Ammoniakwerk Merseburg Kama

Claus Ofen Betrieb
Claus oven operation

Original German Document

Hydrogen Sulfide Schwefelwasserstoff		m^3/h	1100 – 1500
Air Wind Blast		"	1760 – 2400
Spül-CO_2 Wash-CO_2		"	495 – 520
Einspritzwasser oben Water spray above		l/h	60 – 90
" unten " below		"	360 – 425
Vor Filter: Before filter			
	H_2S	%	1,38 – 2,15
	SO_2	%	0,46 – 0,64
Nach Filter: After filter			
	H_2S	%	1,13
	SO_2	%	0,69
Pressures before (Drucke) vor) Kontakt I		mm WS	480 – 730
Zwischenboden Intermediate		"	360 – 570
Multiklon B		"	330 – 530
" A		"	270 – 420
nach Kont. II		"	270 – 420
Ofen Ausgang Oven exit		"	180 – 290
after nach H_2S-Gebläse H_2S blower		"	1600 – 1710
after " Wind-Gebl. Air blower		"	1500 – 1600
Wash Tower Waschturm B.		"	160 – 260
" " " A.		"	160 – 260
Temperaturen Temperatures			
Kessel Ausgang Boiler Exit		°C	280 – 300
Before, (Vor) Kontakt I		"	275 – 295
In (in) " I		"	345 – 355
Under unter Rost I Grate I		"	330 – 345
Multiklon Eingang Entrance		"	280 – 295
" Ausgang Exit		"	255 – 270
Before (Vor Kontakt II		"	255 – 260
In (in) " II		"	270 – 280
Under unter " II		"	270 – 290
Under unter Rost II Grate II		"	270 – 285
Liquid Schwefel flüssig Sulfur		"	150 – 155
Oven Ofen Ausgang Exit		"	155 – 150
Filter (Eingang) Entrance		"	140 – 155
" (Ausgang) Exit		"	140 – 150
CO_2		"	172 – 174
Einspritzwasser Water Spray		"	136 – 147
Under steam superheater Dampfüberhitzer unten		"	420 – 460
Water lower preheater below Wasser unterer Vorwärmer unten		"	315 – 355
Water top preheater below " oberer Vorwärmer unten		"	305 – 325

Abhitzekessel – Anlage Waste heat boiler – Installation

Feed water pressure before regulator Speisewasserdruck vor dem Regler		atü	18,5 – 19,5 atmospheres
Temp. before preheater Temp. vor dem Vorwärmer		°C	120 – 160
" after " nach " "		"	170–202
Steam press. in boiler Dampfdruck im Kessel		atü	14,5 – 16,0 atmospheres
Temperature		°C	325 – 365
Menge Mass quantity		t/h	1,5 – 2,2

