NDIR gas analysis monitors gas mixing equipment

NDIR GAS ANALYSIS – Gas mixers are essential for industrial and medical applications because they produce precise gas mixtures. They are used in areas such as metal processing, medical technology and food packaging. Modern gas analysis systems such as INFRA.sens significantly improve accuracy and ensure high process reliability and quality.

Mixed gases are of great importance for many applications in the industrial and medical sectors. Gas mixers are usually used for this purpose, as they can adjust these gas concentrations precisely and as required. Gas mixers enable the use of the process gas at any time, for a perfect protective atmosphere in food packaging or the optimum mixture for welding and cutting metals. Furthermore, special gas mixtures are also needed in the laboratory or for anesthesia.

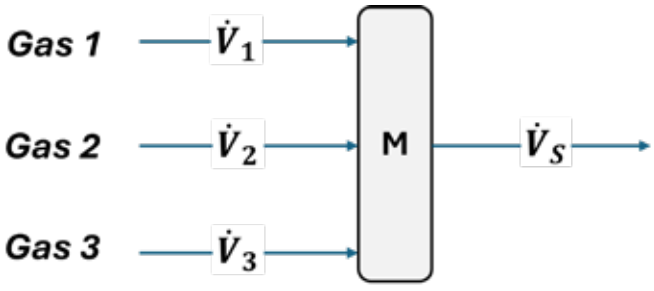
Some gas mixers can also be transported to the point of use, thus enabling economical and flexible use of process gases.

Gas mixers are used in many industrial processes:

- Metalworking
- Medical technology
- Helium leak testing
- Food industry
- Protective gas packaging
- Glass processing
- Laser technology
- Diving technology

How a gas mixer works

Gases are usually mixed dynamically with different volume flows $\dot{V}_n$. By varying the respective volume flows, the desired gas mixtures are thus created, with a defined concentration c_n. At least two gases are required to create variable gas mixtures. In technical applications, however, it can also be almost any gas components that are added. In practice, three gas mixers are probably the most frequently used mixing devices. Since gases mix very quickly with each other, no elaborate mixer M is required. In the simplest case, the gases mix in the subsequent pipeline or in a subsequent buffer volume.

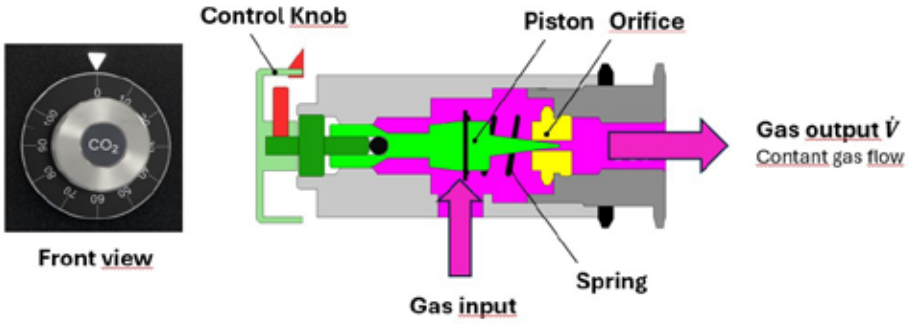


01 Production of technical gas mixtures

The concentrations cx of the individual gases in the gas mixture are given by the following relationship:

$$\dot{V}_S = \dot{V}_1 + \dot{V}_2 + \dot{V}_3$$

$$c_x = 100\ vol.\,\% \cdot \frac{\dot{V}_x}{\dot{V}_S}$$



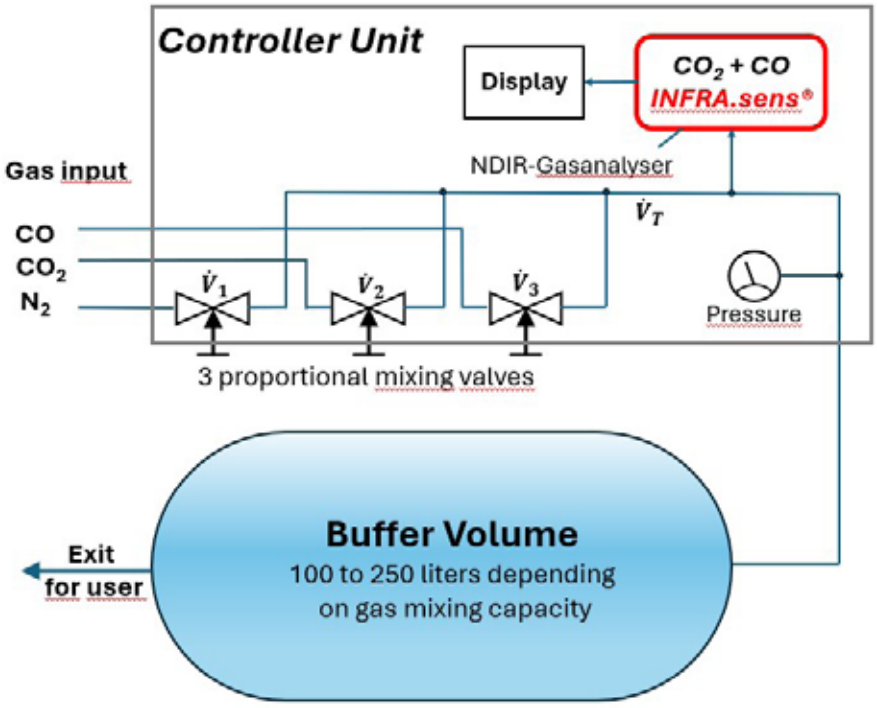
02 Cross-section view of a proportional valve for use in gas mixers

The different volume flows $\dot{V}_n$ can be adjusted in the simplest case with a proportional valve. The accuracy and reproducibility of these valves are limited. The setting accuracy is therefore specified as ± 2 %. Since a separate valve is required for each gas to be added, the accuracy of the gas mixture results from the error propagation of the individual valves and is then ± 3.5 %.

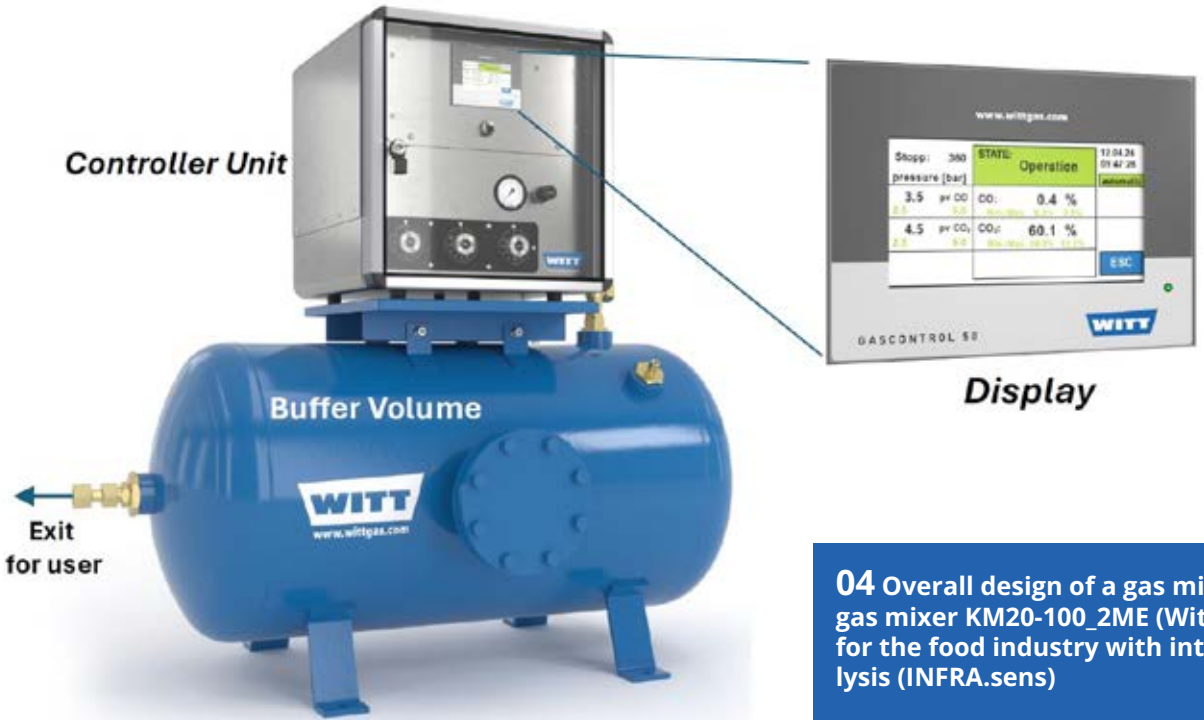
The schematic overall design is shown in Fig. 03. The control valves are connected in parallel so that the outlets are combined in a gas path. After a mixing phase in the supply line, the gas mixture enters the buffer volume. Depending on the application, the buffer volume is designed for a capacity between 100 and 250 liters and various pressure ranges.

