KANDULA SRINIVASA REDDY MEMORIAL COLLEGE OF ENGINEERING (AUTONOMOUS)

KADAPA-516003. AP

(Approved by AICTE, Affiliated to JNTUA, Ananthapuramu, Accredited by NAAC)

(An ISO 9001-2008 Certified Institution)

DEPARTMENT OF HUMANITIES & SCIENCES

CERTIFICATE COURSE

ON

"ALTERNATIVE FUELS"

Resource Persons : Dr. I. Sreevani, **Associate Professor, Dept. of H&S, KSRMCE**

Dr. K. Venkata Ramana, **Assistant Professor, Dept. of H&S, KSRMCE**

Mrs. M. Mary Jasmine, **Assistant Professor, Dept. of H&S, KSRMCE**

Course Coordinator: Smt. M. Mary Jasmine, **Assistant Professor, Dept. of H&S, KSRMCE**

Duration: 04-07-2019 to 08-08-2019

K.S.R.M. COLLEGE OF ENGINEERING

(UGC-AUTONOMOUS)

Kadapa,Andhra Pradesh, India– 516 003

Approved by AICTE, New Delhi & Affiliated to JNTUA, Ananthapuramu.

An ISO 14001:2004 & 9001: 2015 Certified Institution

Lr./KSRMCE/ (Humanities & Sciences)/2019-20

Date: **01.07.2019**

To
The Principal,
K.S.R.M. College of Engineering
Kadapa.

From
M. Mary Jasmine,
Assistant Professor,
Department of H&S,
K.S.R.M College of Engineering
Kadapa.

Respected Sir,

Sub: KSRMCE - (Department of H&S) Permission to conduct Certification course on Alternative fuels–Request–Reg.

It is being brought to your kind notice that, with reference to the cited, the H&S Department is planning to conduct Certification Course on "**Alternative Fuels**" for B. Tech students from July 4th 2019 to August 8th 2019. In this regard I kindly request you sir to grant permission to conduct certificate course. This is submitted for your kind perusal.

Thanking you Sir,

Forwarded to
principal sir
HOD of H&S.

Permitted
V. S. S. Murthy

Yours faithfully

M. Mary jasmine,
Asst. professor,
Dept. of H&S,
K.S.R.M.C.E.

Cr./KSRMCE/(Department of H&S)/2019-20 Date:02-07-2019

Circular

All the B. Tech students are here by informed that Department of H&S is going to conduct Certification course on "Alternative fuels" from 4th July 2019 to 8th August 2019. Interested students may register their names with the coordinator M. Mary Jasmine on before 03-07-2019

For any queries Contact,

Coordinator

M. Mary Jasmine,
Asst. Prof,
Dept. of H&S
Contact No: 9494835212
Room No: CE 302

HOD

Dept. of H&S

Dr. I. SREEVANI M.Sc.,Ph.D.
Head of Humanities & Sciences
K.S.R.M College of Engineering
KADAPA - 516 005

CC

To IQAC

K.S.R.M College of Engineering

(UGC-Autonomous)
Kadapa, Andhra Pradesh, India-516003
Approved by AICTE, New Delhi & Affiliated to JNTUA, Ananthapuramu

Department of Humanities & Sciences

Certification Course on "Alternative Fuels"

Date of event
04-07-2019 to 08-08-2019

Venue
CE-308

Timing
4.00 pm

COURSE INSTRUCTORS

Dr. I. Sreevani
HOD, H&S
M. Mary Jasmine
Asst. Prof, H&S
Dr. K. Venkata Ramana
Asst. Prof, H&S

Mrs. M. Mary Jasmine Coordinator	Dr. I. Sreevani Convener & HOD H&S	Dr. V. S. S. Murthy Principal	Prof. A. Mohan Director	Sri. K. Sivananda Reddy Correspondent

Syllabus of Certification Course

Course Name: Alternative Fuels

Course Objectives:

*To impart knowledge on types & uses of alternative fuels
*To underline concepts and methods behind alternate fuel and energy system

Course Outcomes:

CO1: Understand the various alternative fuels availability & need of alternative fuels in society

CO2: Interpret the characteristics & advantages of vegetable oil as alternate fuel

CO3: Illustrate the method of production of methanol

CO4: Analyze the potential & properties of LPG

CO5: To impart knowledge on use of Hydrogen gas as alternative fuel

Unit-1: Introduction:

Fuels- Introduction, Environmental pollution-Emission of gases from fuel combustion, Need for alternative fuels-Basic Introduction to some of the alternative fuels

Unit-2: Vegetable Oils as Alternative Fuel

Introduction, Characterization of Vegetable oils, Methods to use vegetable oils in Engine, Advantages & challenges in use of vegetable oils

Unit-3: Methanol as Alternative Fuel

Introduction, Potential of methanol, Methanol production, -Renewable resources, methanol safety aspects, Properties of methanol & benefits.

Unit-4: Liquefied Petroleum gas as Alternative fuel

Potential of LPG, LPG Production-Crude oil extraction & refining, , Properties of LPG, LPG Safety aspects, Merits & demerits

Unit-5: Hydrogen as Alternative fuel

Introduction, Hydrogen as Energy carriers, Hydrogen gas production-Pyrolysis, Hydrogen from water, Biohydrogen. Hydrogen gas properties, Hydrogen gas benefits & barriers.

Textbooks:

1. Alternate Fuels by Dr. S. Thipse, Jaico Publications
2. Automotive Emission Control" by Crouse, AND Anglin – McGraw Hill.
3. Alternative Fuels Guidebook" by Bechtold R..
4. Alternative Fuels for Transportation Edited by Arumugam S. Ramadhas, CRC Press

K.S.R.M. COLLEGE OF ENGINEERING

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Kadapa, Andhra Pradesh, India– 516 003

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Date: 01-07-2019

Name of the Event: Certification Course on "Alternative Fuels"

Venue : CE 308

Registration form

S. No	Name	Branch	Roll Number	Signature
1	M. Ganesh	Civil	189Y1A0159	Ganesh
2	Shaik. faizan	Mech	189Y1A0355	faizan
3.	P. Ashraf	Mech	189Y1A0341	P. Ashraf
4.	P. Nedeem khan	mech	189Y1A0344	P. Nandhu Khan
5.	K. Kiran	ECE	189Y1A0464	K. Kiran
6.	K. Tharun	ECE	189Y1A0463	K. Tharun
7.	G. Rajesh	ECE	189Y1A0449	G. Rajesh
8	G. vamikrishna	ECE	189Y1A0440	G. Vamsi
9	A. Prem Reddy	ECE	189Y1A0403	A Prem
10	S. Lokeshwar	CSE	189Y1A0587	Lokesh
11	N. yeswanth	CSE	189Y1A0588	N. Yeswanth
12	B. sujith	mec	189Y1A0307	B. Sujith.
13.	L. Siva Venkata Sai reddy	mec	189Y1A0327	L. Siva Venkata Reddy
14	A. Jamsi	mec	189Y1A0303	A. Jamsi.
15	P. Anil Kumar	Mec	189Y1A0339	P. Anil Kumar
16	P. Sameer khan	MEC	189Y1A0342	P. Sameer khan
17	K. Rohit	EEE	189Y1A0220	K. Rohit
18	M. Venkata Bhaskar	ME	189Y1A0328	M. Venkatabhaskar.
19	manu kumar	ECE	189Y1A0230	manu
20	L. V. V. prasad	CIVIL	189Y1A0155	prasad
21	Y. Sandeep kumar	CSE	189Y1A05F9	Sandeep.
22	R. Murali	ECE	199Y5A0421	R murali
23	Dinesh Pramod	mec	199Y5A0340	Dinesh.
24	C. Lokesh naidu	ece	189Y1A0425	C.Lokesh
25	P. Srinivasulu	ECE	199Y5A0420	Srinu.
26.	M. Sampath	civil	189Y1A0163	M. Sampath
27.	K. Govardhan	civil	189Y1A0146	K Govardhan
28.	Sai pooJith	civil	189Y1A0171	Sai pooJith

29	Md. AZEEZ	Civil	1894IA0168	AZEEZ
30	K. Srinivas rao	EEE	1894IA0223	K. Srinivas
31	P. Sairam	ECE	1894IA0484	Sairam
32	G. Rahul	ECE	1894IA0443	Rahul
33	Mallikarjuna reddy	Civil	1894IA0145	Mallik
34	M. Lokeshwar	civil	1894IA0138	M. Lokeshwar
35	Ganga Maheshwar	ECE	1894IA0468	Ganga Mahesw
36	L. Sravan kumar	Civil	1894IA0154	Sravanakumar
37.	M. Siva prasad	Civil	1894IA0166	Sivaprasad
38.	Samuel	MEC	1894IA0365	Samuel
39	G. Naveen	E.C.E	1894IA0445	G. Naveen.
40	C. Ashok	mec	1894IA0312	C. Ashok

Coordinator | HOD/H&S | Principal

Dr. I. SREEVANI M.Sc.,Ph.D.
Head of Humanities & Sciences
K.S.R.M. College of Engineering
KADAPA - 516 005

V.S.S. Murthy
PRINCIPAL
K.S.R.M. COLLEGE OF ENGINEERING
KADAPA-516003. (A.P.)

K.S.R.M COLLEGE OF ENGINEERING, KADAPA

(Autonomous)

Yerramasupalli, Kadapa, Andhra Pradesh – 516003

Department of Humanities & Sciences

Certification Course on Alternative Fuels

from 04-07-2019 to 08-08-2019

Schedule

S. No	Date	Timing	Course Instructor	Topic to be covered
1.	04-07-2019	4.00 pm – 5.00 pm	M. Mary jasmine	Introduction to fuels, types of fuels, Major uses of fuels in day to day life
2.	05-07-2019	4.00 pm – 5.00 pm	M. Mary jasmine	Environmental pollution-caused by fuels combustion
3.	06-07-2019	4.00 pm – 5.00 pm	M. Mary jasmine	Effects of Emission of gases from fuel combustion
4.	08-07-2019	4.00 pm – 5.00 pm	M. Mary jasmine	Need for alternative fuels
5.	09-07-2019	4.00 pm – 5.00 pm	M. Mary jasmine	Alternative fuels-Examples-Alcohol, methanol, Vegetable oils, Ethers
6.	10-07-2019	4.00 pm – 5.00 pm	M. Mary jasmine	Alternative fuels-Examples-Biodiesel, LPG, Hydrogen gas, Natural gas
7.	11-07-2019	4.00 pm – 5.00 pm	Dr. I. Sreevani	Vegetable oils introduction - Characterization of Vegetable oils
8.	12-07-2019	4.00 pm – 5.00 pm	Dr. I. Sreevani	Methods-Pyrolysis, Trans esterification
9.	15-07-2019	4.00 pm – 5.00 pm	Dr. I. Sreevani	Methods – Dilution, micro emulsification
10.	16-07-2019	4.00 pm – 5.00 pm	Dr. I. Sreevani	Advantages of use of vegetable oils
11.	17-07-2019	4.00 pm – 5.00 pm	Dr. I. Sreevani	challenges in use of vegetable oils
12.	18-07-2019	4.00 pm – 5.00 pm	Dr. K. Venkata Ramana	Methanol- Introduction
13.	19-07-2019	4.00 pm – 5.00 pm	Dr. K. Venkata Ramana	Methanol Potential-Gasoline blend & Diesel blend

14.	20-07-2019	4.00 pm – 5.00 pm	Dr. K. Venkata Ramana	Methanol production-Renewable resources
15.	22-07-2019	4.00 pm – 5.00 pm	Dr. K. Venkata Ramana	Methanol Safety aspects
16.	23-07-2019	4.00 pm – 5.00 pm	Dr. K. Venkata Ramana	Properties of methanol
17.	24-07-2019	4.00 pm – 5.00 pm	Dr. K. Venkata Ramana	Advantages & challenges of methanol usage
18.	25-07-2019	4.00 pm – 5.00 pm	M. Mary jasmine	LPG-Introduction
19.	26-07-2019	4.00 pm – 5.00 pm	M. Mary jasmine	Potential of LPG
20.	27-07-2019	4.00 pm – 6.00 pm	M. Mary jasmine	LPG Production- Natural gas & Crude oil extraction
21.	29-07-2019	4.00 pm – 5.00 pm	M. Mary jasmine	Crude oil refining process
22.	30-07-2019	4.00 pm – 5.00 pm	M. Mary jasmine	LPG Safety aspects
23.	31-07-2019	4.00 pm – 5.00 pm	M. Mary jasmine	Properties of LPG
24.	01-08-2019	4.00 pm – 5.00 pm	M. Mary jasmine	Merits & demerits of usage of LPG
25.	02-08-2019	4.00 pm – 5.00 pm	M. Mary jasmine	Hydrogen as Energy carriers
26.	03-08-2019	4.00 pm – 5.00 pm	M. Mary jasmine	Hydrogen gas production-Pyrolysis, Hydrogen from water
27.	05-08-2019	4.00 pm – 5.00 pm	M. Mary jasmine	Biohydrogen gas production
28.	06-08-2019	4.00 pm – 5.00 pm	M. Mary jasmine	Hydrogen gas Physical properties
29.	07-08-2019	4.00 pm – 5.00 pm	M. Mary jasmine	Hydrogen gas chemical properties
30.	08-08-2019	4.00 pm – 5.00 pm	M. Mary jasmine	Hydrogen gas benefits & barriers.

