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(i) Expand the table of section 5. "Pop up explanations for change in consumption and costs"

A) Increased specific consumption or cost list

#	Reason for increased energy consumption, kWh/ unit output	Reason for increased energy cost, Rs./unit output
1	**Increase in forced outages**	**Fuel cost increased**
1a)	Tripping of compressor/ pumps	Lower calorific value
1 b)	Reformer tube failure	
1 c)	Other mechanical equipment problems	
1 d)	Power failure	
1 e)	Instrument problems	
2	**Increase in scheduled outages**	**Specific consumption increased**
3	**Reduction in output due to lack/ shortage of fuel**	
3 a)	Inadequate supply	
3 b)	Gas supply of lower calorific value	
4	**Reduction in output due to lack/shortage of feed material**	**Credit for exported energy source decreased**
4 a)	Gas supply inadequate	-- for steam export
4 b)	Gas supply of lower calorific value	-- for power
5	**Reduction in output due to equipment constraints**	**Costlier Supplementary fuel/ feed supply used to sustain production**
5 a)	One MUG compressor under maintenance	
5 b)	Cooling water circulation reduced due pump/ fan under maintenance	
5 c)	VAHP Chiller unit not in line	
6.	**Increase in Energy consumption due to**	**Higher handling losses of fuel and feedstock during transportation**
6 a)	Higher steam to carbon ratio in reformer	
6 b)	Deterioration in catalyst activity	
6 c)	Deterioration of insulation of furnaces, heat exchangers etc.	
6 d)	Lower efficiency of compressors, turbines, pumps etc.	
6 e)	Advanced Process Control System not in line	

6 (f)	CO_2 as feed not available disturbing $H_2/(CO+CO_2)$ ratio	
6 g)	Higher supply of exceess air to combustion reformer fuel	
7	**Utility related problems**	
7a**)**	Lower voltage of power supply	
7 b**)**	Lower power factor	
7 c)	Steam leakages	
7 d)	Poor functioning of steam traps	
7 e)	Leakages in compressed air	
7 f)	CW supply temperature high	
8	**Reduction in output due to high inventory for following reasons**	
8 a)	**-** reduced market demand	
8 b)	**-** transportation problems such as transporters' strike, floods etc.	

B) **Decreased Specific Consumption or Cost List**

#	**Reasons for decreased energy consumption, kWh/Unit**	**Reason for decreased energy cost, Rs./unit output**
1	**Improvement in efficiency due to jobs done during planned outage**	**Fuel cost decreased**
1 a)	Turbine	Cheaper alternate source of fuel used
1 b)	Compressors	Use of non-conventional energy source as a part replacement of fuel/ utilities
1 c)	Furnaces	
1 d)	Heat exchangers	
2	**Continuous uninterrupted operation at optimum load**	**Continuous uninterrupted operation at optimum load**
3	**Reduced Utility Losses by attending--**	**Reduced specific energy consumption**
3 a)	-- Steam traps	
3 b)	--- Insulation	
3 c)	-- leakages in compressed air	
4	**Fuel/ feed of higher calorific value**	**Fuel of higher calorific value**
5.	**Lower CW temperature**	**Reduced cost of utilities purchased**
5 a)		Control of maximum demand of power purchased
		Improvement in Power factor
6.	**Better Process control through**	**Credit at higher rate for energy exported**
6 a)	Advanced process control system to optimize plant operating parameters	For steam
6 b)	Replacement of catalyst	For power
		Other (to be specified)
7	**Measures taken as a result of energy audit**	**Output product mix optimized to use energy resources**

6 a)	Equipment installed to recover waste heat	
6 b)	Equipment/ instruments installed to improve efficiencies	
8	**Modernization/ Upgradation/ debottlenecking of Plant**	
8 a**)**	Replacement of inefficient equipment/ machines with efficient ones	
8 b)	Revamping to incorporate latest technology	
8 c)	Debottlenecking to improve production and reduce energy consumption	

(ii) Submit for a real case the appropriate graph for the year 2003/04 with explanations. (A separate file in Excel spreadsheet attached)

A real case based on actual energy consumption of Methanol Plant of RCF, Trombay Unit for the year 2003/04 is presented below.

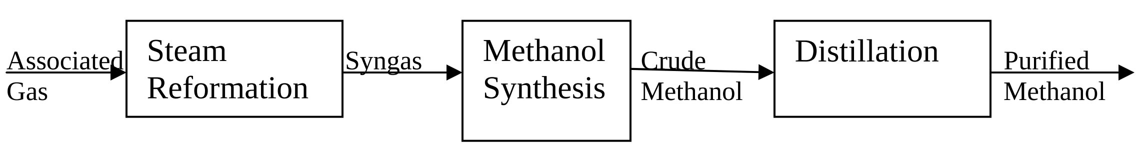
Introduction

RCF, Trombay Unit is having more than 35 year old Methanol Plant with a name plate capacity of 150 MTPD. Initially when installed it had specific energy consumption of 16 Gcal/MT of methanol. However, over the years RCF upgraded the technology and reduced energy consumption to the level of 8.90 Gcal/MT and all efforts are made to reduce it further.