	Hydrogen Sulfide Schwefelwasserstoff	Boiler burner Kesselbrenner	m^3/h	500 - 600
	Aux. burner Hilfsbrenner		"	20
	Wind Air	Kesselbrenner	"	825 - 1010
		Hilfsbrenner	"	40
Water spray	Einspritzwasser	Ofen 1 a Oven 1a	l/h	50 - 76
"	"	Ofen 1 b " 1b	"	91 - 102
Before (Vor) Filter		H_2S	%	1,12 - 1,48
		SO_2	"	0,60 - 0,70
After (Nach) Filter		H_2S	"	1,01
		SO_2	"	0,46
Press. after blower	Drucke nach dem Gebläse		mm WS	1600 - 1710
" before contact	vor Kontakt	Ofen 1 a	"	930 - 1040
" after "	nach "	" 1 a	"	620 - 740
" before "	vor "	" 1 b	"	630 - 740
" after "	nach "	" 1 b	"	240 - 330
" Exit oven 1b	Ausgang	Ofen 1 b	"	220 - 310
Pressure	Waschturm Eingang	Entrance wash tower	"	160 - 260
	" Ausgang	Exit " "	"	160 - 260
	Temperaturen	Kesselbrenner Boiler burner	°C	950 - 975
Under superheater	Überhitzer unten		"	390 - 415
under lower preheater	unterer Vorwärmer unten		"	380 - 405
" upper "	oberer " "		"	240 - 270
Boiler exit	Kessel Ausgang		"	280 - 305
Before	(vor) Kontakt	I	"	275 - 300
Middle of	(mitte) "	I	"	340 - 365
Under	(unter) "	I	"	345 - 364
Liquid sulfur	(Schwefel flüssig)	Ofen 1 a	"	220 - 245
	Ofen Ausgang	Oven exit	"	230 - 250
	Hilfsbrenner	Aux. burner	"	585 - 650
before	(vor) Kontakt	II	"	245 - 260
middle of	(Mitte) "	II	"	269 - 290
under	(unter) "	II	"	260 - 290
Liquid sulfur	Schwefel flüssig	Ofen 1 b	"	120 - 155
	Filter (Eingang)	Entrance	"	120 - 140
	" (Ausgang)	Exit	"	115 - 130
Wash tower extrance	Waschturm Eingang		"	130
" exit	" Ausgang		"	25 - 29
Waste heat boiler	Abhitzekessel - Anlage			
Feed water press. from reg.	Speisewasser-Druck aus dem Regler		atü	18,8 - 20,0
Temp. before preheater	Temp. vor dem Vorwärmer		°C	94 - 118
" after "	" nach " "		"	195 - 200
Steam press. in boiler	Dampfdruck im Kessel		atü	14 - 15,8
Steam Quantity	Dampfmenge		t/h	0,66 - 0,86

Claus Oven : Heats of Reaction
Clausofen : Reaktionswärme

Claus Oven Reaction
Clausofen-Reaktion:

$H_2S + 1/2\ O_2 = S + H_2O + 55$ Kcal
1 $Nm^3 H_2S$ = 2390 Kcal

Verbrennung: Burning

$H_2S + 1\frac{1}{2}\ O_2 = SO_2 + H_2O + 324$ "
1 $Nm^3 H_2S$ = 5587 Kcal

Umsetzung mit SO_2: Conversion with SO_2

$2\ H_2S + SO_2 = 3\ S + 2\ H_2O + 35$
1 $Nm^3 H_2S$ = 790 Kcal

Kesselreaktion: Boiler Reaction

$H_2S + 1/2\ O_2 = 0{,}7\ S + 0{,}8\ H_2O + 0{,}2\ H_2S + 0{,}1\ SO_2 + 49{,}5$ Kcal
1 $Nm^3 H_2S$ = 2230 Kcal.

Claus Oven Operation

Clausofenbetrieb.

Boiler reaction

Kesselreaktion $H_2S + 3/2O_2 = 0,7\ S + 0,8\ H_2O + 0,2\ H_2S + 0,1\ SO_2$

Air requirements at various percentages of Alkacid – Sulfur

Luftbedarf bei verschieden-%igem Alkacid-Schwefelstoff.