Coordinator

HOD, H&S

Dr. I. SREEVANI M.Sc.,Ph.D.
Head of Humanities & Sciences
K.S.R.M. College of Engineering
KADAPA - 516 005

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Date: 05-07-2019

Name of the Event: Certification Course on "Alternative Fuels"

Venue : CE 308

List of Participants

S. No	Name	Branch	Roll Number	Signature
1	K.Kiran	ECE	189Y1A0464	K.Kiran
2	K.Tharun	ECE	189Y1A0463	K.Tharun
3	S.Lokeshwar	CSE	189Y1A0587	S.Lokesh
4.	N. Yeswanth	CSE	189Y1A0588	N.Yesh
5.	B. Sujith	Mech	189Y1A0307	B.Sujith
6	L Siva Venkata Sai Reddy	Mech	189Y1A0327	L.Siva Venkata Sai Reddy
7	G. Rajesh	ECE	189Y1A0449	G. Rajesh
8	A. Vamsi	MECH	189Y1A0303	A. Vamsi
9.	P. Anil Kumar	MECH	189Y1A0339	P. Anil Kumar
10.	L. Vera Venkata Vara Prasad Reddy	CIVIL	189Y1A0155	L. Prasad Reddy
11	Y. Sandeep Kumar Reddy	CSE	189Y1A05F9	Y.Sandeep
12	Shaik Faizaan Habeeb	MECH	189Y1A0355	Faizaan
13	M. Lokeshwar Reddy	Civil	189Y1A0158	M.Lokesh
14	G. Vamsi krishna Reddy	E.C.E	189Y1A0440	[illegible]
15.	Mannu Kumar	EEE	189Y1A0230	Mannu
16	A. Pream Reddy	ECE	189Y1A0403	[illegible]
17	K. Sai Mallikarjuna Reddy	Civil	189Y1A0145	A Pream
18	M. Ganesh	Civil	189Y1A0159	M.Ganesh
19	G. Rahul	ECE	189Y1A0443	G. Rahul
20	C. Lokesh Naidu	ECE	189Y1A0425	C. Lokesh
21	M. Sampath Kumar	Civil	189Y1A0163	M. Sampath
22	P. Srinivasulu	ECE	199Y5A0420	P. Srinivasulu
23	K. Govardhan	Civil	18Y1A0146	K. Govardhan
24	P. Ashraf Ali Khan	MECH	189Y1A0341	P. Ashraf
25	Y. Muni Dinesh prasad	Mech	199Y1A0340	Y. Muni Dinesh

26	N. Venkata Saipoojitha	Civil	1894IA0171	N. Poojitha
27	P. Sameer Khan	MECH	1894IA0342	Sameer
28	K. Rohith	EEE	1894IA0220	K.Rohith
29	K. Ganga Mesheswar Reddy	ECE	1894IA0468	K. Maheshwar.
30	M. Mahamood Azeez	Civil	1894IA0168	Mahamood
31	M. Venkata Bhaskar	Mech	1894IA03[illegible]	M. Venkata Bhaskar
32	P. Nadeemkahn	mec	1894IA0344	P. [illegible]
33	K. Sreenivas Rao	EEE	1894IA0283	Sreenivas
34	P. Sairam	ECE	1894IA04B4	P. Sairam.
35	M. Siva prasad Reddy	Civil	1894IA0166	Siva[illegible]
36.	L. Saisravan Kumar	Civil	1894IA0154	L. Sravan
37.	R. Murali	ECE	1994SA0421	RM

Coordinator

HOD/H&S

Dr. I. SREEVANI M.Sc.,Ph.D.
Head of Humanities & Sciences
K.S.R.M. College of Engineering
KADAPA - 516 005

V. S. S. Murthy

Principal

PRINCIPAL
K.S.R.M. COLLEGE OF ENGINEERING
KADAPA-516003. (A.P.)

K.S.R.M College of Engineering (Autonomous), Kadapa
Department of Humanities & Sciences
Certification Course on Alternative Fuels
Attendance Sheet (4-Jul-2019 to 8-Aug-2019)

S.No	Name of the student	Roll No	Branch	4-Jul	5-Jul	6-Jul	8-Jul	9-Jul	10-Jul	11-Jul	12-Jul	15-Jul	16-Jul	17-Jul	18-Jul	19-Jul	20-Jul	22-Jul	23-Jul	24-Jul	25-Jul	26-Jul	27-Jul	29-Jul	30-Jul	31-Jul	1-Aug	2-Aug	3-Aug	5-Aug	6-Aug	7-Aug	8-Aug
1	K. Kiran	189Y1A0464	ECE	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]
2	K.Tharun	189Y1A0463	ECE	Th	Th	Tharun	Tharun	Tharun	Tharun	Tharun	Tharun	Tharun	Tharun	Tharun	Tharun	Tharun	Tharun	Tharun	Tharun	Tharun	Tharun	Tharun	Tharun	Tharun	Tharun	Tharun	Tharun	Tharun	Tharun	Tharun	Tharun	Tharun	Tharun
3	G.Rajesh	189Y1A0449	ECE	Raj	Raj	Raj	Raj	Raj	Raj	Raj	Raj	Raj	Raj	Raj	Raj	Raj	Raj	Raj	Raj	Raj	a	Raj	Raj	Raj	Raj	Raj	Raj	Raj	Raj	Raj	Raj	Raj	Raj
4	G.Vamsi Krishna Reddy	189Y1A0440	ECE	vamsi	vamsi	vamsi	vamsi	vamsi	vamsi	vamsi	A	vamsi	vamsi	vamsi	vamsi	vamsi	vamsi	vamsi	vamsi	vamsi	vamsi	vamsi	vamsi	vamsi	vamsi	vamsi	vamsi	A	vamsi	vamsi	vamsi	vamsi	vamsi
5	G. Rahul	189Y1A0443	ECE	Rahul	Rahul	Rahul	Rahul	a	Rahul	Rahul	Rahul	Rahul	Rahul	Rahul	Rahul	Rahul	Rahul	Rahul	Rahul	Rahul	Rahul	Rahul	Rahul	Rahul	Rahul	Rahul	Rahul	a	Rahul	Rahul	Rahul	Rahul	Rahul
6	C.Lokesh Naidu	189Y1A0425	ECE	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]
7	K.Ganga Maheswar Reddy	189Y1A0468	ECE	Mah	Mah	A	Mah	Mah	Mah	Mah	Mah	Mah	Mah	Mah	Mah	Mah	Mah	Mah	Mah	A	Mah	Mah	Mah	Mah	Mah	Mah	Mah	Mah	Mah	Mah	Mah	Mah	Mah
8	P.Sairam	189Y1A04B4	ECE	Sai	Sai	Sai	Sai	Sai	Sai	Sai	Sai	Sai	Sai	Sai	Sai	Sai	Sai	Sai	Sai	Sai	Sai	Sai	Sai	Sai	Sai	Sai	Sai	Sai	Sai	Sai	Sai	Sai	Sai
9	S.Lokeshwar	189Y1A05B7	CSE	S.LR	A	S.LR	S.LR	S.LR	S.LR	S.LR	S.LR	S.LR	S.LR	S.LR	S.LR	S.LR	S.LR	S.LR	S.LR	S.LR	S.LR	S.LR	S.LR	S.LR	S.LR	S.LR	S.LR	S.LR	S.LR	S.LR	S.LR	S.LR	S.LR
10	N.Yeswanth	189Y1A0588	CSE	N.yh	N.yh	N.yh	N.yh	N.yh	N.yh	N.yh	N.yh	N.yh	N.yh	N.yh	N.yh	N.yh	N.yh	N.yh	N.yh	N.yh	N.yh	N.yh	N.yh	N.yh	N.yh	N.yh	N.yh	N.yh	N.yh	N.yh	N.yh	N.yh	N.yh
11	Y.Sandeep Kumar Reddy	189Y1A05F9	CSE	Y.S.d	Y.S.d	A	Y.S.d	Y.S.d	Y.S.d	Y.S.d	Y.S.d	Y.S.d	Y.S.d	Y.S.d	Y.S.d	Y.S.d	Y.S.d	Y.S.d	Y.S.d	Y.S.d	Y.S.d	Y.S.d	Y.S.d	Y.S.d	Y.S.d	Y.S.d	Y.S.d	Y.S.d	Y.S.d	Y.S.d	Y.S.d	Y.S.d	Y.S.d
12	K.Sai Mallikarjuna Reddy	189Y1A0145	Civil	K.S.R	K.S.R	K.S.R	K.S.R	K.S.R	K.S.R	K.S.R	K.S.R	K.S.R	K.S.R	K.S.R	K.S.R	K.S.R	K.S.R	K.S.R	K.S.R	K.S.R	K.S.R	K.S.R	K.S.R	K.S.R	K.S.R	K.S.R	K.S.R	K.S.R	K.S.R	K.S.R	K.S.R	K.S.R	[illegible]
13	K.Govardhan	189Y1A0146	Civil	K.Gov	K.Gov	K.Gov	K.Gov	K.Gov	K.Gov	K.Gov	K.Gov	K.Gov	K.Gov	K.Gov	K.Gov	K.Gov	K.Gov	K.Gov	K.Gov	K.Gov	K.Gov	K.Gov	K.Gov	A	K.Gov	K.Gov	K.Gov	K.Gov	K.Gov	K.Gov	K.Gov	K.Gov	K.Gov
14	L.Sai Sravan Kumar Reddy	189Y1A0154	Civil	L.Sai	L.Sai	L.Sai	L.Sai	L.Sai	L.Sai	L.Sai	L.Sai	L.Sai	L.Sai	L.Sai	L.Sai	L.Sai	L.Sai	L.Sai	L.Sai	L.Sai	L.Sai	L.Sai	L.Sai	L.Sai	L.Sai	L.Sai	L.Sai	L.Sai	L.Sai	L.Sai	L.Sai	L.Sai	L.Sai
15	B.sujith	189Y1A0307	Mech	B.Suji	B.Suji	B.Suji	B.Suji	B.Suji	B.Suji	B.Suji	B.Suji	B.Suji	B.Suji	B.Suji	B.Suji	B.Suji	B.Suji	A	B.Suji	B.Suji	B.Suji	B.Suji	B.Suji	B.Suji	B.Suji	B.Suji	B.Suji	B.Suji	B.Suji	B.Suji	B.Suji	B.Suji	B.Suji
16	L.Siva Venkata Sai reddy	189Y1A0327	Mech	L.Sai Reddy	L.Sai Reddy	L.Sai Reddy	L.Sai Reddy	L.Sai Reddy	L.Sai Reddy	L.Sai Reddy	L.Sai Reddy	L.Sai Reddy	L.Sai Reddy	L.Sai Reddy	L.Sai Reddy	L.Sai Reddy	L.Sai Reddy	a	L.Sai Reddy	L.Sai Reddy	L.Sai Reddy	L.Sai Reddy	L.Sai Reddy	L.Sai Reddy	L.Sai Reddy	L.Sai Reddy	L.Sai Reddy	L.Sai Reddy	L.Sai Reddy	L.Sai Reddy	L.Sai Reddy	L.Sai Reddy	L.Sai Reddy
17	P.Anil Kumar	189Y1A0339	Mech	P.Anil Kum	P.Anil Kum	P.Anil Kum	P.Anil Kum	P.Anil Kum	P.Anil Kum	P.Anil Kum	P.Anil Kum	P.Anil Kum	P.Anil Kum	P.Anil Kum	P.Anil Kum	P.Anil Kum	P.Anil Kum	a	P.Anil Kum	P.Anil Kum	P.Anil Kum	P.Anil Kum	P.Anil Kum	P.Anil Kum	P.Anil Kum	P.Anil Kum	P.Anil Kum	P.Anil Kum	P.Anil Kum	P.Anil Kum	P.Anil Kum	P.Anil Kum	P.Anil Kum
18	A.Vamsi	189Y1A0303	Mech	A. Vamsi	A. Vamsi	A. Vamsi	A. Vamsi	A. Vamsi	A. Vamsi	A. Vamsi	A. Vamsi	A. Vamsi	A. Vamsi	A. Vamsi	A. Vamsi	A. Vamsi	A. Vamsi	A. Vamsi	A. Vamsi	A. Vamsi	A. Vamsi	A. Vamsi	A. Vamsi	A. Vamsi	a	A. Vamsi	A. Vamsi	A. Vamsi	A. Vamsi	A. Vamsi	A. Vamsi	A. Vamsi	A. Vamsi
19	M.Venkata Bhaskar	189Y1A0328	Mech	M.V.B	M.V.B	M.V.B	M.V.B	M.V.B	M.V.B	M.V.B	M.V.B	M.V.B	M.V.B	M.V.B	M.V.B	M.V.B	M.V.B	M.V.B	M.V.B	M.V.B	M.V.B	M.V.B	M.V.B	M.V.B	a	M.V.B	M.V.B	M.V.B	M.V.B	M.V.B	M.V.B	M.V.B	M.V.B

