Online Gas Analysis in Ammonia Plants

Application

Emerson provides Rosemount Analytical gas analyzer technology for on-line analysis of ammonia plant streams. Strategically placed gas analyzers improve the process efficiency and the purity of the end product.

Background

Ammonia is used in the production of a variety of products including fertilizer, nitric acid, nylon, pharmaceuticals, and refrigerant.

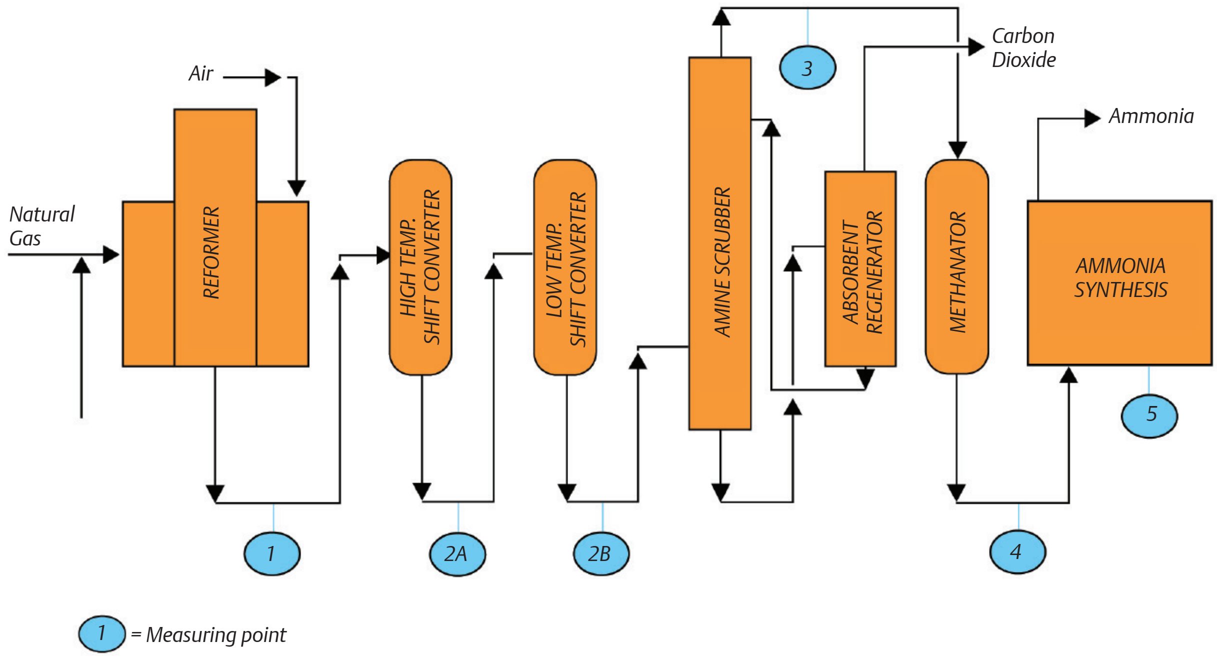
Production of ammonia (NH_3) is a two step process. The first step is to produce hydrogen (H_2) by reacting natural gas or methane (CH_4) with steam in a reformer. The second step is to react hydrogen with nitrogen (N_2) in a 3 : 1 ratio over a high-temperature catalyst in the ammonia synthesis process.

In the process of reforming natural gas or methane to hydrogen, carbon monoxide (CO) and carbon dioxide (CO_2) are formed as by-products. Even at low concentrations, both CO and CO_2 cause irreversible problems in the ammonia synthesis process. When the synthesis gas contains CO, a slow permanent deterioration of the catalyst occurs. The presence of CO_2 in the synthesis gas can result in the formation of ammonium carbamate, a fine white powder, which precipitates out and causes plugging of the ammonia converter. Therefore, to prevent problems in the ammonia synthesis process and to prolong the life of the expensive catalyst, the removal and measurement of CO and CO_2 on a continuous basis is required.

Gas Analyzer Applications

During the production of ammonia, the gases pass through the steam reformer, high- and low-temperature shift converters, amine scrubber and methanator before entering the ammonia synthesis process.

Figure 1 - Gas Analyzer Applications



Measuring Point 1: Steam Reformer

Natural gas and steam react over catalyst to form H_2 and CO:

$CH_4 + H_2O \longrightarrow 3H_2 + CO$

Also present is CO_2 and unreacted CH_4. Reformer efficiency is monitored by measuring unconverted CH_4. CO is also measured in preparation for the shift converters.

Measuring Points 2A and 2B: High - and Low-Temperature

The shift converters remove CO by reacting with steam to form H_2 and CO_2:

$CO + H_2O \longrightarrow H_2 + CO_2$

The CO content is measured to determine the efficiency of the shift converters.

Measuring Point 3: Amine Scrubber

CO_2 is absorbed in amine scrubber. The CO_2 is measured to determine scrubber efficiency.

Measuring Point 4: Methanator

The Methanator removes the remaining traces of CO and CO_2 by converting them to methane:

$CO + 3H_2 \longrightarrow CH_4 + H_2O$

$CO_2 + 4H_2 \longrightarrow CH_4 + 2H_2O$

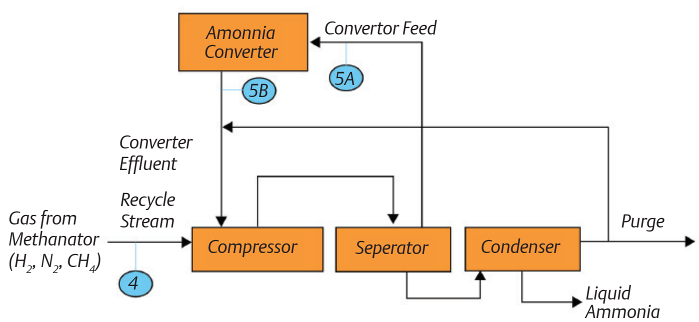
Trace CO and CO_2 are measured because they must be removed before the ammonia synthesis process or the CO will poison the ammonia converter catalyst and the CO_2 will react with ammonia and cause plugging of the ammonia converter. H_2 and CH_4 are also measured to control the feed for ammonia synthesis (described in next section).

The X-STREAM analyzer is extremely well-suited to make the CH_4, CO and CO_2 measurements described above using NDIR (non-dispersive infrared) photometric detectors. Typical analysis ranges after the Methanator are 0 to 10 ppm CO and 0 to 5 ppm CO_2. Abnormally high concentration levels should be alarmed.

Ammonia Synthesis Process

Hydrogen - nitrogen rich gas from the Methanator goes into the conversion - separation loop where it is mixed with recycle gas from the Ammonia Converter. In the Ammonia Converter hydrogen reacts with nitrogen over catalyst to make ammonia.

Figure 2 - Ammonia Synthesis Process



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