THE CARMAGEN Engineering, Inc. 20th Anniversary REPORT©

Partnering in Engineering Excellence

April 2006

CONTENTS

Editor
Lori Carucci

Text Editor
Pat Terry

Writers
Carmagen Engineering, Inc. Staff

The Carmagen Engineering Report© is published periodically by our staff and presents information and viewpoints on engineering topics relevant to the hydrocarbon processing industry. While the contents of The Carmagen Engineering Report© have been carefully reviewed, Carmagen Engineering, Inc. does not warrant it to be free of errors or omissions. Some back issues are available and may be requested while supplies last.

Corporate Office
4 West Main Street, Rockaway, NJ 07866
Tel: 973-627-4455 Fax: 973-627-3133

Website: www.carmagen.com

E-mail: carmagen@carmagen.com

Transition in the Chemical Industry

By Richard H. Schlosberg, Ph.D.

We have entered into an era of significant transition in the chemical industry. The following items are diagnostic of this change.

- Feedstocks for basic chemical building blocks have evolved from coal in the 19th century to petroleum in the 20th century to gas
- Industry leadership has evolved
  - From the beginning of the industry, the leadership was with synthetic companies such as BASF, ICI, DuPont, Bayer, Halcon, and Dow.
  - Sometime in the mid-20th century, petrochemical companies including Shell, Exxon, Mobil, BP, Chevron, and TEF became major players in the chemicals businesses built.
  - Today, national petroleum companies and related entities (SABIC, Qatar Petroleum, Sinopec, Sasol) are major players in the chemical world.
- Polymer products have evolved from: Hydrocarbon Polymers (polyolefins, polystyrene, etc.) to Engineering Plastics. Now the industry is looking toward market segmentation and product differentiation.
- Premium small molecule products have evolved from alkanes, aromatics and halogenates to olefins and oxygenates.
  - DME for fuels; DMC for chemicals; Acrylic Acid, Acrylates; MAN; 1-3 Propanediol; co-monomers such as hexane-1; etc.

Continued on Page 2

Carmagen celebrates 20 years!

Formed in 1986 with just one full time engineer, we've now grown to almost 200. We must be doing something right! We'd like to thank our clients and everyone who works with us for helping us reach this milestone. We look forward to the next 20!

Continued from Page 1

- The public message from the chemical industry has evolved: "Better things for better living through chemistry" to Sustainable Chemistry to REACH and Responsible Care to ???
- The law of unintended consequences is always with us.
  - Consider the history of high octane mogas (aromatics and TEL, then MTBE, now EtOH)
  - Consider the history of refrigerants (hydrocarbons, ammonia, then Freon™, now HFCs)
  - Consider pesticides (DDT) ["Silent Spring"], naphthalene-free (<1000 ppm) products, next???
- Can there be any new "blockbuster" (polymer) products?
  - What is needed to innovate new solutions, demand creation, etc. (a la the electronics industry)???

What does the chemical industry need to do to thrive in this period of great transition? Companies need to achieve raw material supply security (including price), overcome continuing image problems, and generate new technologies to provide solutions that customers want and need. An overriding issue is that of feedstock costs and volatility. To quote a senior industry executive: "There's a problem facing the North American petrochemical industry right now. High North American energy prices - the highest in the world - challenge our competitiveness in a globally traded commodity market.[1]"

Where are the technology opportunities? For the chemical industry today, many technologies are decades old.

- IPA, SBA via weak acid hydration
  - Commercialized by (now) ExxonMobil ~1919-1920
- Cumene to Phenol and Acetone (Hock process) ca. 1945
  - But relatively new route to propylation of benzene via zeolites (1996)
- Ethylene Oxide via Ag catalyzed addition of oxygen to ethylene
  - T.E. Lefort (French) 1931
  - Transformed to commercial process in 1937 (UOP)
- Purified Terephthalic Acid (PTA)
  - Mid-century process (Amoco and Scientific Design) in the 1950's
- Polyolefins
  - Ziegler-Natta (discovery 1953)
  - Metallocene (first ExxonMobil commercialization in 1991)
  - LDPE (Union Carbide's gas phase technology (UNIPOL) (announced 1977)
- PVC
  - Via ethylene chlorination, dehydrochlorination to vinyl chloride
  - Plasticized PVC became important ca. 1930
- PC
  - Phosgenation route (GE, Dow, Bayer)
    + Discovery 1953
    + Used in space program 1962 (astronaut helmet visor)
    + Lexan sheets, etc. introduced by GE Plastics
  - DMC route (ENI - ca. 1990)