				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
20	L.V. VenkataVara Prasad Reddy	189Y1A0155	Civil	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]
21	M.Lokeshwar Reddy	189Y1A0158	Civil	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]
22	M.Ganesh	189Y1A0159	Civil	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	A	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	A	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]
23	M.Sampath Kumar	189Y1A0163	Civil	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]
24	M.Siva Prasad Reddy	189Y1A0166	Civil	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	A	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]
25	M.Mohammad Azeez	189Y1A0168	Civil	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]
26	N.Venkata Sai Poojith	189Y1A0171	Civil	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]
27	Shaik. Faizaan Habeeb	189Y1A0355	Mech	[signature]	[signature]	A	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]
28	Mannu Kumar	189Y1A0230	EEE	[signature]	[signature]	A	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]
29	Patan Ashraf Ali Khan	189Y1A0341	Mech	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	A	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]
30	Patan Sameer Khan	189Y1A0342	Mech	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	A	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]
31	Patan Nadeem Khan	189Y1A0344	Mech	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	A	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]
32	A.Prem reddy	189Y1A0403	ECE	[signature]	[signature]	A	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	A	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]
33	K.Sreenivasa Rao	189Y1A0223	EEE	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	A	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]
34	K.Rohith	189Y1A0220	EEE	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	A	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]
35	V.Muni Dinesh Pramod Raju	199Y5A0340	Mech	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	A	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]
36	P.Srinivasulu	199Y5A0420	ECE	[signature]	[signature]	[signature]	A	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]
37	R.Murali	199Y5A0421	ECE	[signature]	[signature]	[signature]	A	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]
	Signature of Instructor			[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]	[signature]

Coordinator

HOD

Dr. I. SREEVANI M.Sc.,Ph.D.
Head of Humanities & Sciences
K.S.R.M College of Engineering
KADAPA 516 005

K.S.R.M. COLLEGE OF ENGINEERING

UGC - AUTONOMOUS

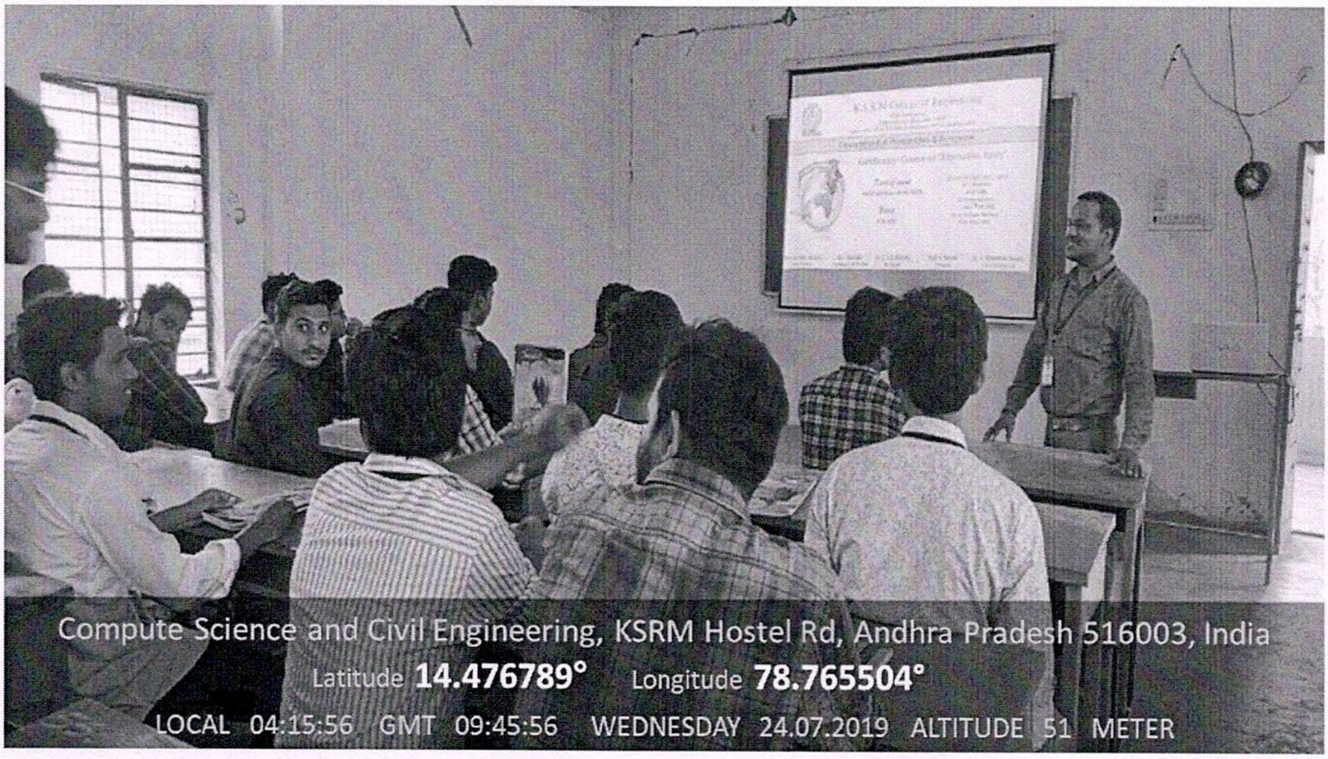
Approved by AICTE, New Delhi & Affiliated to JNTUA, Ananthapuramu.

Kadapa, Andhra Pradesh, India– 516 003

Activity Report

Name of the Activity	Certification Course on Alternative Fuels
Type of Activity	Student Centric Event
Date and Time of Activity	04-07-2019 to 08-08-2019 at 4.00 PM
Venue	CE 308
Details of Participants	Students -37
Coordinator	Smt. M. Mary Jasmine
Organizing Department	Department of Humanities and Sciences
Description	Certification course on "Alternative Fuels" was organized by Dept. of H&S from July 4th 2019 to August 8th 2019 in CE 308. Dr. I. Sreevani, Dr. K. Venkata Ramana & Mrs. M. Mary Jasmine acted as Course instructors. The main aim of the course is to help the students to understand the effects caused by the use of fossil fuels and importance of protection of environment and human life. The students were given awareness on advantages of use of alternative fuels and their challenges that are posed in society. This programme helps the students to understand the basic concepts of types of alternative fuels that are used in now-a-days, their synthetic methods and applications in day to day life. Certification course was successfully completed and certificates were provided to the participants.

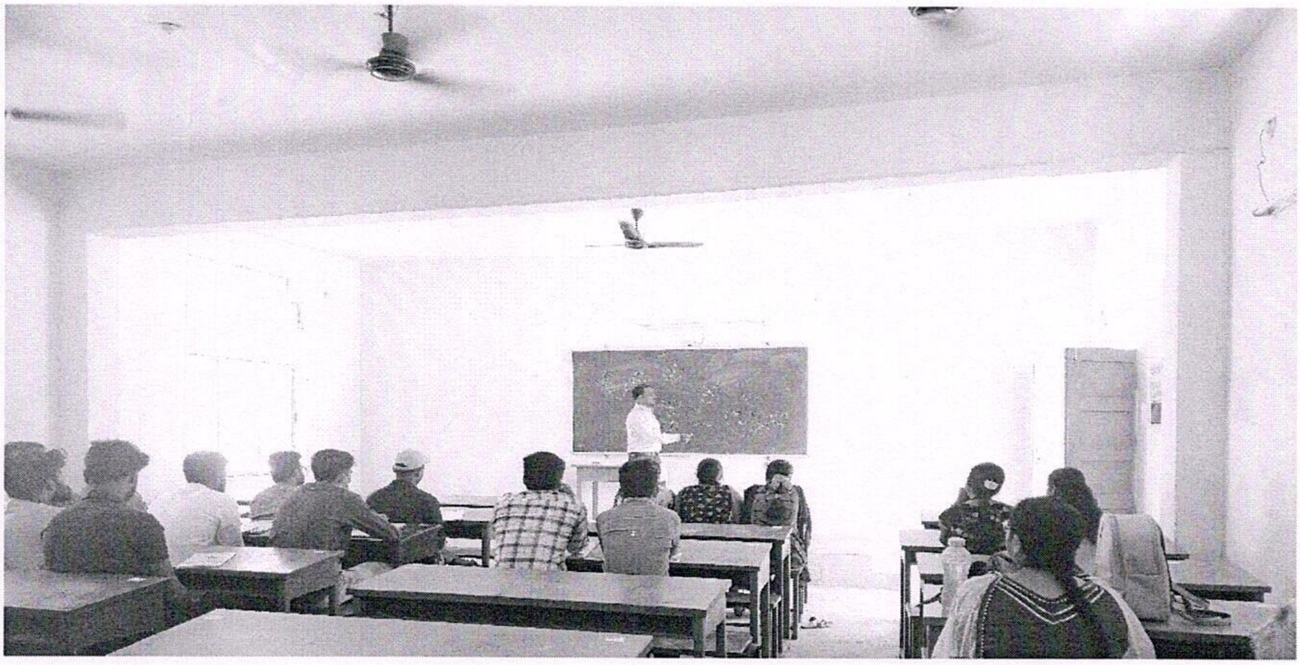
Photo:



Introduction of Course syllabus to Students in Certification Course

Interaction of students with Course Instructors

Course Instructor Explaining the importance of Alternative Fuels



Students listening to Instructor

M. Mary Jasmine
Coordinator

Dr. I. Sreevani
HOD, H&S

Dr. I. SREEVANI M.Sc.,Ph.D.
Head of Humanities & Sciences
K.S.R.M. College of Engineering
KADAPA - 516 005

K.S.R.M COLLEGE OF ENGINEERING, KADAPA

(Autonomous)

Yerramasupalli, Kadapa, Andhra Pradesh – 516003

Department of Humanities & Sciences

Feedback Form
On
Certification Course on Alternative Fuels

(04-07-2019 to 08-08-2019)

1. The course content met your expectation
   [ ] Yes [ ] No

2. The content of the course was useful and interesting
   [ ] Strongly agree [ ] Agree [ ] Disagree [ ] Strongly Disagree

3. The content was explained well with adequate examples by the instructors
   [ ] Strongly agree [ ] Agree [ ] Disagree [ ] Strongly Disagree

4. The course has increased my knowledge on discussed topics
   [ ] Strongly agree [ ] Agree [ ] Disagree [ ] Strongly Disagree

5. The level of the course
   [ ] Low [ ] Moderate [ ] High [ ] Very High

6. What is the level of satisfaction for the course
   [ ] Very satisfied [ ] Satisfied [ ] Neutral [ ] Dissatisfied

Suggestions if any: ……………………………………………………………………

Signature of the participant

K.S.R.M College of Engineering (Autonomous), Kadapa

Department of Humanities & Sciences

Certification Course on Alternative Fuels

Feedback form

Name of the student	Branch	Roll Number	The course content met your expectation	Is the content of the course useful & Interesting	The content was explained well with adequate examples by the instructor	The course has increased my knowledge on discussed topics	Rate the level of the course	What is the level of satisfaction for the course	Suggestions if any
K. Kiran	ECE	189Y1A0464	Yes	Agree	Strongly Agree	Agree	Moderate	Satisfied	No
K.Tharun	ECE	189Y1A0463	Yes	Strongly Agree	Agree	Strongly Agree	Moderate	Very Satisfied	Good
G.Rajesh	ECE	189Y1A0449	Yes	Agree	Strongly Agree	Agree	High	Neutral	Perfectly understand
G.Vamsi Krishna Reddy	ECE	189Y1A0440	Yes	Agree	Strongly Agree	Strongly Agree	Moderate	Neutral	No
G. Rahul	ECE	189Y1A0443	Yes	Strongly Agree	Strongly Agree	Strongly Agree	High	Neutral	Nothing
C.Lokesh Naidu	ECE	189Y1A0425	Yes	Strongly Agree	Strongly Agree	Strongly Agree	High	Very Satisfied	No
K.Ganga Maheswar Reddy	ECE	189Y1A0468	Yes	Agree	Agree	Strongly Agree	Moderate	Satisfied	No..
P.Sairam	ECE	189Y1A04B4	Yes	Agree	Strongly DisAgree	Strongly DisAgree	Very High	Very Satisfied	No..
S.Lokeshwar	CSE	189Y1A05B7	Yes	Agree	Agree	Strongly Agree	High	Neutral	No
N.Yeswanth	CSE	189Y1A0588	Yes	Strongly Agree	Strongly Agree	Strongly Agree	Moderate	Satisfied	No
Y.Sandeep Kumar Reddy	CSE	189Y1A05F9	Yes	Strongly Agree	Strongly Agree	Strongly Agree	High	Very Satisfied	Good course
K.Sai Mallikarjuna Reddy	Civil	189Y1A0145	Yes	Strongly Agree	Agree	Agree	High	Neutral	No
K.Govardhan	Civil	189Y1A0146	Yes	Agree	Strongly Agree	Strongly Agree	Moderate	Satisfied	No
L.Sai Sravan Kumar Reddy	Civil	189Y1A0154	Yes	Strongly Agree	Strongly Agree	Agree	High	Satisfied	It's good
B.sujith	Mech	189Y1A0307	Yes	Agree	Agree	Strongly Agree	Moderate	Satisfied	No
L.Siva Venkata Sai reddy	Mech	189Y1A0327	Yes	Strongly Agree	Strongly Agree	Agree	High	Neutral	No issues
P.Anil Kumar	Mech	189Y1A0339	Yes	Agree	Agree	Strongly Agree	Moderate	Very Satisfied	Noo
A.Vamsi	Mech	189Y1A0303	Yes	Strongly Agree	Strongly Agree	Strongly Agree	High	Satisfied	No issues
M.Venkata Bhaskar	Mech	189Y1A0328	Yes	Agree	Strongly Agree	Strongly Agree	Moderate	Neutral	No issues regarding to this course..
L.V. VenkataVara Prasad Reddy	Civil	189Y1A0155	Yes	Agree	Agree	Strongly Agree	High	Very Satisfied	No
M.Lokeshwar Reddy	Civil	189Y1A0158	Yes	Strongly Agree	Agree	Agree	High	Neutral	Nothing
M.Ganesh	Civil	189Y1A0159	Yes	Strongly Agree	Agree	Strongly Agree	Moderate	Neutral	No issues

