Energy, Mines and Resources Canada
Énergie, Mines et Ressources Canada

CANMET
Canada Centre for Mineral and Energy Technology
Centre canadien de la technologie des minéraux et de l'énergie

PROGRESS REPORT
HYDROCARBON PROCESSING RESEARCH LABORATORY - 1984

prepared by HPRL staff

January 1985

ENERGY RESEARCH PROGRAM
ENERGY RESEARCH LABORATORIES
DIVISION REPORT ERP/ERL 85-12(TR)

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HYDROCARBON PROCESSING RESEARCH LABORATORY

LABORATOIRE DE RECHERCHE SUR LA VALORISATION DES HYDROCARBURES

Manager:	Marten Ternan	Gérant:
Deputy Manager:	Louis Janke	Sous-gérant:
Secretaries:	Susan Gilmour Jocelyne Boudreau	Secrétaires:

SUMMARY

Approximately 40 people are employed at the Hydrocarbon Processing Research Laboratory. All are working on projects related to the recovery or conversion of natural gas, oil sands, oil shales or coal. The approximate budget for FY 1984/85 was as follows:

	$M
SALARIES	1.3
IN-HOUSE RESEARCH	1.8
CONTRACTED-OUT RESEARCH	1.7
	4.8

As indicated above approximately one half of the non-salary budget was allocated to contract research and one half to in-house research. The salary budget was also distributed between the two activities, since staff members are currently monitoring approximately 50 research contracts which are being performed outside the federal government laboratories.

The work of the laboratories is performed within six sections. A brief outline of their activities is described in this report. Details of the work can be obtained by contacting the section heads, concerning in-house research, or the scientific authorities (SA), concerning contracted-out research.

The following table reflects the type and quantity of information disseminated to the public by the laboratory.

SOMMAIRE

Il y a approximativement 40 personnes qui travaillent au laboratoire de recherche sur la valorisation des hydrocarbures. Tous travaillent aux subjets de recouvrement et conversion du gaz naturel, sables d'huiles, schiste argileux d'huiles, et charbon. Le budget approximativement, pour AF 84/85 etait comme suivant:

	$M
SALAIRES	1.3
RECHERCHE à l'interieur	1.8
CONTRACTS à l'exterieur	1.7
	4.8

Comme indiqué en haut près d'une demi partie du budget non-salarié était attribué au recherche qui était accompli dans les laboratoires non-gouvernementaux. L'autre partie était attribué au recherche de laboratoires gouvernementaux. Le budget salairé est utilizé pour les deux activité à cause de notre personnel suivent près de 50 contrats de recherche qui étaient accomplis aux laboratoires non-gouvernementaux.

Il y a six sections dedans notre laboratoire. Un bref profil de leurs activitiés suive. On peut obtenir plus de details des chefs des sections et des autorités scientifiques (SA).

La productivité du laboratoire est mesuré par la quantité d'information qui est mis au domaine publique comme indiqué suivant.

	1982	1983	1984
Patents granted	3	1	0
Patent applications filed	0	4	3
Refereed publications	13	18	16
Published conference preprints	8	5	9
Technical presentations at conferences	14	19	22
Technical presentations at universities and research institutes	16	6	14
Number of Federal Government Employees			
Technicians	22	15	14
Chemists	2	2	2
Physical scientists	3	3	3
Research scientists	18	18	17
Secretaries	2	1	2

CATALYTIC HYDROPROCESSING

Head - Dr. Jerry F. Kriz
Staff - Dr. Michael Wilson, Dr. M. Sekhar, Dr. Craig Fairbridge, Dr. Jacques Monnier, Mr. Edward McColgan, Mr. Michael Fulton, Mr. Michael Stolovitsky, Mr. George Pachulski
Employees on loan from Industry - Mr. Donald Benoit, Mr. Charles McColgan

Projects

1. Asphaltene Conversion for Viscosity Reduction of Heavy Oils and Bitumens

A conversion process for asphaltenes in bitumen and heavy oils is being developed in order to decrease the viscosity of the oil so that it will meet the Interprovincial Pipeline specification. This will allow heavy oils to be transported to refineries where additional processing can be performed.

