UNCOVER WHAT’S NEXT IN HYDROPROCESSING
see page 72
One Innovative Platform for Multiple Uses:
Refining Process Modelling Made Easy.
Develop your refining process models in a way that will increase your engineering effectiveness, improve accuracy of design, and allow you to easily develop a digital twin of your process. Honeywell’s UniSim® Design Suite delivers simulation optimization on the same platform lowering the total cost of ownership for online and offline simulation.

Open Minded.
CONTENTS
March 2018  Volume 23 Number 03

03 Comment
05 World News
12 The US: changing oil trade
   Dr Nancy Yamaguchi, Contributing Editor, discusses the massive changes in US oil trade brought on by the shale boom and the relaxing of crude export restrictions.
21 A strong defence
   Gert Lessing, Hallwood Modular Buildings, USA, outlines practical security measures for high-risk facilities.
25 Blast protection
   Natasa Kobal, RedGuard Specialist Services, UAE, considers the options available to protect people and equipment in the event of an explosion.
29 Going beyond training
   Tibor Szabo, MOL Group, Hungary, explains how operator training simulation is helping to optimise energy and process efficiency at the Danube Refinery.
33 Weighing up the options
   Ilan Toledano, Wattco, USA, explores the differences between circulation heaters and heat exchangers.
36 Unblocking the bottleneck
   Peter Ellery, CALGAVIN Ltd, UK, examines the challenges of vapouriser design and explains how to remove a common bottleneck.
43 The cost of corrosion
   David Astles, Ionix Advanced Technologies Ltd, UK, evaluates the practical challenges of high temperature permanent corrosion monitoring in the refinery environment.
50 Unlocking profit potential
   A comprehensive monitoring and mitigation programme minimises the overhead corrosion risks that newer crudes can bring. Febronio Panarello, Stefano Corti and Giuseppe Satta, Sarlux, along with Marco Respini and Andrea Bighi, Baker Hughes, a GE company, Italy, explain how.
57 A costly mystery
   From underground tanks to big rig engines, Jack Burgazli and Rick Chapman, Innospec Fuel Specialties, USA, explore the known and unknowns of ultra-low sulfur diesel corrosion.
61 Facing the threat
   Ingo Königs, Christophe Foret, Wolfgang Hater and Jürgen Matheis, Kurita Europe, introduce a corrosion inhibition programme based on the application of film forming amines.
65 Cause and effect
   Fabrice Cuqo, Jérôme Vachon and Anthoni W. van Zijl, SABIC Technology & Innovation, the Netherlands, along with Theodore Arntz, Nalco Champion, an Ecolab Company, USA, investigate the relationship between fouling and phase integrity in dilution systems.
72 Conquer the challenges
   Steven Zink, Honeywell UOP, USA, explains how petroleum refineries can meet today’s challenges with improved performance catalysts.
77 Combatting wax content
   Rainer Rakoczy, Clariant, Germany, outlines the process of catalytic dewaxing for improving the cold flow properties of diesel.
80 Active and stable
   George Anderson, Brian Muegge and Luca Moraca, Albemarle, USA, explain how high-activity, high-stability catalysts can help refiners meet Tier 3 challenges.
85 Cracking the shale problem
   Bart de Graaf, Ray Fletcher, Herman van den Bold and Niels van Buuren, InovaCat B.V., the Netherlands, introduce a catalytic process to help refiners convert paraffinic naphthas.
95 A dry run
   Benoit Padoan, Quadrime Chemical, France, discusses technologies for liquid hydrocarbon drying.
101 Benchmarking fuel blending systems (part one)
   Dr Suresh S. Agrawal and Meena S. Agrawal, Offsite Management Systems LLC, USA, outline how to benchmark the state of a refinery’s fuel blending system.
109 Intelligent blending
   Gregory Shahnovsky, Ariel Kigel and Ronny McMurray, Modcon Systems, UK, outline an artificial intelligence based technology for blending automotive fuels.
113 A suitable substitute
   Mark Whittle, Quadriise Fuels International plc, UK, discusses blending technology for the production of oil-in-water emulsion synthetic fuel oil, which can be used as a substitute for conventional HFO.
117 Grab the opportunity
   As opportunity crudes are on the up, Duncan Bailie, LUX Assure, UK, explains how refiners can find the most of the benefits that they offer.
121 A strategic solution
   As the industry prepares for the impending IMO sulfur regulations, Robert Giglio, Sumitomo SHI FW, USA, explains how refiners can find opportunity in a disrupted heavy sulfur fuel oil market.

Copyright © Palladian Publications Ltd 2018. All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, without the prior permission of the copyright owner. All views expressed in this journal are those of the respective contributors and are not necessarily the opinions of the publisher; neither do the publishers endorse any of the claims made in the articles or the advertisements. Printed in the UK. Unprotected images courtesy of www.shutterstock.com.
THE WORLDS LEADING DOWNSTREAM CONFERENCE AND EXHIBITION

3 DEDICATED CONFERENCE STREAMS:

ENGINEERING & CONSTRUCTION
Drive Transformative Change in Productivity, Interoperability and Performance for Downstream Capital Projects

MAINTENANCE & RELIABILITY
Unlock the Savings of Asset Driven Maintenance, Begin the Cultural and Technological Shift

SHUTDOWNS & TURNAROUNDS
Make your Turnarounds Count, Leverage Innovations, Integrate Goals and Maximize Efficiency

2000+ ATTENDEES
150+ EXHIBITORS
200+ SPEAKERS
100+ CONFERENCE SESSIONS

www.downstreamevent.com
Girl power has been hitting the headlines here in the UK over the last few months, and not just because the Spice Girls have confirmed that they are ‘reuniting’ to work on new projects (so far, no news on a potential new album or world tour – sorry Spice fans!). February 2018 marked 100 years since the Representation of People Act 1918 was passed in the UK, which allowed (some) women to vote for the first time. The law change followed years of campaigning, most notably from the suffragettes of the Women’s Social and Political Union, which was formed in 1903 by Emmeline Pankhurst.