M.Sampath Kumar	Civil	189Y1A0163	Yes	Strongly Agree	Strongly Agree	Strongly Agree	Moderate	Very Satisfied	No
M.Siva Prasad Reddy	Civil	189Y1A0166	Yes	Agree	Agree	Strongly Agree	Moderate	Very Satisfied	Nothing
M.Mohammad Azeez	Civil	189Y1A0168	Yes	Strongly Agree	Strongly Agree	Strongly Agree	Moderate	Satisfied	No
N.Venkata Sai Poojith	Civil	189Y1A0171	Yes	Agree	Strongly Agree	Strongly Agree	High	Satisfied	No
Shaik. Faizaan Habeeb	Mech	189Y1A0355	Yes	Strongly Agree	Strongly Agree	Agree	Moderate	Satisfied	No
Mannu Kumar	EEE	189Y1A0230	Yes	Agree	Agree	Strongly Agree	High	Very Satisfied	No
Patan Ashraf Ali Khan	Mech	189Y1A0341	Yes	Strongly Agree	Strongly Agree	Agree	Moderate	Satisfied	No
Patan Sameer Khan	Mech	189Y1A0342	Yes	Strongly Agree	Strongly Agree	Strongly Agree	Moderate	Very Satisfied	No
Patan Nadeem Khan	Mech	189Y1A0344	Yes	Strongly Agree	Agree	Strongly Agree	Very High	Neutral	No
A.Prem reddy	ECE	189Y1A0403	Yes	Strongly Agree	Strongly Agree	Agree	Very High	Very Satisfied	Good course
K.Sreenivasa Rao	EEE	189Y1A0223	Yes	Agree	Strongly Agree	Agree	High	Very Satisfied	No
K.Rohith	EEE	189Y1A0220	Yes	Agree	Strongly Agree	Disagree	High	Neutral	No
V.Muni Dinesh Pramod Raju	Mech	199Y5A0340	Yes	Agree	Agree	Strongly Agree	High	Satisfied	It's good
P.Srinivasulu	ECE	199Y5A0420	Yes	Strongly Agree	Strongly Agree	Strongly Agree	Moderate	Very Satisfied	No
R.Murali	ECE	199Y5A0421	Yes	Agree	Strongly Agree	Agree	Moderate	Very Satisfied	Good Course

Coordinator

HOD, H&S

Dr. I. SREEVANI M.Sc.,Ph.D
Head of Humanities & Sciences
K.S.R.M. College of Engineering
KADAPA - 516 005

K.S.R.M COLLEGE OF ENGINEERING, KADAPA
(Autonomous)
Yerramasupalli, Kadapa, Andhra Pradesh – 516003

Department of Humanities & Sciences

Feedback Form
On
Certification Course on Alternative Fuels
(04-07-2019 to 08-08-2019)

1. The course content met your expectation
   [✓] Yes [ ] No

2. The content of the course was useful and interesting
   [ ] Strongly agree [✓] Agree [ ] Disagree [ ] Strongly Disagree

3. The content was explained well with adequate examples by the instructors
   [✓] Strongly agree [ ] Agree [ ] Disagree [ ] Strongly Disagree

4. The course has increased my knowledge on discussed topics
   [ ] Strongly agree [✓] Agree [ ] Disagree [ ] Strongly Disagree

5. The level of the course
   [ ] Low [✓] Moderate [ ] High [ ] Very High

6. What is the level of satisfaction for the course
   [ ] Very satisfied [✓] Satisfied [ ] Neutral [ ] Dissatisfied

Suggestions if any: ....

K. Kiran
Signature of the participant

K.S.R.M COLLEGE OF ENGINEERING, KADAPA
(Autonomous)
Yerramasupalli, Kadapa, Andhra Pradesh – 516003

Department of Humanities & Sciences

Feedback Form
On
Certification Course on Alternative Fuels
(04-07-2019 to 08-08-2019)

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   [ ] Strongly agree [✓] Agree [ ] Disagree [ ] Strongly Disagree

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   [✓] Strongly agree [ ] Agree [ ] Disagree [ ] Strongly Disagree

4. The course has increased my knowledge on discussed topics
   [✓] Strongly agree [ ] Agree [ ] Disagree [ ] Strongly Disagree

5. The level of the course
   [ ] Low [ ] Moderate [✓] High [ ] Very High

6. What is the level of satisfaction for the course
   [ ] Very satisfied [✓] Satisfied [ ] Neutral [ ] Dissatisfied

Suggestions if any: ....

N. Prajitha
Signature of the participant

K.S.R.M COLLEGE OF ENGINEERING, KADAPA
(Autonomous)
Yerramasupalli, Kadapa, Andhra Pradesh – 516003

Department of Humanities & Sciences

Feedback Form
On
Certification Course on Alternative Fuels
(04-07-2019 to 08-08-2019)

1. The course content met your expectation
   [✓] Yes [ ] No

2. The content of the course was useful and interesting
   [ ] Strongly agree [✓] Agree [ ] Disagree [ ] Strongly Disagree

3. The content was explained well with adequate examples by the instructors
   [✓] Strongly agree [ ] Agree [ ] Disagree [ ] Strongly Disagree

4. The course has increased my knowledge on discussed topics
   [ ] Strongly agree [ ] Agree [✓] Disagree [ ] Strongly Disagree

5. The level of the course
   [ ] Low [ ] Moderate [✓] High [ ] Very High

6. What is the level of satisfaction for the course
   [ ] Very satisfied [ ] Satisfied [✓] Neutral [ ] Dissatisfied

Suggestions if any: ....

K Rohith

Signature of the participant

K.S.R.M COLLEGE OF ENGINEERING, KADAPA
(Autonomous)
Yerramasupalli, Kadapa, Andhra Pradesh – 516003

Department of Humanities & Sciences

Feedback Form
On
Certification Course on Alternative Fuels
(04-07-2019 to 08-08-2019)

1. The course content met your expectation
   [✓] Yes [ ] No

2. The content of the course was useful and interesting
   [ ] Strongly agree [✓] Agree [ ] Disagree [ ] Strongly Disagree

3. The content was explained well with adequate examples by the instructors
   [ ] Strongly agree [ ] Agree [ ] Disagree [✓] Strongly Disagree

4. The course has increased my knowledge on discussed topics
   [ ] Strongly agree [ ] Agree [ ] Disagree [✓] Strongly Disagree

5. The level of the course
   [ ] Low [ ] Moderate [ ] High [✓] Very High

6. What is the level of satisfaction for the course
   [✓] Very satisfied [ ] Satisfied [ ] Neutral [ ] Dissatisfied

Suggestions if any: ....

P. Sairam
Signature of the participant

K.S.R.M College Of Engineering
(Autonomous)

Kadapa, Andhra Pradesh, India -516003
Approved by AICTE, New Delhi & Affiliated to JNTUA, Anantapuramu

LIGHTED TO LIGHTEN

Certificate of Completion

This is to certify that B. Sujith bearing Roll No. 1894-A0307 has successfully completed his **Certification Course on Alternative Fuels** organized by **Department of H&S, K.S.R.M.C.E,** Kadapa, A.P from **04-07-2019 to 08-08-2019.**

M. Mary Jasmine **Coordinator**	**Dr. I.Sreevani** **HOD, H&S**	**Dr. V.S.S.Murthy** **Principal, KSRMCE**

K.S.R.M College Of Engineering

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Kadapa, Andhra Pradesh, India -516003

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Certificate of Completion

This is to certify that K. Kiran bearing Roll No. 18941A0464 has successfully completed his **Certification Course on Alternative Fuels** organized by **Department of H&S, K.S.R.M.C.E,** Kadapa, A.P from **04-07-2019 to 08-08-2019.**

M. Mary Jasmine Coordinator	Dr. I.Sreevani HOD, H&S	Dr. V.S.S.Murthy Principal, KSRMCE

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Certificate of Completion

This is to certify that K. Tharun bearing Roll No. 18941A0463 has successfully completed his **Certification Course on Alternative Fuels** organized by **Department of H&S, K.S.R.M.C.E,** Kadapa, A.P from **04-07-2019** to **08-08-2019.**

M. Mary Jasmine Coordinator	Dr. I.Sreevani HOD, H&S	Dr. V.S.S.Murthy Principal, KSRMCE

K.S.R.M College Of Engineering

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Certificate of Completion

This is to certify that S. Lokeshwar bearing Roll No. 18941A05B7 has successfully completed his **Certification Course on Alternative Fuels** organized by **Department of H&S, K.S.R.M.C.E,** Kadapa, A.P from **04-07-2019** to **08-08-2019.**

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Alternative fuels

Unit-1

Introduction:

Energy is the prime mover for economic growth of any country and is vital to the sustenance of modern economy. Future economic growth crucially depends on the long-term availability of energy from sources that are affordable, accessible, and environmentally friendly as well. The major sources of energy in the world are fossil fuels (petroleum oil, coal, and natural gas), renewable energy (hydro, wind, solar, geothermal, marine energy, and combustible wastes), and nuclear energy. These primary energy sources are converted into secondary energy sources; that is, coal and crude oil are converted into electricity and steam. Combustible wastes include animal products, biomass, and industrial wastes. Coal is the major source of energy for electric power generation where as petroleum products are for the transport sector. Energy consumption is unevenly divided across various sectors of industrialized economies, as it is unevenly divided across geographic regions. Energy consumption continues to grow throughout the world, with most of the growth occurring by use of petroleum, coal, and natural gas.

Petroleum oil, which is the most important and abundantly available energy source, is largely consumed in the world. The price of crude oil is very volatile and supply is driven by market price. While developed industrialized countries consume around 43 million barrels daily on an average, developing countries consume only 22 million barrels per day (MBD). Coal is the second most abundant source of energy in the world and is mainly used in power generation. Natural gas has been the energy source with highest rates of growth in recent years. The high end-use efficiency of natural gas has made it a popular choice for power generation projects. Hydroelectricity has been a major use of hydro sources of energy around the globe. Renewable sources of energy are gaining popularity. However, fuel prices and regulatory policies of different countries play important roles in the development of renewals . The hydrocarbon industry across the world has been a major driver of economic growth and development for developed as well as developing countries. The commercial transportation sector uses a major share on diesel vehicles where as the public transportation two wheelers and light commercial vehicles—auto market completely depend on gasoline-fueled engines.

Energy is one of the important inputs for any country's economic growth and development. Although 80% of the world's population is in the developing countries, their energy consumption amounts to only 40% of the total energy consumption. The high living standards in the developed countries are attributable to high-energy consumption levels. Also, the rapid population growth in the developing countries has kept the per capita energy consumption low as compared with that of developed countries. Continuous availability of energy in various forms in sufficient quantity and at reasonable prices is required. Though the crude reserves are spread all over the world, the major petroleum resources are available only in selected regions particularly in Middle East countries (about 63%). The international trade in oil is subject to violent fluctuations and has often led to war-like situations in the past, especially involving supply from the Gulf countries. The amount of crude oil is finite being the product of burial and transformation of biomass over 200 million years. Even now fossil fuels are being created under pressure and temperature; however, they are more rapidly consumed than they are produced. So there is a chance of a fuel shortage in the near future. The petroleum resources around the world are continuously utilized and thus these resources are fast depleting. This fast depletion of the resources leads to one another global factor (i.e., the ever-increasing cost of fuels). Hence, there is an urgent need to understand the energy crisis and transition from conventional to nonconventional sustainable energy sources.

Environmental Pollution

Presently the world is confronted with the twin crisis of fossil fuel depletion and environmental concern. Environmental pollution is an important public health problem in most cities of the developing world. Epidemiological studies show that air pollution in developing countries accounts for tens of thousands of excess deaths and billions of dollars in medical costs and lost productivity every year. These losses, and the associated degradation in quality of life, impose a significant burden on people in all sectors of society, but especially the poor .

Burning of any hydrocarbon fuel produces carbon dioxide, which is accumulated in the atmosphere. CO_2 is a greenhouse gas that is slowly building in quantity in the atmosphere and it is believed this will raise the temperature of the planet, causing dramatic climate changes. The majority of developed countries have committed to targeted emission reduction through the Kyota Protocol of 1997, which entered into force in February 2005.

Combustion of hydrocarbon fuel generates both "direct" and "indirect" greenhouse gases. Direct gases emitted by transport include carbon dioxide, methane, nitrous oxide, and carbonate fuel cells are radiatively active. The indirect greenhouse gases include carbon monoxide, other oxides of nitrogen, and non methanic volatile organic carbons. These do not have a strong radiative effect in themselves, but influence atmospheric concentrations of the direct greenhouse gases by, for example, oxidizing to form CO_2 or contributing to the formation of ozone—a potent direct greenhouse gas.

The Human Development Report of 2015 says that developed countries should cut their carbon emissions by 20–30% before 2030 and at least by 80% by the year 2050. If emissions continue to rise following current trends, then stocks of the greenhouse emissions will be increasing at 4–5 ppm per year; by the year 2035, it may almost double the current rate. Accumulated stock will have risen to 550 ppm. Even without further increases in the rate of emissions, stocks would reach over 600 ppm by 2050 and 800 ppm by the end of the twenty-first century. India accounts for 5.5% of CO_2 emissions with the population of 17.2% world share. The report also says that the developing countries like India should cut their emissions by 20%. It would stabilize CO_2 equivalent concentration at 450 ppm in the atmosphere, which is currently at 379 ppm.

