Internship Report

On

5-Lump Kinetic Model for Gas Oil Catalytic Cracking

BACHELOR OF TECHNOLOGY

In

CHEMICAL ENGINEERING

By

Rohit Thakur (187016)

Under the guidance of

Dr. Tara Chand Kumawat

Assistant Professor

Department of Chemical Engineering

National Institute Of Technology Hamirpur

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NATIONAL INSTITUTE OF TECHNOLOGY HAMIRPUR
DEPARTMENT OF CHEMICAL ENGINEERING

CERTIFICATE

OF INTERNSHIP COMPLETION

THIS IS TO CERTIFY THAT

Rohit Thakur

3rd Year B.Tech. student, Chemical Engineering Department, National Institute of Technology, Hamirpur, has undergone Summer Training from **01.06.2021** to **15.07.2021** under my supervision. He has sucessfully completed his project work on

" Gas oil catalytic cracking kinetic model with lumps "

During the training, he took keen interest in completing the work assigned to him and his performance in this project was excellent . I wish him all sucess in his academic endeavours and in life

Date: 16/07/2021

DR. TARA CHAND KUMAWAT
ASSISTANT PROFESSOR

NATIONAL INSTITUTE OF TECHNOLOGY

HAMIRPUR

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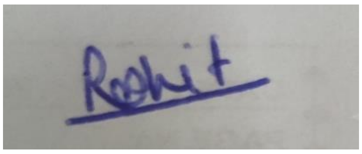
Rohit Thakur (187016)



Department of Chemical Engineering

National Institute of Technology

Hamirpur-177005

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CHAPTER-1

INTRODUCTION:

1.1 Cracking:

Cracking is a process which involves the decomposition of petroleum fractions having huge quantities of higher molecular weight compounds.

There are mainly two types of cracking:

i. Thermal cracking
ii. Catalytic cracking

1.2 Thermal Cracking:

In this process hydrocarbons present int the crude oil are subjected to high heat to break down into shorter chained and lower boiling points hydrocarbons. This process requires large amount of energy.

1.3 Catalytic Cracking:

In this process petroleum vapour passes through a low-density bed of catalyst, causing heavier fractions to crack thus, producing lighter more valuable products. The catalyst enabled the reduction in operating pressure and temperature drastically.

CHAPTER-2

LITERATURE REVIEW

Table 1: Table consists of information of the literature reviewed and also the name of author, topic name and finding of the literature.

S.NO.	Author's Name	Topic Name	About
1.	Jorge Ancheyta-JuaÂrez, Felipe LoÂpez-Isunza , Enrique Aguilar-RodrõÂguez	5-Lump kinetic model for gas oil catalytic cracking	In this paper a 5-lump model for gas oil catalytic cracking is proposed theoretically and experimentally.
2.	Liang-Sun Lee, YU-Wen Chen and Tsung-Nien Haung	Four-Lump kinetic model for fluid catalytic cracking Process	In this paper four-lump model is proposed for gas oil catalytic cracking theoretically and experimental data is given.
3.	Bhaskara Rao	Modern Petroleum Refining Processes	Theory on Catalytic Cracking

CHAPTER-3

Five-Lump Kinetic model for gas oil catalytic cracking

The 5-lump kinetic model for catalytic cracking considers five lumps which are unconverted gas oil, gasoline, LPG, dry gas and coke.

Assumption:

In this model the probability of cracking reaction from gasoline to coke is neglected because kinetic constants for these reactions were of very small magnitude than others.

Advantages of 5-lump kinetic model:

- The main advantage of this model is the prediction of coke formation which supplies heat for heating and vaporization of feedstock and to perform endothermic reactions.
- Coke, LPG and dry gas can be predicted independently from other lumps
- This model has less kinetic parameters to be estimated.

Limitations:

- This model does not consider products heavier than gas oil.
- The parameters of the kinetic model depends on the feedstock and catalyst properties.

3.1 Kinetic Expressions:

Assumptions:

- Gas oil cracking was considered as a second order reaction.
- Gasoline and LPG cracking was considered as a first order reaction.
- Exponential law was assumed for catalyst decay(Ø) which depends on the time-on-stream(tc).
- A selective deactivation model based on hypothesis that Ø is same for all reactions was used.

