

Methanol Plant #494



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1. Executive Summary

1.1 Plant Capacity

- 380 metric tons per day or 130,000 metric tons per year
- Turndown ration 70%.

1.2 Plant History

- Plant was dismantled in 2015.
- Plant has been operated for only 5 months before shutdown. The reason of shutdown is the shortage of natural gas supply and the surging price of natural gas.
- Currently all the equipment is at a storage yard and ready for quick shipment.

1.3 Product Quality

- Refined methanol mass fraction: minimum 99.95%
- Mass fraction of water: 0.02%
- Density: 0.791 – 0.792 g/cm³

1.4 Raw Materials

- Natural gas (CH₄: 97.94%)
- Oxygen (O₂: 95%)
- Carbon dioxide (CO₂: 94.08%)

2. Process Description

The plant uses natural gas and carbon dioxide as feedstock. Steam required for reforming is produced by using the heat of flue and reformed gas. The process comprises the follow stages: (1) desulfurization (2) steam reforming (3) steam-oxygen reforming (4) methanol synthesis (5) distillation.

2.1 Desulfurization

A total Sulphur content of natural gas supplied to this plant is 16 mg/Nm³ maximum. Before enetering the reforming section Sulphur compounds are removed from process natural gas in two steps:

- Hydrogenation of organic Sulphur compounds (mercaptants, carbon sulfide, carbonyl sulphide, disulphides, thiophene) to hydrogen sulfide over aluminum-cobalt-molybdenum catalyst;
- Adsorption of hydrogen sulfide over zinc oxide.

The sulfur content after the desulfurization process is reduced to no more than 0.2 mg/Nm³

2.2 Steam Methane Reforming (Primary Reformer)

Methane and carbon dioxide react in the primary reformer over nickel catalyst at gas outlet temperature from the reaction tubes up to 800 °C at 3 MPa. Heat required for the process is supplied through the walls of the reformer reaction tubes by combustion of fuel gas. The steam to carbon ratio at reaction tubes shall be maintained within 3.34 – 3.35 (mole/mole) to obtain the required composition of gas mixture at reformer outlet. A volume fraction of residual methane at outlet of reaction tubes is 10.5 – 12% by volume on dry gas basis.

2.3 Steam Oxygen Reforming (Secondary Reformer)

The secondary reforming is to produce synthesis gas from steam/gas mixture leaving the primary reformer. In the upper zone of the secondary reformer an exothermic reaction of oxygen with combustible components takes place. At the same time both hydrogen and methane in the gas after the primary reformer are partially burned off. A volume fraction of the residual methane after steam-oxygen reforming is not higher than 1% by volume on dry gas basis. The reformed gas is compressed from 2.6 Mpa to 4.46 Mpa by a centrifugal synthesis gas compressor supplied by Demag-Siemens. The compressor is driven by a backpressure steam turbine.

2.4 Methanol Synthesis

Methanol synthesis is based on the reaction between carbon oxides and hydrogen as the following reactions:



The process uses copper-containing catalyst to ensure a high methanol yield at relatively low temperature of 200 – 250 °C. The methanol production starts at catalyst temperature of 190 °C. A high catalyst at such a low temperature ensures running of the methanol synthesis process under 5 Mpa pressure at a high rate. The optimal temperature for the copper-containing catalyst is 230 – 250 °C. During the early catalyst life, the operating temperature at the reactor inlet is 190 – 200 °C. A good heat removal from the reaction zone is achieved at relatively small amount of cold-shot gas being 22.72% during the early catalyst life and 30.32% at the end when no less than 95% carbon feedstock is consumed.

The gas leaving the methanol converter is cooled to 40 °C by a condenser. At the same time crude methanol formed in the converter is condensed. The cooled circulating gas, constituting a gas / liquid mixture, is sent to a separator where the crude methanol is separated from the circulating gas. The crude methanol is supplied to a let-down vessel from which it goes to the distillation section or to the crude methanol storage.