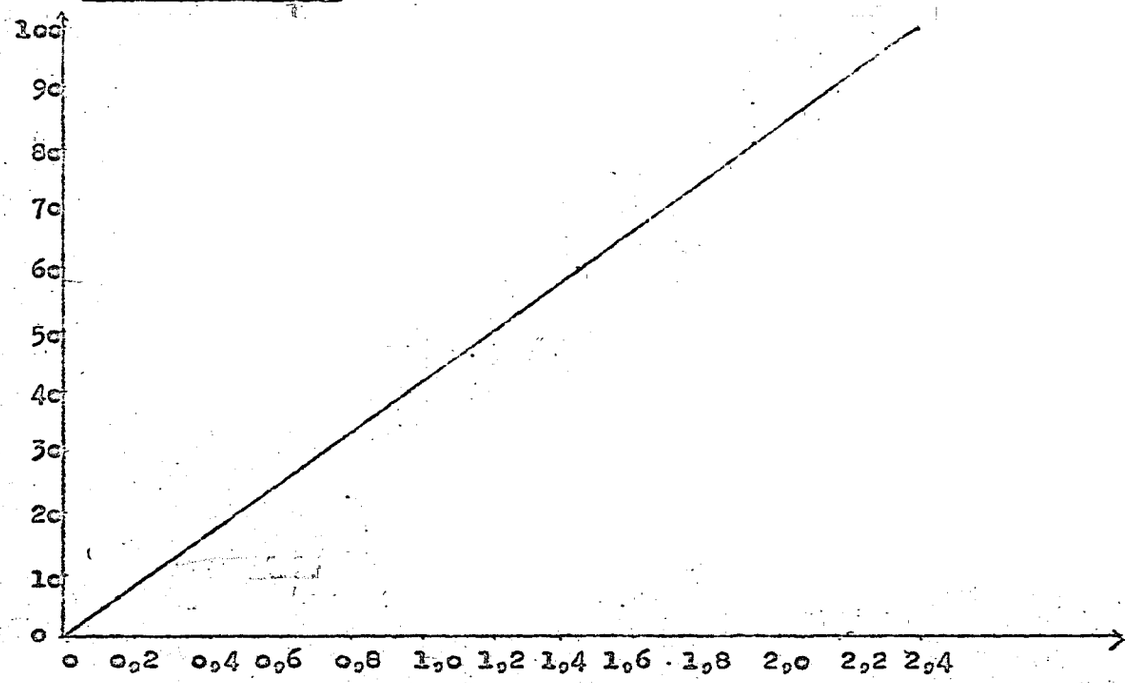
H_2S %ig	Auf 1 Vol.H_2S Vol.O_2	Vol.Luft
100	0,5	2,38
90	0,45	2,14
80		1,91
70		1,67
60		1,43
50		1,19
40		0,95
30		0,713

Factor for theoretical setting

Faktor f.theoretische Einstellung :

$$\frac{\%H_2S}{100} \cdot 2,38 = m^3 Luft/m^3 Alkacid\ H_2S$$

Alkacid-H_2S %ig



Vol. air to 1 vol Alkacid-H_2S

Vol.Luft auf 1 Vol.Alkacid-H_2S

Praktisch nicht benutzt, sondern die Abgasanalyse.

Practically not used, but rather the exhaust gas analyses

Claus Oven - Proposition (self contained)

Clausofen-Aufgabe (selbst gestellt)

2000 m³/h (735 mm & 15°C) 60 % Alkacid-H_2S (remainder CO_2) are to be converted to Sulfur.

Es sollen stündlich 2000 m³ 15°, 735,5 mm 60%iger Alkacid-H_2S auf Schwefel verarbeitet werden. Rest CO_2

Assume radiation and conduction losses of:
Angenommen sei: Strahlungs- und Leitungsverluste

in boiler des Kessels 20 %

in oven des Ofens 30 % bezw. 20 %.

Feed water temperature Speisewassertemperatur 140° C

Water spray " Einspritzwassertemperatur 140°. C

Reaction gases shall leave the boiler at 300°, the oven at 150° and the sulfur flow out at 150°.
Die Reaktionsgase sollen mit 300° aus dem Kessel, mit 150° aus dem Ofen treten, der Schwefel mit 150° abfließen.

The conversion of H_2S with SO_2 in a contact oven will be 90 % complete
Der Umsatz von H_2S mit SO_2 im Kontaktofen werde mit 90 % angenommen.

Description of
Hierstellen sich : Windverbrauch Air requirements

Steam production - Dampferzeugung 15 atü, 325°C 15 atmospheres, 325°C

Quantity water spray — Einspritzwassermenge

Sulfur yield — Schwefelausbeute.

Air requirements Windverbrauch (15°, 735,5 mm):

1 m³ Alkacid-H_2S zur Kesselreaktion: for boiler reaction

$$H_2S + 0{,}5\ O_2 = 0{,}7\ S + 0{,}8\ H_2O + 0{,}2\ H_2S + 0{,}1\ SO_2 + 49{,}5\ Kcal$$

$$\frac{60}{100} \cdot 2{,}38 = 1{,}43\ m^3 \text{ Luft Air}$$

2000 m³ Alkacid-H_2S brauchen 2860 m³ Luft. need air

$= 2830 \cdot 0{,}903 = 2580\ Nm^3$ Luft. air

Steam production in boiler

Dampferzeugung im Kessel.

