沁園燃料研究室
燃料研究專報第十八號
（摘印地質彙報第二十八號）

本所北平油氣廠一年來製氣報告

楊珠瀚著

中華民國二十五年十月
實業部地質調查所印行

地質調查所沁園燃料研究室

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北平本所煤氣廠製氣報告

楊珠瀚著

一，緣起

本所沁園燃料研究室成立伊始，原有裝置煤氣之擬議，嗣以經費支絀，歎無所出，未克舉辦。迨民念一九[illegible]，經費略見充裕，井深感電氣與火酒燈之耗費與不便利，裝置煤氣之議遂決。圖且製就矣，突以長垣告斃，平津垂危，該項進[illegible]復陷停頓。前年春，時局暫告平靜，該項工事，始得經投標手續，由中華氣爐行及公和祥木廠承造矣。三閱月而工事完成，起始製氣，閤所稱便。時民念三年七月上旬也。

二，煤氣場之裝置述要

本所煤氣場之裝置，係劉南筆先生所設計并繪圖，與南開大學之煤氣裝置相仿。其煤氣與所攙合空氣之比例亦同，惟所用之熱裂鍋不同耳。蓋本所所裝者，爲長柱形生鐵鍋，即邱張二氏(一)文中所謂之 Mansfield 式鍋也。據邱張二氏之意，此鍋經熱裂後，所餘之殘渣，清除維艱，勢非將全部鐵鍋舉出爐外不爲功云云，似不盡然。蓋以本所之製氣鍋，固不必經過上述之困難，殘渣即克清除淨盡也，否則設必將重六百餘斤之鐵鍋全部舉出爐外，以事清除，誠恐無人敢於問津此式製氣鍋也。雖然，本所所用之製氣鍋，亦自有其缺點，如熱面狹小，耗費煤斤，及鍋底損蝕，該鍋即失其用等，非如橫陳式之易而爲底功同新鍋也。

三，煤氣之製造

製煤氣之步驟，邱張二氏文中言之頗詳，茲不贅。惟該文於熱裂之溫度，未加表明，試一述之。本所所用煤氣鍋之熱度，向由示熱孔中觀察之，迨見紅熱之時，亦即應滴油之時也。著者曾以熱偶插入此示熱孔中，而以高溫計測之，溫度恆在七百度以上乃至八百度。惟此示熱孔約在熱裂鍋之腰部，則有效之底部溫度，必不止此。茲再以光學測溫計，試該鍋底部之溫度，則爲九百度。任何時以勿使超過此度爲佳，否則產氣量減低，鍋內硬淡加多云。

四，熱裂之煤油

本所熱裂用之煤油，係美孚出品鷹牌煤油，其成色如次：

顏色——微黃綠

比重　〇・八一八〇（攝氏十九度）

起始沸點　一百七十五度

成分

沸點	容量百分比
一七五——一九〇	四・四
一九〇——二〇〇	一〇・二
二〇〇——二一〇	一三・六
二一〇——二二〇	一六・八
二二〇——二三〇	一七・八
二三〇——二四〇	一七・二
二四〇——二五〇	一二・〇
二五〇以上	八・〇
總計	一〇〇・〇

