Innovative Gas Mixing Technology as Core Element for Utilization of Biogas in Combustion Processes

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INNOVATIVE GAS MIXING TECHNOLOGY AS CORE ELEMENT FOR UTILIZATION OF BIOGAS IN COMBUSTION PROCESSES

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ABSTRACT

Biogas and other process related Off-Gases combustion systems play an important role in today's strategic orientation in view to increased renewable fuel share as well as for independent fuel supply. The respective conditioning of these fuels prior feeding them to the furnace are subject to specific requirements which have to be considered within the setup of the combustion process. This paper grants an innovative technological solution approach how modern Gas Mixing Valves are able to clear out process related difficulties to gain highest possible efficiency.

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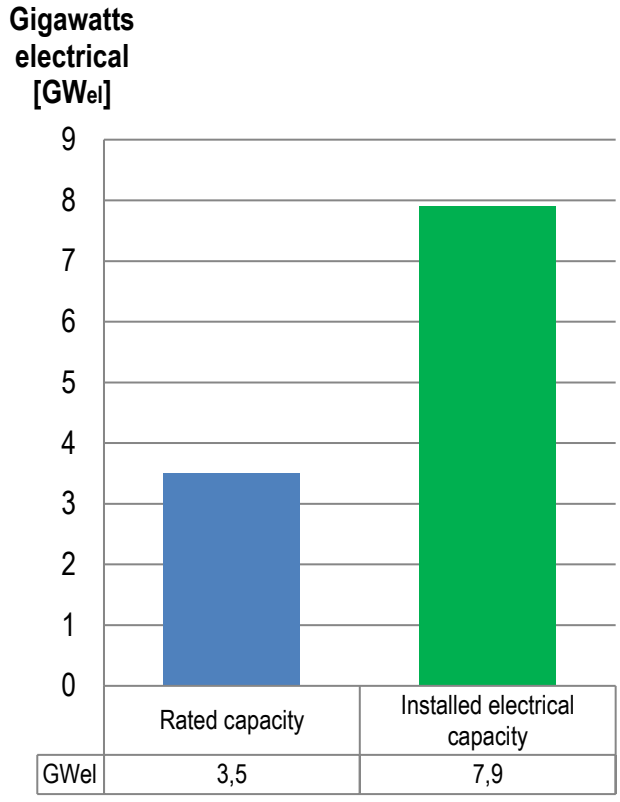
1. INTRODUCTION

Biogas and other process Off-Gases utilization for electrical energy production, heat generation, fuelling vehicles and supplying gas nets represents an essential basis for the global power generation as well as energy providing industry within the portfolio of renewable fuels.

Potential share of Biogas for peak demand 2030(1) (Germany)



Considering an optimized Biogas Plant Pool
Source: Fachverband Biogas e.V., acc. to Frauenhofer IWES, as per 02/2016

Besides the intend to lower emissions due to utilization of these gaseous fuels accruing in respective agricultural or other production processes which is subsidized by the states in many countries of the world various other benefits are given. These rather could be the independent decentralized provision with power (like e.g. in India)(2) regardless to the connected infrastructure for the external supply as well as the ability to react on peak demands which is an important factor in regards to other renewable energy sources not permanently and/or only available fluctuating. Particularly in view to the power balancing energy production can be a strong asset as confirmed by studies. Accordingly the German Fachverband Biogas e.V. has determined for example that 7,9 Gigawatts electrical capacity are available for Germany as share for peak demand if the Biogas Plant Pool is optimized and expanded up to 2030.

In course of the optimization in regards to the utilization of the renewable fuel gases the task is that the respective gas conditioning processes ensure premium quality of the combustible Gases to feed most modern and high efficient combustion systems as well as other related gas consuming equipment. Realizing such stable high quality for efficiency raise is subject to some obstacles and pitfalls which will be outlined in the following.

2. BACKGROUND

The major prerequisite to utilize Biogas and other process Off-Gases for combustion within various industrial applications is an excellent conditioning of the combustible fuels. Even the methane content for Biogas is quite high the comparatively low calorific values do require a blending of the raw Process Gases with a common Fuel Gas - like e.g. Natural Gas - or Air. The blending process to condition the medium for combustion is impaired by fluctuating quality of the Biogas / Off-Gases. In this regards common existing solutions utilizing several collectors and control valves to mix the respective gas ratio in appropriate quality are reacting very slow. Besides the resulting efficiency restriction it must furthermore be taken into account that the mixing accuracy is adversely affected as well.

3. INNOVATIVE GAS MIXING TECHNOLOGY

Innovative Gas Mixing Valves represent the solution for bundling simultaneous combination of the two dimensions flow and quality control for rapid adaptivity as well as ultra-precise quality within one unit. By means of this technological approach an unnecessarily high admixture of regular fossil Fuel Gas securing a sufficient quality of the combustible fuel mix can be excluded due to eliminating the control sluggishness. Furthermore these highly adaptive Valves are securing an outstanding precision in regards to quality control as application studies are showing.