Here, $\boldsymbol{ri}$ - kinetic expression as a function of product yield $\boldsymbol{yi}$;

Ø **-** deactivation function;

$\boldsymbol{ki}$ – kinetic constants;

tc – time-on-stream;

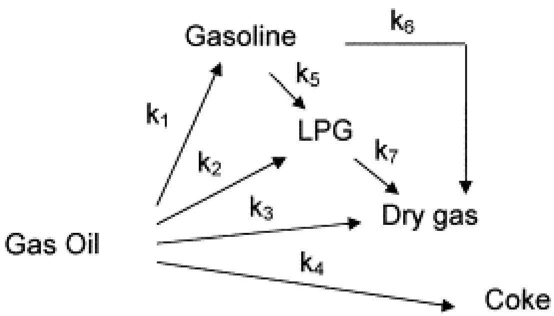

Figure 1:Proposed 5-lump kinetic model

Gas oil: $\boldsymbol{r1} = -(k1 + k2 + k3 + k4)y1^2Ø$

Gasoline: $\boldsymbol{r2} = (k1y1^2 - k5y2 - k6y2)Ø$

LPG: $\boldsymbol{r3} = (k2y1^2 + k5y2 - k7y3)Ø$

Dry gas: $\boldsymbol{r4} = (k3y1^2 + k6y2 + k7y3)Ø$

Coke: $\boldsymbol{r5} = (k4y1^2)Ø$

Decay Function: $Ø = e^{-kdtc}$

3.2 Transport Effects:

Here, **L** – Catalyst Bed Length

dp – Particle Diameter

Pe – Peclet number

Rep – Reynolds number based on particle diameter

x – fractional conversion

n – number of moles

1. $\frac{L}{dp} > \frac{20n}{Pe} \ln\left(\frac{1}{1-x}\right) \quad (33\ vs\ 0.0015)$
2. $Pe > Pemin \quad (56\ vs\ 0.033)$

where,

3. $Pe = 0.087\ Rep^{0.23}(\frac{L}{dp})$
4. $Pemin = 8nln\left(\frac{1}{1-x}\right)$

