OPERATING BALANCE OF KOPPERS POWDERED COAL GENERATOR

Gasification test on Bituminous Coal Dust at Rheinpreussen Mine.

Analysis of dust

H_2O	1.95%
Ash	8.75
H_2	4.27
Pure C	80.50
Sulfur used	1.88
N_2	1.19
O_2	1.46
	100.0

Upper heating value 7977 h.u./kg

Lower heating value 7744 h.u./kg

Analysis of produced synthesis gases (test values)

CO_2	15. %
CO	42.
H_2	42.
N_2	1.
	100.0

Upper heat value 2550 h.u./kg

Lower heat value 2347 " "

Gas yield (94% gasification)

$$\frac{(.805 \times .94)\ \frac{\text{kg C gasified}}{\text{kg coal}}}{\left(.57\ \frac{m^3/C}{m^3\ \text{gas}} \times .536\ \frac{\text{kg C}}{m^3 C}\right)} = 2.47\ m^3/\text{kg dust}$$

H_2 Balance

H_2 in product gas $2.47 \times .42\ \frac{m^3 H}{m^3 \text{gas}} = 1.038\ m^3/\text{kg dust}$

H_2 from feed powdered coal $0.427 \div 0.09 = .475$

H_2 from decomposed steam .563

Undecomposed steam at K = 2.34 at

1200° C. $2.34 \times \frac{.15 \times .42}{.42} \times 2.47 = .868$

Steam req'd 1.431

Steam from raw powdered coal 0.0195/0.81 .024

Actual req'd steam 1.407

Steam decomposition based on additional steam

.563/1.431 39.3%

Steam decomposition based on H_2 content in gas produced .42/(.420 + .351) 54.3%

Oxygen Balance

O_2 in gas produced $(0.15 + \frac{.42}{2}) \times 2.47 = 0.890 \frac{m^3}{kg}$

~~O_2 from decomposed steam 0.563 ÷ 2 = 0.268~~

Additional O_2 required 0.622

Additional O_2 per unit synthesis gas

$0.622 \div 2.47 = 0.252 \frac{m^3}{m^3}$

Heat Balance

Input

Coal: 1 kg	Ho =	7977 h.u.	
Steam: $\frac{1.407 \times 0.81 \times 600}{1.407 \times 0.422 \times 1200}$		685 h.u. 712 h.u.	steam used in process excess steam
		9374 h.u.	

Output

2.47 m^3 synthesis gas x $\frac{2347}{}$	=	5800 h.u.
diff. Ho - Hu 2.47 x 203		510 h.u.
undecomposed steam		
0.868 x .81 x 600		422 h.u.
~~0.868 x .822 x 1200~~		~~439 h.u.~~
C-loss 0.06 x 0.805 x $\frac{8000}{}$		397 h.u.
Sensible heat in Product gas		
2.47 x 0.37 x $\frac{1200}{}$		1095 h.u.
Radiation + line loss		711
		9374 h.u.

~~711/7744 x 100 = 9.2 % loss on 1 kg powdered coal~~

Steam produced and used.
There is available for steam production:

1095 + 439 =	1534 h.u.

Waste heat loss:

0.868 x 0.367 x 300 = 96	
2.470 x 0.330 x 300 = 244	
	340 h.u.
	1194 h.u.

Heat absorption in waste heat boiler:

Steam production 1194 x .9 =	1075 h.u.
Steam consumption (1.05 kg at 3 ats)	-685 h.u.
Excess steam (0.52 kg at 16 ats, 350° C)	390 h.u.

Fuel required:

Preheat 1.407 m^3 steam to 1200° C	712 h.u.
Heat exchange loss (eff = 80%)	178 h.u.
Total fuel required	890 h.u./kg coal dust

Total Efficiency

$$\frac{5800 + 390}{7744 + 890} = 72.5\%$$

Gasification eff.

$$\frac{5800}{7744} = 75\%$$

Summary of Consumption + Production Figures

Quantity of powdered coal	1 kg
Synthesis gas produced	247 m^3
Upper heating value of gas produced	2347 h.u./m^3
Conc. of CO + H_2 in gas produced	84 %
Fuel per kg dust	890 h.u.
O_2 consumption 0.252 m^3/m^3 Sy. gas =	.622 m^3/kg dust
Excess steam production (16 ats, 350°) =	.52 kg
Inlet temperature (preheat) =	1200° C
Steam consumption covered by ann. prod (3 ats) =	1.05 kg
Outlet temp. of product gas after gasific.	1200° C

Gasification Test of Powdered Brown Coal from the Rheinpreussen Mine.