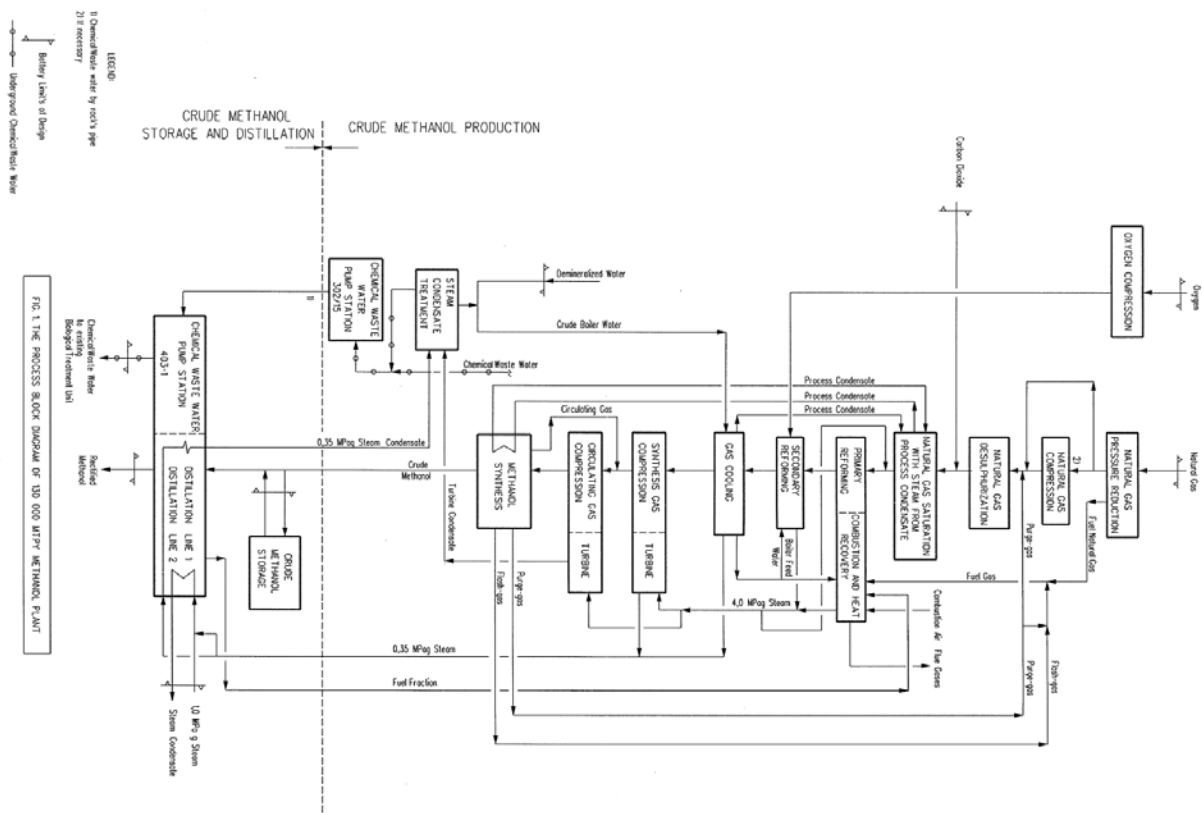
2.5 Distillation

The plant has two lines of distillation, each consisting of topping and refining process sections.

The crude methanol at 35 °C from the synthesis loop or storage after division to Line 1 or 2 is heated by heat exchangers and fed to the topping column. The heat required for topping process is provided by the steam supplied to the reboilers. The methanol overhead vapors leaving the column at 68 °C and containing highly volatile impurities are condensed and cooled in the condenser. The condensed methanol is drained to the distillate tank and uncondensed vapor is sent to another condenser for further condensation. Uncondensed gases containing methanol and highly volatile components are sent to the absorber for methanol recovery.

The topped methanol from the column after heat recovery is cooled down and delivered to the refining column. The methanol vapor leaving the refining column overhead is condensed in the air cooler and water coolers. The distillate is collected as reflux and to the refining column again. Uncondensed gases enter a condenser. The secondary methanol from the refining column is withdrawn from the reflux line and sent to the topping column. The refined methanol is taken from the column and cooled down to 35 °C, subject to cation-exchange filtering and sent to the storage.