2. Laboratory Support for the Start-up of the CANMET Hydrocracking Demonstration Plant

A 5000 bbl/day plant which is to demonstrate the CANMET hydrocracking process is being constructed in Montreal and is to start-up in 1985. A flowsheet of the process is shown in Figure 1. This project consists of three parts. Experiments using a laboratory bench scale processing unit have been performed with feedstocks supplied by prospective process licensors. The second part of the research is directed toward the development of catalytic additives used in the process. The third part concerns hydrotreating studies using distillates from the CANMET hydrocracking process. Because the CANMET Hydrocracking process is being commercialized, research results from this project are kept confidential.

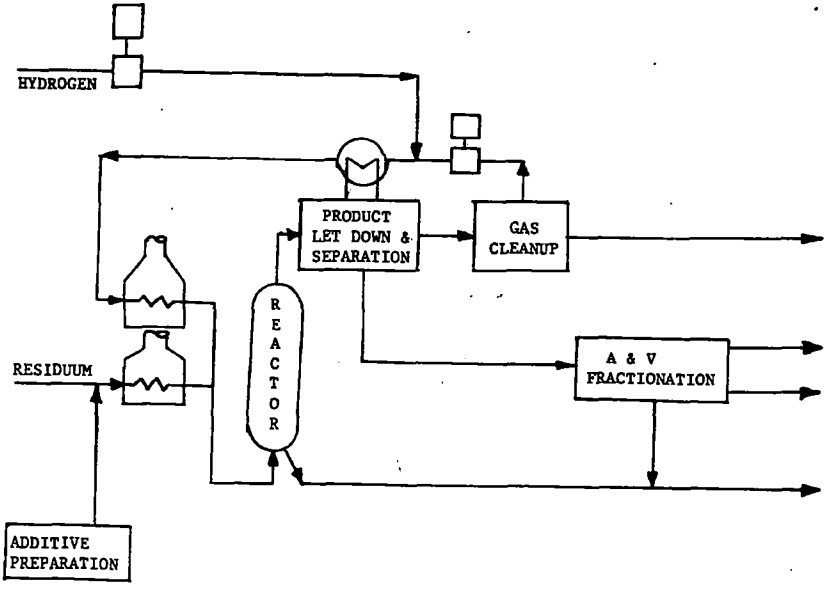

Figure 1 THE CANMET HYDROCRACKING PROCESS

3. Conversion of Refractory Aromatics in Oil Sands Diesel Fuel

Canada's two commercial oil sands Plants, Suncor and Syncrude, produce a diesel fuel fraction which does not meet existing specifications. At present the oil sands material is blended with diesel fuel from conventional petroleum. However, as the number of oil sand plants increase, and the availsbility of conventional petroleum decreases, blending will not eliminate this problem. Therefore, catalysts to convert low cetane number aromatic components to higher quality hydrocarbons are being developed.

4. Disposable Catalysts for Hydrogenating Bitumen and Solubilizing Coal

Catalysts are being developed for the coprocessing of residual oils and coal. The hydrogen donor properties of these heavy oils of petroleum origin enhance the production of liquid fuels from coal. The catalysts being developed will improve both the residual oil and the coal conversions. In addition, the quality of the liquid product will be improved by removing some of the heteroatoms.

5. Hydrotreating Co-processed Distillates

Catalysts are being developed to remove the remaining heteroatoms, particularly oxygen and nitrogen, from synthetic crude distillates, in order to have the advantages of coprocessing of oil sands bitumen/coal mixtures. Coprocessing produces a greater quantity of distillate than would be obtained by processing the bitumen alone. Unfortunately the distillate derived from the coal contains oxygen and nitrogen compounds which must be removed to meet the specifications of some fuels. Emphasis is being placed on the components produced from coal.

Patent Application

Preparation of a Hydrocarbon Fuel by Hydrogenation of a Synthetic Crude Middle Distillate, M.F. Wilson and J.F. Kriz, Canadian Patent Application 462, 789, Filing Date Sept. 10, 1984.

Publications in Journals and Hardcover Books

1. Upgrading of middle distillate fractions of a syncrude from Athabasca oil sands, M.F. Wilson and J.F. Kriz, FUEL 63, 190 (1984).

2. Hydrocracking Bitumen Derived from Oil Sands with Sulphided MoO_3-CoO Catalysts having Supports of Varying Composition, P.M. Boorman, J.F. Kriz, J.R. Brown and M. Ternan, Proceedings of the 8th International Congress on Catalysis, Vol. 2, Verlag Chemie, Weinherm FRG, 1984, p. 281-291.