While the existing technologies are long in the tooth, "there is little doubt that new process technologies with shutdown economics that might have reached full commercialization between 1980 and 2000 are virtually nonexistent.[2]"

Since feedstocks are a major part of most chemical process costs, this is where one might look for new technology opportunities. Many processes are built on relatively expensive, highly purified olefins or purified aromatics. Polyolefins, VCM, acrylic acid, ethylene oxide, propylene oxide, terephthalic acid and others are built from purified monomers which in turn are generated from refinery or gas cracking processes that include significant purification steps. Some have begun to seek opportunities to replace purified olefins with either olefin containing streams and/or with paraffins or with methanol (syngas). Thus, major research efforts are underway to convert propane directly to acrylic acid rather than use propylene. Another example is the partial oxidation of ethane to acetic acid to replace the current technology that employs oxidative carbonylation of methanol. Are there other opportunities of this sort?

Continued on Page 3

Continued from Page 2

Another area that appears ripe for a relook is the area where the current technology generates two stoichiometric products. For example, the pathway to phenol is to alkylate benzene with propylene, peroxidize the cumene and decompose to generate a mole of phenol and a mole of acetone. Another example is the peroxidation route to propylene oxide. Here is one version of the Halcon/ARCO process, isobutene is oxidized to the peroxide which in turn transfers an oxygen to propylene. The products are one mole of propylene oxide and one mole of *tert*-butanol. The by-product *tert*-butanol has been converted to MTBE. Today, it appears that the market for phenol is growing more rapidly than the acetone market prompting the question: is there a direct route to phenol from benzene? Also, with MTBE under environmental question, researchers are asking how they could make propylene oxide directly.

Yet another area to consider is that of catalysis. There always remains opportunities for value to be delivered through new catalysts with higher turnover numbers, longer life, and higher selectivities.

With all of the attention today on low cost manufacturing processes, energy conservation, sustainable chemistry and related items, it's time to think hard about innovative solutions and new technologies to reinvigorate the chemical industry.

A final word: "There is always a well-known solution to every human problem - neat, plausible, and wrong.[3]"

References:

[1] **North American Petrochemicals: Walking a tight rope**. Speaker: Dr. Ramesh Ramachandran, Dow Chemical Canada, Inc., President and HC&E Olefins Business Director, CERI 2005 North American Natural Gas Conference & Calgary Energy Show 2005, Calgary, Alberta 03/07/2005.

[2] Jeffrey S. Plotkin in "The Chemical Industry at the Millenium", Chemical Heritage Press, Philadelphia, 2003, p. 53.

[3] H.L. Mencken, *Prejudices: Second Series, 1920 US editor (1880-1956)*

Richard Schlosberg, Ph.D. is a consultant to the chemical and petrochemical industries with expertise in new product development and introduction, market studies, intellectual property strategy generation and execution, competitive analysis and strategic planning. Dr. Schlosberg has expertise in advising developers, users and/or licensors of processes and product technologies focused in the area of chemical intermediates. Please contact Jerry Lacatena if you'd like more information on Carmagen's expertise in this area.

Significant Energy Savings Achievable Even At "Smaller" Refineries

By Robert F. Dubil

Carmagen Engineering, Inc. (CEI) provided fired heater support to a team of process and equipment specialists performing energy assessments at two "smaller" refineries that were located near each other. The team's mission was to identify major energy losses, quantify their costs, and to advise the client on ways to reduce or eliminate these losses. In several cases, these energy losses could be reduced through relatively low-cost means.

Although the refineries are relatively small (20-22 kB/SD), the team identified a total of over $3M per year combined potential energy savings for both refineries (about 20% of their total energy cost) at an investment of about $3.5M. However, about 70% of the total energy savings could be realized at no or low cost.

The total energy savings attributed to the fired heater area alone were estimated to be approximately $450k/yr at effectively no or low investment cost. These include some basic instrumentation (locations) to allow more efficient firing, as well as reducing furnace casing leakage. In other cases, significant savings can be achieved by operational/procedural changes and energy-focused operator training.

