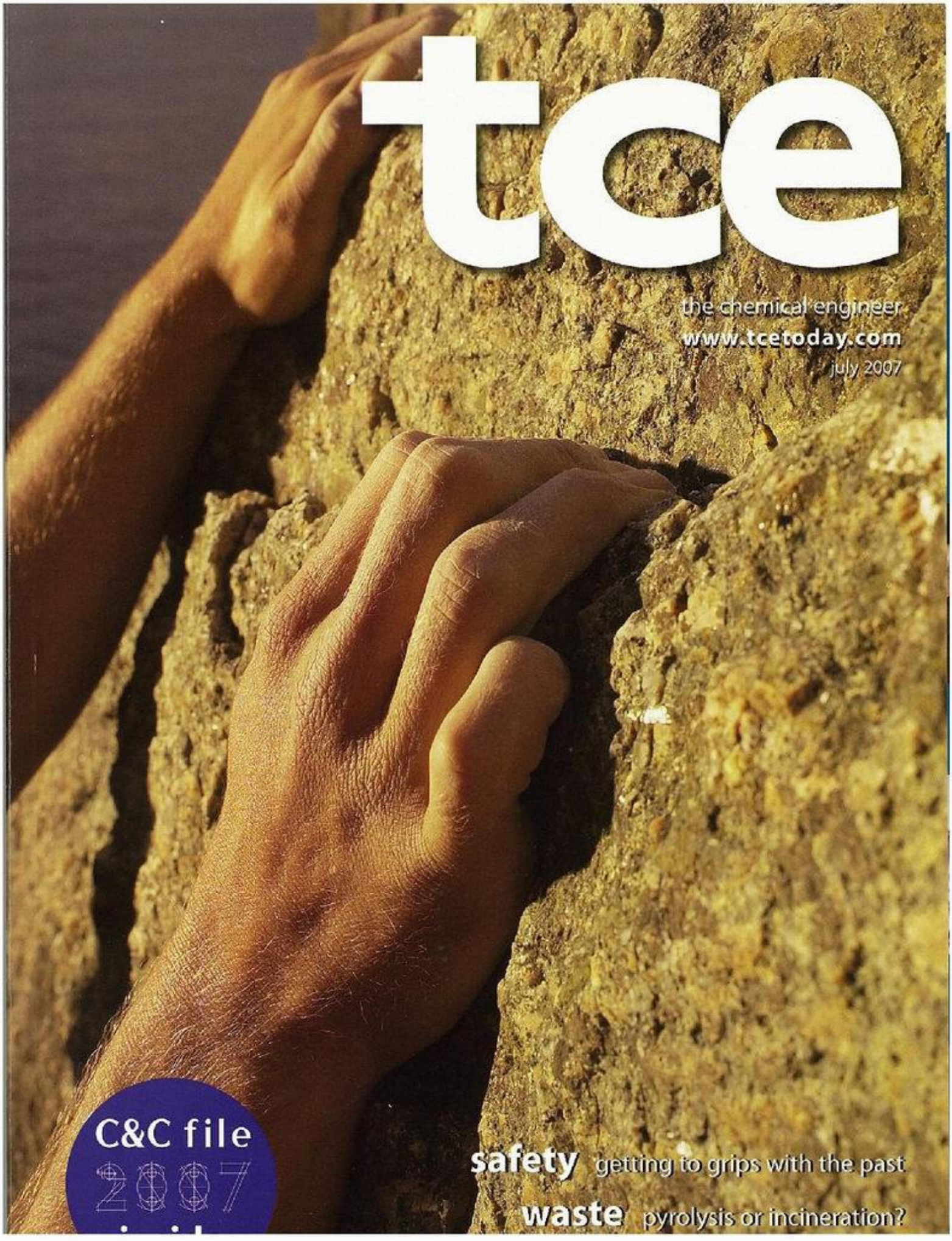
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safety getting to grips with the past
waste pyrolysis or incineration?

Lubrication for the nation

Daniel Cheng details how vibrating membranes recycle waste oil

(Below right): waste oil (feed) and permeate (product)

(Below): Table 1: Comparison of waste oil recycling technologies

DISPOSING of waste oil has always been a big challenge for every city. Untreated or improperly treated waste oil poses a serious pollution problem, contaminating soil, underground water and river water. Even worse, it is often used as cheap fuel, releasing heavy metals and additives such as sulphur into the air. As a result, waste oil treatment/recycling technologies have always been in demand.

Technologies to recycle waste oil have traditionally been weak. But with increasingly strict and legally binding environmental standards, there is no time like the present to improve waste oil recycling processes.

worldwide perspective

EU directives

Europe generates over 5m t/y of waste oil. The Waste Oil Directive ensures that EU waste oils are collected and disposed of.

To minimise the potential harm of incineration emissions, the EU's Waste Incineration Directive (2000/76/EC) has limited the use of reprocessed fuel oil (RFO) since 28 December 2005. As a result, waste oil collectors are looking desperately for new ways to treat, dispose of or recycle waste oil.