However, it wasn’t until the outbreak of the First World War that perceptions of the role of women in British society really started to change. During the war years, approximately 2 million women replaced men in employment, and proved that they could do the work just as well. In turn, the UK government promised to give women the right to vote when the war finished.

Despite this indisputable progress, women in the UK still did not have the same voting privileges as men until the signing of the Equal Franchise Act in 1928. And women’s fight for social equality continues to this day, both in the UK and across the world.

Our industry is not immune to the challenge. A collaborative report from the World Petroleum Council and The Boston Consulting Group suggests that women represent just one-fifth of employees in the oil and gas industry – a significantly smaller share of the workforce than they do in almost any other sector.1 The report also found that a disproportionately large number of these women work in office roles, rather than technical and upper management positions. The consequences, according to the report, are threefold. Firstly, oil and gas companies have to choose from a smaller number of highly qualified candidates when hiring, as women drop out of the industry prematurely or never join in the first place. Secondly, companies are missing out on numerous benefits that companies with larger percentages of female employees enjoy, such as higher quality of teamwork, diversity of perspectives, and creativity when solving technical and business problems. And finally, the industry’s reputation for lacking gender diversity creates a vicious circle, as it ultimately deters women from pursuing a career in oil and gas, making it increasingly difficult for companies to recruit women across the board.

The report offers a number of recommendations to help strengthen the inflow of women into the oil and gas sector, maintain their job satisfaction mid-career, and increase women’s representation at the top of the industry. I would encourage our readers to read the entire report for more information (the URL is available at the bottom of this page). While it is accepted that attracting and retaining greater numbers of women will pose challenges for the industry, these must be overcome to ensure that the industry can reap the rewards of gender balance in the near future.

Cellular glass is the only completely impermeable insulation material. For over 70 years, FOAMGLAS® cellular glass insulation has been proven to resist moisture and provide constant thermal performance.

FOAMGLAS® insulation:
• will not burn
• will not absorb hydrocarbons
• is 100% moisture impermeable
• has superior compressive strength
• is dimensionally stable

FOAMGLAS® insulation does all this and more while providing constant thermal performance. Which is why FOAMGLAS® cellular glass insulation is an excellent choice for cryogenic applications.


Contact us to learn more about FOAMGLAS® insulation and how we can help with all your industrial applications.

www.foamglas.com | 800-545-5001

©2018 Owens Corning. All Rights Reserved.
USA | Ethane on the up

According to the US Energy Information Administration’s (EIA) Short-Term Energy Outlook (STEO), growth in US consumption of ethane in the petrochemical industry will exceed increases in consumption of all other petroleum and liquid products combined over the next two years. The EIA also projects that ethane exports will continue to increase, as ethane is exported both by pipeline to Canada and by tankers to more distant destinations.

The EIA notes that as US natural gas production has increased, the amount of ethane contained in raw natural gas production streams has exceeded domestic demand or the ability to export it abroad. This situation has led producers to leave some of the ethane in the natural gas stream, up to allowable limits set by natural gas pipelines and distribution systems, and to sell it as natural gas, rather than recover and market ethane as a separate product.

Nonetheless, ethane is increasingly being recovered from the natural gas stream, and US ethane consumption is increasing as existing ethylene crackers have expanded and new plants have begun operating. In addition, expanding pipeline networks and two new ethane export terminals have allowed US ethane exports to increase.

USA | ONEOK to invest US$2.3 billion on NGL and natural gas infrastructure

ONEOK Inc. has announced plans to invest approximately US$2.3 billion on its NGL and natural gas infrastructure between now and 2020.

The company plans to construct a new 400 000 bpd NGL pipeline – the Arbuckle II Pipeline – which will create additional transportation capacity between the company’s Mid-Continent infrastructure in Oklahoma and its existing NGL facilities in Mont Belvieu, Texas. The 530 mile, 24 in. and 30 in. dia. pipeline is expected to cost approximately US$1.36 billion.

ONEOK also plans to construct a new 125 000 bpd NGL fractionator – MB-4 – and related infrastructure.

This project is expected to cost approximately US$575 million, and will increase ONEOK’s total NGL fractionation capacity to 965 000 bpd following its completion, which is set for 1Q20.

It also plans to construct a 200 million ft\(^3\)/d natural gas processing facility – the Demicks Lake plant – and related infrastructure in the Williston Basin. This is expected to cost a total of approximately US$400 million and be completed in 4Q19. The company’s Williston Basin natural gas processing capacity will increase to more than 1.2 billion ft\(^3\)/d upon completion of the facility.

Worldwide | BP releases energy outlook

BP has released the 2018 edition of its ‘Energy Outlook’, which considers the forces shaping the global energy transition to 2040.