Analysis of the raw powdered coal:

Water	13.00%		
Ash	5.18%		
Pure C	56.20%	Upper Heat Value	5313 h.u.
H_2	4.71%	Lower " "	5120 h.u.
S^2 by combustion	0.33%		
O + N	20.58%		

Analysis of gases produced: (80% concentration)

CO_2	19.0%		
CO	35.0%	Upper heat. val.	2430 h.u.
H_2	45.0%	Lower " "	2214 h.u.
N_2	1.0%	difference	216 h.u.

Amount of gas: 1.84 nm^3/kg raw powdered coal

C gasification:

$$\frac{1.84 \times 0.536 \times 0.54}{0.562} = 95\%$$

H_2 balance

H_2 in gas produced:	0.450	nm^3/nm^3
H_2 from raw powdered coal	0.284	nm^3/nm^3
H_2 from steam:	0.166	" "
Decomposed steam:	0.166	" "

O_2 balance:

O_2 in the gas 0.365 nm^3/nm^3

O_2 in raw coal: $\frac{0.20}{1.43 \times 1.84} = 0.076$

O_2 from steam: $\frac{0.166}{2} = \frac{0.083}{0.159}$ nm^3

O_2 from outside sources $\frac{}{0.206}$ "/nm^3 synthesis gas

$0.206 \times 1.84 =$ 0.379 nm^3/kg powdered coal

Steam Requirements:

Decomposed steam: $0.166 \times 1.84 = 0.304$ nm^3/kg raw coal

Undecomposed steam, k = 1.6 (1000° C)

$$1.6 \times \frac{0.19 \times 0.45}{0.35} \times 1.84 = 0.716 \text{ nm}^3\text{/kg raw coal}$$

Steam required 1.020 nm^3/kg raw powdered coal

Steam from moisture in combustible $\frac{0.13}{0.81} = 0.160$ nm^3/kg powd. coal.

Steam from outside x 600 = 0.860 " " " "

Decomposition of steam $\frac{0.304}{1.020} = 30\%$

Heat Balance

Brought in:

1 kg powdered raw coal u.h.v.	5313	h.u.
steam: $0.86 \times 0.81 \times 600 =$	417	" "
$0.86 \times 0.422 \times 1200 =$	434	" "
	6164	heat units.

Produced:

~~1.84 nm^3 s.y. gas x 2214 =~~	4076	" "
diff. upper and lower h.u.:		
1.84×216 =	397	" "
undecomposed steam:		
$0.716 \times 0.81 \times 600$ =	348	" "
$0.716 \times 0.41 \times 100$ =	293	" "
Sensible heat of prod. gas:		
$1.84 \times 0.366 \times 1000$ =	225	" "
Radiation and conduction loss=	151	" "
	6164	h.u.

$\frac{151}{5120} \times 100 = 2.95\%$, referred to 1 kg raw powdered coal

Produced and consumed amounts of steam:

Available for steam production: 674 + 293	967 h.u.
Waste heat: 0.716 x 0.361 x 300 = 79 h.u. 1.840 x 0.330 x 300 = 182 " "	261 " "
Taken up from heat boilers	706 " "70 h.u.
Steam production: 3 atm = $\frac{706 \times 0.9}{651.2}$ = 0.97 kg =	636 " "less
Steam consumption: 3 atm = $\frac{417}{651.2}$ = 0.64	417 h.u.
Excess steam: 3 atm 0.33	219 " "
Fuel Requirements:	
Preheating: 0.860 nm^3 steam to 1200° C	434 " "
Producer losses:(= 75%)	145 " "
Fuel to be supplied:	579 h.u./kg raw powdered coal