Process

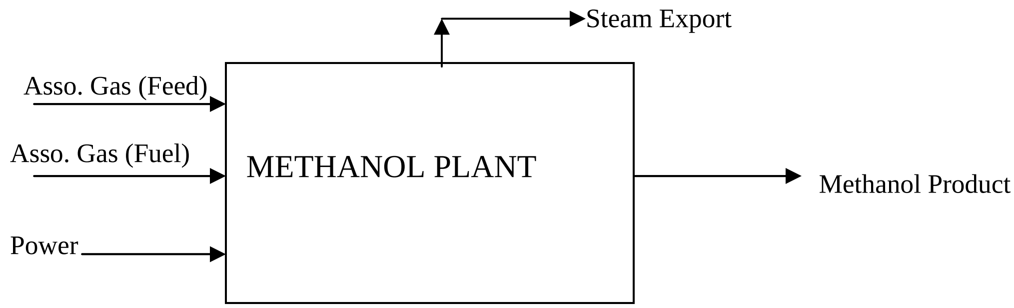
RCF Methanol plant uses gas steam reformation technology for the production of synthesis gas, which is further processed in the Low Pressure Methanol synthesis section to produce crude methanol. The crude methanol is further purified in the distillation section to obtain the desired quality for commercial sale.

For steam reformation, associated gas mainly consisting of methane is used as feedstock and fuel in the Reformer. Other main input is electric power required to run Make Up Gas Compressors and recirculators and pumps in the plant. The surplus steam produced from flue gas waste heat and Reformed Gas Waste Heat Boiler is exported to other plants like Methylamines, ABC etc. A block diagram of Methanol is given below:



Energy Consumption

It is customary to calculate energy consumption of plants like Methanol and Ammonia, which use associated / natural gas or naphtha as feedstock and fuel on the basis of NCV of the energy source. However, as required for aggregated data reporting, energy consumption unit of kWh based on GCV has been used. Therefore, the available data is corrected to bring in required format. A block diagram indicating plant boundary of energy source in the form of feedstock, fuel and utilities is shown below:



Explanations for Reasons of Variation in Specific Energy Consumption

1. Methanol production process is energy intensive process. Therefore, a number of factors affect the specific energy consumption. The Reformer operates at high temperature at about 850 to 1000 ^{o}C and the reformation reaction being endothermic external heat by burning fuel is required to be supplied. Therefore efficiency of the reformer is an important factor. Waste heat recovery from hot flue gases is made by generating steam, heating combustion air and BF Water.

2. The quality of associated gas is judged by its methane content. If the gas is more in methane content (more than 94% or specific gravity less than 0.60) it is considered as lean gas. If the methane content is less than 94% or specific gravity more than 0.60 it is considered as rich gas i.e. richer in higher hydrocarbons. The lean gas contains more hydrogen in its composition. As the flue gas temperature is above 150^{0} C, the latent heat of water formed is not recovered. Therefore, the specific fuel requirement is more in case of lean gas.

   Also, in case of lean gas used as feed, the reformed gas containing hydrogen, carbon monoxide and carbon dioxide is required to supplement with carbon dioxide to adjust the ratio of H_2 to ($CO+CO_2$) to optimize the conditions in the synthesis of methanol. Additional energy is required to compress external supplementary CO_2 available at low pressure (0.40 Kg./cm$^{2)}$ to about 11kg/cm^{2}. Therefore, in case of lean gas the specific energy requirement is more than that in case of rich gas.

3. Methanol plant is a continuous process plant. Any interruption results in energy loss due to energy loss in bringing back the plant to normal condition. In case of interruption in methanol production due to tripping of MUG Compressors, the energy loss is comparatively less as compared to that from tripping of reformer/ front end of the plant. In case of unplanned outage of reformer, energy is lost while taking shut-down as well as start-up. Normally, once in a year a planned shut-down is taken for annual maintenance of equipment and replacement of catalyst, wherever required. To bring the plant into normal production after annual shut-down, it takes about 36 to 40 hours during which un-productive energy is used. Various reasons for the planned and unplanned shutdown are categorized under the sub-head.