五，產生之煤氣

經熱裂所產生之純煤氣，（取自小罐）其成分如次：

二氧化碳	〇·八
未飽和氣	二一·八
氧	〇·八
一氧化碳	——
甲烷	五〇·一
氫	二〇·二
氮	六·三

惟所用之氣，須攙以等容量之空氣，方可供試驗室之用，其成分改動如次：

二氧化碳	〇·二
未飽和氣	七·八
氧	一三·五
一氧化碳	——
甲烷	十九·〇
氫	七·四
氮	五二·二

熱裂氣之產量，據著者測定，其平均值爲每立升之油，產純氣二百立方呎。換言之，每立升之油，產試驗室用煤氣約四百立方呎。

六，熱裂後所凝結之液體

煤油經熱裂作用，而成氣之餘，尙有液體產物。

顏色　暗褐色

比重　〇・九六（攝氏十九度）

氣味　芬芳略有苯及甲苯之氣味

起始沸點　三十度

產量　百分之六・六七（容量百分比）

分級蒸溜結果如后

溫度	油量（容量百分比）	比重	未飽和物（容量百分比）
八十以下	〇・七	〇・八五一五	四〇
八〇——九〇	一二・五	〇・八六八〇	二五
九〇——一〇〇	二・一	〇・八六五〇	三〇
一〇〇——一一〇	二・五	〇・八六〇〇	四二
一一〇——一二〇	三・一	〇・八五六〇	四五
一二〇——一三〇	一・六	〇・八五四〇	三〇
一三〇——一五〇	一・九	〇・八五一〇	六〇
一五〇——二〇〇	九・二	〇，八六一〇	四二
二〇〇——二五〇	二八・六	〇・九〇九〇	五五
二五〇以上	三四・〇	半固體	

損失	
總計	一〇〇・〇

著者以上列油類含未飽和量甚多，每致研究發生障碍，因用普通濃硫酸洗滌而再度蒸溜之，此時之八〇——九〇部分幾爲純苯之氣味，色亦永久不黃。其他高溫之部分，漸有甲苯乙苯等混合氣味，殆溫度高至二百度以上，（二〇〇——二二五〇）蒸溜物一部分爲固體，以氣味辨之乃知爲萘。二百五十度以上之部分，則有蒽之存在。是以知此種液體產物中，除含有稍量直餾煙外，俱爲芬芳組之煙，計有苯甲苯乙苯丙苯萘蒽等，而以苯爲最富，所得亦最純。著者又爲求深一步步解起見，將各部蒸溜物施以硝酸化作用（Nitration），使之成爲硝酸苯硝酸甲苯等，分級蒸溜之，再使以還原作用，使之成爲胺甲胺乙胺等，再分級蒸溜之，由各部分之氣味沸點等物理性質，確知原物含苯甲苯乙苯諸物。著者以作用本身之關係，後部工作（Nitration and Reduction），只限於一三〇度以下之部分，蓋一三〇度以上之部分，硝酸化殊感不宜也。

煤氣廠經常用費（單位圓）

月份	煤油	明柴	塊煤	鐵鍋	工資	其他	總計
七月	四九・八〇	二・四〇	二〇・〇〇	一一七・三七	一五・〇〇	一一・二〇	二一五・七七
八月	五二・〇〇	二・四〇	一〇・五〇	——	一五・〇〇	六・二五	八六・一五
九月	八七・六〇	一・二〇	二八・五〇	——	一五・〇〇	一・五〇	一三三・八〇
十月	七六・六五	二・四〇	一〇・五〇	三・二〇	一五・〇〇	六・八〇	一一四・五五
十一月	六五・七〇	二・四〇	三四・五〇	——	一五・〇〇	九・五七	一二七・一七
十二月	八七・六〇	二・四〇	二二・五〇	六・二〇	一五・〇〇	九・〇〇	一四二・七〇
一月	九九・〇〇	二・四〇	四三・五〇	——	一五・〇〇	三・〇〇	一六二・九〇

二月	二二・五〇	二・四〇	———	———	一五・〇〇	八・九一	四八・八一
三月	六七・五〇	一・二〇	一〇・〇〇	六一・八五	一五・〇〇	———	一五五・五五
四月	七八・七五	二・四〇	三〇・四〇	———	一五・〇〇	一・五〇	一二八・〇五
五月	六七・五〇	一・二〇	三〇・四〇	———	一五・〇〇	一・二五	一一五・三五
六月	五六・二五	一・二〇	一九・〇〇	———	一五・〇〇	———	九一・四五
總計	八一〇・八五	二四・〇〇	二五九・八〇	一八八・六二	一八〇・〇〇	五八・九八	一五二二・二五
平均	六七・五七	二・〇〇	二一・六五	一五・七二	一五・〇〇	四・九二	一二六・八五

由上表可知本所煤氣廠每月需費洋壹百弐拾陸圓捌角伍分正。設每月（除去星期日及例假日）以二十五日計算，則本所工作一日卽需煤氣費約洋伍圓。

茲爲參閱利便起見再就用品之數量按月統計之如次

月份	煤油	磨柴	塊煤	青鉛	棉絲
七月	一五桶	二〇〇斤	二噸	八〇磅	一〇磅
八月	一五桶	二〇〇斤	一噸	五〇磅	———
九月	二四桶	一〇〇斤	三噸	———	———
十月	二一桶	二〇〇斤	一噸	———	———
十一月	一八桶	二〇〇斤	三噸	———	———
十二月	二四桶	二〇〇斤	二噸	六〇磅	———
一月	二七桶	二〇〇斤	四噸	———	二〇磅