3. Process Block Diagram



4. Consumption Data (per ton of refined methanol product)

No	Description	Units of meas.	Consumption per 1 t of refined methanol	Remarks
A	CONSUMPTIONS:			
1	Feedstock			
1.1	Natural gas:			
	- process	Nm ³	691,2	Q=8597 kcal/Nm ³
	- fuel	Nm ³	266,4	
	TOTAL:	Nm ³	957,6	
1.2	Oxygen, 95 %vol.	Nm ³	189,5	
1.3	Carbon dioxide CO ₂	Nm ³	94,76	
2	Utilities			
2.1	MP superheated steam P=2.5 MPa, t=240°C	t	0.0021	In start-up period
2.2	LP steam P=1.0 MPa, t=200°C	t	0.13	In winter time (6 months per year)
2.3	LP steam for distillation	t	0.25	
2.4	Cooling water			
	- crude methanol production	m ³	78.2	Δt=10°C Δt=7°C
	- distillation section	m ³	142.3	
	including: a) Unit 403	m ³	123.3	
	b) Unit 426	m ³	19	
	TOTAL:	m ³	220.5	
2.5	Electric power			
	- crude methanol production	kW	123.6	including 40.17 kW/1t for oxygen compressor K201
	- distillation section	kW	20.2	
	TOTAL:		143.8	
2.6	Demi-water	m ³	1.5	
3	Catalysts			
3.1	Sulphur compounds hydrogenation catalyst	kg	0.0215	
3.2	Hydrogen sulphide absorbent	kg	0.0667	
3.3	Reforming catalyst (primary reforming)	kg	0.0545	
3.4	Reforming catalyst			
	(secondary reforming)			
	- protective bed	kg	0.0111	
	- reforming catalyst	kg	0.0333	
3.5	Methanol synthesis catalyst	kg	0.1657	
B	PRODUCTION			
1	LP steam condensate P=1.0 MPa, t=200°C	t	0.13	In winter time (6 months per year)
2	LP steam condensate from distillation	t	0.25	

4. Equipment List

No.	No.	Item No.	Description	Quantity
			302/14 NG Preparation and Pressure Reduction	
1	1	H101	NG preheater	1
2	2	V101	NG fuel separator	1
3	3	V102	Process NG separator	1
4	4	L101/1,2	NG filters	2
			302/14. Desulphurisation	
5	1	V209A	Comox Vessel	1
6	2	V209	Zinc Oxide Vessel	1
			302/14. Saturation	
7	1	C101	NG saturator	1
8	2	P101/A,B	Circulating condensate pump	2
9	3	H103	Blow-down cooler	1
10	4	V104	Degasator	1
			302/03. Reforming	
11	1	F201	Primary reformer	1
			<i>Convection zone of primary reformer</i>	
12	2	H208	Steam/gas mixture heater	1
13	3	H209	Steam superheater	1
14	4	H210	WH boiler	1
15	5	H212	NG preheater	1
16	6	H213	Combustion air heater	1
17	7	V201	Secondary reformer	1
			<i>Integral equipment:</i>	
18	1	H201/A+F	WH boiler	1
19	2	H211	Steam superheater	1

No.	No.	Item No.	Description	Quantity
20	3	K202/A,B	Air fan	2
21	4	K203/A,B	Flue gas fan	2
22	5	S201	Flare stack	1
23	6	V206	Demiwater tank	1
24	7	P207	Demiwater pump	1
			302/03,07 Steam Generation System	
25	1	V211	Steam drum	1
26	2	V212	Blow-down separator	1
27	3	V213	Deaerator drum	1
28	4	V214	Deaerator dome (tray section)	1
29	5	H216	Blow-down cooler	1
30	6	P202/A,C	Circulating water pump	2
31	7	P204/A,C	BFW pump	2
32	8	W274	Underhung crane	1
			302(302B/13). Oxygen Compression	
33	1	K201	Oxygen compressor	1
			302/02. Gas Compression	
			Synthesis Gas and Circulating Gas Compression	
34	1	K401	Synthesis gas compressor	1
35	2	KT401	Backpressure steam turbine	1
36	3	K402	Circulating gas compressor	1
37	4	KT402	Condensing steam turbine	1
38	5	H402	Synthesis gas compressor aftercooler	1