The total engineering effort expended by CEI on this study from beginning to end was less than two weeks! Thus, there was a fantastic return on the engineering cost expended.

Robert Dubil has provided engineering consulting services in the field of Fired Equipment to the hydrocarbon processing industry for over 38 years; this includes engineering and design, as well as commissioning, maintenance, troubleshooting, operation and training. He is also very active in the development of Industry Standards governing the design and purchase of fired equipment through participation with The American Petroleum Institute. In addition, he has participated in the development of similar international standards, working with the ISO Standards Committee. Please contact Bruce McSkimming if you'd like more information on Carmagen's expertise in this area.

Invention Disclosures and Documentation

By F. Donald Paris

F. Donald Paris is a Patent Attorney associated with the Intellectual Property firm of Lerner & Greenberg, P.A., Hollywood, Florida, USA. He can be reached at 954-925-1100. For more information, their website is www.patentusa.com.

… a good beginning adds value to the patenting process.

While guidelines are never a substitute for legal advice, the following discussion will serve to acquaint inventors, both private and corporate, with the importance of good invention disclosures and also should serve as a reminder to all to be on the alert for patentable ideas.

Patenting can help maximize the protection of an important asset … technology. Technology that is not patented but still desirable of protection, is protected by maintaining it as trade secret. A patent is a legal limited statutory monopoly for a specified period of time depending on the country (20 years from filing an application in the U.S.) - granting the right to exclude others from practicing the claimed invention, while simultaneously providing a potential licensing asset on new developments. The issuance or publication of the patent also can prevent others from subsequently obtaining patent protection for essentially the same invention - often referred to as "freedom of operation."

It is an inventor's responsibility to bring to his/her new inventions, discoveries, and ideas, to the attention of his/her Patent Attorney. The principal way in which this may be accomplished is to document any invention or discovery in an Invention Disclosure (ID). Additionally, the ID when properly completed is a legal document which helps, inter alia, to establish inventorship, the date of conception, and often the breadth of the invention, all of which are important in the successful preparation and prosecution of a patent application, and obtaining a patent.

An ID is not a proposal to do research work or a suggestion to a laboratory to obtain supporting data. However, IDs can act as catalysts to initiate such actions.

An inventor typically prepares the ID and thereafter, works with his/her Patent Attorney to obtain maximum protection for the technology. Inventors also are expected to disclose all relevant facts and material that could bear on the novelty of the invention.

Inventions and ideas are an expression of engineering/research creativity, and when complete and operable they become valuable as proprietary assets, either as trade secrets or know-how or when protected by patents.

The ID is a record of your invention or idea.

The ID is a written disclosure and evidence of your invention at an early stage in its development or can disclose your completed invention. It constitutes a legal record of the conception and evidences what you believe to be the breadth and nature of your invention. When properly completed, it also serves to transmit your invention to an appropriate patent committee and/or Patent Attorney for review and further appropriate action. Laboratory notebooks for recording daily activities are an ancillary part of the patent process and are usually provided to company employees who are involved in research and development. The notebooks should be maintained in accordance with procedures and guidelines established by the company.

The ID should be written as soon as possible after you feel that you have a complete and operable invention (a mere thought or suggestion for research is usually too soon). Emphasis on speed in documenting your idea is well founded in many instances of close conception dates among different inventors within your Company and from other companies, especially in active technical areas. In accord with the U.S. Patent Law, the company files in the name of the inventor(s) who has the earliest documented conception date for the complete invention. Your Patent Attorney will determine proper inventorship pursuant to U.S. or applicable Patent Law. When appropriate, the successful reduction to practice of the invention will be considered by the responsible attorney in determining proper inventorship.

Do not be overly critical of your inventions or ideas when deciding whether they are worth writing up as an ID. Any process, product, or equipment invention, which you believe to be new or patentable and which strikes you as being valuable (especially where it has good technical or economic advantages over the prior art), should be the

Continued on Page 5

Continued from Page 4

subject of an ID. If you are in doubt on the question of novelty or patentability, complete an ID and consult your Patent Attorney to decide whether there is a basis to seek patent protection. Good research and engineering practices dictate the inventor being familiar with the prior art, such as by having a search made for the invention. This is particularly desirable to have before starting a substantial research or development effort. Do not prejudge your inventions negatively - it could be the wrong decision and adverse to your and/or your company's interests.