CHAPTER-4

Simulation

4.1 MATLAB code:

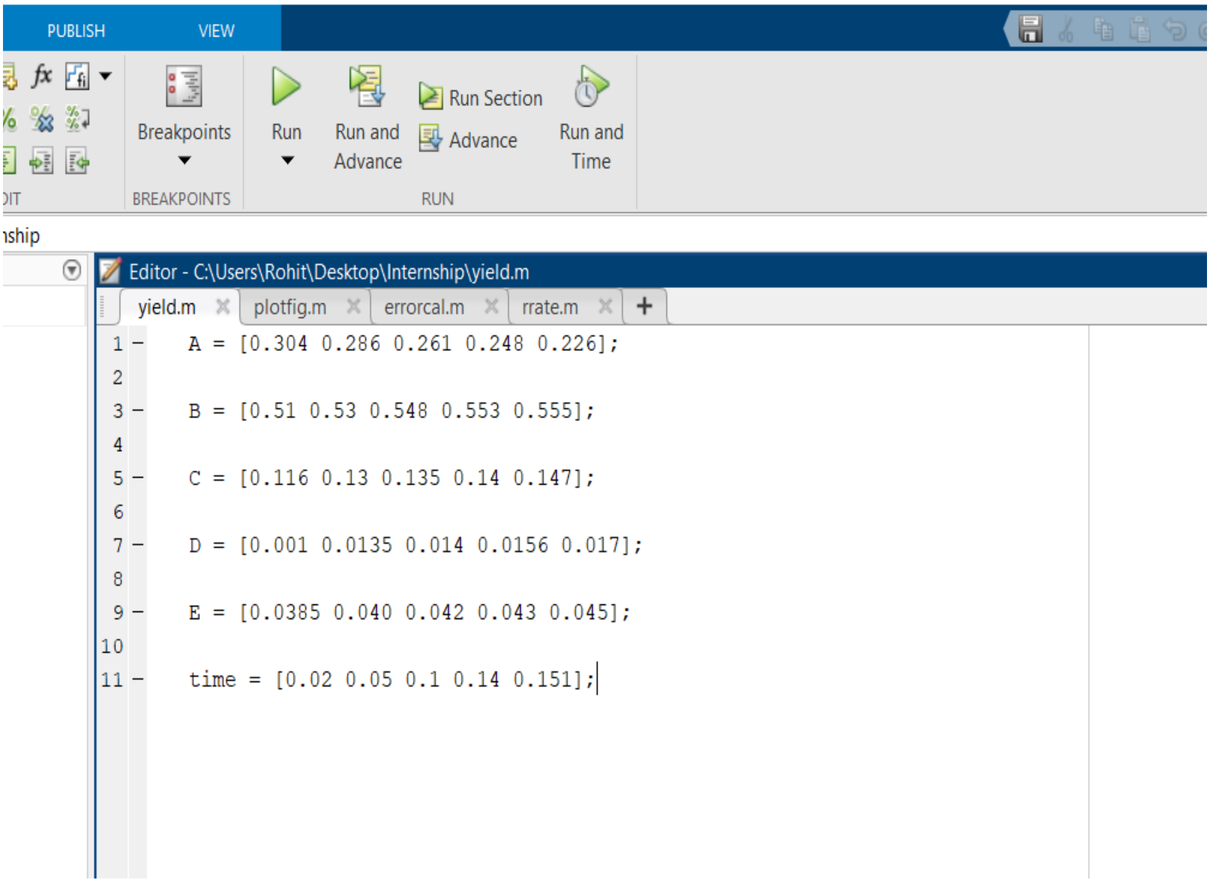

Figure 2 Yield data for 5-lumps

Here, A - Gas oil yield data

B - Gasoline yield data

C - Gas LP yield data

D - Dry gas yield data

E - Coke yield data

All the data is taken at 500 degrees Celsius

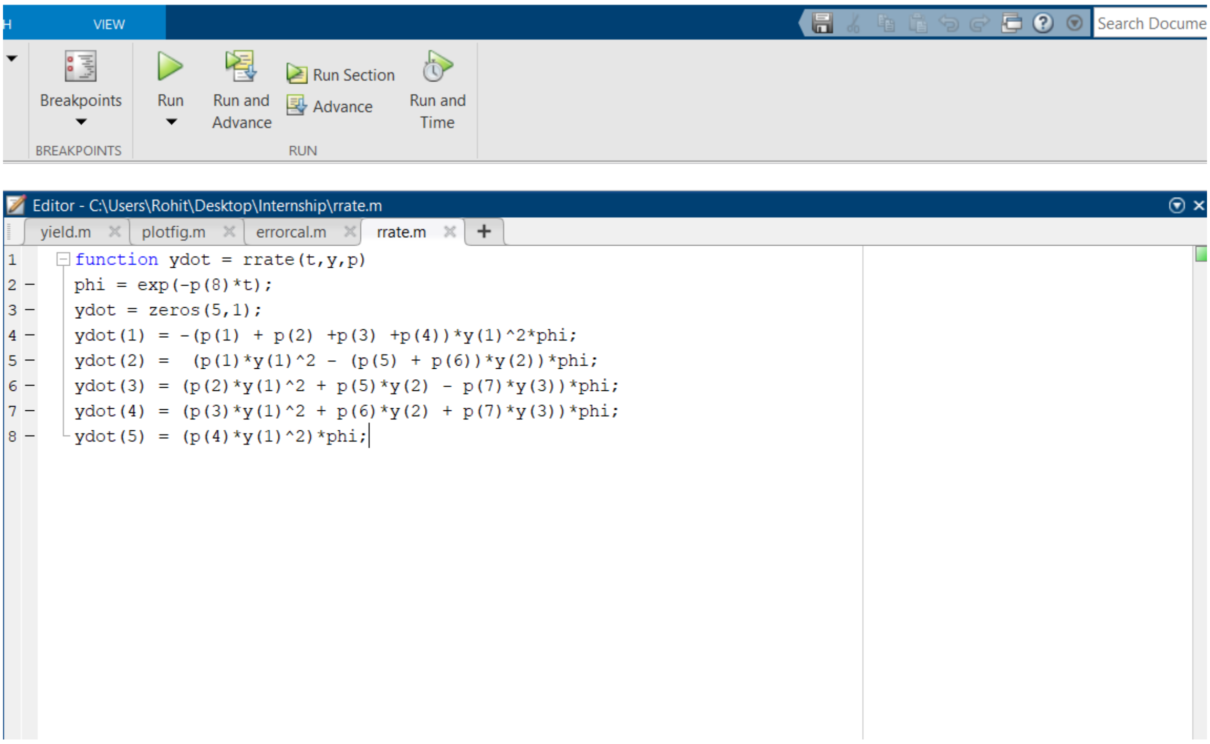

