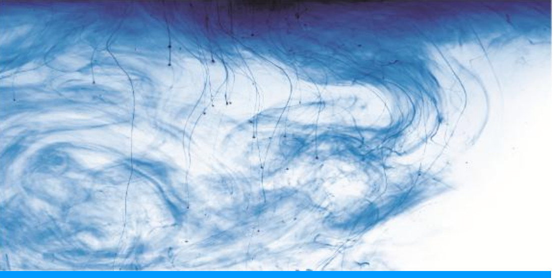


CHEMSYSTEMS
PERP PROGRAM

Direct Coal Liquefaction

PERP 08/09S5

Report Abstract
March 2010

Nexant

CHEMSYSTEMS PERP PROGRAM

Report Abstract

Direct Coal Liquefaction

PERP 08/09S5

March 2010

Nexant

www.chemsystems.com

The ChemSystems Process Evaluation/Research Planning (PERP) program is recognized globally as the industry standard source for information relevant to the chemical process and refining industries. PERP reports are available as a subscription program or on a report by report basis.

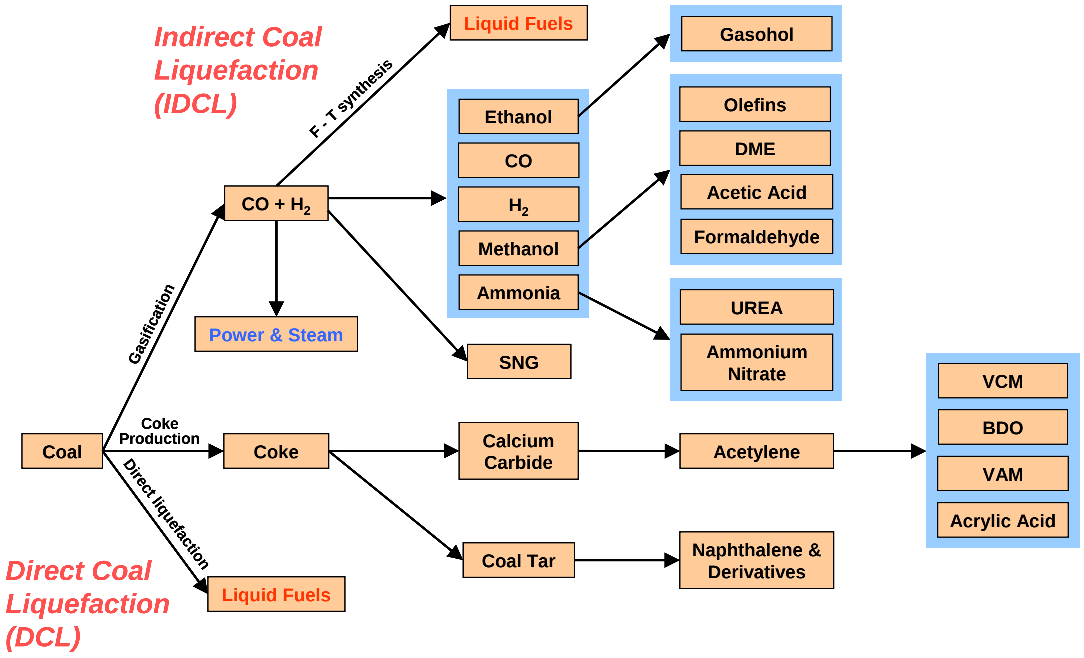
Nexant, Inc. (www.nexant.com) is a leading management consultancy to the global energy, chemical, and related industries. For over 38 years, ChemSystems has helped clients increase business value through assistance in all aspects of business strategy, including business intelligence, project feasibility and implementation, operational improvement, portfolio planning, and growth through M&A activities. Nexant has its main offices in San Francisco (California), White Plains (New York), and London (UK), and satellite offices worldwide.

For further information about these reports, please contact the following:
London, Dr. Alexander Coker, Manager PERP Program, phone: + 44-(20)-70950-1570, e-mail: acoker@nexant.com.
New York, Dr. Jeffrey S. Plotkin, Vice President, phone: + 1-914-609-0315, e-mail: jplotkin@nexant.com;
or Heidi Junker Coleman, Multi-client Programs Administrator, phone: + 1-914-609-0381, e-mail: hcoleman@nexant.com.
Website: www.chemsystems.com

INTRODUCTION

Coal can be converted to fuels and chemicals via gasification, liquefaction and pyrolysis. The figure below demonstrates the three routes of clean coal conversion.

Coal Conversion Routes



In the gasification route, coal is gasified via partial oxidation to form synthesis gas (or syngas) that is composed of hydrogen and carbon monoxide. The syngas formed can be used to synthesize methanol, one of the most important commodity chemicals, or it can, in turn, serve as a feedstock for downstream value chain products such as dimethyl ether (DME), acetic acid, formaldehyde and olefins including ethylene and propylene. Additionally, hydrogen in syngas can be separated and used for producing ammonia, and the ammonia itself can be further employed as feedstock for production of urea, ammonia nitrate, etc. Alternatively, hydrogen and carbon monoxide in syngas can go through methanation reaction to form synthetic natural gas (SNG). Also, the syngas formed can be used in Fischer-Tropsch (FT) synthesis to produce liquid hydrocarbon fuels. Since the liquid hydrocarbon fuels produced in this manner have to go through the gasification step first and then FT synthesis to yield liquids, it is often referred to as Indirect Coal Liquefaction (IDCL).

In the liquefaction route, coal is cracked with heat and pressure first and then hydrogen is added to the coal fragment with the help of a catalyst to produce liquid hydrocarbon fuels. This process is referred to as Direct Coal Liquefaction (DCL).