二月	六桶	二〇〇斤	一噸		
三月	一八桶	一〇〇斤	一噸		
四月	二一桶	二〇〇斤	三噸		一〇磅
五月	一八桶	一〇〇斤	三噸		
六月	一五桶	一〇〇斤	二噸		
總計	二二二桶	二〇〇〇斤	二六噸	一九〇磅	四〇磅
平均	一八·五桶	一六七斤	二噸		

煤油三桶製氣二千立方呎，(撮空氣後)二二五桶煤油應製氣一五〇，〇〇〇立方呎，而消費爲一，五二二·二五圓，則每立方呎之氣，需費洋壹分或每百立方呎需費洋壹圓。茲再計算煤氣之消耗如下：本所煤氣廠年產一五〇，〇〇〇立方呎，每年以三百日算計(按即每月二十五日計算)則每工作一日，卽耗五百立方呎，卽需洋伍圓也。

The oil consumed in this year amounts to 222 tins at the rate of 2,000 cu. ft. per 3 tins of kerosene. It is evident that the total annual output of the gas will amount to 150,000 cubic feet. Since the annual expense of the plant, as we have seen, amount to $1.522.25, the cost of the gas can be easily figured out as 1 cent per cubic foot or one dollar per 100 cubic feet of the gas. At a daily consumption of 500 cubic feet, the expense amounts to 5 dollars per day.

VII. Cost of Gas Produced.

TABLE V

Month	Kerosene	Wooden Chips	Retort	Wages	Others	Coal	Total
July	$49.80	$2.40	$117.37	$15.00	$11.20	$20.00	$215.77
Aug.	52.00	2.40	—	15.00	6.25	10.50	86.15
Sept.	87.60	1.20	—	15.00	1.50	28.50	133.80
Oct.	76.65	2.40	3.20	15.00	6.80	10.50	114.55
Nov.	65.70	2.40	—	15.00	9.57	34.50	127.17
Dec.	87.60	2.40	6.20	15.00	9.00	22.50	142.70
Jan.	99.00	2.40	—	15.00	3.00	43.50	162.90
Feb.	22.50	2.40	—	15.00	3.91	—	48.81
Mar.	67.50	1.20	61.85	15.00	—	10.00	155.55
April	78.75	2.40	—	15.00	1.50	30.40	128.05
May	67.50	1.20	—	15.00	1.25	30.40	115.35
June	56.25	1.20	—	15.00	—	19.00	91.45
Total	810.85	24.00	188.62	180.00	58.98	259.80	1,522.25
Average	67.57	2.00	19.72[1]	15.00	4.92	21.65	126.85

The Table V above shows us that the monthly expense of the plant amounts to $126.85 and assuming 25 official days per month the daily expense will amount approximately to $5.00.

In order to give a more detailed description, the following table is given:—

Distribution of Materials Used.

TABLE VI

Month	Kerosene tins	Wooden Chips catties	Coal tons	Solders lbs.	Cotton lbs.
July	15	200	2	80	10
Aug.	15	200	1	50	—
Sept.	24	100	3	—	—
Oct.	21	200	1	—	—
Nov.	18	200	3	—	—
Dec.	24	200	2	60	—
Jan.	27	200	4	—	20
Feb.	6	200	1	—	—
March	18	100	1	—	—
April	21	200	3	—	10
May	18	100	3	—	—
June	15	100	2	—	—
Total	222	2,000	26	190	40
Average	18.50	167	2	—	—

1. Of the three retorts one is entirely out of order, one about to give way and another is still in good shape.

water. After drying, it is refractionated. The second fraction (80-90) has an odor of pure benzene, while the higher fractions resemble those of toluene and xylenes. When the fraction above 200°C. is redistilled, crystalline mass is obtained, by the odor of which it is found to be a mixture of naphthalene and anthracene. As the presence of toluene and xylenes are so far not conclusive, the author proceeded further investigation with each fraction as follows:

They are separately nitrated with sulphuric-nitric acid mixture *in the cold.* After the separation and distillation of the nitro-compounds formed they are in turn reduced by granular tin in acid medium to corresponding amines. A series of mixtures of amines is thus obtained. By the aid of odors and boiling points the presence of aniline, toluidines and xylidines may be identified. In addition to those mentioned, a quantity of higher aromatic amines may also be found, but what they really are is unknown. Now summarize the constitutional composition of the liquid distillates as follows:—

1. Benzene, toluene, xylenes and higher homologes of benzene;
2. Naphthalene and its homologes;
3. Anthracene and its homologes;
4. Aliphatic neutral oils;
5. Unsaturated hydrocarbons and naphthenes.

Among those constituents only benzene can possibly be isolated pure by fractionation. Owing to the limited amount of benzene present in the distillate, the recovery of which is not worthwhile. Furthermore the distillate contains too much aromatic hydrocarbons, that is, the carbon-hydrogen ratio is too high. It is therefore not suitable for re-cracking, owing to the fact that an enormous quantity of charred products will be formed. This product is still a waste yet.

VI. Carbonaceous Residue.

In addition to the gaseous and liquid distillates there is always a considerable amount of solid residue, that is the decomposition product with probably high free carbon content. The yield is 1.16Kg per 3 tins of kerosene.

TABLE III

Carbon Dioxide	0.2%
Unsaturated Gases	7.8%
Oxygen	13.5%
Carbon monoxide	0
Methane	19.0%
Hydrogen	7.4%
Nitrogen	52.1%
Total	100.0%

The yield of the gas as the author observed has an average value of 20 cubic feet per liter of oil, that is, 40 cubic feet of the laboratory gas per liter.

V. Liquid Distillates.

In the scrubber and receiver a considerable amount of liquid distillate is collected. This liquid is mainly a mixture of the liquid products of cracking associated to some extent with the uncracked oil. Its appearance and some of its physical properties are given:

TABLE IV

Color ——— Dark brown.
Specific gravity 0.960 at 19°C.
Odor ———, Aromatic, with pronouncing odor of benzene and toluene.
First Drop—30°C.
Yield ——— 6.67% (by volume) of the original oil, fractionated for 3 times and the constants are determined as follows: (3.359 liters per 3 tins of oil).

	Oil Yield	Sp. Gr. at 19°C.	Unsaturation
Up to 80°C.	0.7%	0.8515	40%
80— 90°C.	12.5%	0.8680	25%
90—100°C.	2.1%	0.8650	30%
100—110°C.	2.5%	0.8600	42%
110—120°C.	3.1%	0.8560	45%
120—130°C.	1.6%	0.8540	30%
130—150°C.	1.9%	0.8510	60%
150—200°C.	9.2%	0.8610	42%
200—250°C.	28.6%	0.9090	55%
Above 250°C.	34.0%	Semi-solid	—
Loss	3.8%		
Total	100.0		

As the unsaturated contents of the fractions are objectionable to further treatment they are removed by washing with crude concentrated sulphuric acid followed by a dilute solution of sodium carbonate and

cracking temperature of the retort is observed by an optical pyrometer just at the point at which the oil is to be dropped or cracked. The temperature thus determined is always about 900°C.

As soon as the small holder is almost filled with the cracked gas the latter is immediately transferred into the large holder and mixed with an appropriate amount of air. Operation is thus complete and is to be repeated until the large tank is full of mixed gas. The gas used in our laboratory is made to contain about 50% air. This plant usually comsumes 3 tins (about 50 liters) of kerosene for making about 2,000 cubic feet of laboratory gas.