4. Many times constraints are faced in operating the plant at full capacity due to non-availability of sufficient gas from GAIL/ONGC. This results in lowering the load of the plant. At lower load the efficiencies of the equipment are less and also utilities such as cooling tower are fully in operation, which contributes to higher specific energy consumption.

5. Sometimes, due to maintenance of one MUG compressor, the plant production is affected and it results in higher energy consumption.

6. Problems in Vapour Absorption Chilling unit requires to reduce the load of the plant to limit MUG Compressor power consumption within rated value. It contributes to increase in power consumption.

7. For the control of operating parameters at optimum conditions, Advanced Process Control (APC) based on MVC is installed. This gives a benefit of about 1 to 1.50% in specific energy consumption. When APC is not in line the specific energy consumption goes up to that extent.

8. The ageing of the catalyst affects specific energy consumption. The process parameters such higher steam carbon ratio in case of primary reformer catalyst, higher temperatures in case of methanol synthesis catalyst are required to be maintained. The catalyst ageing results in lower production. All these factors results in higher specific energy consumption.

9. .Utility related problems such as lower frequency /electricity voltage requires the plant to reduce load. It results in extra energy consumption. Steam leakages, passing of steam traps, venting of unutilized steam, poor insulation increase specific energy consumption.

10. It is observed that CW temperature affects the specific energy consumption. Lower the CW temperature, less is the power consumption in compressors due to lower gas temperature after intercoolers.

Explanations for Variation in Specific Cost of Production

1. GAIL/ ONGC sells the associated/ natural gas at a price fixed by the Government. The price per 1000 sm^3 is applicable for the gas with10,000 Kcal/ sm^3 (NCV). There are some price components like Royalty, transportation charges, which are fixed irrespective of calorific value of gas. The gas price is adjusted on the basis of calorific value of the gas actual supplied. The adjustment is for the variable portion of the price. It results into higher cost of gas if the gas is lean (more in methane content). Also, the lean gas contributes to higher specific energy consumption. Therefore, the specific cost of production is more in case of lean gas as compared to that with rich gas. It can be seen that in Feb. 2004, the specific cost of production reduced sharply when the gas supplied was rich.

2. Whenever, an augmentation of fuel and/ or feed is required with supplementary energy resource, which is costlier to sustain the production at higher level, it will increase the specific cost of production.

3. There is no further additional explanation required to state that increase in specific energy consumption increase the specific cost of production.

4. The power rate charged by TATA Power depends on their generation cost. Also, it is seen that with the proper control over Maximum Demand, the rate of power can be reduced. It can be seen that the rate per MWh varies from Rs. 3115 to 4189.

5. The credit given to steam export depends on the cost of production of steam in captive boilers. If the cost of production is higher, the credit to steam export is given at higher rate.

6. All the energy resources like gas and power received by the company have to be accounted for. If the energy resources distributed to plants are less than the resources received as per custody transfer meters, the unaccounted resources are distributed to energy consuming plants. This increases specific cost of production.

			Methanol Plant- Energy Data 2003-04									
Production,	**3170**	**5205**	**5020**	**3850**	**4870**	**4160**	**5260**	**4285**	**5265**	**5323**	**4970**	**5312**
Specific Energy Consumption	**April**	**May**	**June**	**July**	**August**	**Septembe**	**October**	**Novembe**	**December**	**January**	**February**	**March**
A Gas(Feed), 000 SM3	0.649	0.641	0.66	0.655	0.67	0.674	0.668	0.668	0.664	0.646	0.574	0.616
A Gas(Fuel), 000 SM3	0.306	0.304	0.303	0.322	0.308	0.317	0.3	0.306	0.3	0.291	0.258	0.304
A Gas (Total), 000 SM3	0.955	0.945	0.963	0.977	0.978	0.991	0.968	0.974	0.964	0.937	0.832	0.92
NCV of Gas, Kcal/SM3	8635	8346	8269	8241	8204	8254	8257	8287	8303	8420	9225	8599
Energy(NCV) from AG,Mkcal	8.246425	7.88697	7.963047	8.051457	8.023512	8.179714	7.992776	8.071538	8.004092	7.88954	7.6752	7.91108
GCV, Kcal/sm3	9567	9237	9176	9146	9106	9159	9163	9195	9212	9333	10195	9528
Energy(GCV) from gas, Mkcal	9.136485	8.728965	8.836488	8.935642	8.905668	9.076569	8.869784	8.95593	8.880368	8.745021	8.48224	8.76576
Power, MWH	0.546	0.52	0.511	0.551	0.531	0.539	0.513	0.552	0.527	0.509	0.516	0.558
Steam Export, MT	-0.674	-0.822	-0.819	-0.883	-0.796	-0.864	-0.786	-0.814	-0.836	-0.831	-0.847	-0.839