In its ‘Evolving Transition’ scenario, which assumes that government policies, technologies and societal preferences evolve in a similar manner and speed to the recent past, BP expects fast growth in developing economies to drive up global energy demand a third higher. The global energy mix is also expected to be the most diverse the world has ever seen by 2040, with oil, gas, coal and non-fossil fuels each contributing around 25%. Renewables will be the fastest-growing fuel source, increasing five-fold and providing around 14% of primary energy, while demand for oil will grow over much of the outlook period before plateauing in later years. Natural gas demand is expected to grow strongly and overtake coal as the second largest source of energy.

Together, oil and gas are expected to account for over half of the world’s energy.

Oman | Duqm Refinery signs EPC contracts

Duqm Refinery has signed contracts with engineering, procurement and construction (EPC) contractors for the construction of a 230 000 bpd refinery. The Refinery’s EPC work has been divided into three separate packages.

EPC package 1 (for the Refinery’s process units) was awarded to a joint venture of Técnicas Reunidas S.A. and Daewoo Engineering & Construction Co. Ltd. EPC package 2 (for the utilities and offsites) was awarded to a joint venture of Petrofac International Ltd and Samsung Engineering Co Ltd. EPC package 3 (for offsite facilities, including the product export terminal in Duqm Port, the Refinery’s crude storage tanks in Ras Markaz and the 80 km interconnecting pipeline from these crude tanks to the Refinery) was awarded to a joint venture of Saipem SpA and CB&I.

Initial mobilisation of both Duqm Refinery and contractor personnel is scheduled to commence in 3Q18.
## UAE | CB&I awarded crude refining project

CB&I has received a letter of award from Abu Dhabi National Oil Co. (ADNOC) to build a crude flexibility project (CFP) valued at more than US$500 million in Ruwais.

CB&I is part of a joint venture (JV) led by Samsung Engineering Co. Ltd, that will execute the US$3.1 billion CFP, which will upgrade the Ruwais Refinery to process heavier offshore crude oil from Upper Zakum fields.

CB&I's scope of work includes the engineering and procurement for two atmospheric residue desulfurisation units, which were previously licensed by Chevron Lummus Global, a JV between Chevron U.S.A. Inc. and CB&I.

Additionally, CB&I's scope of work includes the engineering, procurement, fabrication and construction for 14 flat-bottom tanks and 10 process heaters. Approximately 40% of the value of the project is expected to be spent in the UAE supply chain.

“This award builds on CB&I's proven experience in the refining industry,” said Patrick K. Mullen, CB&I’s President and CEO. “CB&I and Samsung have a history of successful collaboration and safe execution, and we look forward to working with ADNOC Refining to supply these units that will reduce sulfur, enhancing the ability of Ruwais petroleum products to compete on the world market while meeting stringent international environmental regulations.”

## USA | Total, Borealis and NOVA form petrochemical joint venture

Definitive agreements to form a 50/50 joint venture (JV) for petrochemicals on the US Gulf Coast have been formed between Total and Novealis Holdings LLC (a JV between Borealis and NOVA Chemicals).

The new JV will commence subject to customary closing conditions, including receipt of regulatory approvals. It will include: the under-construction 1 million tpy ethane steam cracker in Port Arthur, Texas; Total’s existing polyethylene 400 000 tpy facility in Bayport, Texas; and a new 625 000 tpy Borstar® polyethylene unit at Total’s Bayport site, following a decision on the outcome of an acceptable EPC contract.

## China | Bestgrand Chemical Group's new wet gas sulfuric acid plant now operational

Bestgrand Chemical Group has successfully started-up its wet gas sulfuric acid (WSA) plant in Huizhou, with a production capacity of 300 000 tpy of sulfuric acid. The plant will treat 131 000 tpy of acid gas over-the-fence from the neighbouring world-scale refinery plant, which is operated by a joint venture between CNOOC (China National Offshore Oil Corp.) and Shell.

Haldor Topsoe was awarded the license, engineering design, technology service, and a hardware and catalyst contract for the plant. WSA is a patented Topsoe technology, including equipment and performance catalysts, that removes sulfur from off-gas streams. WSA converts sulfurous gases into concentrated sulfuric acid, which is re-used in production or sold as a commercial product.
ON THE GO.

Round-the-clock availability is essential. This is why ROSEN provides second-to-none service delivery. Get what you need, where and when you need it. Every time.
IN BRIEF

THAILAND
Samsung Engineering (Thailand) Co. Ltd has awarded CB&I a contract, valued in excess of US$95 million, for a brownfield ethylene plant at PTT Global Chemical’s (PTTGC) petrochemicals complex in Map Ta Phut, Rayong. The company’s scope of work includes the license and basic engineering of both the ethylene plant and pyrolysis gasoline hydrogenation unit. It also includes detailed engineering and material supply of SRT® (Short Residence Time) pyrolysis heaters.

NIGERIA
The Dangote Group of Companies and Mammoet have signed a contract for a 650 000 bpd oil refinery. Under the contract, Mammoet will transport, lift and install all over-dimensional cargo for the new multi-billion-dollar refinery, which is scheduled to come onstream in 2019.

RUSSIA
Gazprom and Sibur have signed a preliminary contract for ethane fraction supplies. The document outlines the basic terms of future product supplies from Gazprom’s Amur gas processing plant (GPP) to Sibur’s planned Amur Gas Chemical Complex (GCC). Specifically, the total guaranteed supplies of ethane fraction will amount to approximately 2 million tpy.

CHINA
Haldor Topsoe has signed a shareholder agreement with Jiangsu Industrial Technology Research Institute (JITRI) and Xiangcheng Suzhou District for a joint R&D company in the Jiangsu Province. Based on Topsoe’s insight into the industrial application of catalytic technologies and surface science, the company will focus on the fast commercialisation of new technologies and services.