3. Hydrocracking Heavy Hydrocarbon Feedstocks: Aspects of Catalysis Related to Feedstock Coking Tendency, J.F. Kriz and M. Ternan, Studies in Surface Science and Catalysis, vol. 19, (eds. S. Kaliaguine and A. Mahay), Elsevier, Amsterdam, 1984, pp 545-552.

4. Influence of Carbon on Iron in the Hydrogenolysis of Isopentane, J. Monnier, G. Dénès and R.B. Anderson, Can. J. Chem. Eng. 62, 419-424 (1984).

5. Oxidation of 1-butene by Nitrous Oxide over Manganese (III) and Related Transition Metal Oxides, R.A. Ross and C. Fairbridge, Can. J. Chem. 62, 1483-1486 (1984).

SEPARATION AND CHARACTERIZATION

Head - Dr. Henry Sawatzky
Staff - Dr. Marc Poirier, Dr. Brian Farnand, Dr. Gilles Jean, Dr. Sylvain Coulombe, Mr. Syed Amhed, Mr. Gary Smiley, Mr. Harry Barber, Mr. Edward Bonvie

Projects

1. The Effect of Different Recovery Methods on the Processibility of Bitumen and Heavy Oils

The properties of bitumens and heavy oils obtained by various recovery methods (steam stimulation, fire flooding) will be compared with those obtained from core samples taken from the same reservoirs. The effects of these properties on the operating conditions required in upgrading processes will be investigated.

2. Characterization of Residual Oils of Co-processed Products and of Polynuclear Aromatic Compounds

The development of procedures to accurately measure the molecular weight distribution of residual oils will improve all of the primary upgrading processes (hydrocracking, co-processing). The development of a technique to separate and identify polynuclear aromatics (PNA) will show what types of additional processing steps are required. The compound types in product samples from co-processing will be related to the extent of feedstock conversion.

3. Production of Asphalt Using the Unconverted Pitch from the CANMET Hydrocracking Process

The CANMET hydrocracking process (Figure 1) has a 5-10% yield of unconverted pitch. One possible use for the pitch would be to incorporate it into blends of asphalt. An earlier study showed that 5-10% was the maximum amount of CANMET pitch that could be blended with a 150/200 penetration asphalt cement to produce an acceptable 85/100 penetration road asphalt. More recent studies conducted in our laboratories have shown that 25-35% CANMET pitch could be successfully used in the production of both road and roofing asphalts which meet the specifications indicated in Figure 2. The process consists of blending hydrocracked pitch with a soft vacuum distillation residue to produce an 85/100 penetration grade asphalt cement which meets conventional asphalt specifications. Plans have been made to use some of the pitch from the 5000 bbl/day CANMET hydrocracking demonstration plant to conduct large scale asphalt paving and roofing tests.

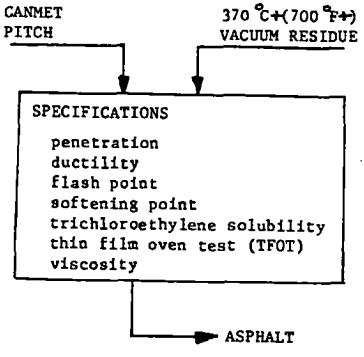

Figure 2 ASPHALT SPECIFICATIONS

4. Physical Treatment of Heavy Oil/Water Emulsions

Most of the bitumen (85%) in the Canadian oil sand deposits will be recovered by in-situ methods (e.g. steam flooding). Heavy oil/water emulsions are produced by these processes. Anticipated water shortages in the oil producing regions of Canada will require the mandatory recycling of produced water in these emulsions, if steam flood technology is to be used on a large scale. Ultrafiltration will be used to produce high quality water from stable heavy oil emulsions. The recovery and reuse of naturally occurring emulsion stabilizing agents is being considered.

5. Removal of Heteroatom Compounds from Synthetic Crude Distillates

Adsorbents are being developed to remove heteroatom compounds (particularly nitrogenous compounds) from synthetic crude distillate fractions. Therefore, a heteroatom free stream will be produced without the need for hydrotreating. The much smaller volume heteroatom rich fractions will be hydrotreated or used in high value products.