It is expected that burning hydrocarbon fuel in the presence of air produces carbon dioxide and water. But, internal combustion engines do not completely burn petroleum products. Hence, these engines release unburned or partially burned/oxidized gases and nitrogen oxides into the atmosphere. The transport sector is a major contributor of air pollution particularly in cities and the vehicular pollution is the primary cause of air pollution in the urban areas (60%), followed by industries (20–30%), and fossil fuels. The pollutants released in the atmosphere interact with other pollutants (like photochemical reactions) and disturb the ecological balance. Faced with the growing air pollution related problems, a number of countries have established ambient air quality standards to protect their environment.

The main pollutants of internal combustion engines include particulate matter, unburned hydro carbons, CO, SO_2, and NO_x. These pollutants have serious effects on human health. Research is being carried out to produce alternative fuels, mainly directed toward reducing these harmful pollutant emissions. At this point, it would be appropriate to discuss the related health effects of various diesel pollutants.

The principal source of nitrogen oxides—nitric oxide (NO) and nitrogen dioxide (NO_2) are collectively known as NO_x. Nitric oxide (NO) emissions from engine exhaust is oxidized to nitrogen dioxides (NO_2), which can react with unburned hydrocarbon emissions and other sources allowing the concentration of ozone to increase around dense traffic. The NO and NO_2 concentrations are greatest in urban areas where traffic is heaviest. Exposure to NO_2 is linked with increased susceptibility to respiratory infection and viral infections such as influenza, lung irritation, edema of lungs, increased airway resistance in asthmatics, bronchitis and pneumonia, decreased pulmonary function, and increase in sensitivity to allergens. Nitrogen oxides combine with water vapor to form nitric acid and are removed from the atmosphere by direct deposition to the ground, or transferred to cloud or rainwater, thereby contributing to acid deposition.

Major sources of sulfur dioxide (SO_2) emissions are diesel automobiles, powerhouses, and petroleum industries. The SO_2 can impair lung function by constricting airways and damaging lung tissue, aggravate asthma and emphysema, and lead to suffocation and irritation to the throat. The SO_2 in ambient air is also associated with asthma and chronic bronchitis. Sulfur dioxide is a corrosive acid gas, which combines with water vapor in the atmosphere to produce acid rain. It causes acidification of lakes and streams and can damage trees, crops, historic buildings, and statues.

Concern about the potential health impacts of PM10 has increased very rapidly over recent years. Airborne particulate matter varies widely in its physical and chemical composition, source, and particle size. The particulates in air of a very small size (< 10 μm) are of major current concern as compared to larger particulates. The smaller particulates are small enough to penetrate deep into the lungs and so potentially pose significant health risks. There are two main groups of hydrocarbons of concern: volatile organic compounds (VOCs) and polycyclic aromatic hydrocarbons (PAHs). Volatile organic compounds are released in vehicle exhaust gases either as unburned fuels or as combustion products, and are also emitted by the evaporation of solvents and motor fuels. The VOCs effects include eye irritation, respiratory irritation, and cancer. The VOC condense together with SO_2 to create particulates, including smoke, soot, and dust. Benzene content in atmosphere is the main sources of emissions emitted in vehicle exhaust.

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Carbon monoxide (CO) is a colorless, odorless, and poisonous gas produced by incomplete combustion of hydrocarbon fuels. The CO interferes with the body's ability to absorb oxygen, impair perception and thinking, slows reflexes, cause drowsiness, and can even cause unconsciousness and death at high levels. Inhalation of CO by pregnant women may threaten growth and mental development of the fetus.
Carbon dioxide, methane, and nitrous oxide and CFCs are called greenhouse gases. The global temperature is increased because of the greenhouse gases. Carbon dioxide pollution building up in the atmosphere is the single biggest contributor to global warming. The reduction in CO_2 is possible only if there is a reduction in combustion of fuel or use of non-hydrocarbon fuels like hydrogen.

Alternative Fuels:

Fast dwindling reserves of fossil fuels, particularly petroleum products, cause hazards of environmental pollution by their combustion. Attempts were made to develop the future energy technologies that are energy efficient, environmentally friendly, and economically viable. Small incremental improvements in current energy technologies are sufficient to tackle the energy crisis and environmental problems. Alternative fuels are derived from other than crude oil resources. In general, alternative fuels include all the fuel used in vehicles other than gasoline and diesel.

The advantages with these fuels include cleaner burning than petroleum-derived fuels, producing lower emissions, and if it is derived from renewable biomass sources it will decrease the dependency on nonrenewable petroleum. However, alternative fuels, need not necessarily refer to a source of renewable energy.

Major advantages are:

- Alternative fuels are mostly produced from domestic resources that reduce the energy dependence.
- Alternative fuels generally reduce the vehicle exhaust emission and hence improve the environmental air quality.
- Some alternative fuels have the potential to operate at a lower cost compared to petroleum products.

The following parameters are to be considered while deciding the alternative fuel

- The fuel should have high volumetric and mass energy density.
- Ease of transportation from production site to delivery points.
- Long-storage life of fuel, minimum handling, and distribution problems.
- Environmental compatibility: While using alternative fuel, the engine performance is expected to improve significantly with regard to regulated emissions and unregulated emissions.
- Manufacturer's warranty: The alternative fuel must guarantee the lifetime of the equipment; its reliability and operational capability are not modified.
- Investment cost: Additional investment on an existing engine must be small to ensure that the operation is competitive with petroleum fuel

Some of the important fuels are listed here:

i. Alcohols (methanol and ethanol)
ii. Vegetable oils and biodiesel
iii. Gaseous fuels (natural gas, hydrogen, and liquefied petroleum gas)
iv. Ethers
v. Electric/fuel cell/hybrid vehicles
vi. Future fuels

Alcohols:
Alcohols are considered as a substitute or additive component for gasoline as they possess a higher octane number. The move toward unleaded fuels produced excessive exhaust valve wear in gasoline engines. This problem was solved by incorporating hardened valve seats and satellite coating of valves. These lead to an increase in the use of alternative fuels, particularly methyl tertiary butyl ether (MTBE), methanol/ethanol blends with gasoline because of their higher octane number.

Methanol

Methanol was used as an automobile fuel during the 1930s to replace/ supplement gasoline supplies in high-performance engines. Currently, methanol is again considered for fuel cell vehicles; that is, methanol is used as fuel to derive the hydrogen for the operation of fuel cells.

Ethanol

Ethyl alcohol, commercially known as ethanol, possesses a number of characteristics favoring its use as an automobile fuel. Ethanol is a by-product in the production of sugar. It can be considered a renewable fuel as it is produced from the sources where there is a potential for greenhouse gas emissions abatement. It depends on the production process, especially the nature of energy inputs used in distillation and other phases. The use of ethanol in spark ignition engines started from the 1950s in countries like United States, Germany, and France.

Vegetable Oils
With increases in crude oil prices, limited resources of fossil oil, and environmental concerns, there has been a renewed focus on vegetable oils and animal fats to make biodiesel fuels. Vegetable oil fuels are not now petroleum competitive fuels because they are more expensive than petroleum fuels. However, vegetable oils and

derivatives have the potential to substitute for a fraction of the petroleum distillates and petroleum-based petrochemicals in the near future. Vegetable oil fueled engines require frequent maintenance (like injector and combustion chamber cleaning) and hence these are suitable for stationary engines that are used for power generation and generator-motor pump sets in rural areas. These could reduce a significant amount of energy savings in terms of diesel or electricity consumption.

Biodiesel

Biodiesel is methyl or ethyl esters of fatty acids derived from edible and non edible type vegetable oils (used or fresh) and animal fats. The major sources for biodiesel production can be jatropha, karanji, palm, soy bean, and sun flower.

Natural Gas

Natural gas occurs as gas under pressure in rocks beneath the earth's surface or more often in solution with crude oil as the volatile fraction of petroleum is composed of mainly methane with varying amounts of the paraffinic hydrocarbon family, ethane, propane, butane, (methane hydrate). Natural gas commercially has been using as a fuel for centuries in China. However, for the past few decades natural gas has been receiving more attention due to the increase in price of petroleum products.

Liquefied Petroleum Gas

Liquefied petroleum gas (LPG), a mixture of propane (C_3H_8) and butane (C_4H_{10}) gas, is a popular fuel for internal combustion engines. It is a nonrenewable fossil fuel that is prepared in a liquid state under certain conditions. This popularity comes from many features of the fuel such as its high octane number for spark ignited engines, comparable to gasoline heating value that ensures similar power output. The LPG is stored as a liquefied gas under pressure at ambient temperature. The percentage composition of the mixture depends upon the season, as a higher percentage of propane is kept in winter and the same for butane in summer.

Hydrogen

Hydrogen is one of the clean fuels in the world, as it does not contain carbon compounds. Hydrogen is a clean and efficient energy carrier with the potential to replace liquid and gaseous fossil fuels. Significant work on hydrogen (i.e., demonstration of hydrogen) for automobiles and power generation has been carried out all over the world.

Hydrogen can be combusted directly in the IC engines or it can be used in the fuel cell to produce electricity, which can operate the vehicle. Hydrogen can be introduced into the engines by manifold induction, direct injection to the cylinder, and hydrogen–diesel duel fuel mode. On combustion of hydrogen, only water vapor is emitted. Therefore, the use of hydrogen as a transportation fuel would result in few or no emissions that affect air quality.

Ethers

Ethers are oxygenating fuel that improves the combustion efficiency. Dimethyl ether is the commonly used blending component in gasoline fuel. Moreover, DME is a potential alternative fuel that can be used in engines as well as onboard hydrogen generation fuel cells.

UNIT-2

Introduction Fossil fuels (i.e., coal and petroleum products) are the major sources of energy in the world. Coal is considered the primary energy source for electric power generation and petroleum products for the transportation sector. Various alternatives are being tried for the substitution of petroleum products, which include biomass derived sources like vegetable oils, biodiesel, alcohols, other gaseous fuels like natural gas and LPG, and engine power trains such as fuel cells and hybrid systems. These efforts were made to reduce the emissions and to improve the fuel security. Significant research work is being carried out around the world on production as well as the application of biomass energy for fuel purposes.

Vegetable oils have two broad classifications: edible oils (sunflower, soy bean, palm oil, etc.) and non edible oils (jatropha, karanji, rubber seed oil, etc.). Edible type oils are mainly used for food purposes whereas non edible oils are used for food purposes. The non edible vegetable oils serve as an important raw material for the manufacture of soaps, paints, varnishes, hair oil, lubricants, textile auxiliaries, and various sophisticated products. After extraction of oil from oil seeds, the oil cakes can be used as cattle feed and fertilizer. Moreover, these oil cakes can be used as biomass feed stock for gasification process. Vegetable oils are derived mainly from four sources (Agarwal 1999). These are

1. Cultivated oil seeds (i.e., groundnut, rape-mustard, soybean, sesame, sunflower, safflower, castor, and linseed)
2. Perennial oil-bearing materials (i.e., coconut and palm)
3. Derived oil-bearing material (i.e., cottonseed and rice bran)
4. Oil seeds of forest and tree origin (i.e., karanji and rubber seed oil)

Most of the countries are encouraging efforts to cultivate the oil yielding trees for vegetable oil production.

Characterization of Vegetable Oils

Vegetable oil molecules are triglycerides with unbranched chains of different lengths and different degree of saturation. Diesel is a complex mixture of thousands of individual compounds, most with carbon numbers between 10 and 22 and mostly of saturates. The natural organic compound in the animal and vegetable fats are made up of various combinations of fatty acids (in sets of three) connected to a glycerol molecule, making them triglycerides. Each molecule of a fatty acid consists of a carboxyl group (oxygen, carbon, and hydrogen) attached to a chain of carbon atoms with their associated hydrogen atoms. The chain of carbon atoms may be connected with single bonds of hydrogen between them, making a saturated fat;

or it may be connected with double bonds, making an unsaturated fat. The number of carbon and hydrogen atoms in the chain is what determines the qualities of that particular fatty acid.The general molecular formula of any vegetable oil is given by

$$\begin{array}{l} CH_2-OOC-R_1 \\ | \\ CH-OOC-R_2. \\ | \\ CH_2-OOC-R_3 \end{array}$$

Structurally, one molecule of glycerol reacts with three molecules of fatty acids to yield three molecules of water and a molecule of triglyceride. The fatty acids vary in their carbon chain length and in the number of unsaturated bonds. When the three fatty acids are identical, the product is simple triglyceride; when they are dissimilar, the product is a mixed triglyceride. The vegetable oils are of mixed triglycerides. The $C_{18:1}$ is denoted as 18 carbon atoms with one double bond and $C_{18:2}$ is denoted as 18 carbon atoms with two double bonds and $C_{18:3}$ is denoted as C18 carbon atoms with three double bonds.

The important properties of vegetable oils in groups are

- Physical properties (viscosity, cloud point, pour point, flash point, etc.)
- Chemical properties (chemical structure, acid value, saponification value, sulfur content, copper corrosion, oxidation resistance, and thermal degradation, etc.)
- Thermal properties (distillation temperature, thermal conductivity, carbon residue, and calorific value, etc.)

