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TOM Reel 43
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U. S. Bureau of Mines
Hydro. Demon. Plant Div.

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OPERATION COSTS IN THE SYNTHESIS GAS PRODUCTION IN RHEINPREUSSEN

The operating costs were computed on the strength of the heat flow sheet of the Treibstoffwerk Rheinpreussen of 7-6-42 and the computations made from it by Mr. Schürhoff on 7-13-42.

1. Computation of operation costs of a water gas installation with 10 producers of 6000 m^3 hourly capacity = 60,000 nm^3 water gas/hour, or 1,440,000 nm^3 water gas/day.

Expense per day:

1.	Coke, $\frac{1,440,000}{1440}$ = 1000 te, @ RM 20.-	RM 20,000.-
2.	75 labor shifts, @ RM 12.-	RM 900.-
3.	Power $\frac{25 \times 1,440,000}{1000}$ = 36,000 kwh @ RM 0.02	RM 720.-
4.	Circulating water $\frac{17 \times 1,440,000}{1000}$ = 25,000 m^3 @ RM 0.02	RM 500.-
5.	Make-up water, 10% of circulating water = 2,500 m^3 @ RM 0.02	RM 50.-
6.	Feed water, 1,800 m^3, @ RM 0.20	RM 360.-
7.	Steam, 3 atm, 1,700 te @ RM 1.50	RM 2,550.-
8.	Amortization, interest and maintenance 12 + 5 = 17% on 12,150,000	RM 5,750
	Total expense, per day	RM 30,830.-

Receipts per day:

1.	Steam, 16 atm, 1,440 te, @ RM 3.- =	4,320
2.	Steam, 3 atm, 325 te, @ RM 1.50 =	487
	Total receipts per day =	RM 4,807.-
	Operating costs, incl. capital service and maintenance	RM 26,023.-

Operating costs/nm^3 water gas $\frac{2,602,300}{1,440,000}$ = 1.818 pfg

Operating costs/nm^3 CO + H_2 : $\frac{1.818}{87.22}$ = 2.075 Pfg

Rheinpreussen uses RM 17.50 as the price per te of coke. This reduces the operating costs per day to RM 23,523, or

per nm^3 water gas to	Pfg 1.635, and
per nm^3 CO + H_2	Pfg 1.875

II. Estimation of operating costs of a gasification plant for fines with 5 producer units of 12,000 nm^3 hourly capacity = 60,000 nm^3 water gas per hour, or 1,440,000 nm^3 water gas per day.

Expenses per day:

1.	Coal $\frac{1,440,000}{2,700}$ = 533 te,	@ RM 14.-	RM 7,460.-
2.	Oxygen, 1,440,000 x 0.17 = 245,000 nm^3	@ 0.025	6,125.-
3.	51 labor days, @	@ RM 12.-	612.-
4.	Power $\frac{25 \times 1,440,000}{1000}$ = 36,000 kwh	@ 0.02	720.-
5.	Circulating water $\frac{17 \times 1,440,000}{1000}$ = 25,000 m^3	@ 0.02	500.-
6.	Make-up water, 10% of circ. water	@ 0.02	50.-
7.	Feed water, 650 m^3	@ 0.20	130.-
8.	Fuel gas, 485 x 10^6 kcal	@ 4.50	2,183.-
9.	Steam, 3 atm, 576 te	@ 1.50	865.-
10.	Amortization, interest and maintenance, 12 + 2% = 14% on RM 9,000,000		3,450.-
	Total expense, per day		RM 22,095.-

Receipt per day: (No. carried from Pg.1) 22,095.-

Steam, 16 atm, 625 te @ RM 3.- 1,875.-
Operating costs, includ. capital services and maintenance. 20,220.-

Operating costs per nm^3 water gas $\frac{2,022,000}{1,440,000}$ = Pfg 1.405

Operating costs per nm^3 CO + H_2 $\frac{1.405}{83}$ = Pfg 1.69

III. Estimate of operating costs of a gas reforming plant for 10,000 nm^3 coke oven gas = 16,000 nm^3 reformed gas per hour = 356,000 nm^3 reformed gas per day.

Expenses per day

1.	Coke oven gas, 240,000 nm^3	@ RM 0.017	RM 4,080
2.	Fuel gas, 232 x 10^6 kcal	@ 4.50	1,045
3.	9 man-days	@ 12.-	108
4.	Power, $\frac{15 \times 386,500}{1000}$ = 5800 kwh	@ 0.02	116
5.	Circulating water, $\frac{18 \times 386,500}{1000}$ = 7000 m^3	@ 0.02	140
6.	Make-up water = 10% of circ. water	@ 0.02	14
7.	Steam, 3 atm, 175 te	@ 1.50	263.
8.	Amortization, interest and maintenance 12 + 2% on 2,000,000 =		767.-
	Operating costs, including capital services and maintenance		6,533.-

Operating costs per nm^3 reformed gas, $\frac{653,300}{386,500}$ = Pfg. 1.69

Operating costs per nm^3 CO + H_2 $\frac{1\ 690}{85.36}$ x 100 = 1.98

Rheinpreussen figures the price of coke oven gas of 1.3 Pfg per nm^3, corresponding to 0.336 Pfg per 1000 kcal.