Heat of the boiler reaction
Wärmetönung der Kesselreaktion 1 $Nm^3 H_2S$ 2230 Kcal

2000 m³ Alkacid-H_2S 15°, 735 ~ 2000 · 0,902 = 1804 Nm^3 H_2S

1804 Nm^3 H_2S enthalten 60 % = 1080 Nm^3 H_2S und 724 Nm^3 CO_2 contain

1080 Nm^3 H_2S entwickeln develop 1080 x 2230 = 2 410 000 Kcal/h

Boiler exhaust gas
Kesselabgas: Temperatur 300°C

Exhaust gas composition
Abgaszusammensetzung

	Nm^3 dry trocken	wet feucht	dry Vol.% trocken	wet feucht	Spec. heat of wet gases spez. Wärme d. feuchten Gases
H_2S	216	-	7,0	5,4	0,021
SO_2	108	-	3,5	2,7	0,012
CO_2	724	-	23,5	18,0	0,080
N_2	2040	-	66,0	50,4	0,157
H_2O	-	939	-	23,5	0,088
	3088	4027	100,0	100,0	0,358

From wet gas

Aus Gasfeuchtigkeit	H_2O g/Nm³	13,8	Nm³ total Ingas. 1804. $\frac{13,8}{1000} \cdot \frac{22,4}{18}$	= 31
wet air Luft-	"	15,8	Nm³ " 2580. $\frac{13,8}{1000} \cdot \frac{22,4}{18}$	= 44
Reaction Reaktion " water	"		1080 . 0,8	= 864
(Insgesamt) Total	"			939

Sensible heat of the 300°c hot exhaust gas
Fühlbare Wärme der 300° heißen Abgase:

300 . 4027 . 0,358 = 432 000 Kcal

of the sulfur vapor in exhaust gas
des Schwefeldampfes im Abgas:

(1000 . 0,7 . 1,43 = 1080 kgS)

350 kg S/Nm³

300 . 1000 . 0,28 = 90 700

Total Insgesamt 522 700 Kcal

With H_2S burning, heat developed is

Bei H_2S-Verbrennung entwickelte Wärmemenge	2 410 000 Kcal
lost from boiler in the exhaust gas Mit dem Abgas Kessel fort	522 700 "
As radiant and conduction losses, estimated Als Strahlungs- u. Leitungsverluste geschätzt	482 000 "
Remaining for steam production Verbleiben für Dampferzeugung	1 405 300 "

Heat content of steam
Wärmeinhalt von Dampf 15 atü, 325°c : 737 Kcal/kg

Feed water temperature Speisewassertemperatur 140° 140 Kcal/kg

total heat for
Erzeugungswärme für
1 Kg superh. steam Heißdampf 597 Kcal/kg

Im Abhitzekessel werden erzeugt $\frac{1405000}{597}$ = 2360 kg = 2,36 t
There are produced in waste heat boiler

Einspritzwassermenge Water spray quantities

a. For extracting heat of condensation from the sulfur vapor
a. zur Aufnahme der Kondensationswärme des Schwefeldampfes

b. For cooling reaction gases to temp. of the contact oven, 150°c
b. zur Abkühlung der Reaktionsgase auf die Temperatur Aus. Kontaktofen 150°

For extracting heat of reaction
c. zur Aufnahme der Reaktionswärme $2\,H_2S + SO_2 = 3\,S + 2\,H_2O$
for 90 % conversion.
Umsetzung zu 90 % angenommen.

zu c) $2\,H_2S + SO_2 = 3\,S + 2\,H_2O + 35$ Kcal 1 Nm³ H_2S 790 Kcal

216 . 0,9 . 790 = 151 700 Kcal

Heat content of steam (Wärmeinhalt des Dampfes/100° at 100°c	639 Kcal/kg
" " water spray d. Einspritzwassers von 140° at 140°c	140 "
Zur Verdampfung aufzuwenden Used for vaporization	499 "
Überhitzung auf 150° Superheating 150°c	
(150 - 100)0,467 =	23 "
Insgesamt Total	522 Kcal/kg
Einspritzwassermenge Quantity water spray	293 kg

After conversion with SO_2 as before

zu b) Nach Umsetzung mit SO_2 noch vorhanden — of the wet gases.

