Catalytic oxidation of VOC – modelling, reactor design and industrial off gas treatment

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Abstract (1500 word limit)

The treatment of industrial off gas that contains VOC (Volatile organic compounds) before is vented to the atmosphere is mandatory according to the legislation in most of the states worldwide mainly due to undesirable VOC photochemical reactions with NOx forming harmful compounds that can lead in negative climate and public health effects. Some of the individual VOC (e.g. benzene, 1,3-butadiene, formaldehyde, and higher molecular weight aldehydes) are considered harmful on their own due to their negative respiratory, carcinogenic, neurological or other effects.

Frequently the abatement of the VOC in the industry is done by thermal oxidation by simply burning the organic vapours with natural gas in the combustion chambers. In many cases of the industrial off gas treatment containing VOC is possible to change the technology from thermal oxidation into catalytic oxidation and reduce operating costs in terms of difference in the savings because the reduced natural gas consumption and the price of used catalyst. Of course some of the conditions like stable gas flow and no sudden changes in VOC concentration loads must be met to get reasonable reactor dimensions and investment return rate.

This contribution aims to address many aspects of this issue, from reactor design of the pilot scale catalytic reactors to modelling of the deep oxidation of VOC in this type of reactors and treatment of off gas containing either only model VOC pollutant or real industry mixture of different VOC in various concentrations.

As for the modelling of the process in larger scales than laboratory scale, the isothermal reactor can't be used, and instead the adiabatic or even better, the non-isothermal reactor with heat dissipation must be considered. The proposed model (if provided with proper kinetic data) considering non-isothermal plug-flow reactor can predict the achievable conversion and temperature gradient across the reactor, which can help in reactor design, technological design of catalytic bed and scale-up to the full-scale technology. The proposed model is considering changes in gas composition and gas properties due to oxidation reactions, temperature rise due to oxidation reactions and on the other hand temperature decrease due to heat losses and change of pressure due to pressure losses across the bulk catalyst bed.

For the purpose of verification of feasibility in industrial case studies of VOC catalytic oxidation and catalyst testing, the modular design pilot plant was proposed and implemented. This unit is scalable and can be used to test the sprinkled catalysts and catalysts in form of the monoliths both in lab or real industrial conditions.

Keywords (up to 3)

Catalysts, Industrial Gases, Chemical Reaction Engineering

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