Vegetable oils have about 10% less heating value than diesel due to the presence of oxygen content in the molecules. The cetane number of diesel/ biodiesel defines its ignition quality. The higher cetane number of fuel is an indication of better ignition properties. The cetane number affects the engine performance parameters like combustion, stability, drivability, white smoke, noise, and emissions of CO and HC. Vegetable oils have a cetane number in the range of 25–45 CN. The molecular weight of vegetable oils is about 3 to 4 times higher than that of diesel. The viscosity of vegetable oil (25–60 cSt) is several times higher than that of diesel (3–6 cSt). The high viscosity, large size vegetable oil molecules are of low volatility in nature that leads poor atomization and incomplete combustion of fuel.

Methods to Use Vegetable Oils in Engines

1. Pyrolysis

Pyrolysis is a promising method for the production of environmentally friendly liquid fuels. It is the chemical reaction caused by the application of thermal energy in the absence of air.

Vegetable oils and animal fats can be pyrolyzed. Pyrolysis process takes place at higher temperatures of about 250–400°C and at higher heating rates. Heating of vegetable oils breaks the bigger molecules into smaller molecules and a wide range of HC are formed.

The pyrolyzed products can be divided into gaseous, liquid fractions consisting of paraffins, olefins and naphthenes, and solid residue.

The pyrolyzed vegetable oils contain acceptable amounts of sulfur, water, and sediment and give acceptable copper corrosion values but unacceptable ash, carbon residue, and pour point. Pyrolyzed vegetable oil contains compounds in the boiling range of gasoline.

The properties of bio-oil depends upon the nature of the feedstock, temperature of pyrolysis process, thermal degradation degree and catalytic cracking, the water content of the pyrolysis oil, the amount of light ends that have collected, and the pyrolysis process used.

The high oxygen content of pyrolysis oil results in a very low energy density in comparison to conventional fuel oils.

2. Micro emulsification

The formation of micro emulsions is one of the potential solutions for solving the problem of vegetable oil viscosity.

Micro emulsions are defined as transparent, thermodynamically stable colloidal dispersions. The droplet diameters in micro emulsions range from 100 to 1000 Å.

The micro-emulsion can be made of vegetable oils with an ester and dispersant (cosolvent), or of vegetable oils, an alcohol and a surfactant and a cetane improver, with or without diesel fuels. Water (from aqueous ethanol) may also be present in order to use lower-proof ethanol, thus increasing water tolerance of the micro emulsions.

Micro emulsion can improve the spray characteristics due to explosive vaporization of low-boiling constituents in the micelle.

Micro emulsion of methanol with vegetable oil can perform nearly the same as diesel. In micro emulsion formation, the stability of the emulsion is determined by the energy input into it and the type and amount of emulsifier needed This emulsion had a viscosity of 6.3 cSt at 40°C and cetane number of 25. Lower viscosities and better spray patterns has been reported with an increase in percentage of butanol.

3.Dilution

Vegetable oils can be directly mixed with diesel fuel and may be used for running diesel engine. Rudolf Diesel used peanut oil to run his engine. Several studies have been conducted to use straight vegetable oil as fuel for diesel engines. Wang et al. (2006) reported that modern diesel engines that have fuel injection systems are sensitive to viscosity change. High viscosity of vegetable oil may lead to its poor atomization, incomplete combustion, choking of the injectors, ring carbonization, and accumulation of the fuel in the lubricating oils. A way to avoid those problems and to improve the performance is to reduce the viscosity of vegetable oil. Dilution of vegetable oils can be accomplished with such materials as diesel fuel, solvent, or ethanol. There has been an increased advantage when blending vegetable oil with diesel as fuel with minimum processing and engine modification.

Blending of diesel with vegetable oil reduces its viscosity and hence improves its combustion characteristics. Straight vegetable oil (neat vegetable oil) can be used as fuel for IC engines with some minor modifications in the fuel system. Straight (raw) vegetable oil fueled engine can be used to run the generator sets to produce electricity in villages where vegetable oils are available locally. Results of short-term tests conducted by various researchers were found to be successful. However, some problems were experienced on mileage accumulation.

1.High viscosity, low cetane number, and high flash point cause cold starting problems. This can be reduced by preheating the vegetable oils before injection or adding suitable additives to improve cold startability.

2. The high flash point of vegetable oils attributes to lower volatility.

3. Both cloud and pour points are significantly higher than that of diesel fuel. These high values may cause problems during cold weather.

4. Vegetable oils are very low in cetane number (25–35 CN) and hence knocking occurs. However, the use of higher compression ratio in engines reduces the knocking tendency.

5. Vegetable oils are of low oxidation stability and hence form injector plugging and gum formation. Filtering of vegetable oils before injection would reduce the injector plugging.

4. Transesterification

Transesterification is a chemical process of transforming large, branched triglyceride molecules of bio-oils and fats into smaller, straight chain molecules, almost similar in size to the molecules of the species present in diesel fuel. This process has been widely used to reduce the viscosity of triglycerides.

The Transesterification reaction is represented by the general equation

R-COOR′ + R″–OH ⟶ RCOOR″ + R′OH. Triglycerides

Triglycerides are readily transesterified in the presence of alkaline catalyst at atmospheric pressure and at a temperature of approximately 60–70°C with an excess of methanol. The mixture at the end of a reaction is allowed to settle. The lower glycerol layer is drawn off while the upper methyl ester layer is washed to remove entrained glycerol and is then processed further. The excess methanol is recovered by distillation and sent to a rectifying column for purification and recycled. The Transesterification works well when the feedstock oil is of high quality. However, quite often low quality oils are used as raw materials for biodiesel preparation. In cases where the free fatty acid content of the oil is above 1%, difficulties arise due to the formation of soap, which promotes emulsification during the water washing stage and at a FFA content above 2%, the process becomes unworkable. The most important variables that influence Transesterification reaction time and conversion are

1. Oil temperature
2. Reaction temperature
3. Ratio of alcohol to oil
4. Type of catalyst and concentration
5. Intensity of mixing
6. Purity of reactants

Advantages of Vegetable Oils

1. Vegetable oils can be used as substitute fuel for diesel engine application.
2. Use of vegetable oil for fuel purposes reduces the import of costly petroleum and improves the economy of agricultural countries.
3. They are biodegradable and nontoxic.
4. Vegetable oils are of low aromatics and low sulfur content and hence reduce the particulate matter emissions.
5. They have a reasonable cetane number and hence possesses less knocking tendency.
6. Vegetable oils are environmentally friendly fuels.
7. Enhanced lubricity, thereby no major modification is required in the engine.
8. Use of vegetable oils improves the personal safety also (flash point of vegetable oil is above 100°C).
9. These are usable within the existing petroleum diesel infrastructure with minor or no modification in the engine.

Challenges for Vegetable Oils

The major challenges that are faced by the vegetable oils for fuel purposes are listed below

1. The price of vegetable oil is dependent on the seed price and it is market based. Moreover, feed stock homogeneity, consistency, and reliability are questionable.
2. Production of vegetable oil derived biofuels are at an optimum cost.
3. Studies are needed to reduce the production cost and identify potential markets in order to balance cost and availability.
4. Studies are needed on oxidation stability and long storage of vegetable oils.
5. Manufacturer warranty and compatibility with IC engine material needs to be studied further.
6. Durability and emission testing with a wide range of feed stocks.
7. Environmental benefits to be offered by vegetable oil over diesel fuel needs to be popularized.
8. Development of additives for improving cold flow properties, material compatibility, and prevention of oxidation in storage, etc.
9. Continuous and long-term availability of the vegetable oils.

UNIT-3

Introduction

Diesel engines are widely preferred to gasoline engines for heavy-duty applications in the agriculture, construction, industrial, and on-highway transport sectors because of their higher thermal efficiency. However, they are also known to be major sources of the emissions such as particulate matter (PM), soot, smoke, and nitrogen oxides (NO_x). On the other hand, emission regulations in many countries have caused the research on improving engine fuel economy and reducing exhaust emissions due to increasing concern of environmental protection and fuel shortage. Using alternative fuel is one of the most attractive methods to improve fuel economy and to reduce environmental pollution. Among the alternative fuels, alcohols (such as methanol and ethanol), vegetable oils, animal fats, biodiesel, and liquefied petroleum gas (LPG) are receiving interest. These alternative fuels are largely environment-friendly, but they need to be evaluated for their advantages and disadvantages if they were used in engine applications. Despite its low cetane number and poor solubility in diesel fuel, methanol is one of the attractive alternative fuels because it is renewable and oxygenated. Practically, to reduce engine emissions without engine modification, adding oxygenated compounds to fuels seems to be more attractive. Therefore, methanol may provide potential to reduce emissions in diesel engines. This chapter reviews the potential, production methods, and fuel properties of methanol as well as its engine performance, combustion, and emissions.

Potential of Methanol

Alternative fuels can be derived from noncrude oil resources. Crude oils are petroleum-based fuels. Among the popular alternative fuels are biodiesel, natural gas, propane, methanol, biodiesel, ethanol, and hydrogen .

The use of alternative fuels in the future is inevitable with rising oil prices and global warming being a dominant environmental issue. The leading goals for both energy security and the clean-air projects have increased interest in the worldwide utilizations of alternative fuels in burners and engines

Methanol is the chemically simplest alcohol, containing one carbon atom per molecule. It is a toxic, colorless, tasteless liquid with a very faint odor and commonly known as “wood alcohol.” Because it is produced as a liquid, methanol is stored and handled like gasoline.

In general, methanol is currently made from natural gas, but it can also be made from a wide range of renewable sources, such as wood, waste paper, coal, and biomass. Methanol is a good candidate for alternative fuel investigations because of its abundances, physical, and chemical properties.

The main uses of methanol as an alternative fuel are: direct use: blend with diesel or gasoline and indirect use: conversion of methanol to dimethyl ether, ingredient in production of biodiesel and hydrogen for use in fuel cell vehicles.

Methanol: gasoline Blends

Methanol may be used directly as an engine fuel just as LPG and ethanol. The direct use of methanol as an engine fuel has advantages and disadvantages. The relative very high-latent heat of vaporization of methanol results in a lower burning temperature in the engine cylinders as it does for ethanol. The direct use of methanol as an engine fuel in passenger vehicles would require nontrivial engine modifications and substantial changes in the lubrication system. Due to its high Reid Vapor Pressure (RVP) that is a measure of affected volatility of blended gasoline, use of methanol as gasoline blending is limited even though it has a high octane rating and is an excellent candidate of oxygenated hydrocarbons. When pure methanol is used, cold start problems can occur because it lacks the highly volatile compounds (butane, iso-butane, propane) that provide ignitable vapor to the engine even under the most frigid conditions. The addition of more volatile components to methanol is usually the preferred solution.

Methanol: Diesel Blends

Methanol and diesel are not very miscible, which makes it difficult to mix the PM together as a diesel engine fuel. Methanol–diesel blends gave good performance when the amount of methanol in the mixed fuel does not exceed 30% by weight and combustion characteristics when the maximum methanol mass fraction was 20% by weight .

Methanol can be blended with diesel fuel although its corrosive nature creates a need for caution in the design of the engine and fuel system like in ethanol. Methanol has half the volumetric energy density relative to gasoline or diesel. It is usually mixed in percentages ranging from 5 to 85%. The combination rate of methanol in the fuel is 85%, which is called M85. At the same time, the aldehyde compound that comes along with burning methanol forms a strong acid.

Methanol Production

Methanol is one of the top 10 chemicals produced globally because it can be produced from various feedstocks, including fossil fuels (e.g., natural gas, crude oil, coal) and renewable resources (e.g., wood and municipal solid wastes).

Methanol from renewable resources

Biomass is unique in providing the only renewable source of fixed carbon, which is an essential ingredient in meeting many of our fuel and consumer goods requirements. Biomass is an organic material, such as urban wood wastes, primary mill residues, forest residues, agricultural residues, and dedicated energy crops (e.g., sugar cane and sugar beets) that can be made into fuel. Biomass can be converted to synthesis gas by a process called partial oxidation and later converted to methanol While most methanol are produced from natural gas and coal, technologies for the production of methanol from renewable feedstocks are already in commercial use, with prices approaching that of conventional feedstock production

For more than 350 years, scientists have been converting wood into methanol. Historically, however, low efficiency rates from wood alcohol extractions made methanol extraction economically unrealistic. But today's technology allows foresters to convert tree waste into methanol at return rates of up to 50%. Methanol is also a more efficient product to produce, because most of the chemical compounds found in wood are converted. One ton of dry wood could produce up to 186 gallons of methanol, which represents an efficiency rate of nearly 50%. While methanol can also be produced from natural gas, using wood as a methanol source could prove more renewable and economically viable than using natural gas.

The biomass alternative would make methanol a renewable resource by the following simplified reaction:

$$\text{biomass} \rightarrow \text{synthesis gas } (CO, H_2) \rightarrow CH_3OH.$$

Biomass can be converted to synthesis gas by a process called partial oxidation and later converted to methanol. In the first step biomass undergoes gasification to produce synthesis gas. Carbon source is reacted with steam (or steam and oxygen) at very high temperatures to produce CO, and H_2 in the gasification is a process that may be summarized into the following equations

$$CH_xO_y + H_2O \leftrightarrow CO + H_2 + CO_2.$$

Reaction can also be carried out as

$$CH_xO_y + O_2 + H_2O \leftrightarrow CO + H_2 + CO_2,$$

Where, the O_2 burns some of the biomass to supply the heat for the reaction. The following equation shows that the synthesis gas is then reacted in the presence of a catalyst to yield CH_3OH by methanol synthesis reaction that represented previously.

$$2H_2 + CO \leftrightarrow CH_3OH \qquad \Delta H = -92 \text{ kJ/mol.}$$

Methanol Safety Aspects

Methanol is a clear, colorless, and volatile liquid with a faint alcohol-like odor, though it is difficult to detect at concentrations below 10 ppm. Methanol is the simplest of the alcohols, having only one carbon atom, and is completely miscible in water. Methanol easily dissolves in other alcohols and chlorinated hydrocarbons, but has limited solubility in diesel fuel, vegetable oils, and aliphatic hydrocarbons. Methanol is a flammable liquid and, as such, represents a fire hazard. Pure methanol is much harder to ignite than gasoline and burns about 60% slower. Methanol burns with a barely visible flame in bright sunlight, but in most situations a methanol fire would be visible.