Should this value be used in the estimate of operating costs, for coke oven gas or fuel gas, the operating costs per day, including capital services and maintenance will amount to RM 5,409.-,

$$\text{or, per } nm^3 \text{ of reformed gas } \frac{530,600}{386,600} = 1.376 \text{ Pfg.}$$

$$\text{per } nm^3 \text{ of } CO + H_2 \qquad \frac{1.376}{83.56} = \text{Pfg } 1.61$$

The operating costs in the above computations were determined with the inclusion of capital services and maintenance, and were:

per nm^3 water gas from coke
per nm^3 water gas from powdered coal
per nm^3 reformed coke oven gas.

Below are given the costs of synthesis gas obtained by mixing of water gas obtained from coke or from powdered coal with the reformed gas from coke oven gas.

A). Synthesis gas with water gas from coke:

65% water gas	+ 35% reformed gas	= 100% synthesis gas
CO_2 7.39%	5.12%	6.50%
O_2 0.17	0.12	0.15
CO 36.69	14.60	29.00
H_2 50.53	70.76	58.00
CH_4 0.37	1.90	1.00
N_2 4.85	7.50	5.35

With a coke price of RM 20.- per to and a coke oven gas price of Pfg 1.7 per nm^3, the cost of synthesis gas will figure to:

$$0.65 \times 1.81 + 0.35 \times 1.69 = \text{Pfg } 1.769 \text{ per } nm^3 = \text{Pfg } 2.035 \text{ per } nm^3 \text{ } CO + H_2$$

With a coke price of RM 17.50/to and a coke oven gas price of Pfg. 1.3/nm^3, the cost of the synthesis gas will figure to:

$$0.65 \times 1.635 + 0.35 \times 1.375 = \text{Pfg. } 1.543/nm^3 = 1.775/nm^3 \text{ } CO + H_2$$

B). Synthesis gas from powdered bituminous coal.

	70% water gas	+ 30% reformed gas	= 100% synthesis gas
CO_2	16.0%	5.12%	12.70%
O_2	-	0.12	0.04
CO	34.0	14.60	28.00
H_2	49.0	70.76	56.00
CH_4	-	1.90	0.56
N_2	1.0	7.50	2.70

With the price of coke oven gas of Pfg. 1.7 nm^3, the cost of synthesis gas will figure to

$0.70 \times 1.405 + 0.30 \times 1.690 =$ Pfg $1.487/nm^3$ = " $1.770/nm^3$ per nm^3 $CO+H_2$

With the coke oven gas at Pfg $1.3/nm^3$, the synthesis gas figures to

$0.70 \times 1.405 + 0.30 \times 1.375 =$ Pfg $1.392/nm^3$ = " $1.660/nm^3$ per nm^3 $CO+H_2$

IV. Estimation of powdered coal producer installation with 5 producer units of 12,000 nm^3 hourly capacity for the direct production of synthesis gas with the proportion of $CO : H_2 = 1:2$, total 60,000 nm^3 synthesis gas per hour, or 1,440,000 nm^3 synthesis gas per day.

Expense per day:

1.	Coal $\frac{1,440,000}{2800} = 514$ te	@ Rm 14.-	Rm 7,200
2.	Oxygen $1,440,000 \times 0.16 = 230,000$ nm^3	@ 0.025	5,750.-
3.	51 man-days	@12.-	612.-
4.	Power $\frac{25 \times 1,440,000}{1000} = 36,000$ kwh	@ 0.02	720.-
5.	Circulating water $\frac{17 \times 1,440,000}{1000} = 25,000$ m^3	@ 0.02	500.-
6.	Make up water, 10% of circul. water	@ 0.02	50.-
7.	Feed water, 720 m^3	@ 0.20	144.-
8.	Fuel gas, 547×10^6 kcal	@ 4.50	2,460.-
9.	Steam, 3 atm, 662 te	@ 1.50	994.-
10.	Amortization, interest, maintenance, 12 + 2 = 14% on RM 9,000,000		3,150.-
	Total expense per day		Rm 21,880.-

Receipts per day:

	Steam, 16 atm., 700 te	@ 3.00	2,100.-

Operating costs, including capital services and maintenance 19,780.-

Operating costs per nm^3 synthesis gas $\frac{1,979,000}{1,440,000}$ = Pfg. 1.370

Composition of synthesis gas:

CO_2	18%
CO	27%
H_2	54%
N_2	1%

Operating costs per nm^3 CO + H_2 = $\frac{1,370}{81}$ = Pfg. 1.690

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