

I 28.23,

Bureau of Mines  
Report of Investigations 5164



GASIFICATION OF LIGNITE IN A COMMERCIAL-SCALE PILOT PLANT:  
PROGRESS REPORT FROM JULY 1, 1950, TO DECEMBER 31, 1951,  
AND SUMMARY OF WORK PREVIOUS TO JULY 1, 1950

BY W. H. OPPELT, W. R. KUBE, M. H. CHETRICK,  
T. W. KAMPS, AND E. F. GOLOB

United States Department of the Interior — December 1955

LIBRARY  
LOUISIANA STATE UNIVERSITY

GASIFICATION OF LIGNITE IN A COMMERCIAL-SCALE PILOT PLANT:  
PROGRESS REPORT FROM JULY 1, 1950, TO DECEMBER 31, 1951,  
AND SUMMARY OF WORK PREVIOUS TO JULY 1, 1950

BY W. H. OPPELT, W. R. KUBE, M. H. CHETRICK,  
T. W. KAMPS, AND E. F. GOLOB

**Report of Investigations 5164**



UNITED STATES DEPARTMENT OF THE INTERIOR  
Douglas McKay, Secretary  
BUREAU OF MINES  
Thos. H. Miller, Deputy Director

Work on manuscript completed November 1954. The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is made: "Reprinted from Bureau of Mines Report of Investigations 5164."

December 1955

GASIFICATION OF LIGNITE IN A COMMERCIAL-SCALE PILOT PLANT:  
PROGRESS REPORT FROM JULY 1, 1950, TO DECEMBER 31, 1951  
AND SUMMARY OF WORK PREVIOUS TO JULY 1, 1950

by

W. H. Oppelt,<sup>1/</sup> W. R. Kube,<sup>2/</sup> M. H. Chetrick,<sup>3/</sup>  
T. W. Kamps,<sup>3/</sup> and E. F. Golob<sup>3/</sup>

---

CONTENTS

	<u>Page</u>
Summary and conclusions .....	1
Introduction .....	3
Acknowledgments .....	3
Section I. Experimental work: July 1, 1950, to	
December 31, 1951 .....	4
Description of commercial-scale pilot plant .....	4
Retort arrangement .....	4
Run 14 .....	7
Run 15 .....	7
Run 16 .....	7
Run 17 .....	7
Operating procedure .....	8
Startup .....	8
Test periods at constant conditions .....	8
Instrumentation and methods of obtaining data .....	9
Sampling methods .....	10
Experimental conditions and objectives of test runs .....	10
Lignites charged .....	10
Analysis and size distribution .....	12
Investigation of process variables .....	12
Run 14 .....	16
Runs 15 and 16 .....	16
Run 17 .....	18
Results and discussion .....	18
General .....	18
Composition of product gas .....	19
Gasification residue .....	19

---

1/ Supervisor, Utilization Section, Bureau of Mines, Region III,  
Grand Forks, N. Dak.

2/ Chemical engineer, Bureau of Mines, Region III, Grand Forks,  
N. Dak.

3/ Formerly chemical engineer, Bureau of Mines, Region III, Grand  
Forks, N. Dak.

## CONTENTS (Con.)

	<u>Page</u>
Ash deposits on retort tube .....	22
Material and heat balances .....	22
Thermal requirements .....	25
Run 14 .....	25
Influence of water-lignite ratio on gasification using divided annulus .....	25
Influence of combustion space temperatures on gasification using divided annulus .....	28
Changes in composition of gasification residue and attachment of ash deposits .....	30
Runs 15 and 16 .....	32
Influence of lignite feed rate on gasification using continuous annulus .....	32
Influence of water-lignite ratio on gasifica- tion using continuous annulus .....	34
Comparison of gasification characteristics of two lignites .....	37
Run 17 .....	39
Comparison of gasification of eight lignites ...	41
Effect of heat transfer on gasification characteristics .....	41
Ash deposits on alloy tube .....	43
Effect of lignite size and composition .....	46
H <sub>2</sub> -CO ratio of product gas .....	49
Summary of factors affecting gasification characteristics .....	49
Performance of retort tubes .....	51
Deformation of 310-alloy tube .....	51
Corrosion of 310-alloy tube .....	53
Corrosion of mild steel inner tube .....	54
Section II. Summary of work on gasification project previous to July 1, 1950 .....	56
Section III. Correlating methods for overall gasification data	60
Gas composition in terms of water-gas equilibrium .....	60
Material balance relationships .....	64
Thermal requirements .....	64
Appendix .....	69
Bibliography .....	80