6. Separation of Synthetic Crude Oil Fractions by Membrane Procesaes

Synthetic crude distillates will be separated into a stream rich in aromatic compounds and a stream rich in paraffinic compounds. This separation will eliminate the need for expensive processing. Membranes will be evaluated in bench scale reverse osmosis test cells which have been proven in the scale up of commercial water purification operations. When bench scale testing yields successful membranes, effort will be transferred to pilot plant testing of membranes in field operations. Support for the preliminary selection of suitable candidate membrane materials will be by liquid affinity chromatographic evaluations.

Patent Application

Road Asphalt Compositions Containing Hydrocracked Pitch, M.A. Poirier, Can. Patent Application 462, 790, Filed September 10, 1984.

Publications in Journals and Hardcover Books

1. Quantitative Analysis of Coal-Derived Liquids Residues by TLC with Flame Ionization Detection, M.A. Poirier, P. Rahimi and S.M. Ahmed, J. Chromatogr. Sci. 22, 116 (1984).

2. A Novel Method for Separation and Identification of Sulphur Compounds in Naphtha and Middle Distillate Fractions of Lloydminster Heavy Oil by GC/MS. M.A. Poirier and G.T. Smiley, J. Chromatogr. Sci. 22, 304 (1984).

3. Reverse Osmosis Separations of Some Inorganic Solutes in Ethanol Solutions Using Cellulose Acetate Membranes, B.A. Farnand, F.D.F. Talbot, T. Matsuura and S. Sourirajan, Separation Science and Technology, 19, 33-50 (1984).

PYROLYSIS AND GASIFICATION

Head - Dr. Edward Furimsky
Staff - Mr. Stanley Soutar, Mr. Michael Channing
Visiting Scientists - Dr. Moto Yumura (National Chemical Laboratory, JAPAN), Dr. David McLean (University of Ottawa), Dr. Yugi Yoshimura (National Chemical Laboratory, JAPAN)

Projects

1. Hot Gas Clean-up for Coal Gasification Processes

The gas produced from coal gasification processes contains particulate matter and sulphur compounds. Both of these constituents cause unacceptable corrosion to the turbine blades used in electricity generation. By cooling the gas it is possible to remove both the sulphur and particulate matter using existing technology. Unfortunately the cooling process removes considerable energy from the gas stream, and the efficiency of the overall process decreases. The purpose of this research is to develop a process which would remove particulate matter and sulphur, when the gas is hot. An example is shown in Figure 3. The long term goal is to improve the efficiency enough, so that the amount of electricity produced from a given quantity of coal will double. Research to date has focused on the development of adsorbents for sulphur removal. In addition equipment has been purchased for the measurement of particle size distributions of very fine solids.

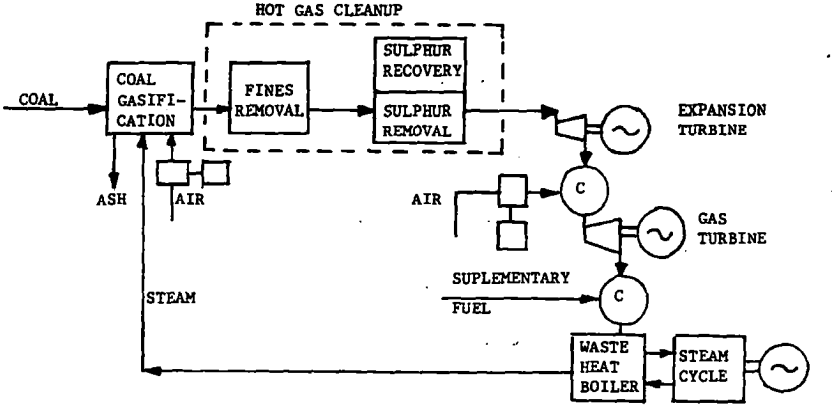

Figure 3 HOT GAS CLEANUP - PART OF A COAL GASIFICATION COMBINED CYCLE SCHEME FOR ELECTRICITY GENERATION

2. Gasification Reactivities of Canadian Coals

Low cost feedstocks which are suitable for gasification will be identified. Additives will be developed which allow gasification reactions to proceed at less severe conditions.

3. Construction of an Entrained Bed Gasifier to Produce Diesel Fuel and Hydrogen from Oil Sand Coke

An entrained bed gasification reactor, large enough to provide accurate carbon material balances, will be constructed. The entrained bed reactor will be used to convert oil sands coke to synthesis gas which can subsequently be converted either to hydrogen or to diesel fuel. Since the cost of oil sands coke feedstocks is extremely low, this processing sequence may produce less expensive hydrogen (than that produced from natural gas) and less expensive diesel fuel (than diesel fuel produced from bitumen).

