ProcessWEST online
Serving Western Canadian Processors

Monday, September 12, 2005 10:16

## *TECHNOLOGYPROFILE: By Ernest Granson*

**The on-going search for New Technology**
in the petrochemical industry in Western Canada

Modern life owes much of its high standard of living to the petroleum industry. It encompasses such a wide array of products and services, that it’s virtually impossible for most people to realize the impact of the industry on everyday life.

Consequently, for those not directly involved in the industry, the high level of research, development and innovation is not always apparent. But ever since the world’s first refinery opened at Ploiesti, Bulgaria in 1861, producing kerosene by simple atmospheric distillation, the demand for petroleum-based products has generated a constant need for research and new technology.

While the main market for crude oil remained kerosene over the next 30 years, near the turn of the century that market changed dramatically. The development of the electric light meant less demand for kerosene, while the emergence of the internal combustion engine created a new market for gasoline.

That market took a huge leap upwards when automobiles begin rolling off the newly developed assembly lines in large numbers and with the occurrence of the First World War. But the existing distillation techniques couldn’t keep up with the demand. Even by then, researchers were actively devising new refining techniques, including the concept of thermal cracking. Using both pressure and heat, the large molecules of heavy fuels were broken into small ones to produce additional gasoline and related fuels. An improvement of this technique, known as “visabreaking” in the late 1930s resulted in even more improved products.

With continued demand and research, catalytic cracking and polymerization processes were developed late in the same decade. In the early 1940s, alkylation, another catalytic process, produced not only higher octane gasoline but also petrochemical feedstocks. Constant research and development through the 1940s, 1950s and 1960s eventually led to the large-scale production of hydrocarbon molecules with a double bond, known as alkenes or olefins. Along with aromatics and methane, alkenes are considered the main building blocks of the petrochemical industry.

Much of the technological advancement in the petrochemical sector is taking place in Western Canada, which is home to some of the largest plants in the world. One example of this innovative technology research is the pilot project being undertaken by a consortium led by Quantiam Technologies Inc.

The Edmonton-based company is helping to develop technology which will increase the efficiency of the manufacture of olefins, a petrochemical derivative of natural gas and oil. Olefins, in turn, are widely used to produce other petrochemicals, which eventually become consumer products like plastics, solvents and many other everyday products. Ethylenes and propylenes produced at the two major petrochemical plants in Central Alberta are part of the olefin group. We'll discuss Quantiam's project further into this profile.

The Central Alberta facilities have been a major component of Canada's petrochemical industry for decades. Beginning in the 1950s, petrochemical facilities in Edmonton and Fort Saskatchewan began producing products such as formaldehyde, acetic acid, anhydride, solvents, hydrochloric acid, ammonia, ammonium nitrate, phosphate and fire-fighting chemicals.

During the ensuing decades, significant technological advancements resulted in a steadily increasing list of products. In the 1970s, that list included methanol, Styrofoam®, ethylene glycol, urea, ammonia, chlorine, vinyl chloride monomer and polyvinyl chloride. In the 1980s, the list expanded to include vinyl acetate, oxygen, nitrogen, glycol, ethylene, styrene, linear low-density polyethylene and carbon dioxide.

Over the last five years, continuing industrial advancement resulted in products such as monoethylene glycol, alpha olefins and low-density polyethylene, air separation and propylene.

Essentially, these are all considered intermediate products and function as feedstocks for the manufacture of consumer end products like plastics and lubricants.

The process to turn natural gas into feedstock actually begins on the pipeline, in facilities such as the Empress II Straddle Plant on the eastern portions of TransCanada's Alberta pipeline and Foothills pipeline system at the Alberta-Saskatchewan border.

Here a cryogenic turboexpander process helps to extract the lighter hydrocarbons like ethane, propane, butanes and pentanes-plus. A turboexpander consists of several sets of nozzles and rotating blades through which vapor or gas flows in a steady-state expansion process. The gas is chilled to about minus 120 degrees Fahrenheit by external refrigerants, condensing the hydrocarbons but leaving the methane in gaseous form

This stream of natural gas liquids (NLGs) then goes on to be partially fractionated into a specific ethane product and a propane-plus mix. The resulting stream from this particular straddle plant actually ends up in Sarnia for further processing. It's owned by the Empress II Partnership, a joint ownership of Inter Pipeline Fund and Inter Pipeline Extraction Trust.

The main natural gas supply for Nova Chemicals' world-scale ethylene facility at Joffre, AB, is delivered through the Fort Chicago Energy Partners L.P.'s Alberta Ethane Gathering System (AEGS), a 1,324 km ethane pipeline system. That same system also pipes in about half of the ethane feedstock requirements for Dow Chemical's ethylene plant located at Fort Saskatchewan, AB., just outside of Edmonton.

"At these main processing facilities, the basic manufacture of the intermediate ethylene is the thermal cracking process of ethane, in the presence of steam, according to Sieghard Wanke, professor of Chemical & Materials Engineering at the University of Alberta.

"Cracking is really a brute force procedure which takes place in cracking furnaces," says Wanke, "where the hydrogen is stripped off. Ethane, minus hydrogen, becomes ethylene, and other byproducts such as propylene. The rest of the processes are really a huge purification to purify and removed unwanted components"

Wanke, who has been involved in the area of catalytic research for 30 years, explains that the use of different types of catalysts is responsible for the wide variety of feedstocks and end products.

"Catalysts are specific to the process," he says. "For example, to produce ethylene oxide, silver on aluminum oxide would be used as a catalyst. To turn ethylene into polyethylene, typically, titanium or a zirconium compound would be used."

