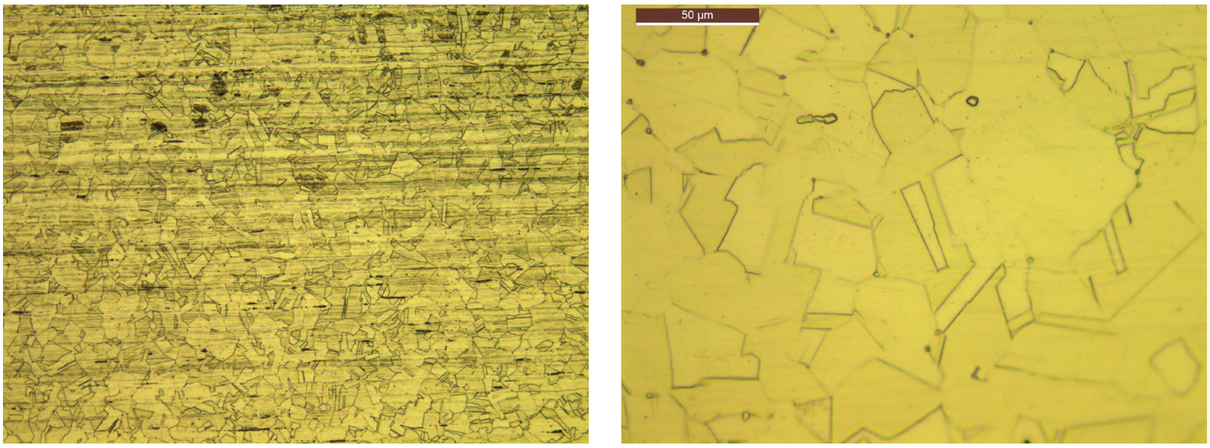

Fig 3. Microstructure of as received Sample Before Producer gas extraction

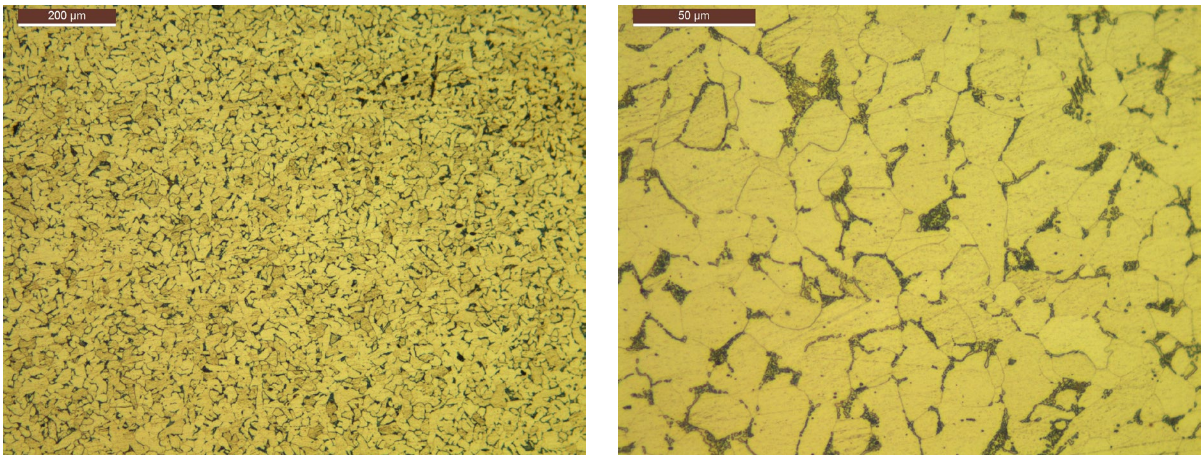

Fig 4. Microstructure of Inlet Sample after Producer gas extraction

The grains appeared to be coarse in nature with visible structural twin grain boundaries shown in Fig 3 at 500x. With process of Producer gas extraction, the Producer gas at higher temperature passes through the inlet pipelines to the filters and exit out through outlet pipelines. The inlet pipelines subjected to the passing Producer gas at higher temperature exhibits changes in its microstructure. The Fig 4 reveals finer grains comparing to the as received samples and refined grain boundary at 500x. The outlet sample microstructure was similar to the received sample with coarse grains shown in Fig 5.