The ID should represent a complete disclosure of your invention.

What Goes Into the ID?

Keep the ID brief, but be complete, concise and accurate in describing your invention. Particularly describe or show data that supports your invention, to the extent available. Attach drawings or extracts from reports, etc., if available. If subsequently it is decided to file a patent application based on your ID, the attorney may ask for any additional data, drawings, etc. needed to prepare the application for filing in the U.S. Patent and Trademark Office.

The title should be descriptive and specific. The abstract, if provided, should clearly summarize the invention, its use, and its novelty and advantages over the prior art (that is, presently known conventional equipment or methods). In many cases, the people who evaluate your ID may be influenced by what your abstract says (especially if it is their first impression). A clear and definitive abstract, therefore, can be a real asset. It is important that the ID contain all of the facts available in a clear and accurate manner. And don't omit the bad data - the attorney needs the complete story.

The ID should include a description of the invention, a brief discussion of all of the prior art that you are aware of, and an outline of the benefits you claim for your invention over the prior art.

Drawings or sketches should be included if the invention lends itself to illustration. And very important - if you have data to support the statements in your ID, include the data in your writeup or in a summary table. Your case is much stronger with data, particularly for chemical type inventions where data often is necessary to file a patent application. Also, if your invention is in use or has been disclosed or is included in a design or a study, note this fact in the ID. It will reflect a measure of interest in your invention. If the invention was made under a Government contract, also make note of that.

Mechanics of Preparing the ID

The final copy of the ID should be signed by the inventor(s) in ink on each page, including sketches, figures and tables, which are on separate sheets. The sketches and figures may be drawn freehand, but they should be made in ink. Each signature should be witnessed and dated by someone who has read and understands the invention disclosed in your ID but is not a co-inventor. The witness should always date his or her signature as of the day the witness (not the inventor) actually signs.

Training the Current and Next Generation of Refinery Engineers

By Winston Robbins, Ph.D.

The engineering expertise available in the petroleum refining industry is graying at an alarming rate. The average age of engineers supporting refineries today is well over 50. The decrease in refinery expertise began in the mid-1980's when the price of crude oil sank to $8 per barrel and a number of veteran personnel elected early retirement. In previous down cycles, the oil industry was able to quickly recover with the help of a strong, talented work force, whose members served as valuable mentors. This is no longer the case; the industry is struggling with training young engineers while its remaining refinery experts are swamped with technical demands that limit their availability for mentoring. Technical consultants are being employed to fill this gap.

Demographic Shifts

The decrease in personnel available for mentoring can be attributed to three factors:

- Rapid merger/acquisition activity since 1986 that eliminated duplication of tasks. This activity also tended to reduce the size of engineering staffs.
- Re-engineering of traditional corporate structures that reduced "careers" to "jobs" in order to reduce engineering costs.
- Increases in new technology that led companies to expect more efficient working methods so that one person could do the work previously done by several.

A combination of these factors with a perceived "old smokestack" industry inhibited hiring until after 2002 when the price of crude oil began its increase. At this point, the remaining experts who are approaching retirement are so stretched handling their work that they have little time for mentoring. It has been estimated that it takes 7-8 years for a young graduate to become fully capable in the industry. The absence of qualified mentors may extend this period. In the interim, less experienced engineers are handling tasks for which they are not necessarily qualified.

Engineer Mentoring

Mentoring is a learning partnership between an experienced engineer (mentor) and a new professional (protégé) for the purpose of sharing knowledge and information. It is an interpersonal relationship, outside the direct chain of command, where an individual receives advice, coaching and/or counseling that will benefit the company. Mentoring can be situational (short term, random, casual, creative, problem driven), informal (voluntary, personal, loose, responsive) or formal (institutional, information driven). Open communications (face-to-face or electronic) allow a protégé an opportunity to develop both personally and professionally. An effective mentor listens without questioning why, provides feedback without dictating, puts problems in perspective without building barriers, suggests ideas without discounting alternatives, and challenges decisions without negative criticism. Over time, a protégé may have many mentors depending on his development. While some relationships may last several years, they may last only days or months. A key to successful mentoring is management sanction and support.