Silver is a versatile and commonly used catalyst. Since the early part of this century it has been utilized to increase the efficiency of the production of formaldehyde from methyl or wood alcohol. Formaldehyde is also produced using the iron oxide or Formox process in which methanol and oxygen react at 400 degrees C. As a petrochemical, formaldehyde is considered one of the most basic elements for manufacturing a broad range of solid plastics.

Wanke points out that one of the most important catalytic breakthroughs was the introduction of zeolites in the 1950s and 1960s. These components helped to revolutionize the cracking process.

"These are crystals with pores the size of molecules - up to two nanometers in size," Wanke says. "Essentially, they are molecular sieves which can screen molecules, letting them in or not, so you can tailor-make the reaction. For example, Mobil Oil (now Exxon) came out with the zeolite ZSM-5 thirty years ago and revolutionized the whole petroleum industry, allowing people to do things in the cracking process which had never been done before."

ZSM-5 is a shape-selective aluminosilicate zeolite which transforms methanol into high octane gasoline and light olefins without affecting dry gas, coke, or unit conversion.

Zeolites occur naturally as minerals, and are mined all over the world; others are synthetically produced for specific commercial uses. These minerals were discovered during the Middle Ages and, in order to uncover their properties, were subjected to the same procedure as other materials were at that time- heated by a blowpipe. When this happened, the crystals released boiling water and thus were named "zeolite", a derivative of the Greek word for "boiling stone".

In the world of catalysts, Wanke sees many new discoveries on the horizon. "This is a whole, huge experimental area - to discover what material will selectively catalyze reactions - where chemical activities are controlled by the nature and size of the pores of these catalysts," he says.

Another fundamental area in which intensive research is taking place is the energy requirement of refineries and other petrochemical processing facilities. That's where the above-mentioned Quantiam Technologies Inc. and the Central Alberta processing facilities come in.

With a $1.45 million contribution from Sustainable Development Technology Canada (SDTC), in addition to $8.3 million from other private and public sources, Quantiam and its corporate partner, NOVA Chemicals Corporation, are constructing a pilot manufacturing plant to demonstrate its newly developed technology.

The heart of the technology is a process enabling petrochemical facilities to consume less heat energy than conventional methods used to produce olefins. Quantiam president, Dr. Steven Petrone, believes this technology could have a substantial impact on energy consumption, and thus, on the overall operating economics of the petrochemical industry.

“The manufacture of ethylene at these plants is the single largest energy consuming petrochemical process in the world,” Petrone says. “For every tonne of ethylene produced, the average energy requirement is 25 gigajoules. That requirement could vary from the low 20s GJ to the high 30s GJ, depending on the location of the plant. About 110 million tonnes of ethylene are produced annually, so if you multiply that by the energy requirements you end up with usage of about 2.8 billion GJ per year.

“Depending on the price of energy, even at $5/GJ, that’s more than $10 billion in energy requirements, so it’s a huge part of the economics of a facility.”

Over the last 50 years, Petrone points out, the temperatures in the furnaces used for steam cracking have become higher and higher, and with operating temperatures of about 1,100 degrees C, are now at the limits of ferrous metallurgy. The premise behind Quantiam’s technology is that, possibly, there’s a better way to produce the same throughput but at lower operating temperatures. That better way, says Petrone, is a new generation of catalytic coatings. The coatings would be applied to the thousands of feet of tubing and their fittings used by those facilities in furnace coils. The coatings target is to provide a positive catalytic impact on the overall process. In addition, they would prevent corrosion along the tubing and shut-down unwanted catalytic processes that form byproducts such as carbon or coke. Overall, if scale-up is successful, the technology could lower furnace operating temperatures by 50-100 degrees C, requiring less heat energy and significantly reducing emissions. Petrone feels the technology could reduce energy requirements by up to 20 per cent. Estimates in Europe and the U.S. suggest savings of up to 40 percent may be achievable.

The Quantiam pilot project is currently aimed at existing petrochemical plants. About 250 plants are in operation worldwide, each using from between 5 to 30 furnaces and about 1,000 to 7,000 linear feet of tubing each with the tubing being replaced anywhere from three to five years on average. That is where the opportunity lies to integrate the new, more efficient, material.

But incorporating such new technology is also likely for upcoming, new furnaces in existing plants and even new petrochemical plants, says Petrone.

“As we take this initial step in reducing operating temperatures by say 100 degrees C, efforts worldwide are searching for a fully-catalyzed approach to olefins manufacture aimed at a reduction of 300-500 degrees C. Such an approach would require a new furnace design, would likely not be retrofittable in existing furnaces, and is likely 10 to 30 years away.”

Development for the Quantiam technology began in 2001. The pilot plant is in construction to come on stream this year. Quantiam plans to manufacture sufficient prototype product to conduct field trials and is projected to complete the pilot project by early 2007.

While the research goes on, Seighard Wanke is not sure it is being continued on the same scale as in the past. In Alberta’s petrochemical sector, there are only two major industrial research efforts being carried out - by NOVA Chemicals in Calgary and Syncrude research in Edmonton.

“I feel petrochemical research in general has decreased considerably in the last couple of decades,” Wanke says. “I held my first research job in the 1960s with Celanese Corporation, which has since closed its research lab like several other companies, for instance PetroCanada and Imperial Oil. I believe that, with some exceptions of course, companies are entrenching. They are concentrating on their core competencies and retreating from major activity outside their core interests. Because of that, in my opinion, many of our new ideas will be coming from underdeveloped countries, such as (those in) Southeast Asia."

Wanke says it's understandable. It's difficult to commit to major new multi-million installations.

"If you are a petrochemical company and something has worked reasonably well for you, do you want to take a risk on a project that might not work?"

*Ernest Granson is a Calgary-based freelance writer and a regular contributor to PROCESSWest.*