PRIMARY JOURNAL FOR THE COATINGS MARKET IN ASIA & THE PACIFIC RIM

APCJ

ASIA PACIFIC COATINGS JOURNAL

VOL 34 • NO 1
FEBRUARY 2021

Inside: Antimicrobial/Antiviral

Inside: Resins

A new horizon

Protecting the world's structures for a more sustainable future

ADDITIVES • SUSTAINABILITY • INDIA • PRINTING INKS

Alexander C Hanf, L+T GASETECHNIK, discusses the company's lean air systems for synthetic resins

Resin production with safe lean air

Lean air in resin production has an impact on product quality, and safety and availability are often even more important. Requirements for quality, safety and availability can be met with a tailored solution.

LEAN AIR IN RESIN PRODUCTION

Lean air is artificially produced "air" with a lower proportion of oxygen. It is used in processes for supplying solvent boilers and reactors, eg in the production of synthetic resins in typical quantities of 15 to 800m³/hr (approx 9-470cfm – cubic feet per minute). Systems for generating such gas mixtures are called lean air systems. Due to regular use of the gas mixture in potentially explosive areas, compliance with the specified oxygen content is essential for the quality of the production process, as well as for safety-related issues.

In resin production, the product is usually covered with pure nitrogen during manufacturing. However, product components require oxygen for the reaction but the oxygen content has to remain safely below a defined limit concentration so that the lower explosion limit is not exceeded. The proportion of oxygen in air of 20.95% by volume must, therefore, be reduced to a lower proportion (eg 4-10% by volume of oxygen in the mixture). For this purpose, either technical air (compressed air) or oxygen (O_2) is mixed with nitrogen (N_2), so that lean air with a safe and constant oxygen concentration is generated. A mixture of eg 4% oxygen in 95.5% nitrogen fulfills the requirement of product reaction and at the same time, avoids deflagrations and serious accidents.

Various regulations must be observed and adapted components must be used. This is especially true if the lean air system is to be installed in an explosive area.

QUALITY, SAFETY AND AVAILABILITY

For process plant operating companies, the influences of quality, safety and availability are essential. With regard to lean air systems, this means:

- Quality: Exact compliance with the defined oxygen concentration in the lean air gas mixture to produce a constant product quality.
- Safety: Safe shutoff if a specified oxygen concentration is exceeded to avoid any risk of explosion.
- Availability: Ensuring the availability of the production plant with redundant, backup or a bypass solution.

QUALITY

The choice of system technology itself has an influence on the gas mixture quality and thus, on the product quality.

Usual values for the repeatability are:

- Static, ie manually controlled, gas mixing systems +/-0.5%
- Dynamic, ie automatically controlled, gas mixing systems +/-0.2%

This applies to full power and operation within the design limits, with the gases being approximately the same temperature and constant pressures.

In recent years, there has been a strong trend towards dynamic lean air systems, which is due to the quality requirements of the chemicals industry. This is ensured first and foremost by constructive measures of the gas mixer.

A gas analyser that continuously monitors the oxygen concentration is often chosen as an additional measure to monitor the correct gas mixture quality. A paramagnetic measuring cell guarantees very reliable, long-lasting and long-term stable measurements.

The measured O_2 value is shown on the integrated display and can be transmitted via 4/20mA interface to a higher-level control system. If the limit value is exceeded, a change in the mixture quality (with automatic, dynamic lean air systems) or a shutoff can be initiated. If the limit is exceeded during start-up processes or after the fault has been rectified, a blow-out line helps not to lead undesired mixtures into the process **(Figure 1)**.

SAFETY

The safe adherence to a defined oxygen concentration influences the safety of the downstream process plant. This functional safety can be further increased by considering a Safety Integrity Level (SIL). A safety requirement level according to the EC 61508/IEC61511 standard is referred to as SIL or safety level. The monitoring system gas analyser – output shutoff valve – blow-out line-solenoid valve is jointly assessed with regard to its reliability, so that the risk of malfunction can be further reduced. Security integrity levels are represented in levels from 1 to 4. Safety integrity level 4 represents the highest level and level 1 the lowest level.

This safety requirement level thus, indicates a measure of the reliability of the system depending on the risk to the health of employees, the environment or goods. Usual lean air systems meet the requirements of SIL-1 or SIL-2. According to this definition, the suitable gas analyser, the output switch-off and the solenoid valve in the blow-out line are selected and connected accordingly. This goes hand in hand with the corresponding SIL calculations **(Figure 2)**.

These calculations take into account the failure behaviour and service life of the assembly, as well as the structural redundancy.

This safety must be maintained during the operation of the lean air system through a regular check, as part of maintenance.