The gas analysis with the INFRA.sens then takes place on the way to the buffer volume. A partial flow from the supply line is fed to the gas analyzer, which is usually designed for low flow rates of < 1 L/minute. The current gas concentration c is displayed on an integrated display without significant time delay (t_{90} time < 3 s) (Figure 04). If deviations occur during the analysis, the respective volumetric flow can be readjusted so that the optimum concentration value is adjusted in each case. The value set in this way remains constant for the rest of the process. The zero-point stability of the INFRA.sens can be regularly checked and, if necessary, readjusted using the nitrogen (N_2) that is already present in the process. An end-point check should be carried out once a year with a corresponding test gas.

To improve the accuracy of the gas mixture, a continuous measurement of the set gas concentration cn with a highly accurate gas measurement system is required. For most technical gases, NDIR gas measurement technology is best



03 Schematic design of a gas mixing system with controlled composition using an INFRA.sens (NDIR gas analyzer)



04 Overall design of a gas mixing device, type gas mixer KM20-100_2ME (Witt-Gasetechnik) for the food industry with integrated gas analysis (INFRA.sens)

suited. The accuracy class of typical gas sensors is ± 2%, so no significant improvements can be expected from their use. The requirements for highly accurate gas analysis are ± 1% and can only be realized by using complex evaluation algorithms. This requires elaborate calibration and compensation processes.

Gas analysis

The gas concentration to be monitored is measured using the proven INFRA.sens module. This sensor technology can detect over 20 gases with a high degree of precision and a low detection limit.

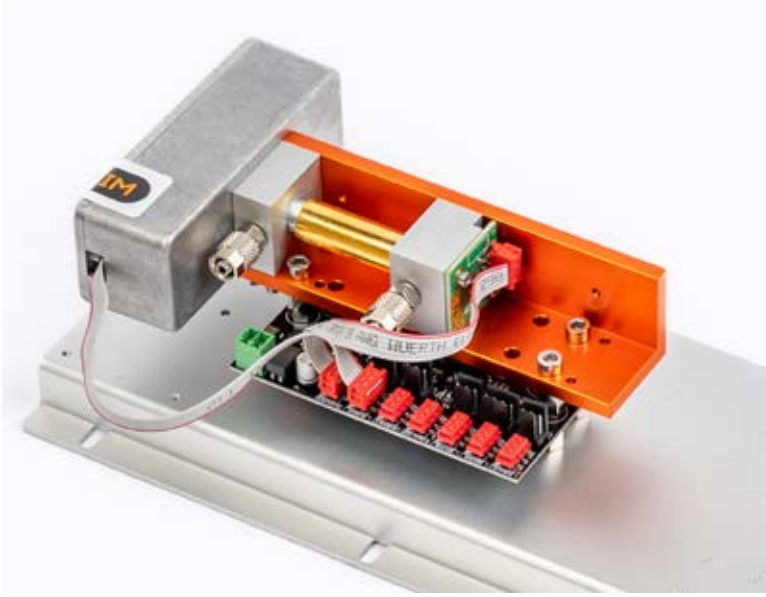
For use in the food industry (packaging), mainly CO and CO_2 gas mixtures in N_2 are used. Since the concentrations can reach values of over 50 vol.-%, the respective measuring ranges must be designed for the range from 0 to 100 vol.-%. Both gas concentrations c_x (CO_2) and c_y (CO) are determined using the NDIR1 method. The INFRA.sens uses a multi-channel detector for this purpose, with which both gases (CO and CO_2) can be detected simultaneously in a measuring cuvette. The INFRA.sens can measure up to three different gases in a single setup. This has the advantage that the different gas concentrations are measured absolutely simultaneously. If the gas sensors were connected in series, there would inevitably be a time lag, which would cause a significant error, especially at low gas flow rates ([1] *Non-dispersive Infrared*).