	Nm³	Vol.%	spec. heat of the wet gases. spez. Wärme d. feuchten Gases
H_2S	22	0,6	0,002
SO_2	11	0,3	0,001
CO_2	724	19,4	0,086
H_2	2040	54,7	0,171
H_2O	939	25,0	0,093
	3736	100,0	0,353

Fühlbare Wärme der 300° heißen Abgase (page 6 / Seite 6)
Sensible heat of the 300° hot exh. gas. 522 700 Kcal

of the 150° hot exhaust gas.
der 150° heißen Abgase

150 · 3736 · 0,353 198 000 "

By From water spray must be taker
Vom Einspritzwasser sind aufzunehmen 324 700 Kcal

Einspritzwassermenge Quantity water 620 kg

zu a) Schwefeldampf aus Kessel Sulfur vapor from Boiler

1080 kg 300° fühlbare Wärme sensible heat 90 700 Kcal

Auftretende Kondensationswärme Resulting heat of condensation

10 Kcal/Mol

3,1 Kcal/kg

1080 · 3,1 = 3350 Kcal

Durch Umsetzung mit SO_2 entstehendem Resulting from conversion with SO_2

196 · 1,5 · 1,45 = 420 kg S

Heat of condensation Kondensationswärme 420 · 3,1 1 300 Kcal

Total — Insgesamt 3350 + 1300 = 4650 Kcal

Cooling from Abkühlung von 300° to auf 150°:

1080
420

1500 · 0,3 (300-150) = 75 000 Kcal

4 600 "

Total Insgesamt 79 600 Kcal

Einspritzwassermenge Spray Water 152 kg

Spray water Einspritzwasser a 152 kg 14,3 %

b 620 " 58,3 "

c 291 " 27,4 "

Insges. Total 1063 kg

Rechnet man bei einem Kontaktofen für Strahlung und Leitung 30 %, so

If we count on losses in the oven, by radiation & conduction, of 30 %

744 kg. spray water are required.

so sind an Einspritzwasser notwendig 1063 . 0,70 = 744 kg

with only 20 % radiation & conduction losses, 850 kg

bei nur 20 % Strahlungs- und Leitungsverlusten 850 kg

Schwefelausbeute Sulfur yield

Boiler reaction	Kesselreaktion	1080 kg S	
Oven conversion	Ofenumsatz (einschl. Elektrofilter	420	
		1500 kg S	
actually in the H_2S	mit H_2S eingebracht	1540 kg S	97,3 %.

English Translation

CLAUS OVEN OPERATION

Hydrogen Sulfide	m³/h	1100 - 1500
Air Blast	"	1760 - 2400
Wash - CO_2	"	495 - 520
~~Water Spray~~ above	l / h	60 - 90
Water Spray Below	"	360 - 425
Before Filter:		
H_2S	%	1,38 - 2,15
SO_2	%	0,46 - 0,64
After Filter:		
H_2S	%	1,13
SO_2	%	0,69
Pressures before Kontakt I	mm WS	480 - 730
Intermediate	"	360 - 570
Multiklon E	"	330 - 530
" A	"	270 - 420
After Kont. II	"	270 - 420
Oven exit	"	180 - 290
After H_2S Blower	"	1600 - 1710
After Air Blower	"	1500 - 1600
Wash Tower E	"	160 - 260
Wash Tower A	"	160 - 260
Temperatures:		
Boiler Exit	°C	280 - 300
Before Kontakt I	"	275 - 295
In Kontakt I	"	345 - 355
Under Grate I	"	330 - 345
~~Multiklon Entrance~~	"	~~280 - 295~~
" Exit	"	255 - 270
Before Kontakt II	"	255 - 260
In " II	"	270 - 280
Under " II	"	270 - 290
Under Grate II	"	270 - 285
Liquid Sulfur	"	130 - 135
Oven Exit	"	135 - 150
Filter Entrance	"	140 - 155

Filter Exit	°C	140 - 150
CO_2	"	172 - 174
Water Spray	"	136 - 147
Under Steam Super Heater	"	420 - 460
Water Lower Preheater Below	"	315 - 355
Water Top Preheater Below	"	305 - 325