4. Liquids Produced from Canadian Oil Shales

Operating conditions and hydrogen consumptions necessary to convert distillates from thermal retorting New Brunswick shale oil into fuels which meet existing specifications will be determined. This information will eventually be used in an engineering study comparing the cost of making fuels from oil shales with the cost of making fuels from oil sands and from coal.

Patent Application

A Novel Method for Removing Oxygen from Coal, N.E. Cooke, P. Khandadia and E. Furimsky, Canadian Patent Office Application 460, 989 filed August 14, 1984.

Publications in Journals and Hardcover Books

1. Gasification Studies of Onakawana Lignite, E. Furimsky, Can. J. Chem. Eng. 62, 257 (1984).

2. Hydrogen Retorting of Oil Shales from Eastern Canada, E. Furimsky, J. Synnott, R.S. Boorman and R.S. Salter, Fuel Proc. Technology, 8, 293 (1984).

3. Effect of Coal Rank on Structure of Tars from Pyrolysis of Canadian Coals, E. Furimsky, L. Vancea and R. Belanger, Ind. Eng. Chem., Prod. Res. Dev. 23, 134 (1984).

4. Chemical Reactivity of Canadian Coal-Derived Chars, D.P.C. Fung and S.D. Kim, Fuel 63, 1197-1201 (1984).

CATALYSIS RESEARCH

Head - Dr. James Brown
Staff - Dr. Jan Galuszka, Dr. Siauw Ng, Mrs. Vincenza Allenger, Mr. Ronald Taylor, Mr. Larry Galbraith

Projects

1. Surface Characterization of CANMET Hydrocracking Additives, Coals and Chars

A quality control surface characterization procedure for additives used in the CANMET hydrocracking process will be investigated. The objective of the procedure will be to predict the performance of the additives in the hydrocracking process from their surface properties. This will greatly reduce the number of screening tests required to select additives suitable for the hydrocracking process.

2. Comparison of Yields from Synthetic Crude Gas Oils in Fluid Catalytic Cracking (FCC)

The FCC yields from the following gas oils will be compared: synthetic crude oil from commercial oil sands operations, crude oil from enhanced oil recovery, gas oil from CANMET hydrocracking, gas oil from oil shale, gas oil from coal liquids, gas oil from co-processing.

3. Catalytic Pyrolysis of Pitch

To convert +525°C residua (e.g. pitch which did not react in the CANMET hydrocracking process, shown in Figure 1) to useful products such as distillate hydrocarbons and hydrogen. The distillates would require further refining to upgrade them into transportation fuels. The hydrogen could be used directly in a hydrocracking or hydrotreating process unit within the same upgrading facility. It is expected that the residua conversion will be accomplished by a combination of pyrolysis and gasification.

4. Conversion of Natural Gas to Liquid Fuels Using Acetylene as an Intermediate

To produce transportation fuels (gasoline, jet fuel) from natural gas using a single process. Natural gas can be converted to gasoline with existing technology using a combination of three processes. There are advantages to using a single process. The overall thermal efficiency should increase significantly and the capital cost for the processing plant should be reduced substantially. The single process will entail converting methane to acetylene at high temperature. The product stream will be cooled subsequently and converted over a catalyst, at lower temperature, to a variety of products including benzene and high octane benzene derivatives.

5. Conversion of Natural Gas to Diesel Fuel via a Synthesis Route

In this approach natural gas would be steam reformed to obtain carbon monoxide and hydrogen which would be used in a synthesis reactor to produce diesel fuel. A computer controlled synthesis reaction system is currently being constructed. Ultimately research will focus on the development of catalysts which selectively produce diesel fuel.

6. Analysis of Catalytic Surfaces

X-ray photoelectron spectroscopy (XPS) is the only technique which can be used to determine both atomic composition and valence state at a solid surface. Chemical and physical differences in catalyst preparation can therefore be readily measured by XPS

Catalysts used for hydrocracking heavy oils and bitumen contain molybdenum and cobalt on an alumina support. In the fresh catalyst the molybdenum is in the oxide state (e.g. MoO_3). In the used catalyst the molybdenum is sulphided (e.g. MoS_2). The molybdenum XPS spectra in Figure 4 show that the Mo^{4+} spectra of MoS_2 (dotted line) are at different binding energies than the Mo^{6+} spectra of MoO_3.