In the pyrolysis or coke production route, coal is first pyrolyzed in inert atmosphere with heat to form coke. The coke produced is used as a reducing agent to react with lime, i.e., calcium oxide, in an electric furnace to yield calcium carbide. The calcium carbide is then further hydrolyzed to produce acetylene. In the first half of the 20th century, acetylene was the most important of all starting materials in the organic synthesis of acetaldehyde, acrylic acid, acrylonitrile, butanediol (BDO), vinyl acetate (VAM), vinyl chloride (VCM) and their derivatives. In the late 1990s, acetylene was largely replaced by olefin feedstocks, such as ethylene and propylene, because of its high cost of production and the safety issues involved in handling acetylene at high pressures. However, as coal is becoming an ever increasing source of acetylene in countries with plentiful and cheap coal supplies, such as China, coal-based acetylene is again being employed for the production of VCM and other chemical feedstocks. In addition to acetylene, naphthalene can also be extracted from the residual coal tar resulting from the pyrolysis process and used as the starting material for naphthalene derivatives.

TECHNOLOGIES

The history of direct coal liquefaction process development dates from just after World War II.

The basic concept of direct coal liquefaction involves cleaning and pulverizing raw coal before it is mixed with recycled/slurry oil that serves as solvent. The coal slurry is constantly agitated to keep the slurry from settling before the injection of hydrogen. The hydrogen and coal slurry mixture is then heated and fed to the coal liquefaction reactors.

The liquefaction reactors incorporate the principle of the ebullated-bed operation. The ebullated-bed reactor system offers substantial advantages over fixed-bed reactors.

The following are discussed in detail in the report:

- The direct coal liquefaction process technology including evolutionary developments of the ebullated-bed reactor system from a one-stage liquefaction reactor system, into an Integrated Two-Stage Liquefaction (ITSL) system and a Catalytic Multi-Stage Liquefaction (CMSL) system are discussed in the report, along with process yield and product quality.

- There are several environmental issues involving direct coal liquefaction which are addressed and discussed in the report.

- There are many key challenges for DCL commercialization which are discussed in the report.

- Recent Developments and potential vendors for direct coal liquefaction technologies are assessed.

ECONOMICS

The USGC and Inner Mongolia production costs for syncrude are evaluated including a detailed breakdown of variable and fixed costs. Total project capital in terms of inside and outside battery limit costs, working capital and other project costs are given.

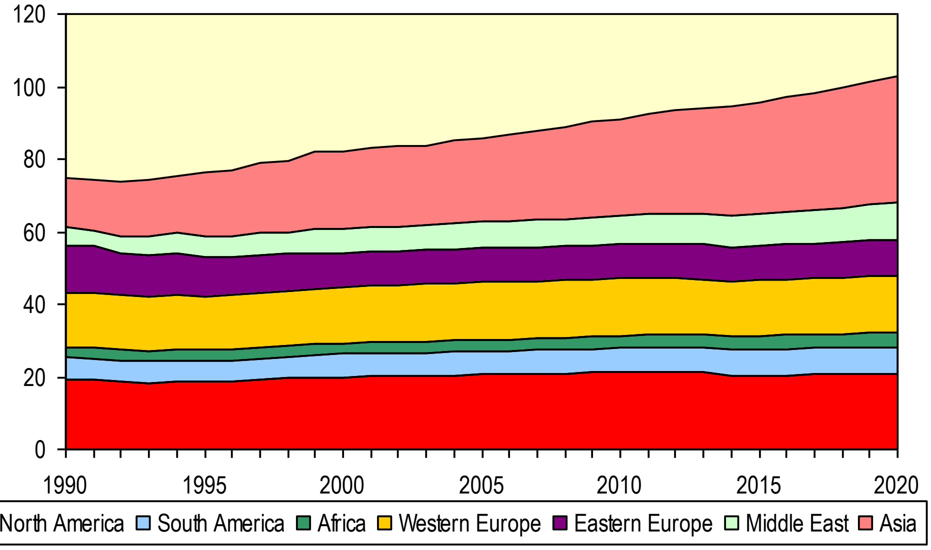
COMMERCIAL APPLICATIONS

Key drivers for refined products (naphtha, gasoline and diesel) are outlined in the report.

Total annual global demand for major petroleum products grew by over 300 million metric tons per year between 2000 and 2008, with diesel/gas oil accounting for about 34 percent of the increase, and gasoline and diesel/gas oil accounting for almost 61 percent of the increase.

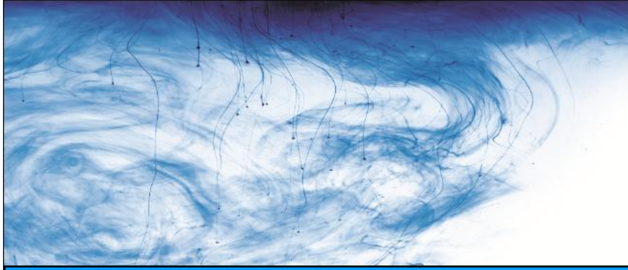
World refining capacity has recently surpassed its previous highs in the 1980s. As shown in the figure below, Asia has experienced the biggest surge in capacity over the past 10 years.

World Refining Capacity
(Million barrels per day)



Q110_00101.0009.4113_Charts.xls\F6.2

- Supply, demand and net trade of naphtha, gasoline and diesel as well as overall refining capacity are analyzed. Global as well as regional markets (North America, Western Europe, the Middle East, South America and Asia) are discussed.



Nexant, Inc.

San Francisco
London
Tokyo
Bangkok
Bahrain
New York
Washington
Houston
Phoenix
Madison
Boulder
Dusseldorf
Beijing
Shanghai
Paris

www.chemsystems.com