



An industrial perspective on the impact of Haldor Topsøe on research and development in synthesis gas production



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ABSTRACT

Haldor Topsøe was a fast follower in syngas technology and soon became a major player in the field. This was based on a development effort supported by fundamental studies of the key problems. This paper summarizes the science behind this parallel approach stressing the collaboration with academia. It was a result of Haldor Topsøe's attitude that this should be a two-way process to the benefit of both parties. It required that his company was active in basic research as well.

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1. Introduction: The history

After the successful introduction of the ammonia synthesis catalyst and reactor technology to industry during the 1950s it was natural for Haldor Topsøe to expand into technologies for the manufacture of synthesis gas (syngas) [1–3]. The main principles of catalytic partial oxidation and steam reforming processes converting hydrocarbons to syngas had been described in an early patent by Mittasch et al. [4] and a later patent [5] claimed a big fraction of the Periodic Table as catalyst components.

Low pressure processes for catalytic partial oxidation were developed in the 1930s, but low pressure meant high compression costs for the synthesis. Thermal processes for partial oxidation at high pressure had been developed around 1945 [6,7], but Topsøe pioneered a hybrid version using partial combustion in a flame followed by catalytic reaction, called autothermal reforming (ATR). This was done at first with the Belgian SBA company [8] during the 1950s, and later alone, first for ammonia plants and later for methanol and gas-to-liquids Plants [3,9,10].

The first industrial steam reforming plants were installed in 1930 [11] based on natural gas as feedstock, but the commercial breakthrough of the technology took place when ICI succeeded in starting two tubular reformers operating at 15 bar pressure in 1962 [12]. Haldor Topsøe was a fast follower [13]. The first Topsøe reformer (operating at low pressure) was started in 1956 and high pressure reformers followed from 1962 onward, with

one operating at 42 bar in 1966 [3]. The introduction of high pressure reforming meant that the energy consumption of the ammonia plants could be decreased significantly [14]. The catalysts consisted of supported nickel, able to withstand the high temperature and partial pressures of steam. Topsøe focused on a ceramic magnesium aluminium spinel support fired at high temperatures [15]. During the first decades, reforming plants of Topsøe design were mainly built in Europe, Japan and India, where naphtha was then the available feedstock [16,17]. This required special alkali-promoted catalysts to deal with carbon formation [13,18,19]. Another approach was the use of an alkali-free catalyst based on active magnesia [17,19,20], which could handle heavier feedstocks (kerosene, light gas oil) owing to its higher activity. An alternative solution was to use low-temperature adiabatic reforming, as pioneered by the British Gas Council [21] and later applied by Topsøe [22,23], as pre-reforming for tubular reactors. This not only avoided the complications of tubular reforming of higher hydrocarbons, but also allowed steam reforming at more economic conditions, with lower steam to carbon ratios and higher inlet/outlet temperatures of the reformer [24]. This, and a better understanding of mechanical stress problems [1,15], made it possible to take advantage of the availability of better tube materials. As a result the reformers of today are designed for average heat fluxes that are about twice of what was industrial practice 30 years ago. This means a smaller number of reformer tubes and hence a cheaper plant.

The limits of the reforming process with respect to heat flux, carbon limits and activity were explored in a full-size monotube

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