No.	No.	Item No.	Description	Quantity
39	6	H403	Kick-back cooler	1
40	7	H404	Turbine steam condenser	1
41	8	H406	Condensate cooler	1
42	9	V409	Synthesis gas separator	1
43	10	P410A	Condensate pump with steam turbine	1
44	11	P410B	Condensate pump with el. motor	1
45	12	V418	Degasator	1
46	13	W419	Top-running bridge crane	1
47	14	H420	Ejectors steam condenser	1
			302/02 Compressor Oil System	
48	1	T408	Oil tank	1
49	2	T411	Degasator	1
50	3	P412	Lube oil pump with steam turbine	1
51	4	P413	Lube oil pump with el. motor	1
52	5	P414	Seal oil pump with steam turbine	1
53	6	P415	Seal oil pump with el. motor	1
54	7	H407/A,B	Oil coolers	2
55	8	L416/A,B	Lube and control oil filters	2
56	9	L417/A,B	Seal oil filters	2
57	10	T422/A,B,C	Oil traps	3
58	11	T423	Overhead tank	1
59	12	T424	Overhead tank	1
60	13	T425	Overhead tank	1
			302/02 NG Compression	
61	1	K101	NG compressor	1
62	2	H102	Kick-back cooler	1
63	3	V103	Separator	1
			302/02 Oil Unit	
64	1	T420/A,B	Oil tank	2
65	2	P421/A,B	Oil pump	2

No.	No.	Item No.	Description	Quantity
			302/04,07, 302(B3-4)/09 Gas Cooling	
66	1	H203/ A,B,C,D	BFW heater	4
67	2	H204	BFW heater	1
68	3	H206	BFW heater	1
69	4	H251	LP steam WH boiler	1
70	5	V252	Separator	1
71	6	H253	BFW heater	1
72	7	H255	Demiwater and treated steam condensate heater	1
73	8	H207	Aftercooler	1
74	9	H259	Process condensate cooler	1
75	10	H257	Air cooler	2
76	11	V254	Separator	1
77	12	V256	Separator	1
78	13	V258	Separator	1
79	14	V260	Degasator	1
80	15	P265/A,B	Process condensate pump	2
			302/07, 302(B3-4)/09. Common Shop Equipment	
81	1	H261	Fusel oil vaporizer	1
82	2	H262	Steam condensate cooler	1
83	3	T263	Condensate tank	1
84	4	T266	Demiwater & treated condensate tank	1
85	5	V605	Instrument air receiver	1
86	6	P206/A,B	Demiwater & treated condensate pump	2

No.	No.	Item No.	Description	Quantity
87	7	P264/A,B	Steam condensate pump	2
			302/05 Methanol Synthesis	
88	1	R601	Methanol converter	1
89	2	H602/A	Recovery heat-exchanger	1
90	3	H602/B	Recovery heat-exchanger	1
91	4	H603	Circulating condensate heater	1
92	5	H604/A,B	Air cooler	2
93	6	H605	Condenser	1
94	7	H606	Start-up steam preheater	1
95	8	V607	Crude methanol separator	1
96	9	T608	Crude methanol let-down vessel	1
97	10	T609	Drainage collection tank	1
98	11	L610/A,B	Crude methanol filter	2
99	12	L611/A,B	Crude methanol filter	2
100	13	P612	Submerged pump	1
			302/07. BFW Additives Preparation	
101	1	T268	Agitated ammonia solution preparation tank	1
102	2	T269	Agitated phosphate solution preparation tank	1
103	3	V270	Ammonia solution metering tank	1
104	4	V271	Phosphate solution metering tank	1
105	5	T273	Drainage collection tank	1
106	6	P203/A,B	Ammonia solution dosing pump	2
107	7	P267/A,B	Plunger-type phosphate solution dosing pump	2
108	8		Hydrazine hydrate station	1

No.	No.	Item No.	Description	Quantity
			302(403)/11 Distillation	
			Line No. 1	
			Topping Unit	
109	1	20	Topping column	1
110	2	21	Reboiler	2
111	3	22/1	Condenser	1
112	4	22/2	Condenser	1
113	5	23	Distillate tank	1
114	6	24/a	Crude methanol/bottoms exchanger	5 elements
115	7	24/b	Crude methanol/condensate exchanger	1
116	8	25	Topped methanol cooler	1
117	9	H151	Condenser	1
118	10	H152	Secondary methanol cooler	1
119	11	27	Hydraulic seal	1
120	12	29/1,2	Reflux pump	2
121	13	30/1,2	Topped methanol pump	2
122	14	35	External chamber	1
123	15	117/2	Topped methanol tank	1
124	16	122/3	Topped methanol pump	1
125	17	123	Topped methanol pump	1
126	18	K171	Absorber	1
			302(426)/11 Refining Unit	
127	1	K-521	Refining column	1
128	2	T-522/1,2	Reboiler	2
129	3	T-523/1,2	Air condenser	2
130	4	E-524	Distillate tank	1
131	5	T-525a	Topped methanol/bottoms exchanger	1
132	6	T-525b	Topped methanol/condensate exchanger	1
133	7	H-526/1,2	Reflux pump	2

