CHE 477 Mystery Auction – Turn 7: Two Gluppity-Glupp Factories

Two Gluppity-Glupp factories which were built in the year 1987 are for sale. The current owner has set a minimum bid of 20% of their original grassroots construction costs.

The process for manufacturing 15,000 tonne/year of Gluppity-Glupp (which has properties like acetone) proceeds via the catalytic dehydrogenation of isopropyl alcohol. An azeotropic mixture of isopropyl alcohol is fed to a surge vessel (V-401) where it is mixed with a recycle stream. This material is pumped to heat exchanger E-401, where it is vaporized prior to entering the reactor. Heat is provided for the endothermic reaction via a circulating stream of molten salt, stream 4. The reactor effluent is cooled in two heat exchangers, E-402 and E-403, prior to entering the phase separator, V-402. The vapor leaving the separator, stream 5, is scrubbed with water in T-401 to recover additional acetone and this liquid in stream 6 is combined with the liquid leaving the separator into stream 9. This stream 9 undergoes additional purification in T-402 to separate acetone and unreacted isopropanol. The streams leaving the process unit are Streams 7 and 10. Stream 7 contains the non-condensable gases and is burned as a fuel supplement in the boiler plant (not shown). The value of fuel gas is assumed to be $0.50 per kg based on off-setting natural gas usage. Stream 10 contains the product, gluppity glupp.

The stream factor is 92% for this process. Assume costs are calculated as specified in chapters 7 and 8 and appendix A of Turton, except that gluppity glupp sells for $2.90 per kilogram.

Table 1 contains stream information. Table 2 contains utility cost specifications. Tables 3a and 3b contain the specifications for a preliminary design of the major pieces of equipment, including utility usage.

Table 1. Abridged stream table for determination of flow rates (streams also shown in Figure 1)

Stream Number	2 (Feed IPA)	8 (DI Water)	10 (Gluppity- Glupp)	7 (Off-Gases)
Temperature (°C)	32	25	22	34
Pressure (barg)	1.3	1	1	0.5
Total flow (kg/hr)	2670	360	1860	240
Component Flowrates (kmol/hr)				
Isopropyl Alcohol	34.82	0	0	0.02
Acetone	0.16	0	32.3	2.67
Water	17.14	20	0.1	1.36
Hydrogen	0	0	0	34.77

Table 2. Utility Cost Specifications

Utility	Temperature (°C)	Pressure (barg)	Cost ($/GJ)	Cost ($/1000kg)
High pressure steam	254	41	5.66	9.61
Medium pressure steam	184	10	2.78	5.56
Boiler Feed Water	115	-	-	1.523
Cooling Water	30°C in, 40°C out	-	0.378	0.0157
Refrigerated Water	5°C in, 15°C out	-	4.77	0.207
Deionized Water	-	-	-	14.5
Electricity	-	-	18.72	$0.0674/kWh

Turn 7 Instructions should include: detailed cost estimates for each piece of equipment, an estimate of the grassroots cost of the plant in 1987, estimated manufacturing costs, and a determination of the maximum bid worth (where the plant is operational in turn 8). Instructions should also include any changes you wish to make for other assets, if applicable.