Methanol also burns with little or no smoke and M85 produces only low levels of smoke. This result is a significant safety benefit, since it reduces the risk of smoke inhalation injury and allows for increased visibility around the fire when compared to conventional fuels.

Methanol may be released into the environment in significant amounts during its production, storage, transportation, and use. It is also naturally occurring in the environment and is biodegradable in aquatic habitats. As is the case with gasoline and diesel fuels, improper handling and storage of methanol—particularly from leaking underground storage tanks—has the potential to contaminate groundwater.

Properties of Methanol

In order to understand the combustion and emissions of a diesel engine, it is important to understand the basic fuel properties of the fuel used in the engine. Therefore, some physicochemical fuel properties of methanol.

However, it is more difficult to fuel diesel engines with methanol because of its very low cetane number, high heat of vaporization, and some other physicochemical properties.

Methanol (CH_3OH) is a simple compound. It does not contain sulfur or any complex organic compounds. However, diesel fuel is a complex mixture of a large number of hydrocarbons (such as C_3–C_{25} hydrocarbons). For this reason, its fuel properties can change depending on the proportion of hydrocarbon types used in the fuel mixture. Methanol contains an oxygen atom so that it is accepted as a partially oxidized hydrocarbon. It has lower energy content than diesel fuel. Therefore, more fuel is needed to obtain the same amount of power with that of a diesel-fueled engine. Its low stoichiometric air–fuel ratio, high oxygen content, and high H/C ratio may be beneficial to improve the combustion and to reduce the soot and smoke.

Methanol has higher latent heat of vaporization than diesel fuel so that it extracts more heat as it vaporizes. Therefore, it can lead to a cooling effect on the cylinder charge. Since methanol has very low viscosity compared to diesel fuel, it can be easily injected, atomized, and mixed with the air introduced into the cylinder. Methanol has poor ignition behavior due to its low cetane number, high latent heat of vaporization, and high ignition temperature. Therefore, it can cause some increase in ignition delay. However, ignition improver, such as diethyl ether, can be added to the blended fuel to compensate for the cetane number.

The auto ignition temperature of methanol is higher than that of diesel fuel, which makes it safer for transportation and storage. On the other hand, methanol has a much lower flash point than that of diesel fuel; this is a safety disadvantage.

Compared with diesel fuel, they found that the penetration of methanol was shorter and the cone angle of methanol was larger under the same experimental conditions.

Methanol Benefits and Challenges

Methanol is one of the most promising sources of hydrogen for fuel cell systems and synthetic fuel in the future with the advantages of high energy density, easy availability, and safe storage. The using of methanol is in the point of view of its power and other characteristics similar to those using gasoline or diesel. Methanol has some advantages and disadvantages in comparison with

conventional fuels. The methanol production technologies have already been proven in practice. They are reliable and widely used (alcohol production). The important advantages of methanol as a fuel are higher energy content per volume than other alternative fuels such as compressed natural gas (CNG) or LPG and the minimal changes needed in the existing fuel distribution network. Methanol can considerably reduce automotive emissions and may require some additives because of its fuel properties. It can be used directly as a replacement for gasoline in the gasoline and diesel blends. Higher octane number allows higher compression and following better effectiveness of the engine.

Methanol is highly corrosive and toxic when ingested or absorbed through the skin. Methanol causes stain of metal parts, removes oil from places where it is needed, and negatively affects plastic parts. Because of methanol's corrosive qualities, engine parts needed to be frequently replaced. Methanol vehicles produce a significant amount of formaldehyde. Compared to conventional fuels, its disadvantages include the possibility of higher CH_2O emissions, higher acute toxicity and lower cost-effectiveness.

Burning methanol is invisible. Starting the engines under the freezing point is also difficult. Warming the fuel similar to diesel helps to solve this problem.

UNIT-4

LPG: Liquified petroleum gas is one of the most important alternative fuel

Potential of LPG

Liquefied petroleum gas (LPG), a mixture of propane (C_3H_8) and butane (C_4H_{10}) gas, is a popular fuel for internal combustion engines. This popularity comes from many features of the fuel such as its high octane number for spark ignited engines, comparable to gasoline heating value that ensures similar power output. Other features include the possibility of transport and storage of LPG in liquid state because of relatively low pressure of saturated vapor in normal temperature range, better exhaust gas composition, and lower cost per energy unit in comparison with gasoline.

The last feature is a reason of rapidly growing popularity of gas fuel in the world. The above mentioned features of LPG also give the possibility to applying this fuel to compression ignition engines with relatively low- compression ratio as the heating value of stoichiometric mixture of diesel oil and air is similar to the heating value of LPG–air mixture and it gives

the possibility to obtain the same power output from the engine fueled with diesel oil and LPG. Also, the high octane number allows compressing of the propane–butane with air in CI engines with low-compression ratio without apprehension of self-ignition appearance and enables non knocking combustion of the mixture. This is in addition to improved exhaust gas composition and lower cost per energy unit from LPG in comparison with diesel oil.

LPG Production

LPG is formed naturally, interspersed with deposits of petroleum and natural gas. Natural gas contains LPG, water vapor, and other impurities that must be removed before it can be transported in pipelines as a salable product. LPG can be produced from natural gas purification or from crude oil refining. It consists of hydrocarbons that are vapors, rather than liquids, at normal temperatures and pressures, but that turn to liquid at moderate pressures; its main constituent is propane, and it is sometimes referred to by that name.

Natural gas and Oil extraction

When natural gas and crude oil are drawn from the earth, a mixture of several different gases and liquids are in fact extracted, with LPG typically accounting for roughly 5% of the whole. Before natural gas and oil can be transported or used, the gases that make up LPG, which are slightly heavier than methane, are separated out.

Crude Oil refining

The process of refining oil is complex and involves many stages. LPG is produced from oil at several of these stages including atmospheric distillation, reforming, cracking, and others. It is produced because the gases of which it is composed (butane and propane) are trapped inside the crude oil. In order to stabilize the crude oil before pipeline or tanker distribution, these "associated" or natural gases are further processed into LPG.

In crude oil refining, the gases that make up LPG are the first products produced on the way to making the heavier fuels such as diesel, jet fuel, fuel oil, and gasoline. Roughly 3% of a typical barrel of crude oil is refined into LPG although as much as 40% of a barrel could be converted into LPG. Although tied to the production of natural gas and crude oil, LPG has its own distinct advantages and can perform nearly every fuel function of the primary fuels from which it is derived.

Properties of LPG

While LPG is stored as a liquefied gas under pressure at ambient temperature, it is usually used in the liquid form for internal combustion engines, being directly injected into the engine by the fuel injection system. The term "LPG" covers a range of mixtures of propane and butane stored as liquids under pressure, but it is propane that is mostly used to fuel vehicles.

An LPG-derived refinery can differ from its refinery counterpart. However, whether refinery or natural gas origin, a mixture of liquefied saturated and unsaturated hydrocarbons in the range of C3–C4 is considered boiling. Commercially, LPG is sold to domestic and industrial customers in four grades.

- LPG propane consisting mainly of propane and/or propylene
- LPG butane consisting mainly of n-butane, isobutene, and/or butylenes
- LPG mixture consisting of C3 and C4 hydrocarbons
- High purity propane containing about 95% propane

LPG in gasoline engine Applications

LPG is an environmentally friendly fuel for SI engines that has potential emission advantages over gasoline. LPG is liquefied under pressure and compressed and stored in steel tanks under pressure that varies from 1.03 to 1.24 MPa. It is used for heating, cooking, and can be used as engine fuel. The fuel is liberated from lighter hydrocarbon fraction produced during petroleum refining of crude oil and from heavier components of natural gas. It is also a by-product of oil or gas mining. Experience shows that LPG has some advantages over gasoline due to the following:

- LPG produces lower exhaust emissions than gasoline
- It reduces engine maintenance
- It offers faster cold starting
- It provides overall lower operational costs

LPG in Diesel engine Applications

The use of LPG as a main fuel in diesel engines that uses the liquid diesel as a pilot fuel is also increasing worldwide. Gaseous fuels, namely LPG and CNG are recognized as clean fuels possessing significant environmental benefits compared to conventional liquid fuels as well as their relatively increased availability at attractive prices.

LPG Safety Aspects

Technology for this fuel is well established, as there are already a significant number of LPG powered vehicles on the road, using “autogas” filling outlets. The major hazards are gross leakage under failure conditions of the main fuel tank (pressure vessel) or piping, fugitive emissions while refueling, and the potential for small continuous leaks from the installation. During refueling, the LPG is passed through a hose to a self-sealing connector that is locked onto the refueling connection on the vehicle. The fuel is transferred until the tank is full, at which point the transfer is stopped. Other hazards are failure to disconnect the transfer hose before driving away, and leakage of the self-sealing coupling allowing gas to escape. Icing due to the rapid boil-off of liquefied gas can also present a hazard if rain-water has entered the coupling. This can freeze self-sealing or self-locking parts of the coupling, and ice formation can cause a major fire hazard. Prevention by good design is required, and the currently proposed standards for use with automotive LPG cover these aspects. Three systems coexist in Europe at present, and adaptors are available at most LPG filling stations to accept nozzles that are standard in other countries. Within the standards, potential for failure of the pressure vessel is already well known, and the tank must be fitted within the main

strong section of the passenger cage, so that impacts to the vehicle minimize the risk of striking the tank.
The potential for small continuous leaks is always present, and it is necessary to store vehicles in well-ventilated garages. LPG being a dense gas, the use of low-level vents will allow the heavy vapors to disperse. The potential for explosions of leaked LPG to occur is known, and at least one has occurred in Belgium and resulted in both the loss of the vehicle and of the house above the basement garage where the vehicle was stored overnight. The ignition source was probably the central locking system being remotely operated, fortunately for the driver, who escaped being injured by being far enough away from the vehicle at the time of ignition. Gross spillage of LPG is similar to a spillage of LNG, in that rapid boil-off occurs on contact with the ground, until the ground has cooled to the atmospheric boiling point of the LPG. Leakage of LPG from a fractured pipe would form a large persistent flammable atmosphere, which is likely to be ignited. This would burn back to the fracture, and if the flame were to impinge on the tank, a boiling liquid expanding vapor explosion (BLEVE) would be likely to occur eventually. Even small cylinders are affected unless over-temperature protection is fitted. Normally the propane cylinders engulfed in fire generally did not rupture quickly when fitted with relief valves, but continued to relieve until the top of the cylinder became overheated and the steel weakened. The cylinder would then rupture. However, on cylinders fitted with *brass* outlet valves, the valve itself became weakened by the high temperature and blew out, thus relieving the pressure and avoiding a rupture. Hence it would seem prudent to fit LPG tanks with both an over-pressure relief valve and an over-temperature relief device, such as a fusible plug.
Other potential explosion hazards are hydraulic locking by overfilling, and rupturing the cylinder due to over-pressure. This can be avoided by careful design of the filling arrangement or a suitable relief valve, which will of course have to vent the LPG to a safe place. The potential problems of concentration of non volatiles encountered with LNG is less of a problem with LPG, as the fuel is invariably taken off in the liquid form, relying on the storage tank pressure to maintain the fuel as a liquid until it is injected into the engine.

LPG Merits and Demerits

LPG is made up of two major ingredients, namely propane and butane. The percentage of the two depends upon the season, as a higher percentage of propane is kept in winter and the same for butane in summer. It is a nonrenewable fossil fuel that is prepared in a liquid state under certain conditions.

With more and more people buying vehicles running on LPG, most of the gas stations provide refueling systems for LPG-run cars. LPG turns out to be a lot cheaper and efficient in comparison to petrol and diesel. After petrol and diesel, LPG is the third most extensively used fuel for transportation over the world. The LPG-fitted cars are very popular in countries such as Japan, Italy, Canada, and Austria. However, people making use of LPG cylinders for cooking is not allowed, as the cylinders in many countries are available at fairly low rates compared to the ones available at gas stations.

Further, LPG is not recommended for mountains or any kind of rough terrain as it does not provide power and torque to the vehicle, as with other fuels. Using LPG means the vehicle drives 20% less than with other sources of fuel, resulting in more frequent refueling. In contrast to petrol or diesel vehicles, starting is always a problem with LPG driven vehicles under 32°F (cold conditions), because at lower temperatures it has a lower vapor pressure. It is considered to be eco-friendly as it reduces the emission of carbon dioxide by more than 40%. The use of LPG in cars is growing day by day, so in future a gradual increase in its consumption can be seen. Also the lack of many refilling stations is another drawback that needs to be improved in future with the availability of the fuel itself. The other disadvantage is that a small amount of trunk space of the vehicle may be lost in order to make room for the LPG tank.

