

Tar Dew point Analyzer (TDA)

Introduction

Biomass is seen as the most important source of renewable energy for the future. Low to medium temperature gasification of biomass always leads to the formation of tar. The gasification conditions and the technology used determine the amount and type of tar formed in the producer gas. Tar is the number one source of equipment fouling, pipeline plugging and unnecessary down-time of gasification systems. Ensuring safe operation involves knowledge about the tar dew point of the producer gas. In 2005 ECN and Michell Instruments developed an on-line tar dew point analyzer. The TDA provides useful information about the onset of tar condensation. The results of the TDA have been verified using a tar condenser and using the Solid Phase Adsorption (SPA) method. The TDA has been successfully tested downstream several gasifiers throughout Europe

Tar related problems

Tar is commonly described as (aromatic) hydrocarbons that have a larger molecular weight than benzene. Low gasification temperatures (<750°C) result in lower molecular weight tar molecules which contain more heterogeneous atoms. At higher temperatures (>750°C) these tars will react with other gas molecules to form larger tar molecules. Their respective reactivity will go down, but their dew point will increase.

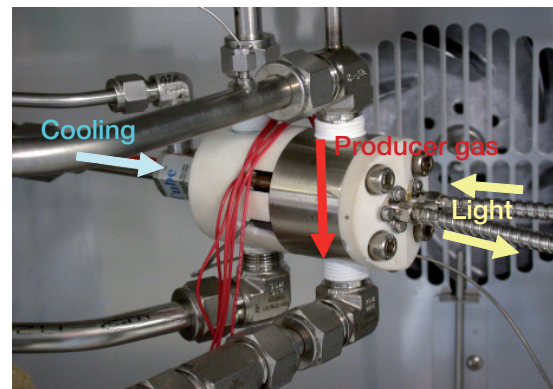


Tar condensation can cause pipes to plug, reduce the effectiveness of reactor, poison catalysts or cause a complete shut down of a gasification setup. Tar condensation is determined by the partial pressure of the respective tar molecules in the gas phase.

Working principle of the TDA

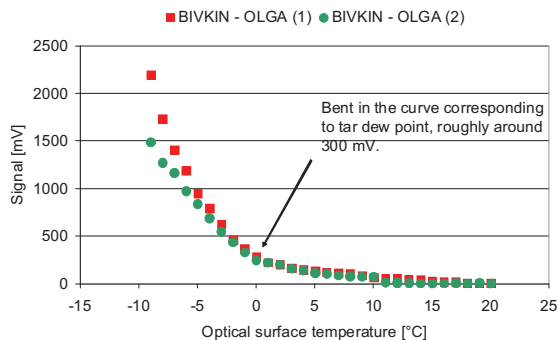
The key element of the TDA is the measuring cell, which is depicted in the next picture. The fiber optics focuses a beam of light (yellow arrows) on the measuring cell, which is an optical surface.

The reflection is measured and converted to a mVolt signal. This signal is plotted against the optical surface temperature and from the response curve the tar dew point is obtained. The optical surface is actively cooled using compressed air in a vortex cooler (blue arrow). The producer gas (red arrow) flows past the optical surface and based on the temperature tar will condense here.



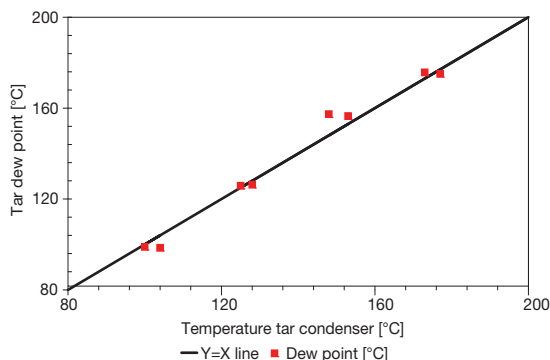
There are two modes in which the TDA is functioning. In one setup it can be used as an active guard. Where a set point is given to the TDA and when tar condensation takes place on the optical surface it will warn the operators about this condensation (within ~ 1 minute). The second mode is the active measuring mode, in which the TDA measures continuously the tar dew point. It takes about 15 minutes for one measurement and another 15 minutes to clean the optical surface for the next measurement. A typical response curve is depicted in the next

graph. These are results from the CFB gasifier (BIVKIN) coupled to the OLGA at ECN. On the x-axis the optical surface temperature is depicted. This is the temperature created with the vortex cooler. On the y-axis is the measured response depicted. The increase in signal is caused by the condensation of tar.



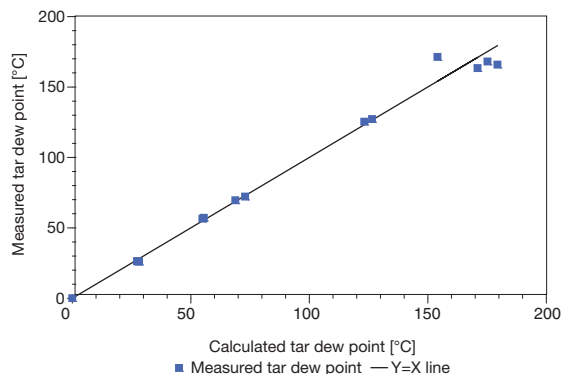
Validation of the TDA

The TDA has been validated using two methods. The first setup was a tar condenser, which was used to create a gas with a well defined tar dew point. The maximum deviation between the set tar dew point with the tar condenser and the TDA was 3°C.



The second method was with the SPA method followed by GC analysis. The tar condenser was used to obtain a gas with a well defined tar dew point and the SPA method was used to analyze the concentration of the different tar components. At the same time the tar dew point was measured using the TDA. Based on the results from the SPA the tar dew point was calculated (www.thersites.nl) and compared with the results from the TDA.

Again the results proved to be very accurate although at 170°C the measured tar dew point was around 7°C lower than the calculated tar dew point.



Characteristics of the TDA

The characteristics of the TDA are the following.

- Temperature range -25°C – 220°C
- Measuring above the water dew point
- Measuring below the water dew point
- Online measurements for direct information about the tar dew point (~15 minutes).
- Online measurements as a guard device for indication of the onset of tar condensation (~1 minute).

Further plans

At the moment three areas are under development for the technology to mature.

The fiber optics of the TDA are limited to about 220°C. Future work focuses on replacing these parts that cannot withstand high temperatures for temperature stable components.

The removal of water from the gas is done with a non-regenerable filter. This filter gets fouled easily and is sensitive to NH₃. Future work focuses on a regenerable water removal system that can remove water to the same level as the current filters. The third field of development is the automation of the TDA. At the moment all work is being done manually, which makes it a time consuming machine. The automation focuses on the development to a pc operated TDA. Where all aspects from the TDA can be controlled from a pc. All improvements are expected to be ready in 2009.

Further information

Publications

www.ecn.nl/publications

Tar dew point calculations

www.thersites.nl