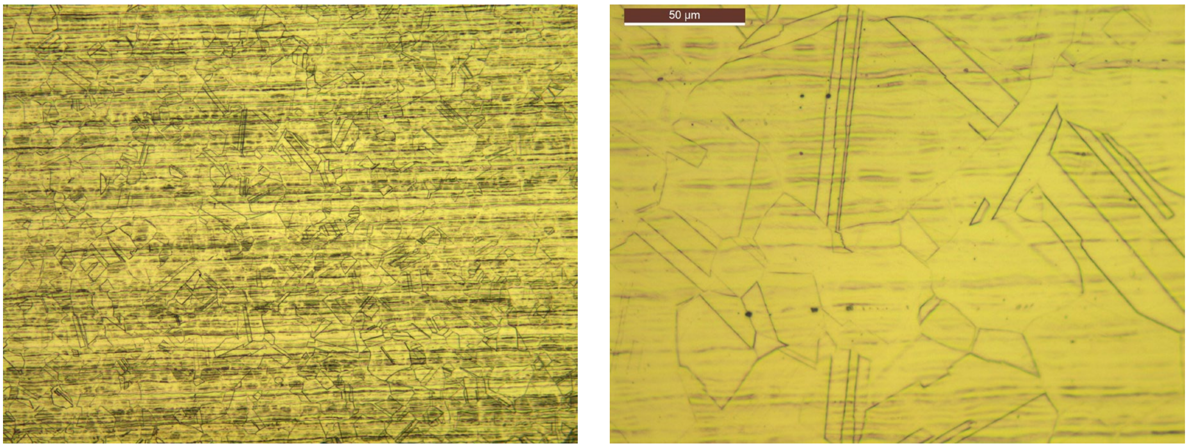

Fig 5. Microstructure of as Outlet Sample after Producer gas extraction

Hardness Test

The resistance towards indentation is measured using Rockwell hardness machine. Load of 100kg is applied to the samples. The hardness of the samples is tabulated in table 3

Table 2. Hardness

	Trial 1(HRB)	Trial 2(HRB)	Trial 3(HRB)
As Received Material	91	93	92
Inlet	72	70	68
Outlet	77	78	77

The hardness test result implies the resistance towards indentation been affected due to flow of Producer gas with moisture content as inlet pipe suffers reduction in hardness as opposed to outlet pipe. The outer pipelines have better hardness comparing to inlet pipelines, because only Producer gas coming out of filter which has relatively lower moisture content had influence towards them.

Corrosion Test

The samples as-received, inlet and outlet were tested for corrosion by salt spray test method. The samples were exposed to chamber temperature of 34.5 -35.5o C, pH value of 3.15-3.25 at air pressure ranging 14 -18 Psi. The volume of salt solution collected is 1.00 – 1.50 ml. 4.80 to 5.30 % of Nacl + Acetic acid been employed for carrying out the salt spray test. The results indicates that no red rust formation exposing to the concentrated solution for 24 hours in the as received sample. However, formation of the samples of inlet and outlet exhibits red rust formation on concentration to the solution.

Conclusion

The corrosion occurring on the pipelines has negative impact towards the efficiency of the gasification process and also affects integrity in terms of safety in the working environment. The corroded pipelines need constant replacement, which increases the overall cost and time consumption is setting up during otherwise a continuous operation. The present study infers that corrosion induced attack are mainly caused due to the moisture content present in the Producer gas rather than the contents in most case as some traces of Sulphur and other elements may have some influence towards corrosion. From the results the inlet pipe is more vulnerable towards failure as hardness of the material reduced compared to the outlet pipe. The hardness of the inlet pipe reduced up to 24 % and outlet pipe reduced up to 16 % of HRB indicates, the moisture content in the producer gas after passed through scrubber influences the property change. Research related to addition of corrosion of inhibitors and surface coatings to gasifier components has shown promising developments increasing the utilization of pipelines for extended time periods.

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