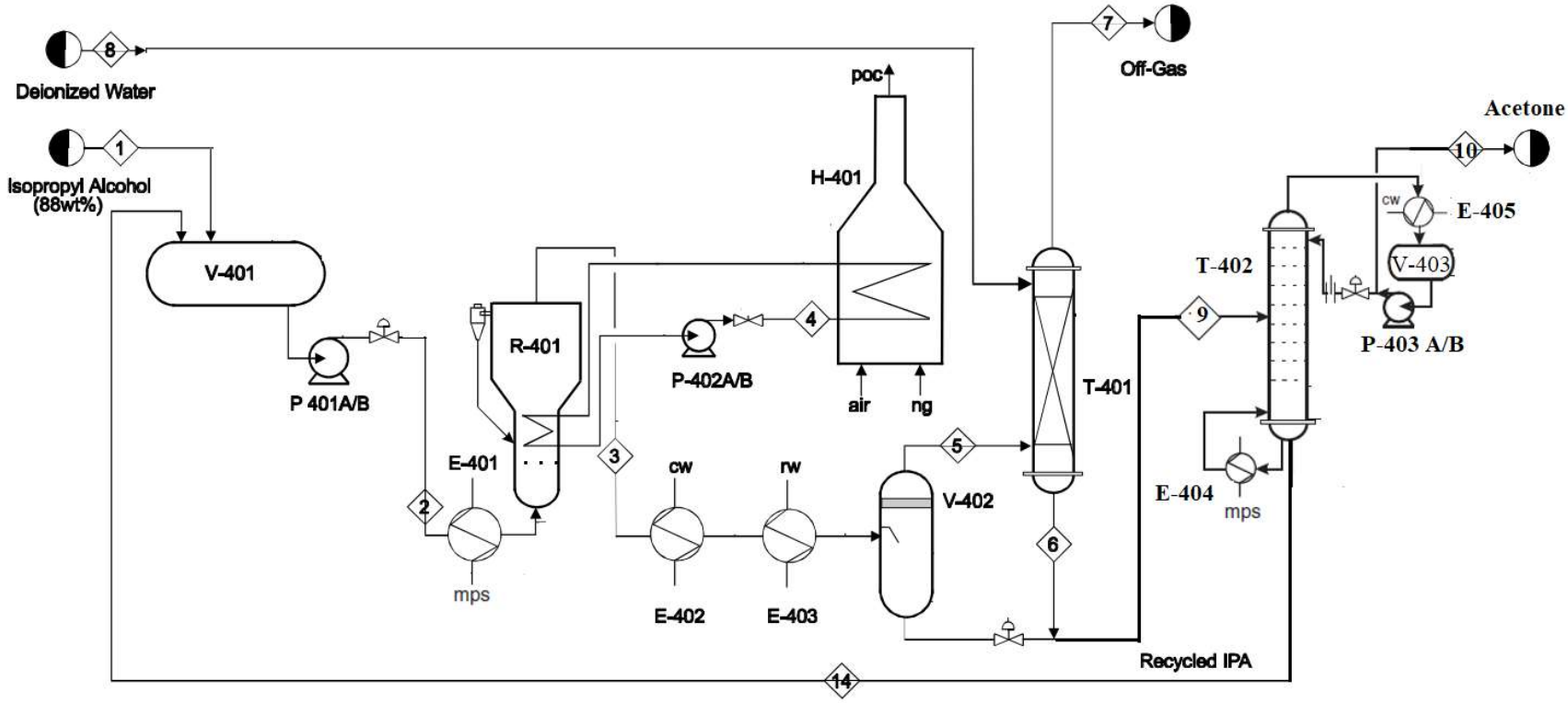

Figure 1. Process Flow Diagram for Acetone from Isopropyl Alcohol Facility

Table 3a. Major Equipment Summary for Unit 400

	P-401 A/B	P-402 A/B	P-403 A/B	E-401	E-402	E-403	E-404	E-405
Type	Centrifug.	Centrifug.	Centrifug.	Floating Head Vaporizer	Floating Head Partial Condenser	Floating Head Partial Condenser	Kettle Reboiler	Floating Head Partial Condenser
Area, m^2	-	-	-	83.2	77.3	9.2	28.5	75.0
MOC	CS	CS	SS	CS	CS	CS	SS	CS
Design P, barg	10	2.2	2.2	10	2.2	2.2	2.2	2.2
Heat Duty (MJ/hr)	-	-	-	2,850	3,251	568	8,300	2,850
Utility	Electric	Electric	Electric	mps	cooling water	refrigerated water	mps	cooling water
Utility usage (kg/hr)	-	-	-	1,280	77,800	13,600	15,000	63,000
Shaft Power, kW	0.43	1.58	1.3					
Efficiency	40%	50%	75%					

Table 3b. Major Equipment Summary for Unit 400, continued

	V-401	V-402	V-403	T-401	T-402	R-401	H-401
Type	Horizontal	Vertical	Horizontal	Vertical	Vertical	Vertical	Fired Heater
Design P, barg	1.0	1.63	1.0	1.0	1.0	10	3.0
MOC	CS	CS	CS	CS	CS	SS	CS
Diameter, m	0.8	0.75	1.0	0.8	2.1	4.57	
Length, m	2.4	2.25	3.2	4.5	8.4	5.0	
Internals		SS Demister		3.5 m of Packing (1” Ceramic Rashig Rings)	9 Valve Trays	Fluidized bed containing 4.5m catalyst	Heat Duty = 3800 MJ/h Utility = natural gas = $111,000 per year