Figure 3 Reaction rates

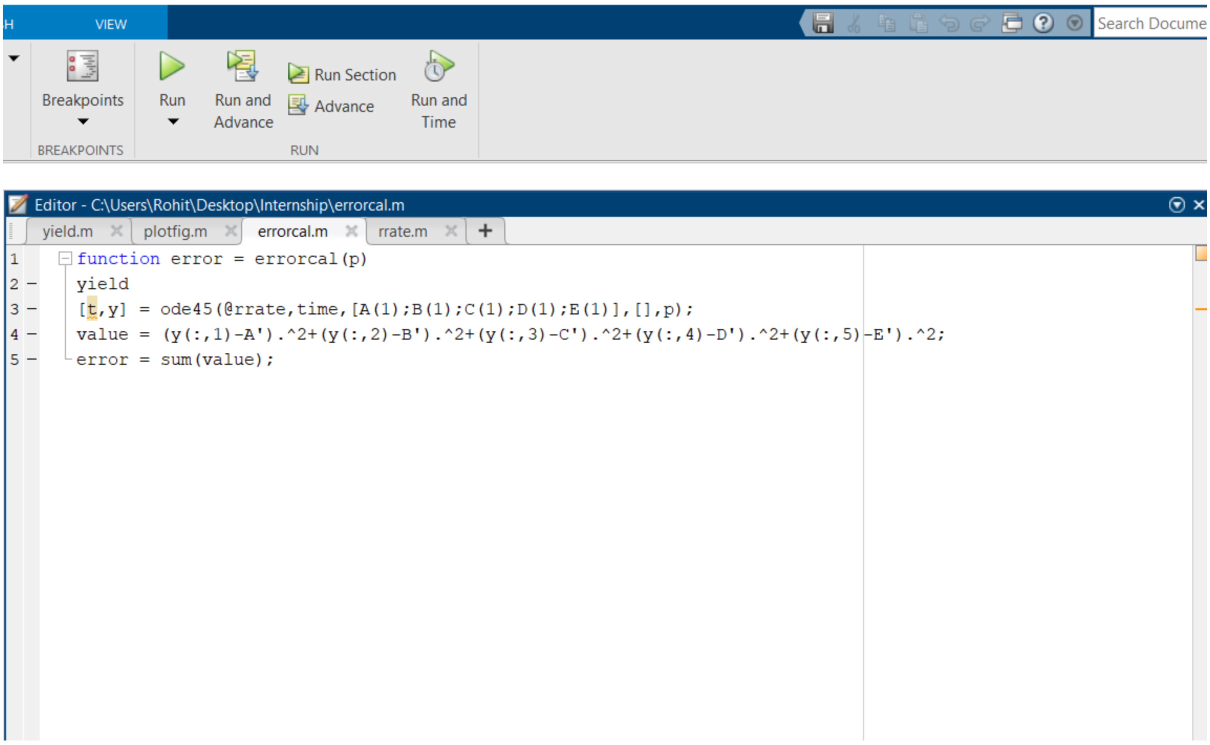

Figure 4 Function for calculating error

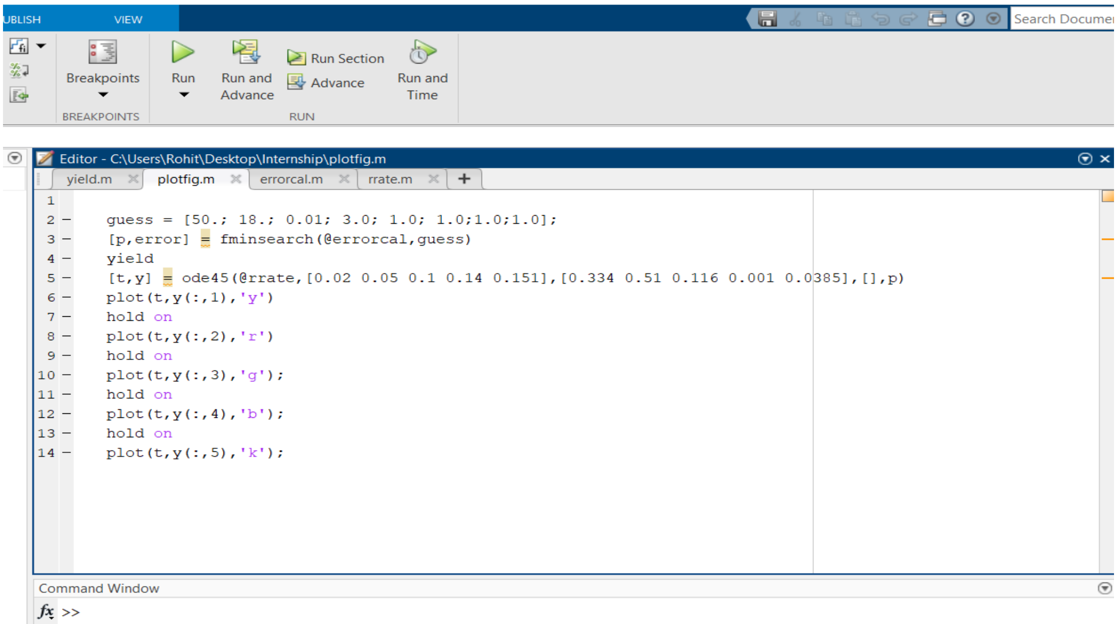

Figure 5 Function for plotting yield vs time curve

4.2 Plotting:

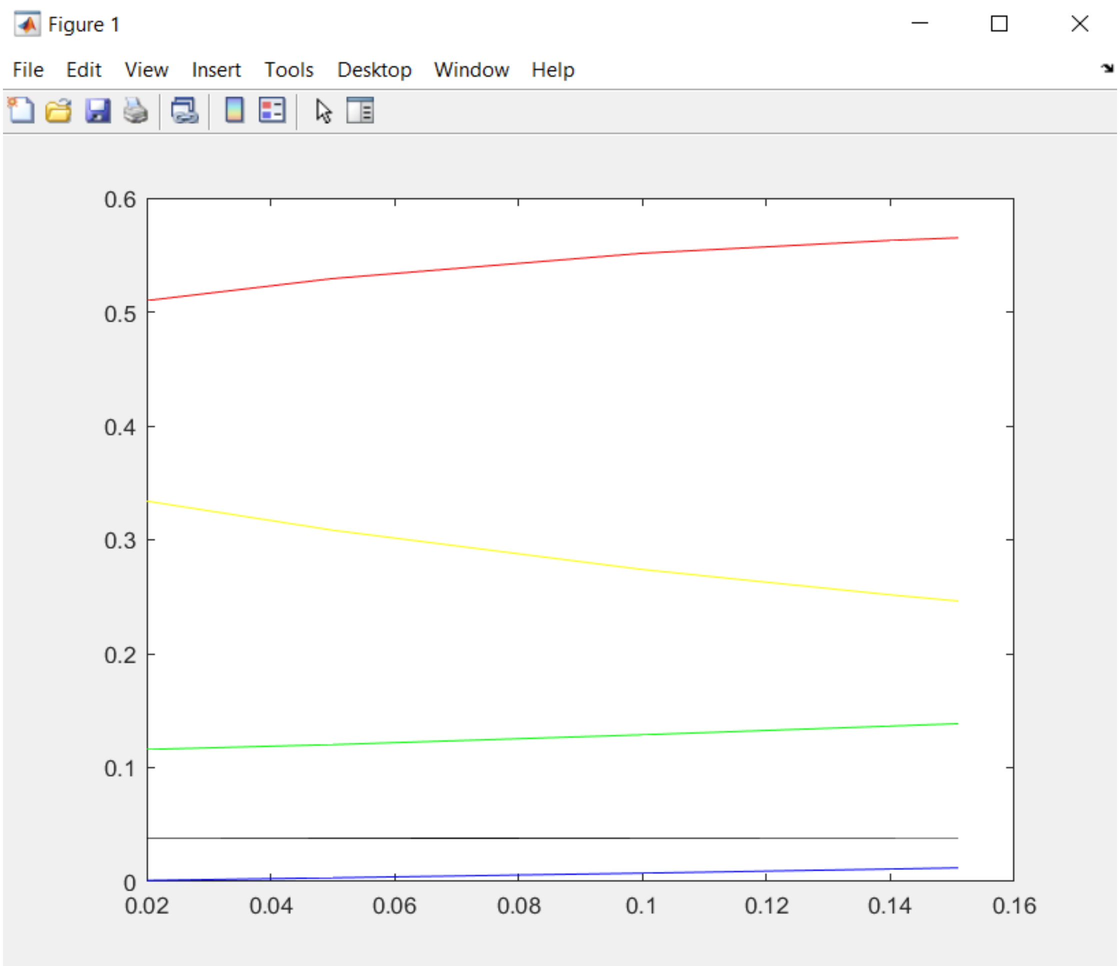

Figure 6 Yield vs time curve at 500 degrees Celsius