3.1 BASICS AND TYPICAL APPLICATIONS

Innovative Gas Mixing Valves allow the mixing of 2 elements, respectively gaseous fuels. In this course the aim is to secure a homogenous and highly precise blending of the gases for stable output.

The respective technological approach targets applications in which low calorific gases are conditioned by means of selective admixture of a regular Fuel Gas e.g. :

- Combustion processes like furnaces or boilers
- Biogas feedings
- Thermoprocessing plants

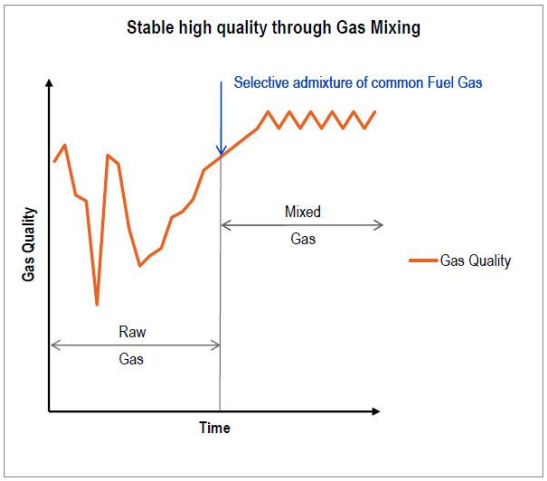


Figure 1
Selective Gas Mixing

- Gas supply and distribution systems
- Waste incineration plants

Within the above named applications various options of potential gaseous fuels - for both the Raw Gas to be blended as well as for the common Fuel Gas admixtured for increase and stabilization of the calorific value - are possible. The following table shall give an idea on the most common fuels which are utilized in aforementioned applications:

Low Calorific Raw Gas *(to be blended)*	**Regular Fuel Gas** *(for upgrading the caloric value through admixture)*
• Biogas • Landfill Gas • Blast Furnace • Converter Gas	• Natural Gas • Propane • Butane • Hydrogen

Table 1
Listing of potential gaseous fuels for mixing

3.2 TECHNICAL DESIGN

Two Dimensional Gas Mixing Valves are characterized by their outstanding performance in regards to rapid adaptive quality control. By means of fully automatic handling of the two dimensions mixing ratio and flow rate those valves are able to warrant a stable high quality. The selective mixing is carried out by linear motion - for flow control - and rotary motion - for quality control - within a mixing chamber in which the Low Calorific Raw Gas and Regular Fuel Gas are influxed by their individual upstream port of the valve. The electro-pneumatical or optionally fully electrical actuators are receiving their respective control inputs directly from the PLC based upon caloric value metering downstream of the mixing valve which is schematically illustrated hereafter.