Oman | Suhar Refinery improvement project completed

Petrofac has celebrated the completion of the Suhar Refinery Improvement Project (SRIP) with a ceremony. The team in attendance were joined by representatives of Orpic, the company’s joint venture partner, Daelim Industrial Co. Ltd, and other partners.

Located 230 km north west of Muscat, Petrofac’s scope in the project encompassed engineering, procurement, construction, start-up and commissioning services. The contract included building a state-of-the-art refinery and improvements at the existing refinery.

The facility is expected to increase previous output by more than 70%.

Canada | Jacobs maintenance and turnaround contract extended by Shell

Jacobs Engineering Group Inc. has received a five-year contract renewal from Shell Canada Ltd to provide mechanical maintenance and turnaround services on the company’s Scotford site, located in Fort Saskatchewan, Alberta.

Employing approximately 300 full-time personnel on the site, Jacobs will continue to provide mechanical maintenance and turnaround services for the full facility.

Shell’s Scotford complex consists of a bitumen upgrader, oil refinery, chemicals plant and a carbon capture and storage (CCS) facility.

“Jacobs has been safely delivering mechanical maintenance and turnaround solutions to Shell at their Scotford site for three and half decades,” said Jacobs Construction, Maintenance and Turnarounds Senior Vice President and General Manager, Stephen Hillier. “As we begin this five-year renewal contract, we will continue to innovate and support the successful operations at Scotford and help provide employment opportunities to the Fort Saskatchewan community.”

Saudi Arabia | Turnaround and inspection project conducted at Ras Tanura Refinery

Ras Tanura Refinery (RTR) has successfully completed a major turnaround and inspection (T&I).

Production up-time of the gas condensate fractionation and the platformer/naphtha hydrotreater (NHT) units is key at RTR. The T&Is were conducted on both units and were completed in a new best-in-class duration for the respective units as per globally accepted Solomon Study refinery benchmarks.

The fractionation unit T&I was completed in 27 days, and the platformer unit T&I was completed in 32 days, against benchmarks of 28 days and 35 days, respectively.

The units were shut down to carry out the inspections and maintenance, as per the equipment inspection schedule (EIS). Other projects that require downtime were also completed. The plants are on a five-year T&I cycle.
Let’s do the math.

Grace custom catalyst solutions, co-developed with you, are about more than performance—and more than chemistry. They’re designed to add to your bottom line.

In some cases, the difference between our refinery customers’ financial return on Grace technologies versus the alternative has reached into eight figures.

If you’re ready to put Grace chemistry to work to strengthen your business, we’re ready to show you how we can help. Call us to get started with the calculations.


grace.com/value

Learn more about how Grace has delivered value to its customers through collaboration.

Visit grace.com/value
USA | Honeywell to provide NGL fractionation plant

Honeywell’s UOP Russell business will provide a fractionation plant capable of producing 60,000 bpd of NGLs to MarkWest Energy Partners.

The company, which is a wholly owned subsidiary of MPLX LP, will install the plant at its Hopedale facility in Jewett, Ohio. The fractionation system will recover propane, isobutane, normal butane and pentane – or natural gasoline – from mixed NGLs for use in petrochemical manufacturing. Fractionation units are used to separate mixtures of extracted NGLs into individual pure components. The resulting products are used to manufacture a wide range of petrochemicals that are made into plastic resins, films and fibres, rubber, and fuel-blending components.

The UOP Russell fractionation plant is customised for the large capacity requirements of MarkWest, and it represents an expansion of UOP Russell’s portfolio of pre-engineered fractionation products.

Mexico | IEA welcomes Mexico as 30th member

Mexico officially became the International Energy Agency’s (IEA) 30th member country on 17 February 2018, and the agency’s first member in Latin America.

The membership came after the signed IEA treaty (the IEP Agreement) was deposited with the government of Belgium, which serves as the depository state, following ratification by the Mexican Senate.

Mexico’s accession is a cornerstone of the IEA’s ongoing modernisation strategy, including ‘opening the doors’ of the IEA to engage more deeply with emerging economies and the key energy players of Latin America, Asia and Africa, towards a secure, sustainable and affordable energy future.

The IEA family of 30 Member countries and seven Association countries now accounts for more than 70% of global energy consumption, up from less than 40% in 2015.

USA | ExxonMobil commissioning ethane cracker in Baytown complex

A new 1.5 million tpy ethane cracker at ExxonMobil’s Baytown, Texas, complex is mechanically complete, with commissioning progressing well. Project startup is expected during 2Q18.

Part of ExxonMobil’s multi-billion dollar Baytown chemical expansion project, the ethane cracker will provide ethylene feedstock to the new performance polyethylene lines in Mont Belvieu, which began production in autumn 2017.

The expansion project is a key component of ExxonMobil’s previously-announced ‘Growing the Gulf’ initiative.
The Right Catalyst System for You

Are you getting the right hydroprocessing catalyst system to maximize your profits?

With Advanced Refining Technologies, you can count on our practical refinery expertise, state-of-the-art technology and R&D, strong technical service, and global manufacturing to improve your run lengths, product quality, and yields.

When you optimize unit profitability, you know you’ve found the right catalysts... and the right partner.

Let’s work together.

artcatalysts.com

The global leader in hydroprocessing catalysts

A joint venture of Grace and Chevron
Dr Nancy Yamaguchi, Contributing Editor, discusses the massive changes in US oil trade brought on by the shale boom and the relaxing of crude export restrictions.