## TABLES

1. Size distribution of lignite as charged during representa- tive test periods, runs 14 through 17 .....	13
2. Representative proximate and ultimate analyses of lignites charged to gasifier, runs 14 through 17 .....	14
3. Composition of ash from eight lignites used in gasification experiments .....	15
4. Summary record of operations from July 1, 1950, to December 31, 1951, Bureau of Mines pilot plant, Grand Forks, N. Dak. ....	18
5. Typical analyses of product gas at various hydrogen-carbon monoxide ratios .....	19

## TABLES (Con.)

	<u>Page</u>
6. Proximate and ultimate analyses of gasification residue for selected test periods .....	20
7. Size distribution of gasification residue for selected test periods .....	21
8. Weight of ash deposits collected from inner wall of 310-alloy tube .....	22
9. Influence of lignite feed rate on performance of gasifier using continuous annulus .....	33
10. Operation of continuous annulus arrangement without addition of process steam .....	37
11. Comparison of gasification characteristics of eight lignites .....	42
12. Variation in composition of lignites gasified during run 17, m.a.f. basis .....	49
13. Summary of operation using various reaction tubes .....	53
14. Chromium and nickel in ash deposits removed from alloy tube, runs 11 through 17 .....	54
15. Typical lignite analyses used in calculation of equilibrium composition of product gas .....	62
16. Summary data on gasification of natural lignite, runs 14 through 17 .....	70
17. Experimental data and calculations converted to moisture- and ash-free basis, runs 14 through 17.....	74
18. Material balances for runs 14 through 17 .....	76
19. Heat balances for runs 14 through 17 .....	77

## ILLUSTRATIONS

Fig.

1. Flow diagram of commercial-scale pilot plant for gasifying lignite. Bureau of Mines, Grand Forks, N. Dak. ....	5
2. Arrangement of gasification retort during runs 14, 15, 16, and 17 .....	6
3. Source of lignites gasified during runs 14 through 17 ....	11
4. Material entering and leaving annulus during gasification.	23
5. Heat distribution during gasification as a function of $H_2\text{-CO}$ ratio of product gas and carbon gasified .....	24
6. Influence of total water available on carbon gasified and $H_2\text{-CO}$ ratio of product gas, combustion-space-temperature distribution as parameter, divided annulus .....	26
7. Influence of total water available on rate of gas produc- tion and rate of heat transfer, combustion-space-tem- perature distribution as parameter, divided annulus ....	27
8. Influence of combustion space temperature on lignite gas- ification, total water to lignite ratio as parameter, divided annulus .....	29
9. Fluctuation of ash and sulfur in gasification residue during test period 14-F .....	31
10. Influence of lignite feed rate on gasification, divided and continuous annulus .....	35
11. Influence of total water available on gasification in continuous annulus .....	36
12. Gasification characteristics of two lignites as a function of lignite feed rate .....	38

## ILLUSTRATIONS (Con.)

<u>Fig.</u>		<u>Page</u>
13.	Temperature of inner tube at various distances from bottom of retort, feed rate and source of lignite as parameters .....	40
14.	Carbon gasification as a function of inner tube temperature .....	44
15.	Change of inner tube temperature with time, run 17 .....	45
16.	Ash fusibility of lignite as charged, runs 14 through 17.	47
17.	Carbon gasification versus size of lignite as charged, periods 17-G through 17-O .....	48
18.	$H_2$ -CO ratio of product gas as a function of steam leaving gasifier, run 17 .....	50
19.	Variation in radial dimensions of 310-alloy rolled-plate tube during runs 14, 15, 16, and 17 .....	52
20.	Flame guard of 310-alloy steel after 7,000 hours of operation .....	55
21.	Lower section of mild-steel inner tube after run 16 .....	57
22.	Gas composition as a function of steam-lignite ratio; comparison with calculated curves based on water-gas equilibrium .....	61
23.	$H_2$ -CO ratio of product gas as a function of steam-lignite ratio; comparison with calculated curves based on water-gas equilibrium .....	63
24.	Rate of production of ( $H_2+CO$ ) as a function of lignite feed rate .....	65
25.	Effect of percent carbon gasified on production of ( $H_2+CO$ ) .....	66
26.	Gas made versus rate of heat release in the gasifier heating furnace .....	68