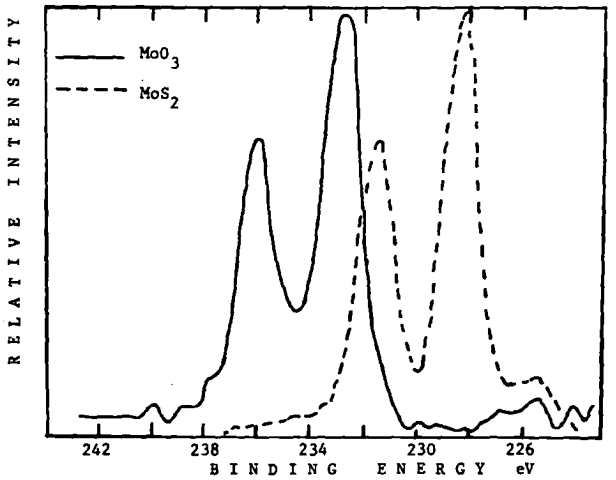

Figure 4 MOLYBDENUM 3d XPS SPECTRA FOR MoO_3 and MoS_2

Publications in Journals and Hardcover Books

1. In Situ X-ray Photoelectron Spectroscopic Examination of a Co-Mo Alumina Hydrotreating Catalyst, J.R. Brown and M. Ternan, Ind. Eng. Chem., Prod. Res. Dev. 23, 557-564 (1984).

2. Some Physical Properties of Canadian Coals and Their Effects on Coal Reactivity, S.H. Ng, D.P.C. Fung and S.D. Kim, Fuel 63, 1564-1569 (1984).

3. The Surface Chemical Characterization of a Sulphided Co, Mo γ alumina (HDS) catalyst by XPS/AES/SAM, J.R. Brown, in Studies in Surface Science and Catalysis, vol. 19 (eds. S. Kaliaguine and A. Mahay), Elsevier, Amsterdam, pp 267-274 (1984).

4. Iron Surface Morphology Factor in the Growth of Filamentous Carbon, J. Galuszka and M.H. Back, Carbon 22, 141 (1984).

5. Infrared Study of Coadsorption of CO and H_2 on Alumina-Supported Nickel Catalyst, J. Galuszka and Y. Amenomiya, in Studies in Surface Science and Catalysis, vol. 19 (eds. S. Kaliaguine and A. Mahay) Elsevier, Amsterdam, p. 63.

ANALYSIS AND STANDARDIZATION

Head - Mr. Louis Janke
Staff - Mr. Mark Farrell, Mr. Jan Skulski, Mrs. Jara Glasa, Mr. Timothy Moher, Miss Teresa Psutka, Mr. Allan Martineau, Mrs. Patricia Mallard
Employees on Loan from Industry - Mr. Peter Zourdos, Miss Helga Koethe

Projects

1. Analyses to Support CANMET Research Projects

A capability to perform virtually any standardized test on solid fuels and related materials is maintained. Proximate (moisture, volatile matter, fixed carbon and ash), ultimate (C,H,N,S), ash analyses (atomic composition), ash fusion temperature, and heating value are measured routinely. Specialized equipment includes, atomic adsorption, ion chromatography, inductively coupled plasma spectroscopy, and X-ray fluorescence.

2. CANSPECS - CANMET's SERVICE PROGRAM FOR THE EVALUATION OF COAL STANDARDS

CAN SPECS is an analytical round robin testing program which distributes commercially produced Canadian coals to 50 public and private sector laboratories associated with the production, assessment and utilization of coal in Canada and abroad. The market value of coal is estimated and evaluated from analytical data obtained by using nationally and internationally standardized procedures. These standards are being continually reviewed and revised to assess wider ranges of coal quality or to evaluate properties which have an impact on novel technological applications. CAN SPECS accumulates the analytical data relating to nine parameters of coal quality (moisture, ash, volatile, carbon, hydrogen, sulphur, nitrogen, heat value and free swelling index) from the participating organizations. The data are subjected to standard statistical tests to provide reports which:

(a) assess existing national and international standards used to evaluate Canadian coals.

(b) test proposals for new standards, and for revisions to existing standards. Changes must be consistent with Canadian industrial interests.