UNIT-5

Introduction

Hydrogen is a very promising alternative fuel and has been receiving more attention all over the world in recent years. Research and development activities were carried out out of curiosity, mainly with an objective to evaluate the suitability of hydrogen as an engine fuel. During an energy crisis and World Wars I and II, hydrogen is used as fuel in a dual fuel mode or as a sole fuel. The abundant availability of petroleum products suppresses the commercialization of hydrogen as fuel for vehicles. Currently the search for alternative fuels has picked up all over the world and hence, the research and demonstration of alternative fueled vehicles have begun. For the past few decades many renewable clean-burning alternative fuels have been studied.

Hydrogen is the ideal candidate as an energy carrier for both mobile and stationary applications while averting adverse effects on the environment and reducing dependence on imported oil for countries without natural resources. Biodiesel, alcohols (both ethanol and methanol), compressed natural gas (CNG), liquefied petroleum gas (LPG), biogas, producer gas, and hydrogen were investigated as alternative fuels for both spark ignition (SI) and compression ignition (CI) engines. Hydrogen is sometimes called the fuel of the future and certainly has a number of inherent attractive features when considered as a fuel for road vehicles. Hydrogen is by far the most abundant element in the universe (90% on the basis of number of atoms), and in the earth's crust it is one of the most abundant elements. On Earth, hydrogen is almost exclusively found in chemical compounds, as opposed to free molecular hydrogen that is virtually unseen in nature.

The production of industrial hydrogen is currently based mainly on fossil fuels, but to some extent electricity is also used. If considered as an alternative fuel, hydrogen should not be produced from fossil fuels, since this would not lead overall to decreased emissions of greenhouse gases (GHGs). Hydrogen is a very attractive transportation fuel in two important ways. It is the least polluting fuel (as it does not contain carbon) that can be used in an internal combustion engine (ICE), and it is potentially available anywhere there is water and a clean source of power. Hydrogen-fueled internal combustion engines (H_2-ICEs) operate as clean and efficient power plants for automobiles. Hydrogen produces water only when it is combusted in the ICE and makes it a very environmentally clean fuel. Hydrogen combustion does not produce any of the major pollutants such as CO, HC, SO_x, smoke, lead, or other toxic metals except NO_x. Sulfuric acid deposition, benzene and other carcinogenic compounds, ozone and other oxidants, are intrinsically absent in a well-designed neat hydrogen engine.

A special reason for the technological interest in hydrogen is that hydrogen works very well within fuel cells. Most fuel cells are basically powered by hydrogen, even though the primary fuel is not always pure hydrogen. Using hydrogen in a fuel cell leads to optimized energy efficiency (for the conversion of chemical to mechanical energy) compared with use of hydrogen in an ICE. Conversion efficiencies approaching 70% may be possible (significantly depending though on operation mode and conditions) and this is at least two times better than the conversion efficiency observed for ICEs. In this chapter the hydrogen production, fuel properties, how to use gaseous fuel in vehicles, storage, safety, and challenges associated with hydrogen economy are discussed.

Need for energy Carriers

The available energy sources on earth are: nuclear reactions; sun radiation (directly or indirectly considering that wind and water receive energy for their movement by sun radiation); and fossil fuels. They are considered in this document as *primary energy sources*. Hydrogen is not among them.

Potential energy from primary sources need to be converted into other forms to be of use. The most important energy forms for their final use by mankind are: thermal energy (used for heating); mechanical energy (for moving objects); and electric energy (to feed purely electric appliances—computers, consumer electronics, etc.).

This conversion can in principle be made in two ways: concentrated in a few power plants or in several small devices located near the corresponding final utilization devices. It is obvious that for the latter option to take place, the final energy form needs to be easily transportable, which is not often the case. For technical reasons, potential energy from nuclear reactions cannot be converted in small distributed systems, it needs large power plants. At present, indeed, energy from nuclear reactions is converted in large power plants first into heat. The heat is then converted into mechanical movement, then into electricity that is fed into the electric transmission and distribution network. Electricity is a very good means of transferring energy from concentrated plants to their place of final use.

Role of electricity

Today by far, the most widely used energy carrier is electricity. Electricity is a very flexible means of transferring energy from concentrated conversion points into the areas of final utilization. However, electricity has the disadvantage of requiring wiring to be conveyed. This is exploited in railways using electrified lines and catenary for electricity distribution to trains. A way to exploit electricity in mobile vehicles not having wiring connecting them to earth is to store it onboard. This can be done converting chemical potential energy into onboardinstalled reservoirs that are the well known "batteries." Indeed, this is not very effective because of two reasons:

Energy per unit of volume that can be stored in batteries and mass is much lower than that of a fossil fuel (more than an order of magnitude).

"Refilling time," which for a battery is recharging time, is much larger than the filling time of a traditional fuel tank (more than an order of magnitude).

Role of Hydrogen

When hydrogen is put in contact with oxygen, it reacts with it, releasing large quantities of energy. If this contact is direct, the released energy takes the form of heat. If it is made by first ionizing hydrogen and using different paths for ions and electrons, it takes the form of electricity (thermodynamics of the two reactions are different, the differences in the amounts of potentially available energy are not very large however, and are disregarded in this reasoning). As a consequence of this, given the wide availability of oxygen in the air, it can be said that hydrogen carries energy with itself. On the other hand, hydrogen is not available free in nature, it is embedded in a lot of natural substances such as water, carbohydrates, and hydrocarbons. To draw hydrogen from these substances, energy must be spent. If, for instance, hydrogen is taken out of water using electrolysis, the theoretical energy needed for this operation is the same theoretically made available during hydrogen recombination with oxygen.
These twin reactions that allow creation of hydrogen from natural substances (e.g., water) with energy expense and recreation of water by hydrogen reaction with oxygen, makes it possible to use hydrogen as an energy carrier.

Hydrogen Production

Hydrogen can be produced from renewable as well as nonrenewable fuels sources. Renewable fuel sources includes water, biomass, and from conventional fuels. Fuel processing technologies convert a hydrogen containing material such as gasoline, ammonia, or methanol into a hydrogen rich stream. Fuel processing of methane is the most common hydrogen production method in commercial use today. Below one shows the various hydrogen production technologies.

Pyrolysis

Pyrolysis converts the hydrocarbon into hydrogen and carbon without air/ water/oxygen. Pyrolysis can be done with any organic material. If air or water is present then significant CO_2 and CO emissions will be produced. Among the advantages of this process are fuel flexibility, relative simplicity and compactness, clean carbon by-product, and reduction in CO_2 and CO emissions. The chemical reaction can be written as,

$$C_n\ H_m \rightarrow nC + \frac{1}{2}\, mH.$$

Hydrogen from Water

Electrolysis of water can produce very high purity hydrogen with high efficiency. Electrical current passes through two electrodes to separate water into hydrogen and oxygen. Commercial low temperature electrolyzers have system efficiencies of 56–73%. Solid oxide electrolysis cells (SOEC) electrolysers are more efficient. The SOEC technology has challenges with corrosion, seals, thermal cycling, and chrome migration. Electrolyzers are not only capable of producing high purity hydrogen, but recently, high-pressure units.

$$H_2O \rightarrow H_2 + \frac{1}{2}\, O_2.$$

Hydrogen properties

Physical Properties

Hydrogen is a clean fuel. Hydrogen is the lightest element and has one proton and one electron. Hydrogen with atomic weight 1.00797 and atomic number 1 is the first element in the periodic table. Three isotopes of hydrogen are hydrogen, deuterium, and tritium, respectively. Hydrogen is colorless, odorless, tasteless, and is about 14 times lighter than air. It diffuses in air at a faster rate than any other gases.

A stream of hydrogen from a leak is invisible in daylight. Hydrogen has a very low density of about 0.09 kg/m^3 20°C. The liquid density of hydrogen is 70.03 kg/m^3. Higher cylinder capacity is required to store sufficient amounts of hydrogen for the operation of a vehicle. Moreover, as the energy density reduces, the power output also decreases. On cooling, hydrogen condenses to liquid at –253°C and to solid at –259°C. Hydrogen in gaseous form has a heat capacity of 14.4 kJ/kgK

Hydrogen engines will not face any starting problems as it has a very low boiling point. Even in very severe winter temperatures a hydrogen engine will start easily. Expansion ratio is the ratio of the volume at which a gas or liquid is stored to the volume of the gas or liquid at atmospheric pressure and temperatures. Hydrogen's expansion ratio is 1:848; that is, gaseous hydrogen occupies a volume of 848 times more than at a liquid state. When hydrogen is stored as a high-pressure gas at 250 bar and atmospheric temperature, its expansion ratio to atmosphere is 1:240. This necessitates that a large volume of hydrogen is required to be carried for adequate running of a vehicle.

Chemical Properties

Hydrogen atoms are chemically very reactive. When a small amount of ignition energy in the form of spark is provided to the hydrogen–air mixtures, the molecules react with air in the atmosphere very actively and release significant amounts of heat and water vapor. At room temperatures these reactions are very slow, but is accelerated by catalysts such as platinum and spark. Very high temperatures (>5000 K) are needed to dissociate hydrogen molecules into atomic hydrogen completely. Hydrogen is considered an energy carrier to store and transmit energy from primary energy sources.

Hydrogen Safety

The safety use of hydrogen was elaborately analyzed by Carcassi and Grasso (2004) and the summary is as follows: We analyze the safety risks (unintended hazards due to natural or technological causes) rather than security related risks (intended hazards, i.e., malicious acts) and in particular the risks due the use of hydrogen. Technologies are a key element in the world we are living in. Public authorities, society and community, besides making technologies possible and favoring them, should be responsible for their safety. Every technological innovation should guarantee a level of safety and reliability that prevents potential hazards for human beings. It follows that, in every technology, rules must regulate technical aspects while the choices on responsibility and resulting risks management must be taken at a political level.

The preliminary hazard lists posed by the properties of gaseous hydrogen are as follows

Physical properties

• Lighter than air, odorless and colorless gas

• Low viscosity (leaks easily)

• Highly diffusive

Pressure

• High-pressure storage can result in pressure rupture, flying debris
• High-pressure gas jet impingement on body can cut bare skin
• Oxygen displacement in confined spaces

Chemical

• Flammable, with nonluminous flame, no toxic combustion products

• Explosive, 4–74% by volume can deflagrate (typically only a modest over pressure,

• Low ignition energy, 0.02–1 mJ spark to ignite a deflagration

• Modest autoignition temperature, 574°C

Hydrogen Benefits

The positive aspects of hydrogen for its engine applications that include

1. Environmentally clean automobile fuel suitable for I.C. engines. Fuel leakage to atmosphere is not a pollutant.
2. It can be produced from an abundant raw material, water
3. Hydrogen is an excellent additive in relatively small concentrations to fuel such as methane
4. Hydrogen high burning rates make the hydrogen-fueled engine performance less sensitive to changes to the shape of the combustion chamber, level of turbulence, and the intake charge swirling effects.
5. Hydrogen ignition limits are much wider than gasoline so it burn easily and gives higher efficiency.
6. Requirement of less spark advance contributes to better efficiencies and improved power output.
7. Hydrogen burns nearly 10 times faster than gasoline mixtures.
8. Moderately high compression ratio operation is possible with lean mixtures of hydrogen in air that permits higher efficiencies and increased power output.
9. The exhaust heat can be used to extract hydrogen from the hydride.

10. The thermodynamic and heat transfer characteristics of hydrogen tend to produce high compression temperatures that contribute to improvements in engine efficiency and lean mixture operation.

Hydrogen Barriers and Challenges

Switching from diesel to hydrogen provides a number of environmental benefits, avoiding the local pollution (NO_x, CO_2, and particles) in any case. If the electricity is produced by renewable energy sources it can be justified to name the electrical trains as well as the hydrogen trains "ZEV, zero emission vehicles." With hydrogen and fuel cells, the energy efficiency is lower due to the conversion losses in electrolysis (0.8), hydrogen storage (0.9), fuel cell (0.45), and electric motors (0.9). Hydrogen fuel produced from renewable energy will still have comparable overall energy efficiency to diesel traction—roughly 30% before taking into account the considerable energy efficiency gains that will be achieved when adding regenerative breaking.
Hydrogen has the potential for use as a fuel source for engines as well as fuel cells. However, like other fuels it has its own problems.

- Poor engine volumetric efficiency
- Higher NOx emissions because of its higher flame temperature
- Higher fuel cost
- Infrastructure for distribution network
- Storage of hydrogen in vehicles
- Low energy density
- Flame trap and flash back arrestors are necessary for hydrogen systems
- Hydrogen requires 1/50th of energy gasoline-air mixtures to ignite.

Use of hydrogen as a fuel in the transport sector would require significant changes in infrastructure. Distribution of hydrogen and local fueling of cars could not be done in the same way gasoline is handled today. Therefore the infrastructural problems must be given careful consideration, both concerning economy and safety, in relation to possible utilization of hydrogen as an energy carrier.

However, the commercialization of hydrogen associated with fuel cost, infrastructure, and viability of technology depends on: high costs with the onboard hydrogen storage or hydrogen production and fuel cells vehicles as there is limited infrastructure for hydrogen distribution, it will be difficult to establish markets for hydrogen vehicles or fuel cell vehicles and vice-versa; technological advancement on development of fuel cell vehicles and more mileage; and public awareness about safety and acceptance. These problems will need to be overcome by government policies and the necessary actions to protect the environment as well.

............................*The End*...............................