China: the world factory

Riding on the success in joining WTO, the hosting of the 2008 Olympics and the big business potential in carbon trade, the Chinese government decided to tighten its environmental laws and put forward the 11th Five-Year Plan (2006–2010) with a major investment in environmental protection at RMB1375b ($180b), equivalent to 1.4–1.6% of the GDP.

The State Environmental Protection Agency in 2001 identified China's 4m t/y of waste oil as hazardous waste, only to be handled by authorised treatment centres. Yet, the availability of affordable technologies is a major concern.

North America: lessons from superfund sites

Both the US and Canada do not impose a nationwide policy as stringent as that of the EU. This is despite the expensive cleanup of several contaminated Superfund sites in the 1950s and 60s.

Australia: product stewardship levy

Oil producers and importers have to pay a product stewardship levy which offsets subsidies paid to oil recyclers. Currently, most of the waste oil is recycled by distillation plus hydrogen finishing, and the levy stands at 5.449 cents per litre.

Middle East

Demand for low grade lubricant oil and recycled lubricant oil has been rising. There are about 100 waste oil recycling plants in Iran alone. Most of them use the acid clay process, which is not as good as distillation and centrifugation.

Japan

Due to its fragile environment and limitated natural resources, Japan has imposed legislation over the past decade to protect its environment. Consuming around 2m t/y of lubricants, Japan also burns as fuel or incinerates over 95% of its collected waste oil.

South East Asia

Indonesia, Malaysia and many other countries in the Asia Pacific region have set up networks to collect and handle waste oil. The degree of sophistication and mode of practices depend on the culture, environmental awareness, local economy, technological expertise and financial affordability. Although being banned in many areas, acid clay treatment (sulphuric acid plus clay) is still being used to recycle waste oil in some illegal operations, creating secondary pollution to soil and underground water.

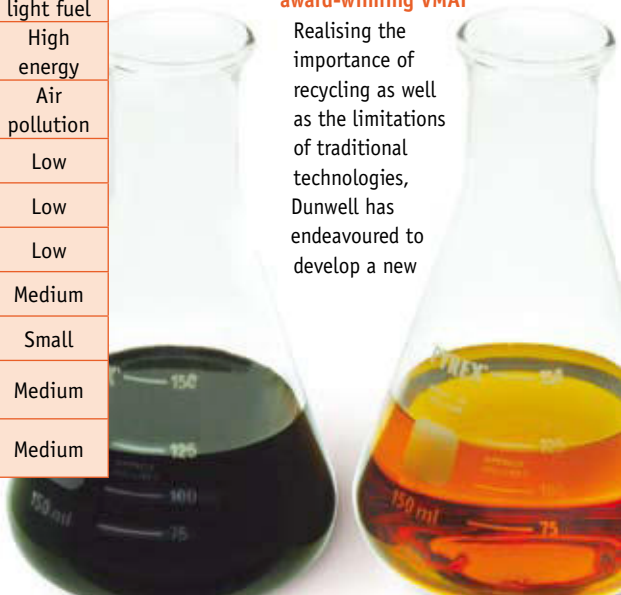
Hong Kong

Hong Kong's waste oil re-refinery activity first started in 1989 when the Australian company Lubrico built a re-refinery in Yuen Long Industrial Estate. 18 months later, Lubrico went bankrupt after losing over $10m. In 1993, Dunwell acquired and revitalised the re-refinery to resume oil re-refining in Hong Kong.

	VMAT	*Distillation*	*Distillation with H_2 finishing*	*Centrifuge*	*Thermal cracking*
Operating nature	Physical + chemical	Chemical	Chemical	Physical	Chemical
Operating temperature	Medium (80–90°C)	High (300–350 °C)	Very high	Low	Medium
Operating pressure	Low (200–300 kPa)	Very high (vacuum)	Very high	Low	Medium
Engineering complexity	Medium	High	Very high	Low	Medium
Ability to process synthetic lubricant	Yes	No	No	Yes	Yes
Colour of finished product	Clear tea colour	Yellow	Pale yellow	Black	# 0–3 light fuel
Technological limitations		Synthetic lubricant	Very expensive and complicated	Low value product	High energy
Major environmental impact	N/A	Air pollution	Air pollution	N/A	Air pollution
Energy efficiency	High	Low	Low	Medium	Low
Operating cost	Medium	High	Very high	Medium	Low
Capital cost	Medium	Very high	Very high	Low	Low
Workplace safety	High	Low	Low	Medium	Medium
Footprint	Small	Large	Large	Small	Small
Capacity expandability	Easy	Difficult	Difficult	Medium	Medium
Payback time on investment	Short (< 2 years)	Long	Long	Medium	Medium

award-winning VMAT

Realising the importance of recycling as well as the limitations of traditional technologies, Dunwell has endeavoured to develop a new



recycling technology that is simple, efficient and affordable. After years of research and development, we developed the first commercialised vibrating membrane system (VMAT) for waste oil recycling.