Consultants as Mentors

In many ways the role of a mentor parallels that of a consultant:

For the Client, the Consultant

- Is Available
- Provides Technical Expertise
- Is Contracted from the Outside
- Brings Broad Experience
- Provides Problem Perspective
- Suggests Technical Options
- Identifies Other Active Experts
- Listens/Shares Career Experience
- Avoids Institutional Barriers
- Reviews Results and Reports

For the Protégé, the Mentor

- Is Available
- Provides Technical Expertise
- Comes from Outside Line Organization
- Has Industry Knowledge
- Puts Problems in Context
- Helps Identify Approaches
- Suggests Contact People
- Counsels on Career Concerns
- Provides Advice on Internal Systems
- Reviews Results and Reports

Continued on Page 7

Continued from Page 6

Consultants are hired because of well-established, long term expertise in a field that includes "institutional memory" that may be hard to access otherwise. To compensate for the loss of internal experts, organizations have created "knowledge databases" using information technology. Often, the databases have been built rapidly with little evaluation of information quality. If there is no internal expert to guide a young engineer in gathering adequate background, progress in solving refinery problems can be slow. Even with data mining technology, an inexperienced engineer may face a large body of conflicting data before moving forward. An experienced consultant, on the other hand, knows how to interrogate the database to obtain relevant, reliable data and quickly move forward.

The role of consultant and mentor differ in two important ways. First and foremost, a consultant addresses problems directly while a mentor guides an individual addressing a problem. Second, a mentor can provide company career advice based on knowledge of the inner working of the organization while a consultant can only reflect on his experience to give feedback on career path options.

Consultant Mentoring Programs

Consultant mentoring supplements company training programs for young engineers. For years, industry has used academic consultants as mentors. Professors "working at the cutting edge" are contracted to visit company sites periodically and maintain informal networking contacts with those working in their fields of expertise. Similar programs may be established with experienced (often retired) experts who remain actively engaged in their field. This requires an interest on the part of a company to sponsor a consultant and a willingness by young employees to take advantage of his availability.

There are many ways that a company may structure a consultant mentoring program once it recognizes its need for outside expertise in a specific area. One approach is to contract the consultant for a number of site visits and a number of hours of availability over the course of a year. For example, a consultant may be hired for two site visits per year and to provide up to 40 hours of on-line or phone contact. The details of the site visit (seminar, face-to-face mentoring, management contacts, etc.) and remote contacts must be structured to satisfy company requirements.

Hired as a mentor, a consultant is available as a sounding board rather than as a problem solver. While making suggestions, asking questions, or pointing to alternate options as a technical consultant would, the mentor consultant refrains from pushing decisions and often plays the role of devil's advocate to force the protégé to defend a position. By challenging him to "look at the big picture" (e.g., cost, scale, by-products, available space, materials of construction, institutional prejudice, etc.), the mentor helps his protégé develop into a valued, experienced engineer.

A consultant mentor program is a way for a young engineer to access expertise and experience that can help in his growth personally and professionally. Such a program also clearly benefits the company by helping it to develop the technical capabilities of its staff comparable to the way it was done in the "old days."

Win Robbins has extensive analytical expertise in the areas of reactive sulfur/naphthenic acids characterization, HPLC-2 ring type definition technology, and polynuclear aromatic hydrocarbons (PNA) characterization. Please contact Jerry Lacatena if you'd like more information on Carmagen's expertise in this area.