WASTE HEAT BOILER INSTALLATION

Water Pressure before regulator	°C	18,5 - 19,5 atmospheres
Temperature before preheater	"	120 - 160
Temperature after preheater	"	170 - 202
Steam pressure in boiler	"	14,5 - 16,0 atmospheres
Temperature	"	325 - 365
Quantity	t/h	1,5 - 2,2
Hydrogen sulfide boiler burner	m^3/h	500 - 600
Aux. burner	"	20
Wind air Boiler burner	"	825 - 1010
Aux. burner		40
Water spray oven 1 a	l/h	50 - 76
Water spray oven 1 b	"	91 - 102
Before filter:		
H_2S	%	1,12 - 1,48
SO_2	"	0,60 - 0,70
After Filter:		
H_2S	"	1,01
SO_2	"	0,46
Pressure after blower	mm WS	1600 - 1710
Pressure before contact oven 1 a	"	930 - 1040
Pressure after contact oven 1 a	"	620 - 740
Pressure before contact oven 1 b	"	630 - 740
Pressure after contact oven 1 b	"	240 - 330
Pressure exit oven 1 b	"	220 - 310
Entrance Wash tower	"	160 - 260
Exit Wash Tower	"	160 - 260
Temperature boiler burner	°C	950 - 975
Under superheater	"	390 - 415

Under lower preheater	°C	380 - 405
Under upper preheater	¤	240 - 270
Boiler exit	¤	280 - 305
Before Kontakt I	¤	275 - 300
Middle of Kontakt I	¤	340 - 365
Under of Kontakt I	¤	345 - 364
Liquid sulfur oven 1 a	¤	220 - 245
Oven exit	¤	230 - 250
Auxiliary burner	¤	585 - 650
Before Kontakt II	¤	245 - 260
Middle of Kontakt II	¤	260 - 290
Under Kontakt II	¤	260 - 290
Liquid sulfur oven 1 b	¤	120 - 155
Filter entrance	¤	120 - 140
Filter exit	¤	115 - 130
Wash tower entrance	¤	130
Wash tower exit	¤	25 - 29
Waste heat boiler	Atu	18,8 - 20,0
Feed water pressure from regulator	°C	94 - 118
Temperature before preheater	¤	195 - 200
Temperature after preheater		
Steam pressure in boiler	Atu	14 - 15,8
Steam quantity	t/h	0,66 - 0,86

CLAUS OVEN : HEATS OF REACTION

Claus oven - Reaction:

$H_2S \diamond 1/2\ O_2 = S \diamond H_2O \diamond 53$ Kcal

$1\ Nm^3 H_2S = 2390$ Kcal

Burning:

$H_2S \diamond 1\ 1/2\ O_2 = SO_2 \diamond H_2O \diamond 124$ Kcal

$1\ Nm^3 H_2S = 5587$ Kcal

Conversion with SO_2 :

$2\ H_2S \diamond SO_2 = 3\ S \diamond 2\ H_2O \diamond 35$ Kcal

$1\ Nm^3 H_2S = 790$ Kcal

Boiler Reactions:

$H_2S \diamond 1/2\ O_2 = 0{,}7\ S \diamond 0{,}8\ H_2O \diamond 0{,}2\ H_2S \diamond 0{,}1\ SO_2 \diamond 49{,}5$ Kcal

$1\ Nm^3 H_2S = 2230$ Kcal.