Here, Red line – Gasoline

Yellow line – Gas Oil

Green line – Gas LP

Black line – Coke

Blue line – Dry gas

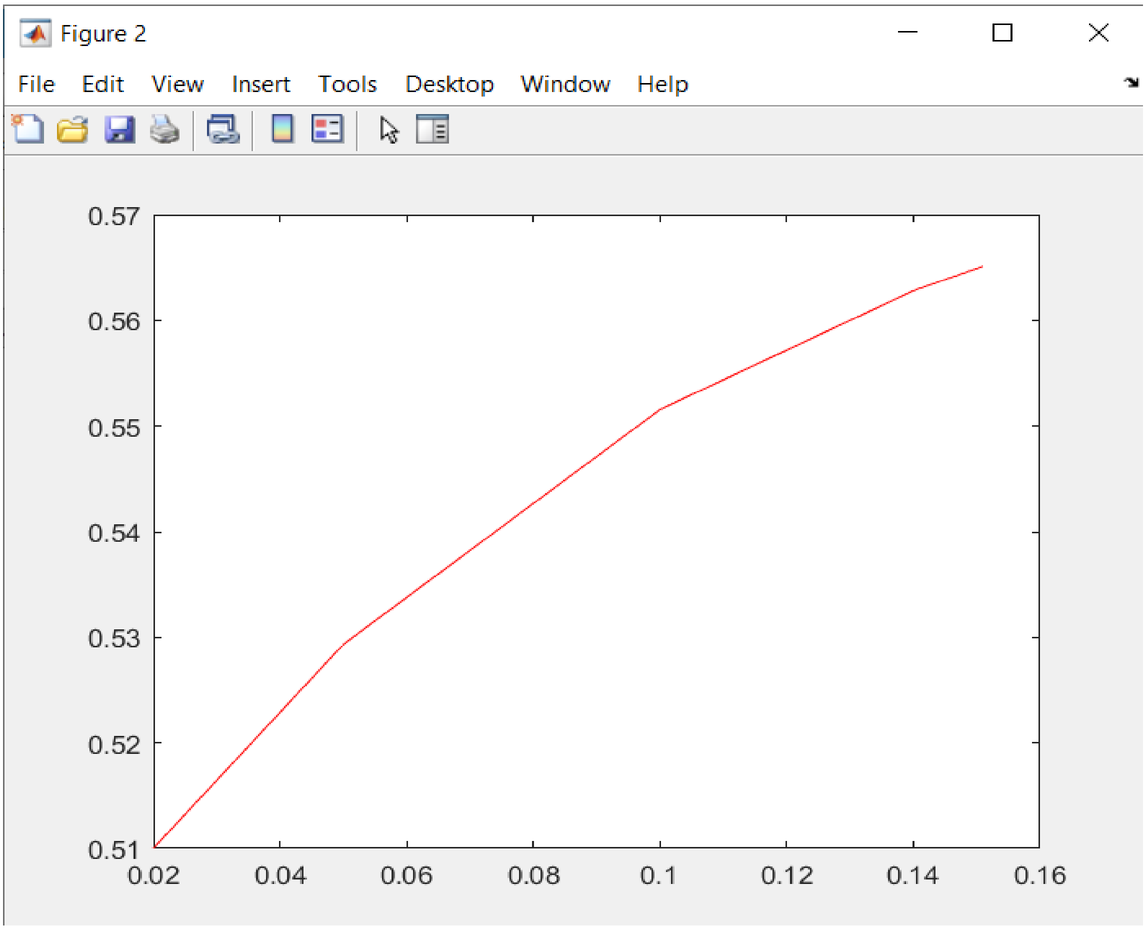

Figure 7 Gasoline Yield vs time curve at 500 degrees Celsius

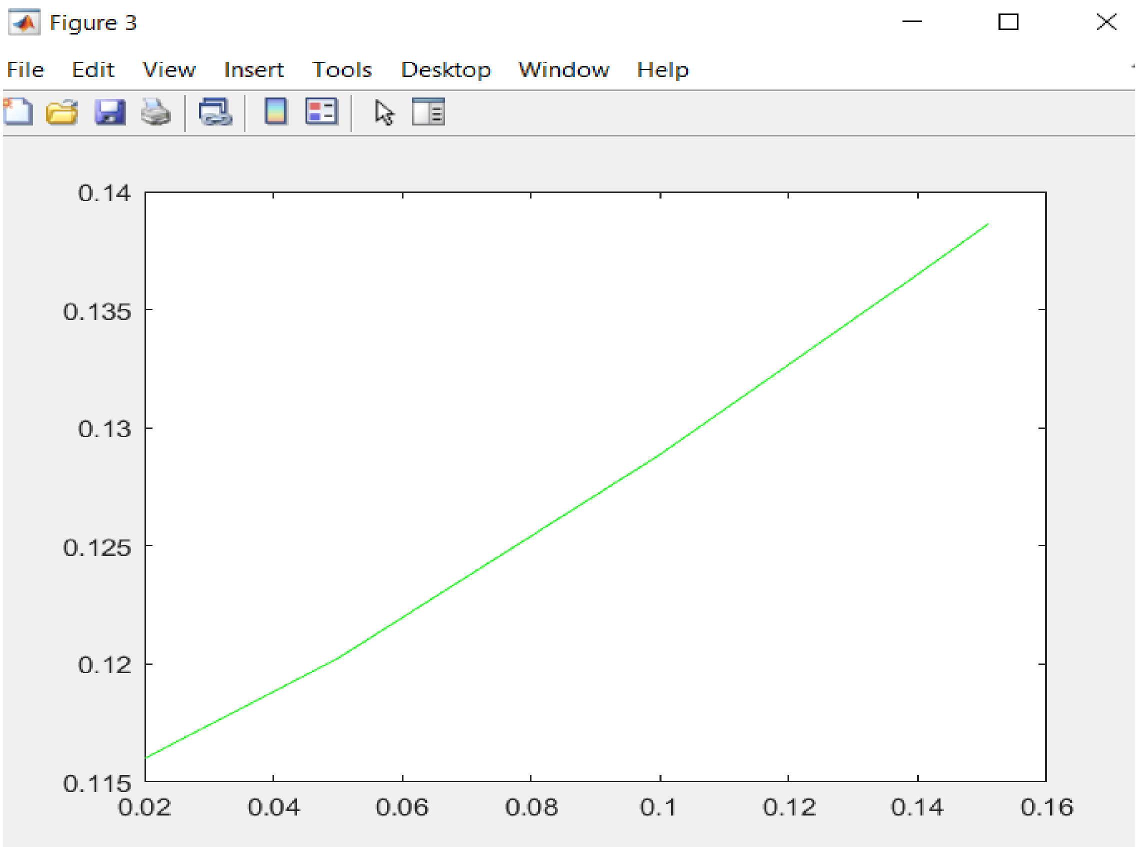

Figure 8 Gas LP yield vs time at 500 degrees Celsius