(c) evaluate laboratory performance.

3. Development of National and International Analytical Standards

Laboratory personnel represent Canada in the development and formal acceptance of analytical test methods for the Canadian Government Standards Board, the American Society for Testing and Materials and the International Standards Organization. Laboratory personnel enaure that "the accepted test procedures" which are used to place a commercial value on exported resources (e.g. coal) are good procedures for demonstrating the useful properties of Canadian resources.

4. Bi-annual Canadian Coal Survey

The properties of coals produced from all coal mines operating in Canada are measured bi-annually. The most recent inventory has been published as CANMET report 84-1.

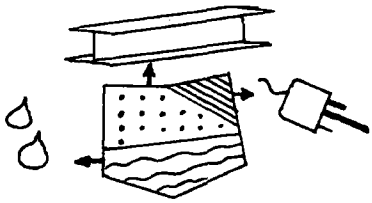

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Figure 5 STANDARDS ORGANIZATIONS

HYDROCARBON CONVERSION

Head - Dr. David Fung
Staff - Mr. Milan Skubnik

Projects

1. Biomass Gasification

A summary of the technology development on wood gasification which has been performed in Canada will be prepared. The overall goal of the project is to have wood gasification technology available which is cost effective for the generation of electricity in isolated Canadian communities.

2. Contracted-Out Research

Management and coordination of all research which is contracted outside the federal government using scientific authorities within the Hydrocarbon Processing Research Laboratory.

Part of the program is cost shared with industrial groups on a 50/50 shared basis. Some of the contracts are funded 100% by the federal government to complement the in-house research activities. A list of contracts in progress follows: The total cost of each contract is shown. Since many contracts are performed over a lengthy time period, part of the money will have been spent in the previous fiscal year, the current fiscal year and the next fiscal year.

Federal Government Contract Cost K$	% of Contract Funded by Federal Government	Contract Title	Contractor/ (Scientific Authority)
95	100	Treatment of Pitch with Methanol	Sandwell-Beak Research Group(Dr.M.A. Poirier)
64	100	Valorisation des residues d'huiles lourdes par pyrolise sous vide	Université de Sherbrooke (Dr. J. Monnier)
65	100	Selective identification of olefins and paraffins in synthetic crude middle distillate	SSC* (Dr. S. Coulombe)
8	100	Determination of the molecular weight of asphalt samples by gel permeation chromatography	Ontario Research Foundation (Dr. M.A. Poirier)
126	50	Diesel and middle distillate quality and yield improvement	Gulf Canada (Dr. H. Sawatzky)
106	50	Compositional study of nitrogen and oxygen compounds in products of heavy oil primary and secondary upgrading	Gulf Canada (Dr. S. Coulombe)
170	100	Technical and economic assessment of the application of membrane technology for treating oil/water mineral emulsions	Zenon Environmental (Dr. B. Farnand)
49	100	The evaluation of adsorbents for treating stable oil/water/mineral emulsions produced from in-situ bitumen/H.O.	Zenon Environmental (Dr. M.A. Poirier)
60	100	Reverse osmosis separation of model compounds in heptane and toluene solutions	SSC* (Dr. B. Farnand)
75	100	Investigation of extraction of catalyst deactivating components from synthetic crudes with CO_2 and N_2O	SSC* (Dr. H. Sawatzky)
75	100	Separation of nitrogenous materials from naphtha	SSC* (Dr. G. Jean)
100	100	Novel concepts for segregation of problematic components	SSC* (Dr. H. Sawatzky)
70	100	New concepts for treating emulsions using a rotating membrane	SNC Inc. (Dr. B. Farnand)