Total efficiency: $\frac{4076 + 219}{5120 + 579}$ = 75.5%

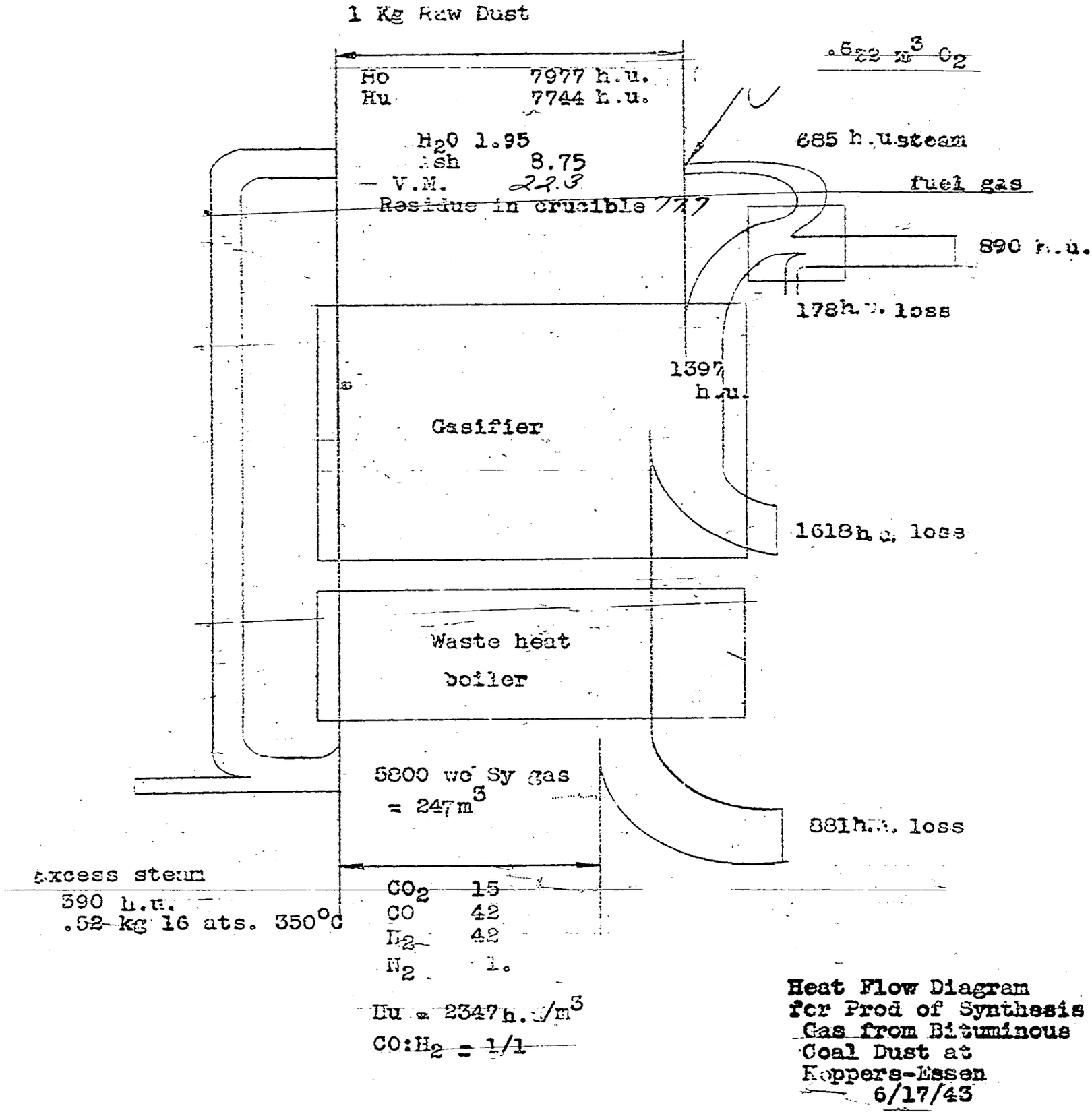
Gasification efficiency: $\frac{4076}{5120}$ = 79.6%

Summary of Consumption and Production figures:

Raw powdered coal:	1 kg.
Sy gas produced:	1.84 nm^3
lower h.v./nm^3 gas produced:	2214 h.u.
Concentration CO + H_2	80%
Fuel to be supplied per kg raw powdered coal	579 h.u.
O_2 consumption: 0.206 nm^3/nm^3 =	0.379 nm^3/kg raw powdered coal
Steam production, 3 atm	0.97 kg.
Steam consumption, 3 atm	0.64 kg
Excess steam, 3 at.	0.33
Intake temperature (preheating)	1200° C
Outlet temperature of the producer gas (v. heat flow sheet I.O.S. 178,467)	1000° C

/s/ for Heinrich Koppers, G.m.b.H.
illegible.

W.M. Sternberg
12/13/46



Heat Flow Diagram for Prod of Synthesis Gas from Bituminous Coal Dust at Koppers-Essen
6/17/43