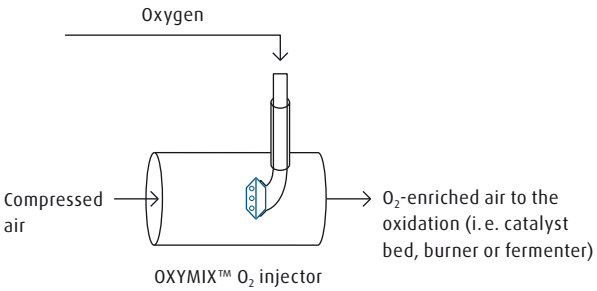
THE LINDE GROUP

Oxygen for the chemical industry. Process intensification of air oxidations by O_2 enrichment.

Basic concept of O_2 enrichment

Oxidations with molecular oxygen are among the most important reaction types in chemical processing. They are applied for the production of chemicals as well as for disposal of waste streams. The predominant oxidant for catalytic and thermal oxidations is air which is characterised by a rather limited oxygen content (21 vol. %) and a high proportion of inert nitrogen. Inevitably, air sent through the process generates high off-gas volumes. This drawback can be overcome by adding oxygen to the process air – especially when combined with a reduction of the air flow, i. e. also the nitrogen load.



O_2 enrichment by injection of oxygen into the pipe with compressed air

Effects of O_2 enrichment

Such an additional use of oxygen is applied for the intensification of many oxidation processes. Its increasing popularity is due to the potential productivity enhancement, which in many cases can be combined with advantages in operation, often including the mitigation of environmental impact.
Possible effects of O_2 enrichment:

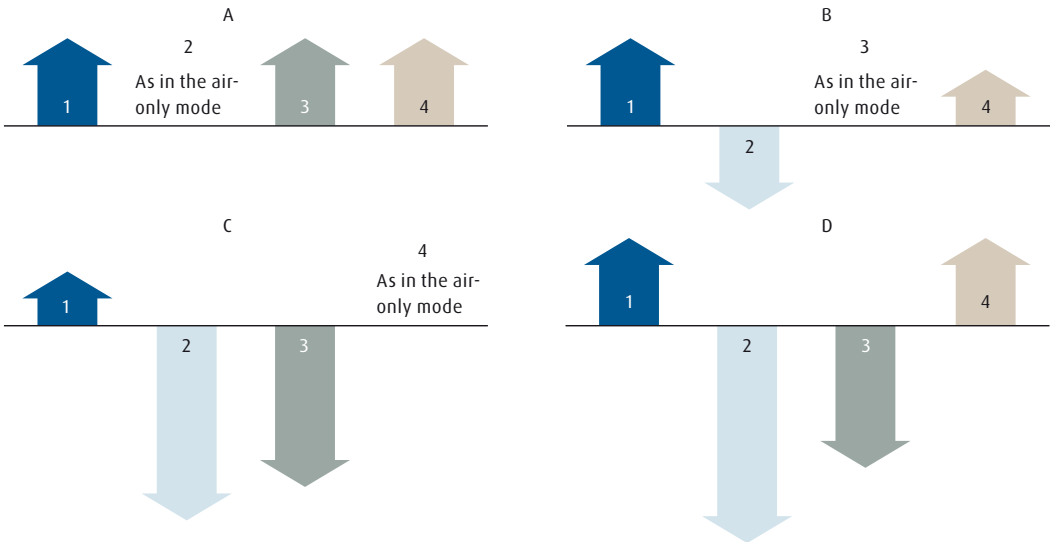
- Capacity increase (often by 10–20 %)
- Higher yield
- Increase of oxidation temperature
- Improved flexibility of operation
- Lower off-gas volume
- Reduced CO_2 emission

Oxygen enrichment can be implemented with only minor effort and therefore low investment.

