STEAM EXTRACTION AND DEVOLATILIZATION OF COAL WITH PARTICULAR REFERENCE TO ENHANCED LIQUID PRODUCTION

By

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Submitted

in fulfilment of requirements of the Degree of

DOCTOR OF PHILOSOPHY

To the

INDIAN INSTITUTE OF TECHNOLOGY, DELHI

DECEMBER, 1983

CERTIFICATE

This is to certify that the thesis entitled "STEAM EXTRACTION AND DEVOLATILIZATION OF COAL WITH PARTICULAR REFERENCE TO ENHANCED LIQUID PRODUCTION" being submitted by Mr. M. Ganapathi to the Indian Institute of Technology, Delhi, for the award of the degree of Doctor of Philosophy in Chemical Engineering, is a record of bonafide research work carried out by him. Mr. M. Ganapathi worked under our guidance and supervision and has fulfilled the requirement for the submission of this thesis, which to our knowledge has reached the requisite standard.

The results contained in this thesis have not been submitted in part or full to any other University or Institute for the award of any degree or diploma.

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ACKNOWLEDGEMENT

The author sincerely thanks Professor M.K. Sarkar for his invaluable guidance through energetic involvement and constant encouragement through out the course of this work.

The author gratefully appreciates the timely help extended by Dr. D.K. Sharma, Dr. M.G. Dastidar and Dr. T. Rajeshwara Rao.

The author also wishes to acknowledge the help rendered by Mr. P. Gopalan and all other staff of the department for their contribution for the progress of this work.

The companionship of Dr. K. Chidambaram and Dr.S.Balasundaram has made the author's life pleasant and memorable during his stay in the campus.

The financial support provided by the Centre of Energy Studies is gratefully acknowledged.

M. GANAPATHI

ABSTRACT

The present thesis reports the results of an experimental research programme with an aim to explore the possibility of obtaining enhanced liquid volatile products under the conditions of Low Temperature Carbonization at atmospheric pressure. Under such pyrolytic conditions coal molecules would be expected to be broken into lower molecular weight fragments. Some of these fragments would escape as volatile products while others combine with each other forming polymeric coke. These reactive fragments, if stabilized through hydrogenation, could result in enhanced volatile products. In order to effect the hydrogenation under atmospheric pressure, a scheme of in-situ generation of nascent hydrogen through water gas shift reaction was attempted.

A detailed experimental study was conducted on devolatilization of coal in carbon monoxide-steam atmosphere. A micro reactor to accommodate about 5 gm of coal sample (impregnated with shift catalyst) was employed to conduct these experiments. Of the few catalysts used, a zinc oxide-potassium carbonate combination was found to show devolatilization yield to the extent of 38% (on moisture-free coal) at temperature around 480°C compared to 26% under only steam extraction. Analysis of products showed that a substantial amount of hydrogen (produced through shift reaction) was missing in the product gas suggesting that a part of shift-generated hydrogen had reacted with the coal molecules or coal

fragments. Material balance also revealed that estimated liquid fraction was over 85 percent of total devolatilization yield.

The findings of the present thesis could point to an atmospheric pressure process of total liquefaction of coal by combining devolatilization of coal (super imposed with shift reaction), gasification of residual char and Fischer-Tropsch synthesis of partially shift converted gaseous products.

In order to gain a better understanding of the decomposition reactions under pyrolysis conditions, a kinetic study on coal pyrolysis was conducted. Thermogravimetric experiments were conducted in a thermobalance under both isothermal and non-isothermal (linear heating rate) conditions under oxygen-free nitrogen atmosphere. Results of thermogravimetric analysis revealed that the assumption of coal pyrolysis to be a reversible, first-order, homogeneous reaction was valid under non-isothermal conditions up to a temperature of 460°C. The activation energy for such reaction was found to be around 30 k cal/mole. Data of isothermal experiments conducted in a fixed-bed micro-reactor were also found to show similar activation energy, 32 k cal/mole, for a first-order, homogeneous, reversible reaction model.

CONTENTS

		Page
	Acknowledgement	i
	Abstract	ii
	List of Figures	vi
	List of Tables	viii
	PART I	
Chapter 1	INTRODUCTION	1
Chapter 2	LITERATURE REVIEW	12
	2.1 Fischer-Tropsch Catalytic Synthesis	12
	2.2 Catalytic Hydrogenation of Coal	14
	2.3 Liquid Phase Dissolution or Extraction	16
	2.4 Pyrolysis and Hydrocarbonization	21
Chapter 3	EXPERIMENTAL STUDIES	25
	3.1 Experimental Set-up	28
	3.2 Carbon monoxide Source	32
	3.3 Coal Preparation	33
	3.4 Experimental Procedure	35
Chapter 4	RESULTS AND CONCLUSION	38
	4.1 Preliminary Experiments	38
	4.2 Detailed Study with Zinc Oxide-Potassium Carbonate Catalyst	43
	4.3 Conclusions	57
Chapter 5	A CONCEPTUAL TECHNOLOGY FOR TOTAL COAL LIQUEFACTION UNDER ATMOSPHERIC PRESSURE	60

Page

PART II

Chapter 1	INTRODUCTION	64
Chapter 2	LITERATURE REVIEW - COAL PYROLYSIS	66
Chapter 3	KINETICS STUDIES ON COAL DEVOLATILIZATION	70
	3.1 Thermo Gravimetric Analysis	70
	3.1.1 Thermobalance	70
	3.1.2 Experimental procedure	71
	3.1.3 Influence of oxygen	76
	3.1.4 Kinetics of Devolatilization	78
	3.2 Studies with Batch reactor	105
	3.3 Conclusions	113
	REFERENCES	115
Appendix I	Test Procedures for Analysis of Coal/Char	124
Appendix II	Carbon, Hydrogen Estimation	125
Appendix III	Calculation of Weight Loss from Ash-content	128
Appendix IV	Effect of Time on Fractional Conversion at Different Temperatures	129
Appendix V	Effect of Temperature on Fractional Conversion at Different Heating Rates (From TGA Traces)	132