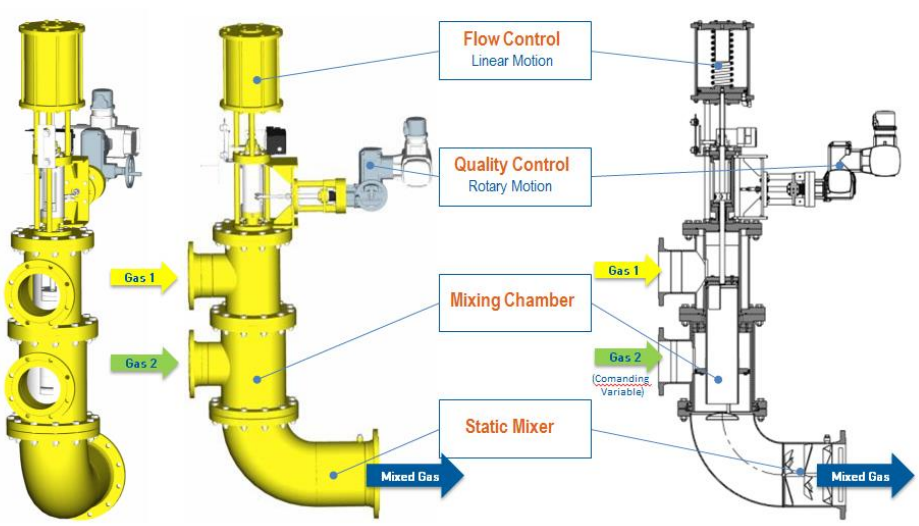


Figure 2
Design features of Two-Dimensional Mixing Valve

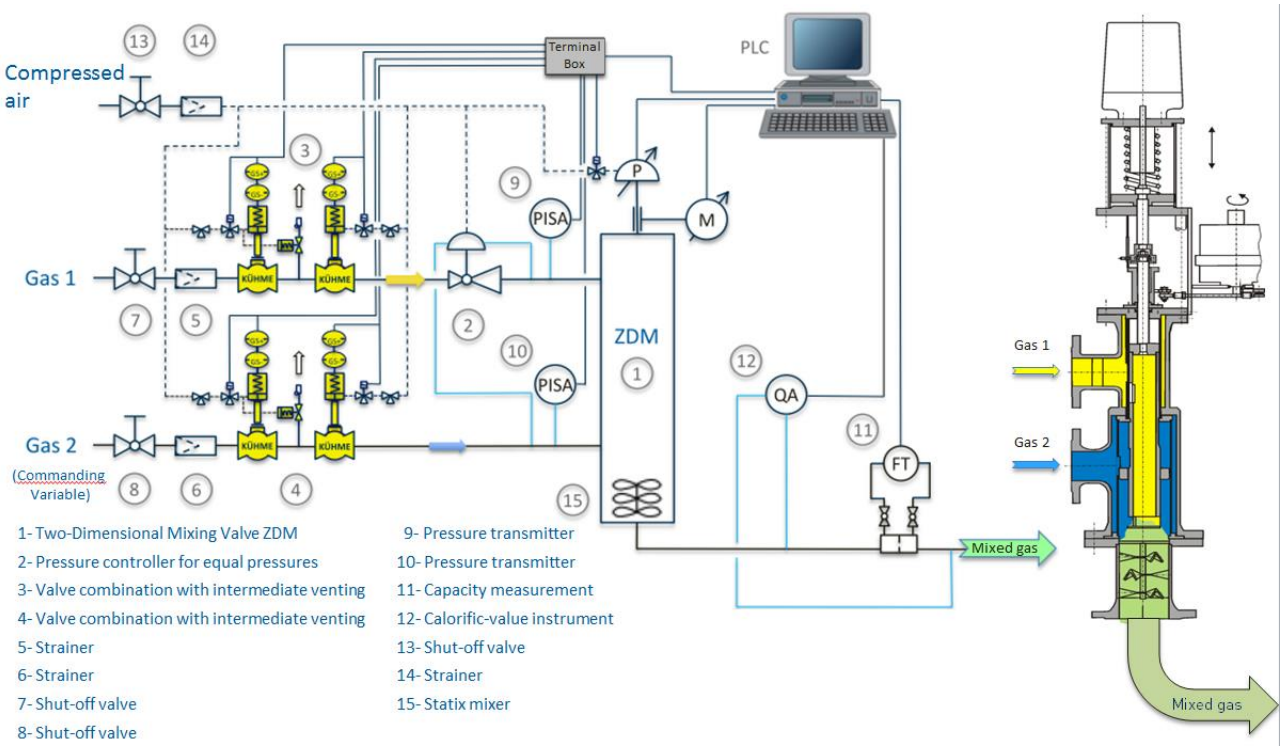


Figure 3
Full System Setup for Mix Gas Combustion

The system shown displays the complete package for conditioning the Low Calorific Gas to directly feed the Mixed Gas to the combustion. Besides the Quick-Closing Shut-Off Valves (double block and bleed design) along with instrumentation which are adding the safety implications to the process the system is equipped with a pressure regulator equalizing the pressure of both Gases on the basis of the Commanding Variable. The Two Dimensional Gas Mixing Valve is automatically controlling flow and quality based upon PLC input commands based on downstream caloric value metering, e.g. by calorimeter or Wobbe-index measuring device. Quality fluctuations of the Low Calorific Gas are immediately and efficiently balanced due to the fact that the control process is based on the final Mix Gas quality. Furthermore the innovative technology guarantees extremely high control accuracy in view to the output quality.

3.3 Hands-on Experiences a Case Study

A Swedish energy provider was forced to shut down their regular cracker due to environmental policies and therefore was in need of a replacement fuel to feed the municipal gas net of the metropolitan city with town gas. The final solution was found in the intention to utilize Natural Gas and/or Biogas blended with compressed air. For this challenge an appropriate Mixing Valve had to be foreseen which was able to fulfill the following performance parameters.