Claus Oven Operation

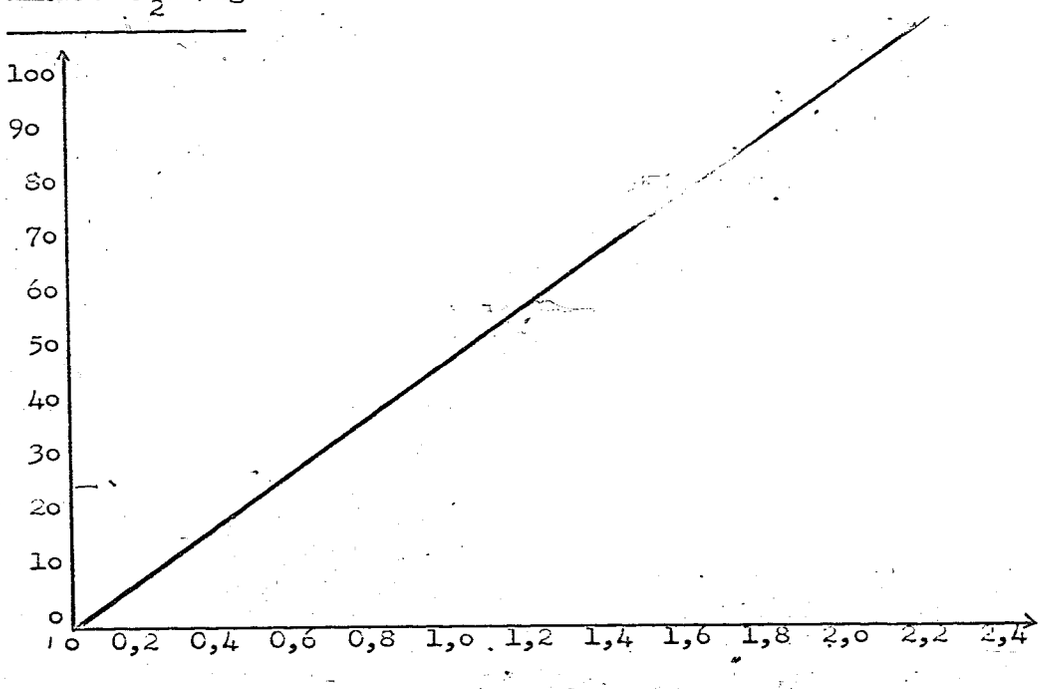
Boiler reaction $H_2S + 1/2O_2 = 0{,}7\ S + 0{,}8\ H_2O + 0{,}2\ H_2S + 0{,}1\ SO_2$

Air Requirements at various percentages of alkacid - sulfur

Factor for theoretical setting:

$\frac{\%H_2S}{100} \cdot 2{,}38 =$ m^3 Luft/ m^3 Alkacid H_2S

H_2S %ig	Auf 1 Vol. H_2S Vol.O_2	Vol.Luft
100	0,5	2,38
90	0,45	2,14
80		1,91
70		1,67
60		1,43
50		1,19
40		0,95
30		1,713



Practically not used, but rather the exhaust gas analyses.

Claus Oven - Proposition (self contained)

2000m³/hr (735mm and 15°C) 60 % alkacid -H_2S (Remainder CO_2) are to be converted to sulfur. Assume radiation and conduction losses of:

in boiler	20%
in oven	30% bezw. 20%
Feed water temperature	140°C
Water spray temperature	140°C

Reaction gases shall leave the boiler at 300°C, the oven at 150°C and the sulfur flow out at 150°.

The conversion of H_2S with SO_2 in a contact oven will be 90% complete.

Description of: Air requirements

Steam production - 15 atmospheres, 325°C

Quantity water spray

Sulfur yield

Air Requirements (15°, 735,5 mm):

1 m^3 Alkacid -H_2S for boiler reaction.

$$H_2S + 0{,}5\ O_2 = 0{,}7\ S + 0{,}8\ H_2O + 0{,}2\ H_2S + 0{,}1\ SO_2 + 49{,}5\ Kcal$$

$$\frac{60}{100} \cdot 2{,}38 = 1{,}43\ m^3 \text{ air}$$

2000 M^3 Alkacid-H_2S need 2860 m^3 air,

$= 2860 \cdot 0{,}902 = 2580\ Nm^3$ air.