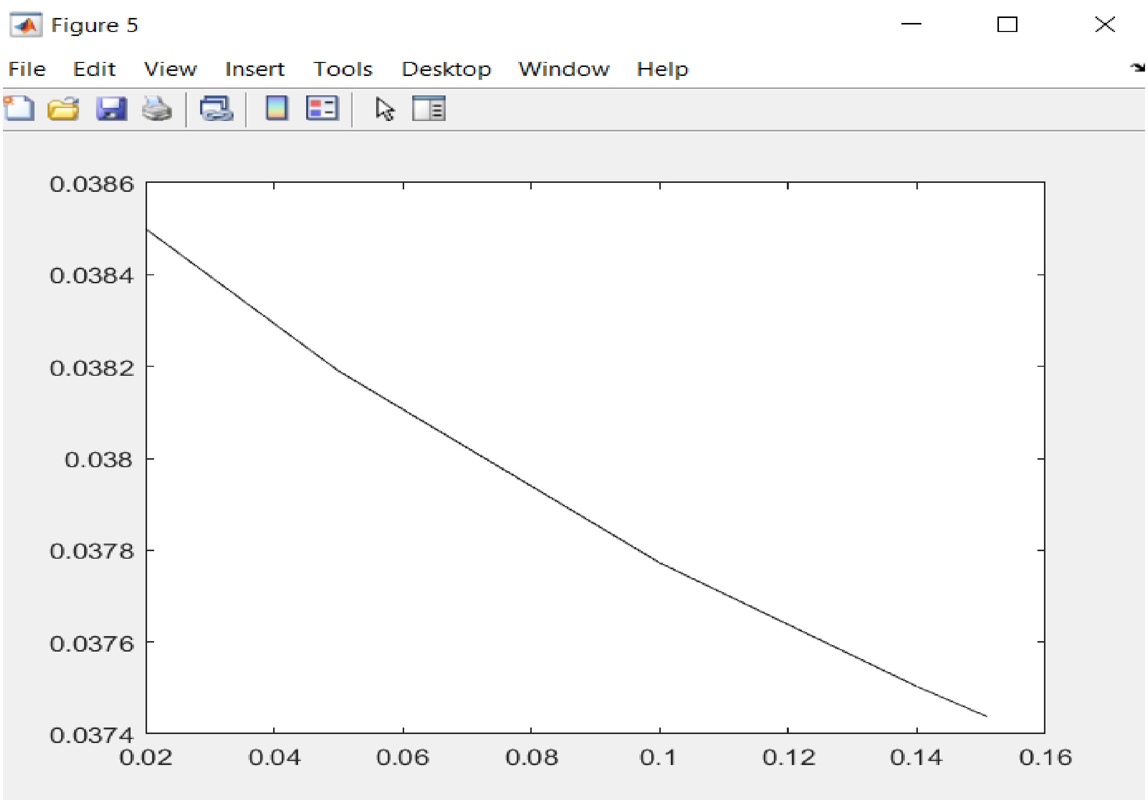

Figure 9 Coke Yield vs time at 500 degrees Celsius

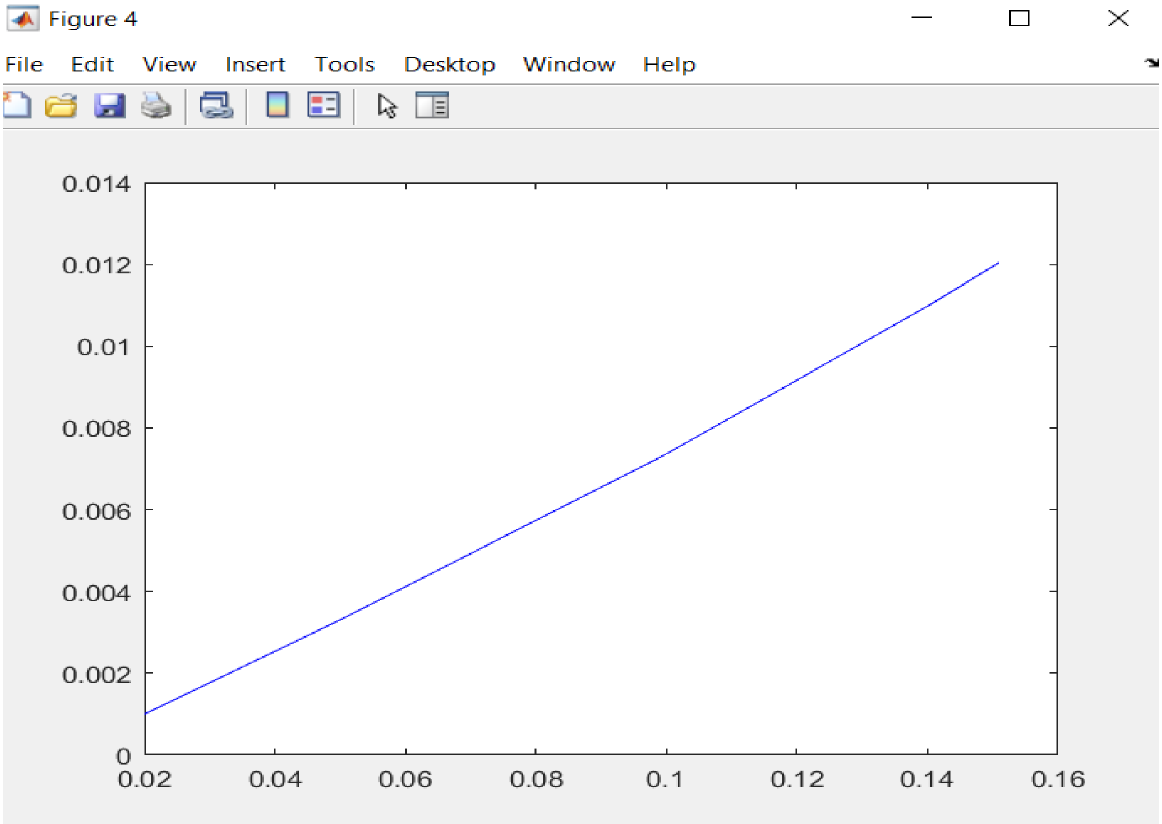

Figure 10 Dry Gas yield vs time at 500 degrees Celsius

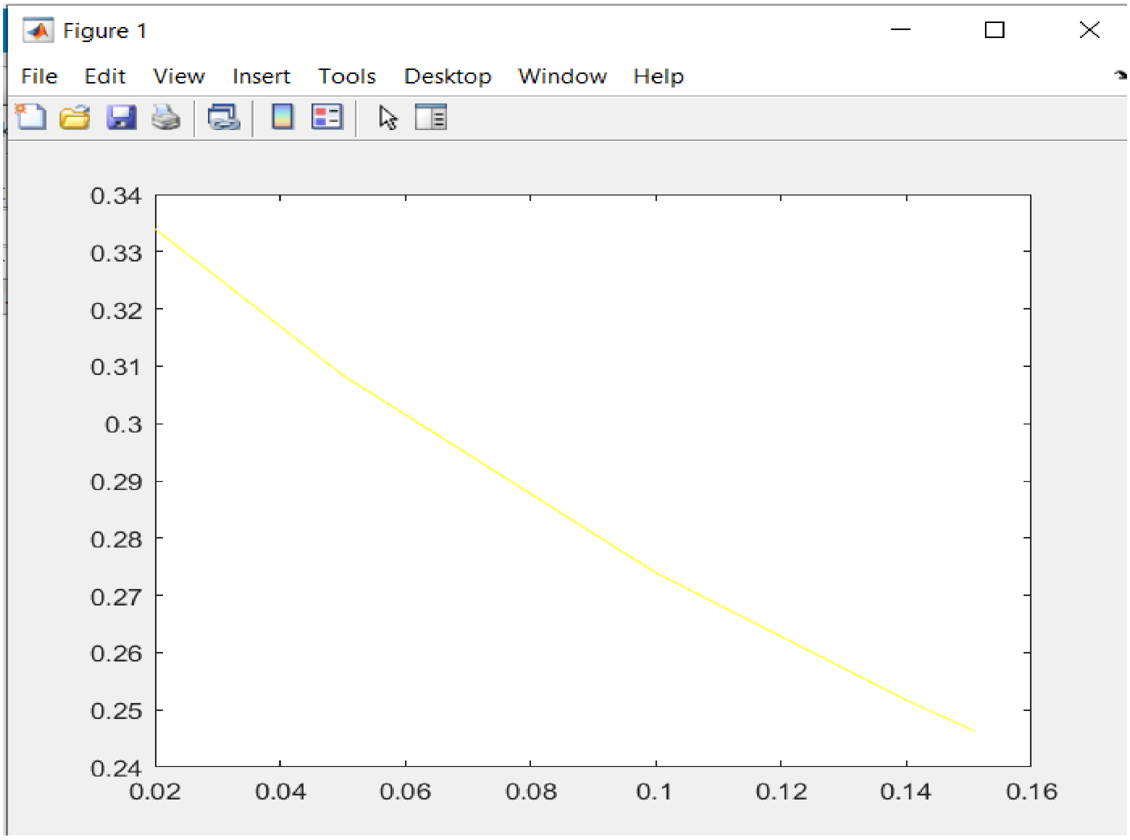

Figure 11 Unconverted Gas oil vs time at 500 degrees Celsius

CHAPTER-5

CONCLUSION

In this paper, there is a proposed 5-lump model for gas oil catalytic cracking into gasoline, Gas LP, Dry gas and coke. Some important points about this model are listed below:

1. With the help of this model we can predict the LPG and dry gas yields separately from other lumps.

2. This model has only seven kinetic constants to be estimated which are very less as compared to other models.

3. Gasoline yield is maximum near small values of space velocity because smaller space velocity increases the contact time and favours gasoline yield.

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