III. Oil Used.

The oil used for cracking in our plant is the Eagle Brand of the Standard Oil Co., New York, and its physical properties are as follows:—

TABLE I

Color			Slightly yellowish
First Drop			175°C.
Specific Gravity			0.8180 at 19°C.
Distillation Range,			
175°-190°C.	4.4%	(by volume)	4.4%
190°-200°C.	10.2%	(„ „)	14.6%
200°-210°C.	13.6%	(„ „)	28.2%
210°-220°C.	16.8%	(„ „)	45.0%
220°-230°C.	17.8%	(„ „)	62.8%
230°-240°C.	17.2%	(„ „)	80.0%
240°-250°C.	12.0%	(„ „)	92.0%
above 250°	8.0%	(„ „)	100.0%

IV. Cracked Gas.

The cracked gas which is not yet mixed with air is of the following composition:—

TABLE II

Carbon Dioxide	0.8%	(by volume)
Unsaturated Gases	21.8%	
Oxygen	0.8%	
Carbon Monoxide	0	
Methane	51.1%	
Hydrogen	20.2%	
Nitrogen	5.3%	
Total	100.0%	

The gas used in our laboratory usually contains about 50% of air so its composition is altered as follows:—

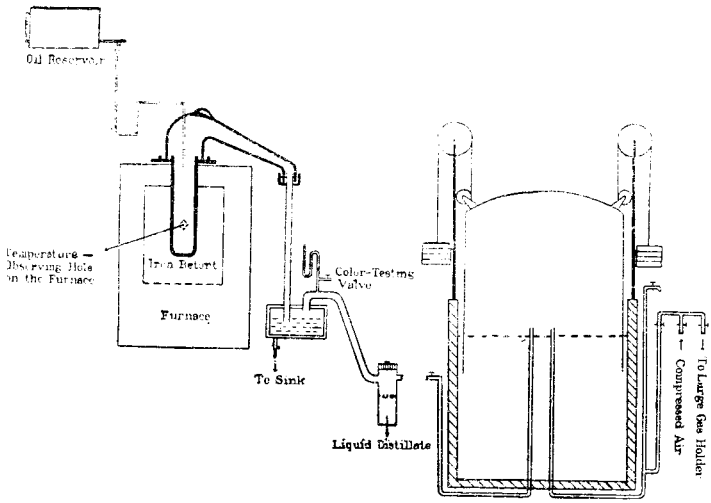


Fig. 1

gas through the testing valve. The temperature of the retort is always slightly higher than 700°C. which is determined from the temperature-observing hole by a thermocouple accompanied by a pyrometer. Sometimes it may be as high as 800°C. but it should not be allowed to exceed the last mentioned temperature, otherwise the yield of charred products remaining in the retort will be seriously increased.

The temperatures mentioned above may not be the true cracking temperatures of the retort, since the temperature-observing hole on the furnace is too far above the cracking surface of the retort and the actual

CRACKING OF KEROSENE

A REPORT ON THE GAS-MAKING PLANT OF THE GEOLOGICAL SURVEY (PEIPING OFFICE).

By C. H. YOUNG.

I. INTRODUCTION.

The gas-making plant of the Geological Survey in Peiping was erected at the beginning of June, 1934 and gas was produced on the 10th of July. The detailed description of the plant may be found in Chiu and Chang's paper[1], since our Plant is almost the same with that which they described. The main difference lies in the shape of the retorts employed in both plants. Our plant is composed of the following (See also Fig. 1) :—

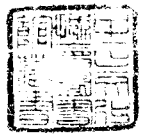
1. Iron retort set vertically (differring from Nankai's horizontal type) in a refractory brick furnace;
2. A scrubber and a receiver for collecting the liquid distillate;
3. One oil reservoir with oil-dropping device;
4. One small gas holder of about 200 cubic feet capacity, with counter-balancing weights;
5. One large gas holder of 2,500 cubic feet capacity.

In addition, one air compressor is installed for transferring the gas from the small holder into the large one and for compressing an appropriate amount of air into the large holder to render the gas suitable for laboratory use.

II. OPERATING CONDITIONS.

The plant is equiped with 2 sets of retorts and they are working alternately. Each retort is sufficient to make about 2,000 cubic feet of mixed gas within 10 hours. The operative manual may be quoted briefly as follows: — The retort is preheated to red hot and cracking is then started by dropping the oil on to the inner surface of the retort in fine streams, the rate of which is regulated by testing the color of the cracked

1. Science Report (in Chinese), No. 1 of Nankai University, Tientsin. 南開大學應用化學研究報告第一卷



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THE SINYUAN FUEL RESEARCH LABORATORY

GEOLOGICAL SURVEY OF CHINA

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