HIGHLIGHTS

- Providing refractory consulting assistance for a Canadian client in support of turnaround planning activities.
- Assisted a European client with troubleshooting furnace operating problems.
- Continued to provide a US client full-time mechanical engineering assistance in performing Finite Element Analyses.
- Continued to provide a US client extensive heat transfer support.
- Providing expert witness assistance to four US based clients.
- Assisting a US client in the development of valve purchase specifications.
- Providing machinery inspection/test witnessing assistance to several US clients.
- Providing refractory consulting assistance to a US client in reviewing the FCCU external riser lines for three refineries.
- Provided refractory review assistance to several US clients.
- Concluded marine terminal engineering expert witness support to a Far East client.
- Completed the initial phase of a reliability and maintenance implementation program for a European client.
- Updated technical and design practices for a US client.
- Continued to provide electrical engineering support to a US client.
- Provided metallurgical expert advice to a US client for fixed equipment repairs.
- Continued to provide project management planning support to a US client for an upstream project.
- Provided project management services for a US client in multiple locations.
- Began a turnaround improvement program for a European client.
- Provided a cold eyes review of a novel process technology.
- Provided a column inspection plan for a Middle Eastern client.
- Provided an assessment of thermal NO_x reduction to meet emissions targets for a US client.
- Prepared a new training course for a US client that covered storage tank basics plus in-depth discussion of storage tank maintenance and API 653 requirements. The product also included "instructor notes" to make it easier for the client's experienced engineers to present the course to other engineers and inspectors.
- Presented two sessions of Carmagen's course on the Design and Maintenance of Aboveground Atmospheric Storage Tanks at a major Caribbean refinery.
- Participated in management planning meetings to improve the operations and mechanical reliability of a major European refinery. This multi-year program currently encompasses operations improvements for all desulfurization units, crude and vacuum units, and a visbreaker; storage tank maintenance; and turnaround planning. As the program progresses, it is expected to expand into other areas such as corrosion control and overall reliability and maintenance planning.
- Continued providing extensive process design services to a major technology developer/licensor.
- Performing process design follow-up of vacuum unit overhead system upgrade for European refinery.
- Performing pilot plant scale-up development for domestic refiner.
- Providing plot layout support for domestic and international refiners.
- Providing continuous support of a major Middle Eastern LNG project via engineering services at the contractor and the sub-contractor's offices in Europe and the Far East.
- Provided hydrogen plant startup, and technical support services to a Gulf Coast refiner.

Continued on Page 9

- Provided consultation and vendor screening/ selection regarding modification options to meet H_2S emission requirements via vent gas caustic scrubbing.
- Performing hydrotreater "Cold Eyes Review" and Distillate HTU revamp screening for licensor.
- Provided vessel specification design review.
- Providing extended lube hydrotreating pilot plant support services.
- Continued to supply specialized, high-value added services to several novel process developments pursued by major technology companies.
- Continued to provide patent search support assistance.
- Provided LP planning support.
- Performing calcium naphthenate and organic acids research .
- Provided support to major refiners corporate strategic research, intellectual property development, heavy oil upgrading, and carbon fibers.
- Provided long range planning, catalyst/licensor evaluation, and strategic pilot plant support to an international refiner.
- Provided a screening study to evaluate reuse of methanol spheres in butane service.
- Evaluated new catalyst packing/hydraulics in benzene saturation unit.
- Performing preliminary flare network hydraulic analysis, including selecting relief valves and flare load development.
- Continued relief system "helpdesk" support for major refiner.
- Performing long-term coordination/support on-site at international refiner's facility during development of their strategic refinery reliability and improvement program.
- Performed Mogas Blending automation scoping study on-site at international refiner's facility.
- Performing strategic reliability initiatives for an international refiner, including the vacuum units, visbreaker, and two hydrocrackers and hydrotreaters, and H_2 system.
- Performing process design, including option studies, and selected cost estimates for fluid coker coke transport and cooling system. Optimization consultation also being provided.
- Performing fluid coker on-site test run support and high level debottlenecking study based upon the results of the performance test.
- Providing on-going fractionation specialist support to a major refiner.
- Providing on-going lubes consultation to a major refiner.
- Performing FCCU PSV/safety evaluations for a domestic refiner.
- Developing a hydroprocessing seminar for a major refiner's training workshop, and assisting licensor develop hydroprocessing yield and product property predictions.
- Supporting hydrotreater startups in Australia, Canada, and Singapore.
- Performing process heat transfer and exchanger design review of novel AGHR process.
- Developing a new safety course for operations supervisors for a domestic refiner.
- Developing corporate safety standards for a domestic refiner.
- Performed "Cold Eyes Review" of novel "fluid bed-type process."
- Developing LOPA standards for a domestic refiner.
- Performing Fractionation tower tray installation inspection services for a domestic refiner.
- Preparing standardized process design notes for a client's licensed technology.