

Production of Acetone via Dehydrogenation of Isopropyl Alcohol (IPA)

Gaurang Pitale, Mayuresh Pilke, Nolan Pereira, Archit Pavale

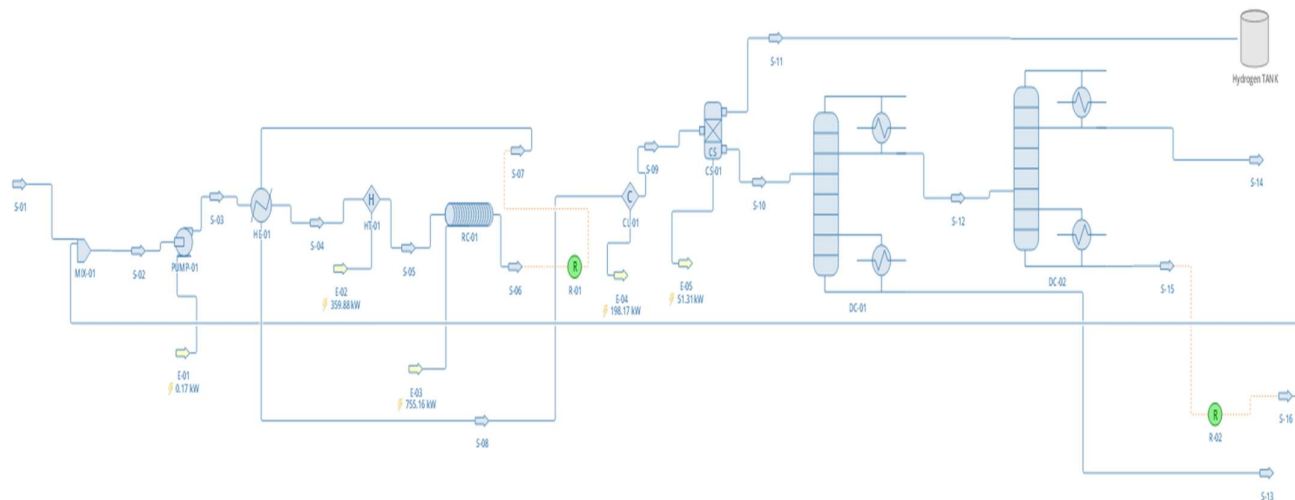
Thadomal Shahani Engineering College

Background and Description of the Flowsheet

Acetone is an important industrial solvent widely used in the pharmaceutical, paint, cosmetic, and polymer industries. Due to its increasing demand, efficient production methods are required to obtain high-purity acetone with minimum environmental impact. Among the available production routes, the dehydrogenation of isopropyl alcohol (IPA) is preferred because of its simple process design, high selectivity, and the production of hydrogen as a valuable by-product. In this project, the production of acetone from IPA was simulated using DWSIM to study the process performance and separation efficiency.

The developed flowsheet consists of feed preparation, reaction, separation, purification, recycle, and heat integration sections. Fresh IPA is mixed with the recycled IPA stream and vaporized before being heated to the required reaction temperature. The vaporized feed is then sent to a Plug Flow Reactor (PFR) containing a copper-based catalyst, where catalytic dehydrogenation converts IPA into acetone and hydrogen. The reactor outlet is subsequently cooled and fed to a flash separator for hydrogen recovery. The liquid stream containing acetone, IPA, and water is then sent to an acetone distillation column, where high-purity acetone is obtained as the distillate. The bottom product is further processed in an IPA recovery column, where unreacted IPA is separated and recycled back to the reactor, while the water-rich stream is removed from the process. To improve the overall energy efficiency, heat integration was incorporated by recovering heat from the hot process streams to preheat the incoming feed, thereby reducing external heating requirements. The UNIQUAC–Peng Robinson property package was selected for the simulation because it accurately represents the non-ideal liquid-phase behaviour of the acetone–IPA system while providing reliable vapor-phase property and vapor–liquid equilibrium calculations.