Skyline of Houston, Texas, US.
With the largest oil market and refining industry, the US is a dominating force in the global oil industry. The country is the birthplace of many key technologies relating to oil exploration, development, processing, transport and storage, and it was the largest oil producer globally for many years until production began to decline in the 1990s, when it was overtaken by Russia and Saudi Arabia. The US was then the largest importer of crude oil, and import requirements were forecast to keep rising.

Yet this is now changing. The ‘shale boom’ reversed what had been considered an inevitable decline in US crude production. Oil import dependency has been reduced, meaning that the US could very well re-take the lead as the world’s largest oil producer. Moreover, the federal government lifted its 1970s-era policy that restricted exports of domestically-produced crude, which freed up crude exports. The US is an active trader in crude oil, as well as all types of refined petroleum products. Its role in global oil trade is changing dramatically. This article will discuss the changes in US crude supply and trade, and how oil flows are adapting.

The turnaround in US crude supply
Output rises, falls and rises again
For decades, the US was the world leader in oil production. Figure 1 shows the long-term trend in production from 1900 through 2017 (January – October average). Unless otherwise noted, the data and infographics within this article are based on data published by the US Energy Information Administration (EIA). As of the time of this writing, the data are current through to October 2017.

Between 1900 and 1970, the US achieved astounding growth in crude oil production, going from 174,000 bpd in 1900 to 9.64 million bpd in 1970. This was the peak of US output. This equated to an average rate of growth of 5.9% per year.

Production was maintained at high levels through the late 1980s because new supplies in Alaska began to replace declines in other mature fields in the lower 48 states. Alaskan output peaked at 1.97 million bpd in 1988. Thereafter, US output began a long, downward slide. Between 1985 and 2008, production fell by 3.97 million bpd, a drop in output that averaged 2.5% per year.
By 2008, however, the shale revolution was in full swing, and oil output rebounded with amazing velocity. Oil production of 5 million bpd in 2008 jumped to 91 million bpd in 2015. During this time period, Saudi Arabia backed away from its role as price-moderator, and ramped up its production to drive prices down and drive some US shale producers out of the market. The strategy worked to some extent: hundreds of oil rigs in the US were shut down, and many shale companies went out of business. According to the Baker Hughes Active Rig Count, there were over 1900 active rigs in the US in November 2014. This plunged to 404 active rigs in May 2016. However, the remaining companies and rigs were much more efficient and productive, and their numbers gradually began to creep back up.

The end of the oil price war brought a production cut agreement between key OPEC and non-OPEC oil producers, and oil prices began to recover. Oil and natural gas rigs, both in the US and elsewhere, began to come back into service. During the first 10 months of 2017, US production averaged 9,18 million bpd. The EIA also publishes weekly estimates and, based on these, US production rose to approximately 9.33 million bpd in 2017. At the end of the year, there were 929 active oil and gas rigs, compared to 658 active rigs at the end of 2016.

US lifts crude export restrictions

There was a new twist to the US crude market in 2016, which caused an increase in crude oil trade. In late 2015, the US eased restrictions on crude exports. This was often mistakenly termed 'lifting the export ban'. In reality, crude exports were restricted rather than banned. However, for most would-be exporters, the restrictions were enough of a disincentive that exports were unlikely.

The key laws governing US crude exports are the Mineral Leasing Act of 1920, the Energy Policy and Conservation Act of 1975 (EPCA), as well as the Export Administration Act of 1979. The 1970s brought a new era in oil, with the rise of OAPC and OPEC. The government had to contend with the first serious oil price shocks brought on by the Arab oil embargo and the Iranian revolution.

At the time, the public believed that restricting the export of US domestic crude would enhance supply security and perhaps reduce prices for motor gasoline—a politically sensitive subject. It is not clear that the laws did anything to enhance supply security. Indeed, a good argument can be made that the opposite was achieved: attempting to shield consumers from high gasoline prices discouraged the development of domestic energy supplies and stunted the growth of alternative energy sources. Nonetheless, the US energy market adapted to the policies, and the idea of removing them caused much debate. These policies shaped many aspects of the US energy market, including trade patterns, and the markets are now adapting to removal of the restrictions.

The regulations are complex, so a brief overview is in order. US crude exports were regulated under the provisions of the Export Administration Regulations (EAR), administered by the Bureau of Industry and Security (BIS) within the US Department of Commerce. The regulations are delineated in the ‘Short Supply Controls,’ section 754.

The chief focus of the BIS is national security, including homeland security, cyber security, economic security, and export controls to prevent the spread of weapons of mass destruction. The Short Supply Controls cover an odd combination, including crude petroleum, petroleum products, unprocessed red cedar, and horses exported by sea.

The license requirements concerning crude oil described several types of permissible exports, including:

- Exports from Alaska’s Cook Inlet (state waters).
- Exports to Canada for consumption therein.
- Exports in connection with refining or exchange of Strategic Petroleum Reserve (SPR) oil.
- Exports of California heavy crude (less than 20˚ API) not to exceed an average volume of 25,000 bpd.
- Exports consistent with international agreements.
- Exports found by the President of the US to be consistent with other statutory controls.
- Exports of foreign crude that have not been commingled with domestic crude, with some specific rules pertaining to SPR crude.
- Other exports heard on a case-by-case basis that are consistent with the national interest and the purposes of the Energy Policy and Conservation Act.
Latest News

FLUOR COMMENCES FEED WORK IN THE GULF OF THAILAND

Fluor has commenced front-end engineering design (FEED) work for the Electricity Generating Authority of Thailand’s (EGAT) planned FSRU and associated facilities in the upper Gulf of Thailand. Located 20 km off the coast of Thailand, the FSRU will allow LNG to be received from cargo ships and transferred as natural gas to pipelines and power plants. Fluor’s scope includes the FSRU, marine berth and jetty, as well as onshore and offshore pipeline connections.