The INFRA.sens has a very high measurement accuracy of < 1 %. To achieve this, all measurement errors are electronically compensated. These are in particular:

- Temperature compensation between 5 and 45 °C
- Air pressure compensation between 600 and 1 200 hPa
- Carrier gas dependency between c_x (CO_2) and c_y (CO)
- High long-term stability (= low drift rate) through a spectral reference measurement

The temperature and pressure measurement values required for compensation are recorded directly in the analysis cuvette using a microsensor. This provides the exact physical data of the gas to be measured and thus also improves the quality of the electronic compensation.

Data communication is via an RS232 interface. A USB interface, a CAN interface and a Modbus protocol are also available. The module is supplied via a 24 V DC con-



nection, with an electrical power consumption of P < 2 watts.

Example: Modified atmosphere packaging of minced meat or red meat

In principle, MAP[2] packaging is used to extend the shelf life of the packaged food. To do this, the ambient air/oxygen is replaced by a mixture of CO_2 and N_2. The table lists the optimal gas concentrations for different foods ([2]*Modified Atmosphere Packaging*).

Red meat requires an additional function. The red color of the product should be preserved as much as possible by the protective atmosphere. Consumers prefer this appearance, as it is often associated with a higher quality (‚fresher') product. To achieve this, a small amount of CO is added to the gas mixture. The typical composition is 60 - 70 % CO_2, 0.4 % CO, remainder N_2. The mixer uses three mechanical mixing valves to create a mixture and feeds it into the buffer tank. From there, the packaging machine takes the gas mixture in cycles and feeds it into the packaging before it is sealed. The integrated gas analysis with CO/CO_2 sensors permanently monitors the correct composition of the mixture in the container. If the limit values are violated, an alarm is triggered. This ensures a high level of process reliability and consistently high quality of the MAP packaging. For high-quality and flawless food.

Product	O_2	CO_2	N_2
Raw red meat	70	20–30	0–10
Raw offal	80	20	0
Raw poultry with skin	0	30	70
Raw poultry without skin	70	20–30	0–10
Cooked meat and sausages	0	20–30	70–80
Hard cheese	0	30–100	0–70
Soft cheese	0	10–40	60–90
Cheese, sliced	0	30–40	60–70
Cream cheese	0	100	0
Yoghurt	0	0–30	70–100
Milk powder	0	0–20	80–100
Raw low-fat fish	20–30	40–60	20–40
Raw fatty fish	0	40	60
Shellfish and crustaceans	30	40	30
Cooked/smoked fish	0	30–60	40–70
Baked bread/bread rolls	0	50–100	0–50
Cakes, pastries	0	50	50
Fruit	3–10	3–10	80–90
Vegetables	0	30	70
Prepared dishes	0	30–60	40–70
Pasta/pizza	0	30–60	40–70
Sandwiches	0	30	70

Table: Examples from the EU of optimal gas mixtures in vol.%

Summary

Gas mixing devices can be improved by a factor of 3-4 in terms of the accuracy of the gas mixture through the use of NDIR gas analysis (INFRA.sens). The use of this sensor technology is therefore recommended. The costs for this effort are reasonable and can significantly improve quality control. In particular, the flexible use of INFRA.sens technology for different gases opens up new types of applications that could not be realized with previous sensor technology.

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Images/Table: *Wi.Tec-Sensorik GmbH*

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05 INFRA.sens gas measurement module for the simultaneous analysis of carbon monoxide (CO) and carbon dioxide (CO_2) with a gold-plated analysis cuvette (AK50mm)