Flowsheet :-



Results:-

Master Property Table							
Object	S-15	S-14	S-13	S-12	S-11	S-10	S-09
Temperature	99.8799	56.2306	99.7419	56.3984	20	20	20 C
Pressure	1.01325	1.01325	1.01325	1.01325	2.1	2.1	2.1 bar
Mass Flow	24.7603	2669.2	99.1701	2693.96	91.9734	2793.13	2885.1 kg/h
Molar Flow	1.37401	46.4705	5.4995	47.8445	45.6245	53.344	98.9685 kmol/h
Volumetric Flow	0.0258386	3.54344	0.103489	3.55313	529.516	3.42007	598.11 m3/h
Molar Fraction (Mixture) / Isopropanol	2.84839E-05	0.0021218	0.000315285	0.00206168	0	0.00188164	0.0010142
Molar Flow (Mixture) / Isopropanol	3.91371E-05	0.0986011	0.00173391	0.0986403	0	0.100374	0.100374 kmol/h
Mass Flow (Mixture) / Isopropanol	0.00235194	5.92543	0.104199	5.92779	0	6.03199	6.03199 kg/h
Molar Fraction (Mixture) / Water	0.999872	0.0160965	0.999585	0.0443488	0	0.142829	0.0769847
Molar Flow (Mixture) / Water	1.37383	0.748013	5.49722	2.12185	0	7.61906	7.61906 kmol/h
Mass Flow (Mixture) / Water	24.75	13.4757	99.0339	38.2257	0	137.26	137.26 kg/h
Molar Fraction (Mixture) / Hydrogen	0	0	0	0	1	0	0.461
Molar Flow (Mixture) / Hydrogen	0	0	0	0	45.6245	0	45.6245 kmol/h
Mass Flow (Mixture) / Hydrogen	0	0	0	0	91.9734	0	91.9734 kg/h
Molar Fraction (Mixture) / Acetone	0.0001	0.981782	0.0001	0.95359	0	0.85529	0.461001
Molar Flow (Mixture) / Acetone	0.000137401	45.6239	0.00054995	45.6241	0	45.6246	45.6246 kmol/h
Mass Flow (Mixture) / Acetone	0.00798012	2649.8	0.0319406	2649.81	0	2649.84	2649.84 kg/h
Phases	L	L	L	L	V	L	V+L
Energy Flow	-107.634	-3152.68	-430.832	-3258.97	-1.81047	-3755.63	-3706.13 kW
Object	S-08	S-06	S-05	S-04	S-03	S-02	S-01
Temperature	46.3103	350	350	151.407	25.6823	25.6413	25 C
Pressure	2.1	2.2	2.2	2.2	2.3	1.01325	1.01325 bar
Mass Flow	2885.1	2885.1	2885.1	2885.1	2885.1	2885.1	2860.16 kg/h
Molar Flow	98.9685	98.9685	53.344	53.344	53.344	53.344	51.96 kmol/h
Volumetric Flow	854.133	2330.65	1256.22	855.873	3.57748	3.57753	3.562 m3/h
Molar Fraction (Mixture) / Isopropanol	0.0010142	0.0010142	0.857169	0.857169	0.857169	0.857169	0.88
Molar Flow (Mixture) / Isopropanol	0.100374	0.100374	45.7248	45.7248	45.7248	45.7248	45.7248 kmol/h
Mass Flow (Mixture) / Isopropanol	6.03199	6.03199	2747.84	2747.84	2747.84	2747.84	2747.83 kg/h
Molar Fraction (Mixture) / Water	0.0769847	0.0769848	0.142829	0.142829	0.142829	0.142829	0.12
Molar Flow (Mixture) / Water	7.61906	7.61907	7.61907	7.61907	7.61907	7.61907	6.2352 kmol/h
Mass Flow (Mixture) / Water	137.26	137.26	137.26	137.26	137.26	137.26	112.329 kg/h
Molar Fraction (Mixture) / Hydrogen	0.461	0.461	0	0	0	0	0
Molar Flow (Mixture) / Hydrogen	45.6245	45.6245	0	0	0	0	0 kmol/h
Mass Flow (Mixture) / Hydrogen	91.9734	91.9734	0	0	0	0	0 kg/h
Molar Fraction (Mixture) / Acetone	0.461001	0.461001	2.59457E-06	2.59457E-06	2.59457E-06	2.59457E-06	0
Molar Flow (Mixture) / Acetone	45.6246	45.6246	0.000138405	0.000138405	0.000138405	0.000138405	0 kmol/h
Mass Flow (Mixture) / Acetone	2649.84	2649.84	0.00803843	0.00803843	0.00803843	0.00803843	0 kg/h
Phases	V+L	V	V	V	L	L	L
Energy Flow	-3507.96	-2691.99	-3447.15	-3807.03	-4623	-4623.18	-4514.76 kW

Reference :-

Analysis, Synthesis and Design of Chemical Processes. (Fifth Edition), Turton, Bailie, Whiting, Shaeitwitz and Bhattacharya – Appendix B (Information for the Preliminary Design of Fifteen Chemical Processes)