HTE AND SINOPEC RIPP COLLABORATE IN CHINA

hte – the high throughput experimentation company – has announced the handover of three high throughput testing systems for the development of petroleum refining technology to SINOPEC Research Institute of Petroleum Processing (RIPP) in Beijing, China.

KBR AWARDED CONTRACTS FOR POLYCARBONATE PROJECT

KBR Inc. has been awarded both a license and engineering (LBED) and a proprietary equipment supply contract by Cangzhou Dahua New Materials Co. Ltd (CDNM). Under the contracts, KBR will provide its PCMAX™ technology, basic engineering design package and equipment supply for a new 100 000 tpy single train polycarbonate plant in Cangzhou City, China.

RUSSIAN AND NORWEGIAN GAS EXPORTS UP

Gas exports to Europe from both Russia and Norway climbed to record levels in 2017, according to Rystad Energy. Gas exports to Europe (including Turkey) reached 194 billion m³ and 122 billion m³, respectively, last year, representing a year-on-year increase of more than 15 billion m³ for Russia and 9 billion m³ for Norway. Both countries have shown upward output trends since 2014. However, while Russia is projected to further strengthen its position, Norwegian output is poised to decline in the coming years.

For further information go to: www.hydrocarbonengineering.com
Issues of supply security and national interest often spark debate and questions such as “who gets to determine what is in the best interest of the nation?” An oil producer may believe that a healthy and profitable industry is the key. A consumer may believe that reliable and affordable supply is the key. It is easy to imagine specific cases where crude exports should receive expedited licensing, such as hurricanes or other natural disasters that leave domestic crude cargoes with no place to go except overseas. The rest of the time, the issue is contentious, and it took many years of political negotiations to lift the export restrictions.

The export restrictions had been supported by those who believed that they would increase US crude supply security. They were also supported by shipping companies with US-flagged vessels. With a world seemingly awash in oil, the supply security argument lost some potency. The restrictions were primarily seen as creating barriers to efficient trade. In particular, light tight oils (LTOs) from landlocked areas had a transport disadvantage, and they were sold at low prices to refineries along transport routes. This was a chief cause of the widening Brent-West Texas Intermediate (WTI) crude price differential. US market prices diverged from global prices. The refineries with access to the inexpensive crudes increased utilisation, as well as their product sales and exports. Other refineries suffered in comparison.

Figure 2 shows the long history of US crude exports since 1910. In the early years, the US was one of the world’s key exporters. However, demand rose swiftly, absorbing domestic output. By the 1970s, the export restrictions took hold. As noted, these were restrictions, as opposed to a ban, so exports continued at variable levels. When the restrictions were lifted at the end of 2015, a major surge in exports was seen in 2016. Crude exports skyrocketed to 591,000 bpd in 2016, and they continued to soar, averaging 960,000 bpd during the January – October 2017 period.

**Crude trade and regional variation**

The shale boom is having a mixed impact on crude trade, not only because of new volumes of LTOs, but also due to the location of the shale deposits relative to centres of refining and demand. The largest fields are in the centre of the country, with major hydraulic fracturing operations in the following Petroleum Administration for Defense Districts (PADDs): Midwest (PADD 2), Rocky Mountains (PADD 4), and Gulf Coast (PADD 3). The Midwest and Rocky Mountain oil-producing areas are landlocked. International trade is possible with Canada, but most crude must find its way to domestic refineries or be transported via pipeline to the Gulf Coast or East Coast if it is intended to leave the US via tanker. The sudden rise in production in central US caused a massive shift in crude trade patterns, not just in volume, but also in source and direction.

As Figure 3 illustrates, the West Coast PADD 5 in the 1980s and 1990s was the chief, and sometimes the only, exporter of crude oil. The export restrictions made allowances for exchanges with Canada, for example, which was a logical market for Alaskan crudes. Crudes produced in Alaskan state waters were of high quality, and they could be exported to Asia. The regulations also allowed exports of certain volumes of California crudes.

When Alaskan crude production was high, the exports often went all the way to refineries in the Virgin Islands, via the Panama Canal. In the Virgin Islands, the crude was refined, and the products were re-exported back to the US. As Alaskan production dwindled, this export vanished.

In recent years, surplus crude exports have shifted to PADD 1, PADD 2 and PADD 3, where most of the prolific new shale plays are located and where export avenues exist for them. Crude exports jumped from a minuscule 9000 bpd in 2002 to nearly 600,000 bpd in 2016.

Removing the restrictions on crude exports has also opened the global market, and US crude exports are spreading far and wide. As noted, PADD 5 had been the chief district exporter before Californian and Alaskan production began to decline. After exports to the Virgin Islands vanished, Canada was the main export outlet. Between 2000 and 2015, Canada was the only destination for US crude exports for nine years out of the 16. After the export restrictions were lifted, Canada remained a key trading partner, but US exports also began to reach diverse markets across the globe. Some exports have remained in the Western Hemisphere, going to countries such as the Bahamas, Brazil, Colombia, Curaçao, Peru and Argentina. Shipments to Asia have grown, with China becoming a significant customer, and exports going also to Japan, South Korea, India, Hong Kong, Singapore, Malaysia and Thailand. Exports to Europe include shipments to the UK, the Netherlands, Italy, France, and Spain. Cargoes have also gone to markets in Africa and the Mediterranean.