Modes of O_2 enrichment

Oxygen enrichment can be realised by choosing different flow patterns, thus influencing not only the O_2 concentration, but also the resulting oxidation potential and the total gas flow of O_2-enriched air to the oxidation reactor. Accordingly, the following scheme depicts four possible variations of O_2 enrichment (A–D) which is widely applied in oil refineries as well as in the (petro-)chemical industry. Corresponding deviations from usual air-only mode conditions – represented by the horizontal base line – are given qualitatively by the arrow types 1–4:

1 Added oxygen (flow rate)
2 Air from the compressor (flow rate)
3 O_2-enriched air to the oxidation reactor (total flow rate)
4 Amount of molecular oxygen in the O_2-enriched air (indicating the increase of the oxidation potential provided by O_2 addition)



Total flow rate constant

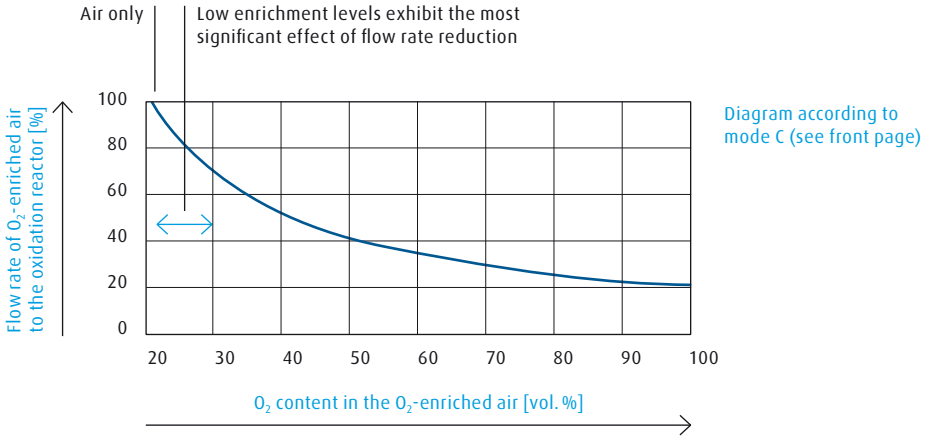
In principle, the presented modes (A–D) allow for a wide variety of O_2 concentrations in the O_2-enriched process air.

Example according to mode B:
When the addition of oxygen yields an O_2 content of 28 vol. % in the enriched air while keeping the flow of the oxidation gas to the reactor at a constant level, the additional amount of O_2 provided for the reaction per time unit amounts to 33 %.
This increase of the oxidation potential already indicates that enrichment levels well below 28 vol. % suffice in many cases to considerably increase the productivity of the oxidation step.

Total flow rate reduced

The treatment of effluent gas from oxidation reactors often poses a problem because of a too high gas flow rate. In this case, O_2 enrichment according to mode C or D can be considered as an option for debottlenecking.

The diagram below shows the change of the total flow rate with increasing O_2 concentration when the amount of molecular oxygen supplied to the oxidation reactor is kept at a constant level.



Applications

The effects of the different modes of O_2 enrichment fulfil different purposes. Typical correlations are e. g.:

- → Need for more capacity → A, B, D
- → Need for off-gas reduction → C
- → Need for more capacity at lowered off-gas appearance → B, D
- → Maintaining nameplate capacity at limited availability of compressed air → B, C, D
- → Achieving an increased furnace temperature in thermal oxidation steps → A, B, C, D

Services and know-how

Linde's expertise in gases and procedural issues provides the basis for an individual and straightforward project handling. Efficient and approved process simulation programs and proprietary databases ensure optimum design, safe plant operation and economic use of technical gases. Moreover, Linde has extensive experience with O_2 applications and can therefore offer comprehensive services that cover all stages of an O_2 enrichment project, including the provision of appropriate hardware, trial preparation and execution on the technical scale as well as implementation and start-up.

Linde AG
Linde Gases Division, Seitnerstrasse 70, 82049 Pullach, Germany
Phone +49.89.7446-0, Fax +49.89.7446-1230, www.linde-gas.com

43486069 0210 – 1.1 L&P Subject to change.