AVAILABILITY

To ensure the availability of a lean air system, at least the following measures are usual:

- Gas filtering on the inlet side to avoid the functioning of the fittings being impaired by particles;
- Pressure regulation of compressed air (or oxygen) and nitrogen to the same mixed pressure, so that Avogadro's law of ideal gas applies, ie the density of the gases is proportional to the

molar mass at the same pressure and temperature;
- Interconnection of the constant pressure regulators in the input lines, so that the impermissible enrichment of admixture gas is excluded at all times. Additional locking via the gas analysis so that a redundant safety lock is created;
- Measurement of the volume flow (temperature and pressure compensated);
- Use of non-return gas valves in each individual gas line to prevent transferring of the gases;
- Enabling continuous or discontinuous gas mixture acceptance through constructive measures;
- Ensuring the independent plant operation, even if a higher-level process control system is disturbed;
- Equipment suitable for the installation location (eg for outdoor installation, installation in ex-areas or in an aggressive environment);
- Pressure holding valve, for breaking the vacuum and protecting the lean air system.

Availability of a system often has a financial impact. This is made up of the costs for production downtime and troubleshooting. The assessment of the likelihood of error leads to the taking of measures to avoid errors and to preventively increase the technical reliability.

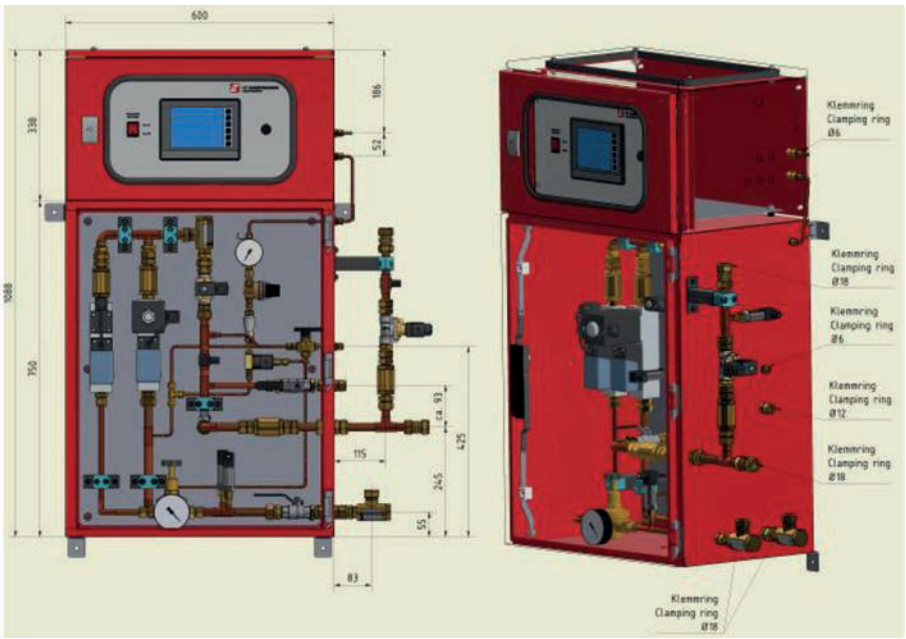

Figure 1. Drawing of a dynamic lean air system with gas analyser

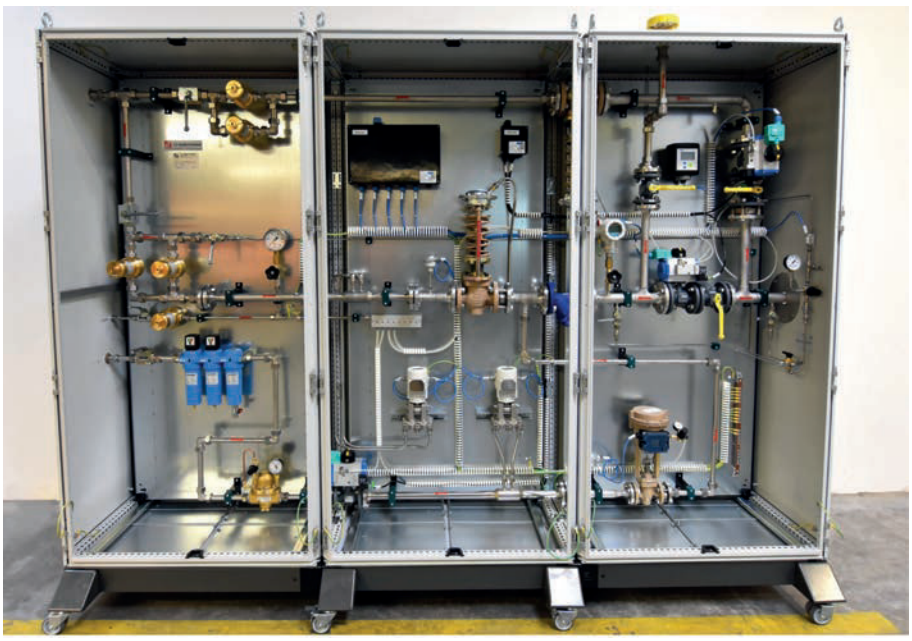

Figure 3. Lean air system for 800Nm³/hr for erecting in an ex-area

In the context of the analysis of potential causes of errors and error frequencies in the supply with lean air, experience has shown that the following components should be analysed in more detail:

1. Nitrogen gas supply fails
2. Compressed air or oxygen supply fails
3. Nitrogen gas tank is empty
4. Lean air system fails

Typically, a single gas supply system is responsible for multiple production facilities. This can lead to bottlenecks, such that a failure of this system has significant impact on the availability of the production facilities.