Figure 4 shows the decline in PADD 5 crude production. Between 1981 and 1986, California produced over 1 million bpd of crude. This was cut in half by 2016, when production averaged 0.5 million bpd. Data for the first 10 months of 2017 show that production has declined further to 0.48 million bpd.

Alaskan production climbed to a peak of over 2 million bpd in 1988, allowing it to surpass Texas as the premier oil producer in the country for that year. This only happened in 1988, however, and Alaskan production then began to decline. It fell below 0.5 million bpd in 2014 and has remained at this level.

PADD 5 crude imports have climbed as its production has fallen. The area’s imports of foreign crude grew from
You’ll find the right solutions for your business in our broad portfolio of high-performance catalysts and process technologies.

As a leading operator of refining and petrochemical facilities, we use and continually improve our catalysts and process technologies to:

• Boost operational efficiency and production capacity
• Enhance safety and environmental performance
• Produce value-added products

Through a commitment to long-term collaboration, we provide world-scale expertise throughout the life of the catalyst and use of the process technology. Let’s work together for your success and a better tomorrow.

Find out more at catalysts-licensing.com, and about how our catalysts and process technologies can power your success.
Because of the shale boom, however, the Gulf Coast PADD 3 market is experiencing the opposite of the trend seen in PADD 5. As shown in Figure 5, PADD 3 crude production declined from 4.22 million bpd in 1981 to 2.72 million bpd in 2008. Subsequently, LTO production from the massive shale deposits in the Permian Basin and Eagle Ford caused production to surge to nearly 5.5 million bpd in 2016, and it averaged 5.76 million bpd during the first 10 months of 2017. PADD 3 contains the largest concentration of refineries in the US, and this region was accustomed to importing massive volumes of foreign crude. Crude imports peaked at nearly 5.8 million bpd in 2004. Thereafter, however, imports plateaued and began to fall. In 2016, PADD 3’s crude imports had fallen to approximately 3.37 million bpd, and they averaged 3.15 million bpd in January – October 2017.

**Growth in non-crude oil exports**

The buildup of crude oil supplies in the central part of the US also caused a surge in refinery throughput and the export of refined products. Exporting refined product was a way to adjust to the restrictions on exporting crude, since the oil supplies exceeded local demand. Moreover, many refineries close to the new LTO producing areas were able to purchase crude feedstock at steeply discounted prices. Refinery utilisation rates, which had fallen significantly during the economic recession, began to rise. The increase was most noticeable in PADDs 2, 3, and 4, which had better access to domestic supplies. Utilisation rates in these areas were often in the range of 90 – 93%.

Figure 6 shows the upward trend in non-crude oil exports by PADD. ‘Non-crude’ includes refined products plus other hydrocarbons such as NGLs and unfinished oils. PADD 3 has become a key exporter of crude oil, but it is an even larger exporter of non-crude liquids. PADD 3 exported 0.33 million bpd of non-crude petroleum in 1989. This jumped to 3.63 million bpd in 2016, an increase of 3.3 million bpd. To place this in context, oil demand in the UK was 3.63 million bpd in 2016.

Overall, US non-crude exports jumped from 0.7 million bpd in 1989 to 4.7 million bpd in 2016. This included 0.64 million bpd of motor gasoline and 1.38 million bpd of diesel. Exports continued to rise during the first 10 months of 2017, with gasoline exports averaging 0.68 million bpd and diesel exports averaging 1.37 million bpd.

**Impacts on global oil trade**

The EIA conducts an annual forecasting exercise called the ‘Annual Energy Outlook’ (AEO). Each year, new data is available on prices, supply, demand, technology, policy directions, and so forth, for all types of energy in all end-use sectors. The AEO exercise forecasts the various energy market data series 30 years into the future. Naturally, as each new year brings a new set of data and policy directions, the next AEO forecast changes. Sometimes the changes are minor, but with respect to the oil market, the changes have been massive.

The shale revolution has caused one of the most momentous changes in the long-term forecast of
The Challenge
A US refining company contacted us to discuss a separation problem in the feed to an alkylation process. Caustic entrainment from their selective hydrogenation unit was poisoning the hydrofluoric acid catalyst in the alkylation unit.

The continuous phase feed to the alkylation unit consisted of ~180m3/hr of mixed C4 hydrocarbons, mainly butanes and butylenes, with varying levels of 10 – 20% caustic solution entrained as a dispersed aqueous phase.

Sulzer was commissioned to design, engineer and manufacture a solution to the problem which would reduce the caustic entrainment to less than 30 ppmv.

The Solution
Examination of the process upstream of the alkylation reactor revealed that separation of the caustic entrainment should have occurred in a gravity separator. Calculations suggested that the gravity separator would be capable of droplet removal down to about 60 microns. However, the low interfacial tension in the hydrocarbon/caustic system was likely to result in much more finely dispersed droplets and coalescer internals were therefore recommended.

Originally planned as a retro-fit project for the gravity separator, the customer decided that potential contamination with hydrofluoric acid presented too many safety issues and a decision was made to replace the vessel with a new skid-mounted coalescer complete with prefilters and caustic flash drum.

