Production of Sulfuric Acid by DCDA Process.

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Background:

The Double Conversion Double Absorption (DCDA) process is the most widely adopted industrial route for manufacturing sulfuric acid due to its high conversion efficiency and ability to meet strict emission standards. In this process, molten sulfur is burned to form sulfur dioxide which is then catalytically oxidized to sulfur trioxide and finally absorbed in strong sulfuric acid to produce concentrated H_2SO_4. This process achieves higher overall conversion rates of SO_2 to SO_3 than the single contact process, resulting in increased acid yield and reduced sulfur oxide emissions.

Description:

The process begins with molten sulfur being transferred from the storage tank to the sulfur burner. Here, it is atomized and combusted using a dry air supply to form an SO_2-rich gas stream. The combustion gases exit at high temperature and are routed to a cooling unit to bring the temperature within the optimal range required for catalytic oxidation. After cooling, the gas enters **PFR-1**, the first catalytic converter modeled as a plug flow reactor. In this reactor, SO_2 is partially oxidized to SO_3 over a vanadium-based catalyst. Owing to the exothermic nature of the reaction, the temperature increases across the bed, limiting the conversion achievable in this stage, and only partial conversion takes place in this first pass. The partially converted gas is then cooled again to to maintain favorable absorption conditions.

The cooled gas then moves to **ABS-1**, the first absorption tower. In this unit, the SO_3 produced in PFR-1 is absorbed into circulating strong sulfuric acid, forming oleum. Early removal of SO_3 prevents reverse reaction in the subsequent converter and creates a favorable driving force for further SO_2 oxidation. The gas exiting ABS-1 still contains unreacted SO_2. This gas is reheated and fed to **PFR-2** for the second catalytic oxidation stage. Because SO_3 was eliminated in the first absorption, the equilibrium in PFR-2 shifts toward higher conversion, allowing almost complete oxidation of the remaining SO_2. The outlet gas is again cooled to match the requirements of the final absorption stage.

The SO_3-rich gas is then directed to **ABS-2**, the final absorption tower. Here, circulating sulfuric acid absorbs the SO_3 formed in PFR-2, producing concentrated sulfuric acid. A portion of this acid is withdrawn as product, while the rest is recycled to maintain tower operation. Any residual gases, containing only traces of SO_2, are treated in a tail-gas scrubber to ensure environmental compliance. The final acid product from ABS-2 is cooled and transferred to storage tanks.

Flowsheet:

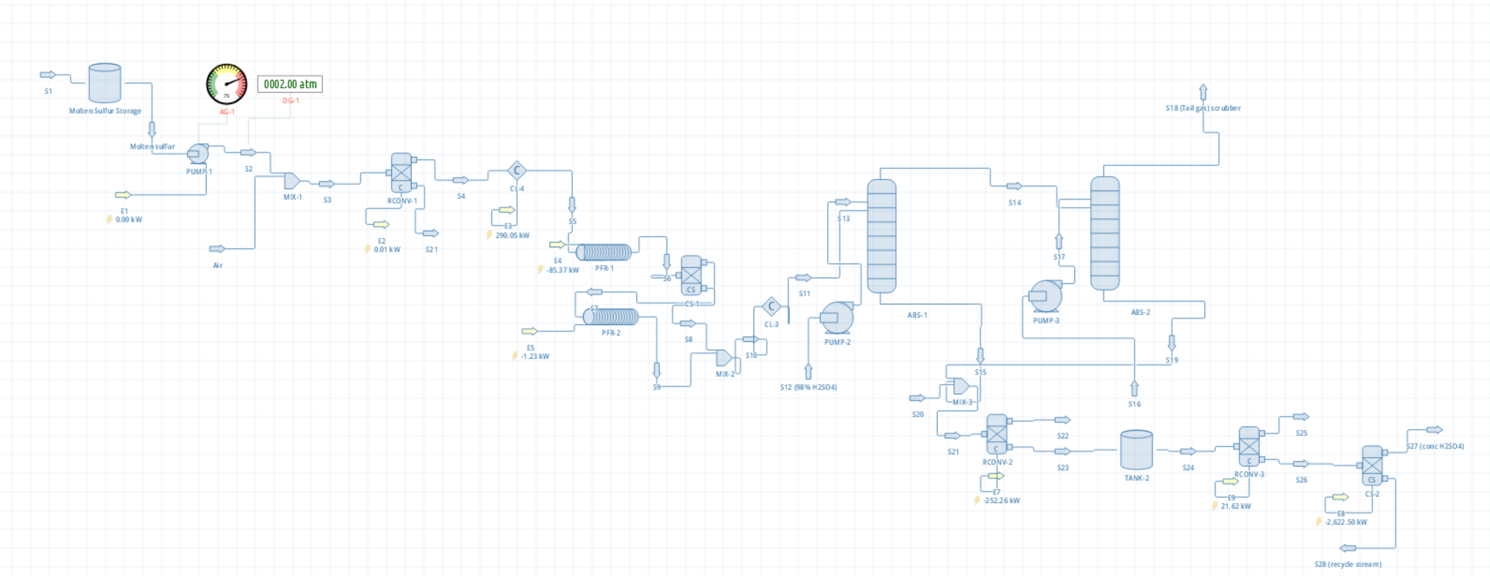

Figure: **Manufacturing of Sulfuric Acid By DCDA Process**

Result:

The DCDA process enables the production of high-purity, concentrated sulfuric acid with very high conversion of SO_2 to SO_3 and minimum atmospheric emissions. The two-stage conversion and absorption system significantly enhances efficiency and environmental performance.

Object	S7	S5	S4	S3	S2	S1	Air	
Temperature	1141.57	673.15	3170.95	140.949	298.107	298.15	298.15	K
Pressure	101324	101324	101324	101325	202650	101325	101325	Pa
Mass Flow	35.0349	442	442	442	163	163	279	kg/h
Molar Flow	1.09451	8.71908	8.71908	13.8025	5.08342	5.08342	8.71908	kmol/h
Molecular Weight (Mixture)	32.0098	50.6934	50.6934	32.0232	32.065	32.065	31.9988	kg/kmol
Specific Enthalpy (Mixture)	864.836	292.928	2655.34	-1008.04	-3144.71	-3144.78	-0.240408	kJ/kg

Object	S9	S8	S13	S12 (98% H2SO4)	S11	S10	
Temperature	1027.45	1141.57	149.975	150	150	1131.37	K
Pressure	101324	101324	301325	101325	101324	101324	Pa
Mass Flow	35.0349	406.965	400	400	442	442	kg/h
Molar Flow	1.09432	5.08305	4.14606	4.14606	6.17736	6.17736	kmol/h
Molecular Weight (Mixture)	32.0153	80.0632	96.4772	96.4772	71.5515	71.5515	kg/kmol
Specific Enthalpy (Mixture)	739.121	723.557	-1197.22	-1197.37	-104.106	724.791	kJ/kg

Object	S20	S19	S18 (Tail gas) scrubber	S17	S15	S14	
Temperature	298.15	81.9514	81.6174	149.987	299.176	81.5449	K
Pressure	101325	101325	100000	202650	101325	10000	Pa
Mass Flow	3600	100.144	34.7822	100	807.074	34.9261	kg/h
Molar Flow	199.83	1.04101	1.08698	1.03651	9.23194	1.09148	kmol/h
Molecular Weight (Mixture)	18.0153	96.1986	31.9988	96.4772	87.4219	31.9988	kg/kmol
Specific Enthalpy (Mixture)	-2630.81	-11617.1	-200.118	-1197.3	-688.785	-197.497	kJ/kg

Object	S27 (conc H2SO4)	S26	S25	S24	S23	S22	S21	
Temperature	298.15	298.15	298.15	298.15	298.15	298.15	3170.95	K
Pressure	101325	101325	101325	101325	101325	101325	101324	Pa
Mass Flow	996.265	4507.22	0	4507.22	4507.22	0	0	kg/h
Molar Flow	10.1578	205.024	0	205.025	205.025	0	0	kmol/h
Molecular Weight (Mixture)	98.0785	21.9838	0	21.9838	21.9838	0	0	kg/kmol
Specific Enthalpy (Mixture)	-890.536	-2301.58	0	-2234.78	-2234.78	-0.268819	0	kJ/kg

Reference:

Dryden, G. N. (Dryden's Outlines of Chemical Technology), *Double Conversion Double Absorption (DCDA) Process for Sulfuric Acid. section.*