Steam production in boiler:

Heat of the boiler reaction 1 $Nm^3 H_2S$ 2230 Kcal

2000 m^3 Alkacid-H_2S 15°, 735 ~ 2000 . 0.902 1804 Nm^3 H_2S

1084 Nm^3 H_2S contain 60% = 1050 Nm^3 H_2S and 724 Nm^3 CO_2

1080 ~~1804~~ Nm^3 H_2S develop 1080 x 2230 2 410 000 Kcal/h

Boiler exhaust gas: Temperature 300°C

Exhaust gas composition

	Nm^3		Vol.%		
	dry	wet	dry	wet	spec. heat. of wet gases
H_2S	216	-	7.0	5,4	0,021
SO_2	108	-	3,5	2,7	0,012
CO_2	724	-	23,5	18,0	0,080
N_2	2040	-	66,0	50,4	0,157
H_2O	-	999	-	23,5	0,088
	3088	4027	100,0	100,0	0,358

From wet gas H_2O g/Nm^3 13,8 Nm^3 total: $1804 \cdot \frac{13,8}{1000} \cdot \frac{22,4}{18} = 31$

From Wet Air " " 13,8 Nm^3 " : $2580 \cdot \frac{13,8}{1000} \cdot \frac{22,4}{18} = 44$

Reaction water " " $1080 \cdot 0,8 = 864$

Total " " 939

Sensible heat of the 300°C hot exhaust gas:

$300 \cdot 4027 \cdot 0,358 = 432\,000$ Kcal

of the sulfur vapor in exhaust gas?

$(1080 \cdot 0,7 \cdot 1,43 = 1080$ kgS)

350 g S/Nm^3

$360 \cdot 1080 \cdot 0,28 = 90\,700$

Total 522 700 Kcal

With H_2S burning, heat developed is: 2 410 000 Kcal

Lost from boiler in the exhaust gas 522 700 "

As radiant and conduction losses, estimated 482 000 "

Remaining for steam production 1 405 300 "

Heat content of steam 15 atu, 325°C : 737 Kcal/Kg

Feed water temperature 140° 140 Kcal/kg

Total heat for

1 kg superh. steam 597 Kcal/kg

There are produced in waste heat boiler $\frac{1405000}{597} = 2360$ kg = 2,36 t

Water spray quantities

a. For extracting heat of condensation from the sulfur vapor

b. For cooling reaction gases to temp. of the contact oven, 150°C

c. For extracting heat of reaction $2\ H_2S + SO_2 = 3\ S + 2\ H_2O$

for 90% conversion.

$2\ H_2S + SO_2 = 3\ S + 2\ H_2O + 35$ Kcal 1 $Nm^3 H_2S$ 790 Kcal

$216 \cdot 0,9 \cdot 790 = 151\,700$ Kcal

Heat content of steam 100o C 639 Kcal/kg

Heat content of water spray at 140°C 140 Kcal/kg

Used for vaporization 499 Kcal/kg

Superheating 150°C

$(150 - 100)\ 10,467 = 23$ Kcal/kg

Total 522 Kcal/kg

Quantity water spray 291 Kg

After conversion with SO_2 as before.

	Nm^3	Vol. %	Spec. heat of the wet gases.
H_2S	22	0,6	0,002
SO_2	11	0,3	0,001
CO_2	724	19,4	0,086
N_2	2040	54,7	0,171
H_2O	939	25,0	0,093
	3736	100,0	0,353

Sensible heat of the 300° hot exh. gas (page 6) 522 700 Kcal

of the 150° hot exhaust gas

150 . 3736 . 0,353 198 000 "

By water spray must be taken 324 700 Kcal

Quantity water 620 kg

Sulfur vapor from boiler 1080 kg 300° sensible heat 90 700 Kcal

Resulting heat of condensation

10 Kcal/ Mol

3,1 Kcal/kg

1080 . 3,1 = 3350 Kcal

Resulting from conversion with SO_2

196 . 1,5 . 1,43 = 420 kg

Heat of condensation 420 . 3,1 1 300 Kcal

Total 3350 + 1300 = 4650 Kcal

Cooling from 300° to 150°

1080
420

1500 . 0,3 (300-150) 75 000 Kcal

4 600 "

Total 79 600 Kcal

Spray water quantity 152 kg

Spray water			
	a	152 kg	14,3%
	b	620 "	58,3"
	c	291 "	27,4
	Total	1063 kg	

If we count on losees in the oven, by radiation and conduction, of 30%

744 kg spray water are required 1063 . 0,70 744 kg

with only 20% radiation and conduction losses, 850 kg

Sulfur yield

Boiler reaction	1080 kg S	
Oven conversion	420	
	1500 kg S	
actually in the H_2S	1540 kg S	97,3 %