Course Code ESE-800	Credit Hours (Th-Pr) 3-0	**Clean Coal Technologies (Elective)**	Contact Hrs/Week (Th-Pr) 3-0	Total Contact Hrs (Th-Pr) 45-0

Course Outline:

Direct coal liquefaction
Indirect coal liquefaction (FT)
Hybrid approach to synthesize liquid fuels
Clean coal gasification process description
Integrated gasification combine cycle (IGCC)
Under ground coal gasification (UCG)
Carbon capture techniques

Eligibility Criteria:

B.E in Mech., Elect (Power), Chemical, Industrial, Process
B.S (4-years) Or M.Sc. degrees in Physics

Recommended Books:

S. No.	Title	Author(s)	Assigned Code	Remarks
1.	Clean Coal Engineering Technology	Bruce G. Miller	BM	Reference
2.	Emerging clean coal technologies	Paul W. Spaite	PS	Reference
3.	Coal Gasification and Its Applications	David A. Bell, Brian F. Towler	DB	Reference
4.	Coal Liquefaction Fundamentals	D. Duayne Whitehurst	DW	Reference
5.	Fischer Tropsch Technology, Studies in Surface Science and	Andre Steynberg and Mark Dry (Editors)	AM	Reference

	Catalysis 152			
6.	Carbon Capture and Storage, 1st Edition	Stephen A. Rackley	SR	Reference

Course Objectives:

The primary objectives of this course are to familiarize students with clean coal technologies incorporating Gasification/FT in producing accessible energy, to foster technical knowledge beneficial for exploiting the vast coal reserves in the country. To generate the ability of scale up design from pilot plant models.

Learning outcome:

The students will be able to differentiate between various options on clean coal technologies leading to both liquid & gaseous fuels. The course will provide an in-depth knowledge to coal utilization through fabrication of catalyst and reactor design.

Topics Covered:

No.	Topics	Book	Contact Hours
1.	**Coal to liquid (CTL)** • **Direct coal liquefaction:** ▪ Process description ▪ Process parameters & flow sheet diagrams ▪ Heat, pressure & catalyst requirements ▪ Hydrocracking/Hydrotreating reaction mechanism and kinetics ▪ Single stage & two stage liquefaction ▪ DCL catalytic reactors/ overview ▪ Commercial Plants ▪ Environmental considerations • **Indirect coal liquefaction (FT Process):** ▪ Process Description/ Process Flow diagrams ▪ Syn gas formation/ composition	DW, PS & BM AM	10 10

	▪ Syn gas cleaning (Hulphur (H2S and COS, CS2) and CO2 Removal) ▪ FT Process/ Reaction mechanism & kinetics ▪ FT process parameters ▪ Catalyst Preparation & Characterization ▪ FT Reactor core concepts/Process control ▪ Energy analysis/ Heat exchanger network optimization in FT synthesis ▪ Products refinery ▪ Products analysis • **Hybrid Concept** ▪ Comparison of ICL & DCL ▪ Hybrid approach description/ Process flow diagrams		
2.	**Clean coal gasification:** • Coal gasification basics/types • Pre treatment of coal/ milling, drying • Coal gasifier designs/Reaction kinetics • Direct blowing & reverse blowing concepts • Air separation and gas cleanup * * The CO2 removal used in the gas cleanup can be used as CO2 capture for CCS. • **Integrated gasification combined cycle: IGCC** ▪ Process description ▪ Thermodynamic cycle of IGCC ▪ Development of process flow diagram ▪ CO_2 pre combustion capture & storage ▪ Energy requirements • **Underground Coal Gasification (UCG)**	DB, PS	6 6 6

	▪ Technology Description ▪ Geological aspects in UCG/ coal seam, overburden and water table ▪ Process flow diagrams ▪ Channel formation b/w injection & production wells ▪ Process parameters/Coal & Rock properties ▪ Economics of UCG		
3	**Carbon dioxide Capture** • Power Generation technologies incorporating CO_2 Capture • CO_2 Capture Chemical Processes ▪ Amine-based systems ▪ Ammonia-based systems	SR & BM	7

MS research projects will be based on:

- Micro reactor design and fabrication
- Catalyst preparation & Characterization
- Pilot plant Experimental runs
- Modelling & simulation using Aspen-Hysys