The main feature of the package was a 78” diameter horizontal separator vessel complete with an Enhanced DC Coalescer™ internals and an enhanced flow distribution device.

The Enhanced DC Coalescer was manufactured as a co-knit composite packing of 316L SS and special multifilament fluoro-polymer fiber (PTFE). The combination of materials with different surface free energies provides accelerated rates of droplet coalescence at each of the thousands of point contacts between the materials – a property of the Sulzer DC Coalescer originally patented by KnitMesh Ltd (now a part of Sulzer Chemtech). The use of the fibrous PTFE multifilament provides exceptional direct interception efficiency for very small droplets, allowing them to accumulate, coalesce and eventually drain to the bulk phase interface in the boot of the vessel.

Two prefilters with 10 micron cut-off size were provided as part of the package to protect the coalescer from particulate contamination in the feed.

Results
The complete package was engineered, manufactured and delivered within a 15 week lead time. Installation of the equipment has reduced the entrainment levels from the original 10-20% to the target levels of < 30 ppmv providing the operator with substantial benefits in terms of:

- Reduced downtime
- Increased catalyst life
- Reduced catalyst cost

The Sulzer Applications Group
Sulzer has over 150 years of in-house operating and design experience in process applications. We understand your process and your economic drivers. Sulzer has the know-how and the technology to design internals with reliable, high performance.

---

Legal Notice: The information contained in this publication is believed to be accurate and reliable, but is not to be construed as implying any warranty or guarantee of performance. Sulzer Chemtech waives any liability and indemnity for effects resulting from its application.
March 2018 HYDROCARBON ENGINEERING

AEO2004 forecast of net crude imports

Figure 7. AEO forecast of net US crude imports revised down sharply (million bpd).

US % of Global Oil Imports

US % of Global Oil Exports

Figure 8. The US accounts for a smaller share of global oil imports and a larger share of global oil exports (source: BP).

the US oil market. Figure 7 compares how the forecast of US net crude imports has changed between the AEO in 2000, 2004, and 2017. In AEO 2000, net imports began at 8.46 million bpd in 1997, declined to 5.5 million bpd in 2004, then crept up to 7.6 million bpd in 2025. Four years later, the AEO 2004 began the forecast of net crude imports at 9.3 million bpd in 2001 and projected that this would grow to 15.7 million bpd in 2025. Along the way, AEO 2004 projected that net crude imports would reach 11.2 million bpd in 2010.

The current AEO 2017 now places 2010 actual net crude imports at only 4.9 million bpd, which is 6.3 million bpd below what had been expected in AEO 2004. According to the AEO 2017 baseline data, net crude imports rose to 7 million bpd in 2016, and they are expected to remain at this level until the year 2020. Thereafter, the AEO 2017 now forecasts that US net crude imports will decline gently to approximately 5.7 million bpd in 2040.

The US now has a drastically different role in global oil trade. Figure 8 uses the BP Statistical Review of World Energy to calculate the US percentage share of global oil imports and global oil exports. The US has been the single-largest country in terms of its share of global oil imports. This share rose from approximately 20% in the early 1980s to as much as 25 – 26% during the 1987 – 2006 period. The US accounted for only around 2 – 3% of global oil exports. The shale revolution is changing this and causing the lines to converge more closely. In 2016, the US’ share of global oil imports had fallen to 15.4%, while its share of global oil exports had surged to 7.2%.

Conclusion

It is difficult to overstate the dramatic reversal in the US oil market. Before the shale revolution, the world expected that US crude production would continue to dwindle and US oil import requirements would continue to rise. The US was expected to export little or no crude oil, though refined product trade was expected to continue.

The US is now vying for the position of number one global oil producer, and it may well claim this title by overtaking Saudi Arabia and Russia this year, if these countries cleave to their agreed-upon production levels. Weekly preliminary data indicate that US crude production was exceeding 9.7 million bpd at the end of 2017. Crude prices have risen significantly, with WTI prices at approximately US$64/bbl and Brent prices at around US$68/bbl. Many analysts believe that oil prices of US$70/bbl or more will stimulate growth in US output, and that crude production could easily rise above 11 million bpd. Recall that just 10 years ago, production was approximately 5 million bpd.

This is having an immense impact on global oil trade. Recent years brought a confluence of events that pared away the political sensitivity of the crude export restrictions. Firstly, the shale boom brought a rebound in crude production. Secondly, global oil prices were low. Thirdly, US oil prices fell below global prices. Fourthly, even with low prices, demand in 2015 was lower than it had been 10 years prior. There was greater economic incentive to free up oil trade. The US could continue to optimise its crude trade patterns by exporting more crude from crude-rich areas and importing more in crude-deficit ones. This may also optimise refinery operations and refined product trade.

The swings in US oil production and trade are measured in millions of barrels per day. Most countries in the world measure their entire oil markets in tens of thousands or hundreds of thousands of barrels per day. The US is the world’s largest oil consumer and refining centre. It is likely to become the largest oil producer as well, and it is becoming a major exporter of crude and non-crude oils. The developments in the US are also changing the Western Hemisphere and the world as a whole.

Reference

Don't want to miss out?

You will need to be a subscriber to read the full edition. Please log in to www.hydrocarbonengineering.com or alternatively, click here to subscribe.

For more information about the comprehensive Hydrocarbon Engineering subscription package, please contact us:

www.hydrocarbonengineering.com
E: subscriptions@hydrocarbonengineering.com
T: +44 (0)1252 718999

That was a sample of Hydrocarbon Engineering March issue.