The following concepts are used by default in the industry:

- Bypass
- Backup
- Redundancy

Solutions can be combined with each other for these three concepts, thus, making it possible to increase the technical reliability in line with the probably avoided error costs **(Figure 3)**.

Companies operating lean air systems also make use of these concepts. An often chosen solution is the nitrogen bypass. In the event of a fault in the compressed air or oxygen supply or the generation of lean air, there is a fully automatic switchover to the nitrogen bypass. This then protects the production until the fault has been eliminated. The bypass can, of course, only work if nitrogen is available, ie errors 2 and 3 listed above do not occur.

The emergency supply has established itself as a backup solution: If the regular

Figure 2. Lean air system with SIL 1 gas analyser

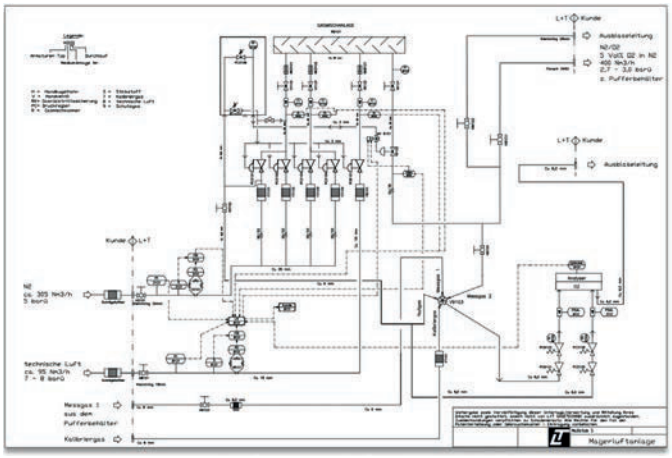

Figure 4. A well-equipped, medium sized system for 400m³/hr lean air

gas supply is disturbed, switched over to an emergency supply (usually cylinder station or bundle supply) with ready-mixed or pure nitrogen. Premixing the lean air and storing it in a buffer tank is usually not economical because of the gas pressures that arise and the lean air volumes that are constantly required by production – but it can also be considered in individual cases.

A supply concept with two lean air systems in parallel is used to achieve redundancy. On an adjustable time slice, usually alternating weekly, there is an automatic switch-over between the two lean air systems in order to ensure an even load and at the same time, the functionality of both lean air systems. In addition, it is often possible to use additional pressure signals to operate both lean air systems in parallel if the lean air requirement is temporarily increased.

This redundancy can also extend to the gas analysis system with redundant analysis system with double analysis, ie with two independent measuring cells. Two sensors continuously determine the O_2 concentration in the lean air. Each measuring cell is responsible for one lean air system, so independent redundancy is guaranteed. The gas analysis system is supplied with the sample gas from the corresponding gas mixer monitored via solenoid valves. When switching over, the fact of a fault with priority switching is taken into account.

In addition to the measured value, the display shows the operating status of the lean air system; or in case of redundancy, of the respective lean air system. Messages, such as the below, are transmitted by interface to the central control room, so that the operating staff is promptly informed about statuses and any malfunctions that may occur:

- Operating condition lean air system 1/2;
- Lean air system fault 1/2;
- Limit values;
- Analysis of actual value lean air system 1 and 2 of the continuous measurement as an analog signal.

SUMMARY

The requirements of lean air system operating companies for quality, safety and availability can be met individually by the following measures:

Compliance with a defined oxygen concentration to achieve a defined product quality:

- Usage of adapted technology (static or dynamic system);
- Design measures;
- Gas analysis.

Safe shutoff to prevent the risk of explosion

- Gas analyser with shutoff valve;
- SIL-compliant shutoff circuit.

Ensuring the availability of the production plant by redundancy and/or backup solutions

- Nitrogen bypass;
- Emergency supply;
- Redundant lean air systems.

In this way, an adapted solution can be combined according to individual needs and the existing budget. A well-equipped, medium sized system for 400m³/hr lean air is shown as an example in **Figure 4**, a piping and instrumentation diagram. ■

Author: Alexander C Hanf, Managing Director, L+T GASETECHNIK, Klöpper-Waldmann GmbH & Co KG
Tel: +49 231 961 0700
Email: a.hanf@lt-gasetechnik.com
Website: www.lt-gasetechnik.com