Nitric Oxide Production from Ammonia

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Background & Description:

The primary use of nitric acid is in producing ammonium nitrate for fertilizers, and it is also crucial for manufacturing explosives like TNT and nitroglycerin, dyes, fibers such as nylon, pharmaceuticals, and polymers.

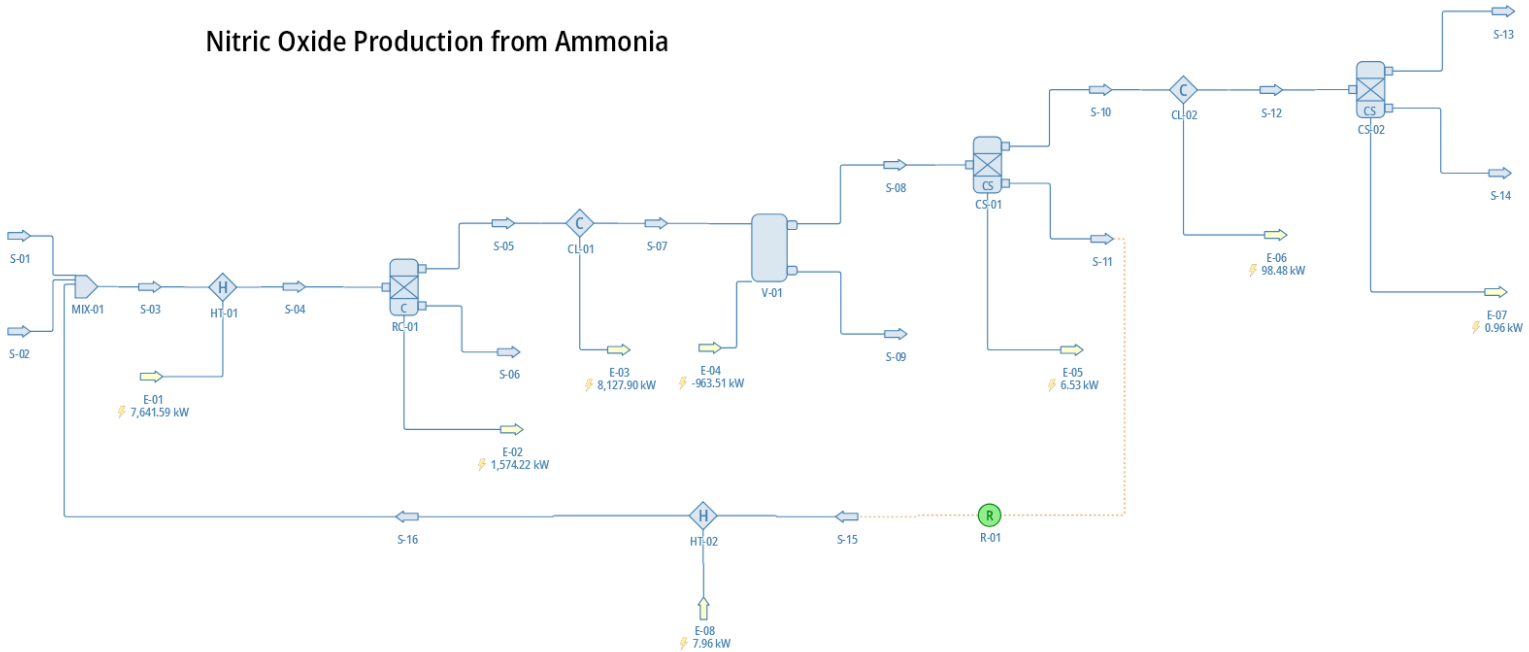
In this study, a production plant for nitric oxide is simulated using DWSIM. The Non-Random Two-Liquid (NRTL) method is used as the thermodynamic property package. Two streams, ammonia and air (which contains 79% nitrogen and 21% oxygen), both at 160 °C and 7.5 bar, are mixed together and heated to 1000 °C. This mixture is then fed into a conversion reactor operating at 1000 °C, where the ammonia and air react to form nitric oxide. This is an exothermic reaction and releases a significant amount of heat.

The stoichiometric reaction occurring in the reactor is as follows:

$$4NH_3\ (g) + 5O_2\ (g) \rightarrow 4NO\ (g) + 6H_2O\ (g)$$

The product from the reactor is cooled down to 100 °C and sent to a flash (gas-liquid separator) operating at 40 °C, where the water formed by the reaction is separated. The vapor outlet from the flash is fed to a compound separator, where unreacted ammonia is separated from the mixture and recycled back to the mixer. The top product from the compound separator is cooled to 30 °C and fed to another compound separator, where pure nitric oxide is separated from the mixture.

Flowsheet:



Results:

Object	S-01	S-02	S-03	S-04	S-05	S-07	S-08	S-09
Temperature (°C)	160	160	159.855	1000	1000	100	40	40
Pressure (bar)	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Molar Flow (kmol/h)	25	975	1001.29	1001.19	1007.54	1007.54	979.756	27.7808
Molar Fraction (Vapor)	1	1	1	1	1	1	1	0
Molar Fraction (Liquid)	0	0	0	0	0	0	0	1
Mole Fraction (Mixture):								
NH_3 (Ammonia)	1	0	0.02625	0.02625	0.00130	0.00130	0.00132	0.00063
N_2 (Nitrogen)	0	0.79	0.76925	0.76925	0.76448	0.76448	0.78616	5.27E-05
O_2 (Oxygen)	0	0.21	0.20448	0.20448	0.17223	0.17223	0.17711	2.45E-05
NO (Nitric oxide)	0	0	0	0	0.02479	0.02479	0.02549	5.07E-06
H_2O (Water)	0	0	0	0	0.03718	0.03718	0.00990	0.99928

Object	S-10	S-11	S-12	S-13	S-14
Temperature (°C)	40	40	30	30	30
Pressure (bar)	7.5	7.5	7.5	7.5	7.5
Molar Flow (kmol/h)	978.464	1.292	978.464	24.977	953.486
Molar Fraction (Vapor)	0.999993	1	0.99575	1	0.99549
Molar Fraction (Liquid)	6.63E-06	0	0.00424	0	0.00450
Mole Fraction (Mixture):					
NH_3 (Ammonia)	5.07E-06	1	5.07E-06	0	5.21E-06
N_2 (Nitrogen)	0.787202	0	0.787202	0	0.807823
O_2 (Oxygen)	0.177347	0	0.177347	0	0.181993
NO (Nitric oxide)	0.025527	0	0.025527	1	6.70E-18
H_2O (Water)	0.009918	0	0.009918	0	0.010178

Reference: https://youtu.be/SkXo-hMYg88?si=1c2y8TzKfo22aSyI