Performance Parameters defined
(for Mixing Valve)

- **Stable Wobbe-index using either Natural Gas, Biogas or available Mix**
- **High Wobbe quality accuracy with max. ±5% tolerance**

Table 2
Performance Criteria for Mixing Valve

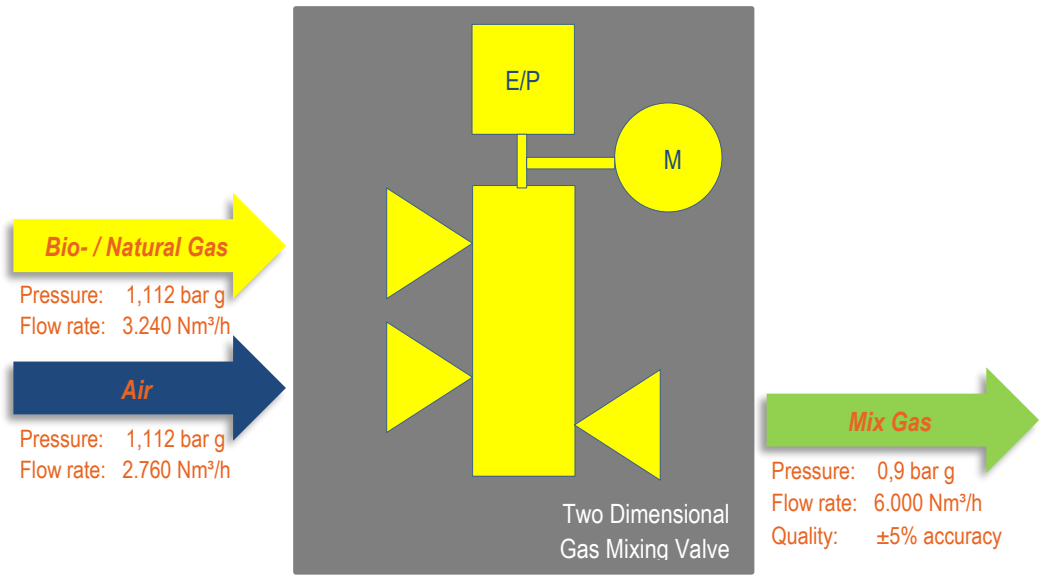


Figure 4
Simplified Schematic

In course of investigating for a potential supplier the assigned plant designing company found that company KÜHME Armaturen GmbH is able to fulfill respective performance demands. As a result 2 + 1 pc(s). Two Dimensional Gas Mixing Valves have been installed in the newly erected Gas Conditioning and Feeding Units of which one represents the main Unit (with 2 pcs. feeding lines) and one the backup Unit (with 1 pc. feeding line).

The key parameters in brief:

- 2 + 1 pc(s). Two Dimensional Gas Mixing Valves installed
- Each Mixing Valve is dimensioned:
  - DN 200 (8”) inlet for Bio- / Natural Gas
  - DN 200 (8”) inlet for Air
  - DN 300 (12”) outlet for Mix Gas
- Securing a min. mixing performance of 6.000 Nm³ / h(3)
- Achieving a mixing quality of ±0,5% Wobbe accuracy

Figure 5
Two Dimensional Gas Mixing Valve
installed in Main Conditioning / Feeding Unit

After 5 years of continuous and failure free operation the end user is more than satisfied with the performance of those Mixing Valves. Achieving a quality of ±0,5 Wobbe accuracy over exceeded the expectations by far.

Figure 6
Pleased Operator

3.4 Benefits of Innovative Gas Mixing Technology

The benefits of innovative Gas Mixing Technology in utilization of renewable fuels are numerous as displayed. State of the art Mixing Valves are characterized with important performance assets as a basis to optimize the respective downstream combustion process. The following table shall grant a summarizing overview:

Performance Characteristics and Assets *(for Two Dimensional Mixing Valve)*
• **Immediate availability of the selective Mix Gas quality** • **Extremely precise control of the Mix Gas quality** • **Possible flow control range of 1:30** • **Rapid adaptivity in case of inlet quality fluctuation** • **High quality consistency of 0,5% variation** • **Efficient admixture of common fossil Fuel Gases** • **Applicable for compensating peak loads**

4. Conclusion and Outlook

Increasing the renewable share and efficiency fossil fuels is and will be a global endeavor for the power generation industry over the upcoming years. The utilization of Biogas or other Off-Gases from various industrial processes represents a strong cornerstone based on the high flexibility of related combustion

systems as well as the possibility to operate the units independently. Potential off-grid solutions are especially interesting in large countries in which respective fuel supply linkage is difficult due to the unavailable infrastructure in remote regions.

In course of the optimization of renewable combustion processes Innovative Gas Mixing Technology is a most valuable asset. Gas Mixing Valves like described are ensuring prime plant performance and reliability. Appropriate equipped plants are able to condition with high adaptivity resulting in a stable ultra-high quality of the Mix Gases feeded to the combustion.
Complete systems carrying integrated Gas Mixing Valves as wells as Safety Shut-Off Valves furthermore allow an increased plant safety and can be delivered to site tailored as plug and play solution.

If the trend for utilization of Biogas and other Off-Gases will continue or even extended, it will be impossible to waive on further optimized fuel conditioning processes with integrated Innovative Gas Mixing Technology like demonstrated in this paper.

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