No.	No.	Item No.	Description	Quantity
134	8	T-527	Refined methanol cooler	1
135	9	T-528	Fusel oil cooler	1
136	10	T-529	Condensate cooler	1
137	11	T-530	Methanol vapor condenser	1
138	12	E-531	External chamber	1
139	13	T-533/1,2	Condenser	2
140	14	203	Condensate tank	1
141	15	T170	Waste water tank	1
142	16	X-1	Hydraulic seal	1
143	17	H165	Methanol emergency discharge cooler	1
			Cation-Exchange Methanol Treatment	
144	1	200/1,2	Cation-exchange filter	2
145	2	201	Anion-exchange filter	1
146	3	204	Drainage collection tank	1
147	4	205	Submerged pump	1
148	5	206	Hydraulic seal	1
149	6	207	Hydraulic seal	1
			Line No. 2	
			302(403/11) Topping Unit	
150	1	40	Topping column	1
151	2	41/1,2	Reboiler	2
152	3	H168(42/1)	Methanol vapor condenser	1
153	4	T163(43)	Distillate tank	1
154	5	H164/a(44/a)	Crude methanol/bottoms exchanger	1
155	6	H164/b(44/b)	Crude methanol/condensate exchanger	1
156	7	X166(46)	Hydraulic seal	1
157	8	H154	Condenser	1

No.	No.	Item No.	Description	Quantity
158	9	H157	Topped methanol cooler	1
159	10	53/1,2	Reflux pump	2
160	11	T169(35)	External chamber	1
161	12	117/1	Topped methanol tank	1
162	13	122/1,2	Topped methanol pump	2
163	14	K172	Absorber	1
			302(403)/11 Refining Unit	
164	15	51K28	Refining column	1
165	16	51C29	Reboiler	2
166	17	42/2,3,4	Condenser	1
167	19	43	Distillate tank	1
168	20	44/a	Topped methanol/bottoms exchanger	2 elements
169	21	44/b	Topped methanol/condensate exchanger	2 elements
170	22	46	Hydraulic seal	1
171	23	48	Refined methanol cooler	1
172	24	50/1,2	Methanol fractions cooler	2
173	25	35	External chamber	1
174	26	H155	Condenser	1
175	27	H158	Bottoms cooler	1
176	28	52/1,2,3	Reflux pump	3
177	29	E-153	Paraffin settling tank	1
178	30	H167	Methanol emergency discharge cooler	1
			Caustic Solution Preparation Section	
179	1	90	Caustic solution dissolving tank	1
180	2	91	10% caustic solution tank	1
181	3	94/1,2	Caustic solution dosing pump	2
182	4	95/1,2	Caustic solution circulation pump	2

No.	No.	Item No.	Description	Quantity
183	5	96	Buffer tank	1
184	6	34	Condensate pump	1
185	7	P34	Condensate pump	1
			Steam distribution and condensate collection	
186	1	140	Flash tank	1
187	2	141	Condensate tank	1
188	3	H159	Steam condenser	1
189	4	P174/1,2	Condensate pump	2
190	5	P175/1,2	Condensate pump	2
191	6	81	Drainage collection tank	1
192	7	82	Drainage pump	1
193	8	H156	Condensate cooler	1
			302/16. Steam Condensate Treatment	
194	1	T501	Non-treated condensate balancing tank	1
195	2	T511	Reused acid water tank	1
196	3	T513	Reused alkali water tank	1
197	4	T515	Chemical waste water balancing tank	1
198	5	T517	Gravity chemical waste water collection pit	
199	6	P502/A,B	Non-treated condensate pump	2
200	7	P512	Reused acid water pump	1
201	8	P514	Reused alkali water pump	1
202	9	P516/A,B	Chemical waste water pump	2
203	10	P518	Submerged chemical waste water pump	1

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