Federal Government Contract Cost K$	% of Contract Funded by Federal Government	Contract Title	Contractor/ (Scientific Authority)
117	100	Adsorption of nitrogen compounds	SSC* (Dr. G. Jean)
106	50	The impact of problematic components on synthetic crude processing	Gulf Canada (Dr. H. Sawatzky)
141	50	Separation of saturated and aromatic components in synthetic crudes	Gulf Canada (Dr. H. Sawatzky)
111	100	Compositional analyses of hydrotreated middle distillates from synthetic crude oils	Gulf Canada (Dr. M. Wilson)
42	100	Determination of aromatics in oil sand distillates	Carleton University (Dr. M. Wilson)
119	100	Hydrogenation of model compounds	SNC Inc. (Dr. E. Furimsky)
50	100	The fabrication of thin film well defined Co, Mo, alumina catalysts and their fabrication	Univ. of Western Ontario (Dr. J. Brown)
197	100	Characterization and Storage Stability of untreated and hydrotreated liquids from spouted bed pyrolysis of Canadian coals.	Univ. of British Columbia (M. Skubnik)
85	100	Software development for automated R&D reactor system for distillate upgrading	Sharon Professional Serv. (Dr. C. Fairbridge)
74	100	Pilot scale conversion of Estevan lignite into hydrocarbon distillate by hydroprocessing	Sandwell Beak Research Group (Dr. C. Fairbridge)
78	100	Préparation de catalyseurs à base de métaux supportés sur ZSM5	Université de Laval (Dr. J. Monnier)
50	100	Studies of hydrodesulphurization reactions on thin films of Co, Mo catalyst	Univ. of Western Ontario (Dr. J. Brown)
150	100	Upgrading synthetic crude distillates with commercial hydrotreating catalyst	SSC* (Dr. M. Sekhar)

Federal Government Contract Cost K$	% of Contract Funded by Federal Government	Contract Title	Contractor/ (Scientific Authority)
60	100	Role of the catalyst in heteroatom removal	Univ. of Alberta (Dr. C. Fairbridge)
186	50	Development of improved synthetic crude processes and their impact on distillate quality	Gulf Canada (Dr. M. Wilson)
111	50	Study of Incorporating Heavy Oil and synthetic crude residua into a fluid catalytic cracking (FCC) feedstock	Gulf Canada (Dr. S. Ng)
122	50	The impact of nitrogen compounds on the processing of synthetic gas oil	Gulf Canada (Dr. J. Monnier)
68	50	Hydrogenation of synthetic crude feedstock and its effect on FCC yields	Gulf Canada (Dr. S. Ng)
160	100	Direct partial oxidation of methane to methanol over designed heteropoly catalysts	Univ. of Waterloo (Dr. J.R. Brown)
82	100	Direct conversion of natural gas to aromatics/gasoline	Univ. of Saskatchewan (Dr. S. Ng)
72	100	Study on the direct oxidation of natural gas to methanol	Univ. of Manitoba (Dr. D.P. Fung)
38	100	Conversion du méthane en essence automobile par réaction en cathode creuse	U de Q à Chicoutimi (Mrs. V. Allenger)
41	100	Automation of receiver system for a catalyst testing unit	Stearns Catalytic (Dr. J. Galuazka)
125	50	Transportation Fuels and Hydrocarbon Products from Natural Gas	SNC Inc. (Dr. D.P. Fung)
148	50	Gaz de synthese/essence synthetique	Centre de Recherche Industriel de Quebec (Dr. G. Jean)
50	100	Carbon deposit morphology on metal surfaces during hydrocarbon synthesis	Univ. of Ottawa (Dr. J. Galuszka)

Federal Government Contract Cost K$	% of Contract Funded by Federal Government	Contract Title	Contractor/ (Scientific Authority)
131	100	Gasification of Western Canadian Coals in a Spouted Bed	Univ. of British Columbia (Dr. D.P. Fung)
142	100	Gasification of Oil Sands Coke	Univ. of British Columbia (Dr. D.P. Fung)
33	100	Rapid pyrolysis of New Brunswick oil shales	Univ. of British Columbia (Dr. E. Furimsky)
58	100	Effect of Temperature and Hydrogen Pressure on Liquid Yields from selected oil shales	Research & Productivity Council of New Brunswick (Dr. E. Furimsky)
55	100	Entrained bed gasification of Suncor and Syncrude coke	SSC* (Dr. E. Furimsky)
50	100	Evaluations of processing options for the oil shales of Ontario	Watt, Griffis & McQuat (M. Skubnik)
63	100	Upgrading of Nova Scotia oil shales	Technical Univ. of Nova Scotia (L. Janke)
19	100	Gasification reactivities of ultrasonically treated coal rejects	Carleton University (Dr. B. Nandi)
127	100	A demonstration of an integrated oil shale system	Research & Productivity Council of New Brunswick (Dr. E. Furimsky)
146	100	Conversion of coal rejects to liquid fuels via indirect liquefaction	Esso Resources/Westar (Dr. E. Furimsky)

SSC* indicates that a contract is being negotiated with Supply and Services Canada.