In 2006, VMAT won three back-to-back awards around the world, including the IChemE ABB Engineering Services Environment Award, Wall Street Journal's Asian Innovation Award, and the Grand Award in Machinery and Equipment Design at Hong Kong Awards of Industry, recognising VMAT's innovation, contribution to safety, environment, sustainable development and improvement in the quality of life.

the process

The VMAT process starts with the waste oil feed being put through a sedimentation tank to separate free water and large solids. This is followed by heating and vacuum dewatering at 90–100 °C, which reduces water content to less than 1%. The oil is then fed into the vibrating membrane. Small amounts of water and volatile organic may be extracted, which could be removed by condensation or activated carbon. Dewatered feed is maintained at 80–85 °C entering the vibrating membrane.

The vibrating membrane filters the feed into permeate and concentrate. The permeate is a clear tea-coloured intermediate-grade lubricant, with viscosity at 40 °C between 40–45 cSt. The concentrate is a viscous dark lubricant containing viscosity improvers and residual additives, and has a viscosity at 40 °C of 130–140 cSt. The concentrate is fed back to the feed tank through a specially-designed high speed centrifuge. The centrifuge takes gummy tar out of the feed to increase filtration flow rate. Depending on the quality of feed, up to 80% of permeate can be retrieved from waste oil.

The permeate is ideal for motor oil blending stock; medium/low grade lubricant for some farming equipments (eg tractors or 2-stroke motorcycle oil); and quality boiler fuel oil conforming to the EU Directives. As for the concentrate, it can be applied in the asphalt industry as asphalt extender. In principle, VMAT processes a chemical waste into 100% useful resources and generates zero waste.

integration of technologies

Membrane technology and polymer science

Selecting the right type of membrane is important. However, due to the molecular sizes of lubricant molecules, additives found within the waste oil, physical and chemical properties of waste oil etc, Dunwell had to evaluate over 200 types of membrane before finding the right one.

Because of its hydrophobic nature, the polarised lubricant molecules of waste oil can react with some membranes. Extensive tests showed that a specially modified polymeric membrane was best suited to the process, and Dunwell has to manufacture this special membrane for use in VMAT.

tribology

Tribology is the science, engineering, and technology of interacting surfaces in relative motion. It evolved from the classical fields of friction, lubrication, and wear. Dunwell has been working with researchers at local universities to characterise the interaction of additives with the lubricating surface.

lubricant properties

Lubricants can either be mineral-based or synthetic. This significantly affects the yield of a distillation. Mineral-based lubricants can be distilled at over 350 °C. Synthetic lubricants have a more stable but also complex structure, which results in gelling and affects the efficiency of conventional distillation processes. Processing mixtures of the two is still an ongoing research topic for the industry. When designing the VMAT system, Dunwell has considered all three scenarios and resolved the problem by staying below 100 °C.

vibrating membrane mechanism

The vibrating membrane mechanism is an innovative way of removing solids from liquids. Dunwell has specifically optimised the system performance through proper inflow, temperature, moisture content, and vibrating frequency in order to attain the best possible results.

The vibrating membrane has solved the inherent fouling problem of membranes by introducing intense shear waves at the membrane surface, which repels foulants. Thus, VMAT does not require high pressure deviation between membranes.

environmental technology

Dunwell has unique technologies in place to process the waste oil, handle the oily wastewater and eliminate potential secondary pollution.

Proprietary post-treatment nanotechnology improves yield and permeate colour. The nanomaterial can be regenerated for reuse, avoiding potential secondary pollution.

conclusion

The VMAT process has the potential to revolutionise waste oil recycling and water treatment. It is simple, small, efficient and cost-competitive, giving municipalities around the world an affordable way of handling waste oil and wastewater as well as improving the environment. tce

The award winning waste oil recycling system – VMAT at Dunwell

Case Study

Indonesia: payback within 24 months

VMAT technology has allowed an Indonesian lubricant blending company to expand its business into a one-stop oil service centre, producing lubricant while at the same time recycling waste oil. Collected waste oil is treated by VMAT and the permeate is being used as a blending stock, saving a large amount of base oil that would cost on average $800/t while keeping the quality of the end-product. As a result, the company forecasted a 24-month payback period for its first phase VMAT system and plans to boost capacity to 15,000 t/d within the next two years.

China: preparing for the 2008 Olympics

As host for the 2008 Olympics, China has been working to improve in every aspect, including its environmental performace.

One of the cities hosting an Olympic event will use VMAT to treat the waste oil generated in the region. This will avoid the pollution caused by improper disposal of waste oil and retain useful resources.

Beyond petroleum

The vibrating membrane can also be used in wastewater treatment, both municipal and industrial, chemicals recovery, and even in the food and beverages industry.

case study

The city of Zhengzhou in Henan province is constructing a 300t/d comprehensive leachate treatment plant. In 2006, Zhengzhou's municipal government upgraded this leachate treatment plant to meet the GB8978-1996 comprehensive sewage discharge standard. The phase I of this project has applied effective biological method to reach Level II quality but still requires further polishing to reach Level I of the standard.

The vibrating membrane system was found to be best suited for treating leachate in both new and existing landfills. The contract was signed in early 2007 and the work is expected to be complete by mid-2007.

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