To:	Randy C. Stubbs(rstubbs@meterskid.com)
Subject:	U.S. Trademark Application Serial No. 97120088 - OIL REFINING
Sent:	August 23, 2022 12:26:11 PM EDT
Sent As:	tmng.notices@uspto.gov

Attachments

screencapture-www-merriam-webster-com-dictionary-oil-16612701391671
screencapture-www-merriam-webster-com-dictionary-refining-16612703581031
screencapture-www-sciencedirect-com-topics-engineering-oil-refining-16612706676031

United States Patent and Trademark Office (USPTO)
Office Action (Official Letter) About Applicant's Trademark Application

U.S. Application Serial No. 97120088

Mark: OIL REFINING

Correspondence Address:
Randy C. Stubbs
1138 Misty Lake Dr.
Sugar Land TX 77498 UNITED STATES

Applicant: Randy C. Stubbs

Reference/Docket No. N/A

Correspondence Email Address: rstubbs@meterskid.com

NONFINAL OFFICE ACTION

**The USPTO must receive applicant's response to this letter within <u>six months</u> of the issue date below or the application will be [abandoned](). ** Respond using the Trademark Electronic Application System (TEAS). A link to the appropriate TEAS response form appears at the end of this Office action.

Issue date: August 23, 2022

<u>Introduction</u>

The referenced application has been reviewed by the assigned trademark examining attorney. Applicant must respond timely and completely to the issue(s) below. 15 U.S.C. §1062(b); 37 C.F.R. §§2.62(a), 2.65(a); TMEP §§711, 718.03.

Summary of Issues

- Search Results - No Conflicting Marks Found
- Section 2(e)(1) – Merely Descriptive Refusal
- Advisory Regarding Mark Appearing To Be Generic
- Drawing Amendment Not Accepted Due to Material Alteration - Original Drawing Remains Operative
- Entity Type Mismatch - Amendment Required
- Advisory Regarding Hiring a Trademark Attorney

Search Results - No Conflicting Marks Found

The trademark examining attorney has searched the USPTO database of registered and pending marks and has found no conflicting marks that would bar registration under Trademark Act Section 2(d). 15 U.S.C. §1052(d); TMEP §704.02.

Section 2(e)(1) – Merely Descriptive Refusal

Registration is refused because the applied-for mark merely describes a feature and characteristic of applicant's goods and services. Trademark Act Section 2(e)(1), 15 U.S.C. §1052(e)(1); *see* TMEP §§1209.01(b), 1209.03 *et seq.*

A mark is merely descriptive if it describes an ingredient, quality, characteristic, function, feature, purpose, or use of an applicant's goods and/or services. TMEP §1209.01(b); *see, e.g.*, *In re TriVita, Inc.*, 783 F.3d 872, 874, 114 USPQ2d 1574, 1575 (Fed. Cir. 2015) (quoting *In re Oppedahl & Larson LLP*, 373 F.3d 1171, 1173, 71 USPQ2d 1370, 1371 (Fed. Cir. 2004)); *In re Steelbuilding.com*, 415 F.3d 1293, 1297, 75 USPQ2d 1420, 1421 (Fed. Cir. 2005) (citing *Estate of P.D. Beckwith, Inc. v. Comm'r of Patents*, 252 U.S. 538, 543 (1920)).

Here, applicant has applied to register the mark **OIL REFINING** for use in connection with "petroleum, raw or refined" in Class 4, "oil refining machines" in Class 7, "industrial refining towers for distillation" in Class 11, and "refinement of fuel materials; fuel refining; oil refining; production, treatment and refinement of fuel, diesel fuel, biofuel and biodiesel fuel for others" in Class 40.

The combination of "OIL", meaning "petroleum", and "REFINING", meaning "to become pure or perfected", immediately conveys that applicant's goods and services pertain to perfected petroleum as a good and perfecting petroleum as a service. *See* attached dictionary definitions from *Merriam Webster*. In fact, applicant's identification confirms that its goods and services feature this characteristic because it states that applicant provides "petroleum, *refined*" in Class 4, "*oil refining* machines" in Class 7, "industrial *refining* towers for distillation" in Class 11, and "*refinement* of fuel materials; fuel *refining*; *oil refining*; production, treatment and *refinement* of fuel, diesel fuel, biofuel and biodiesel fuel for others" in Class 40. *See* applicant's identification. Moreover, the attached Internet evidence demonstrates that the terms "OIL REFINING" are used commonly in the industry to refer to "transforming crude oil into marketable products such as fuels, lubricants, and kerosene". *See* attached evidence from *Science Direct.* Thus, based on this evidence, the terms "OIL" and "REFINING" merely describe a feature and characteristic of applicant's goods and services in that applicant transforms crude oil into marketable products such as fuel.

Generally, if the individual components of a mark retain their descriptive meaning in relation to the goods and/or services, the combination results in a composite mark that is itself descriptive and not registrable. *In re Fat Boys Water Sports LLC*, 118 USPQ2d 1511, 1516 (TTAB 2016) (citing *In re Tower Tech, Inc.*, 64 USPQ2d 1314, 1317-18 (TTAB 2002)); TMEP §1209.03(d); *see, e.g.*, *DuoProSS Meditech Corp. v. Inviro Med. Devices, Ltd.*, 695 F.3d 1247, 1255, 103 USPQ2d 1753, 1758 (Fed. Cir. 2012) (holding SNAP SIMPLY SAFER merely descriptive for various medical devices, such as hypodermic, aspiration, and injection needles and syringes); *In re Fallon*, 2020 USPQ2d 11249, at *12 (TTAB 2020) (holding THERMAL MATRIX merely descriptive of a heat-responsive, malleable liner that is an integral component of an oral dental appliance).

Only where the combination of descriptive terms creates a unitary mark with a unique, incongruous, or otherwise nondescriptive meaning in relation to the goods and/or services is the combined mark registrable. *See In re Omniome, Inc.*, 2020 USPQ2d 3222, at *4 (TTAB 2019) (citing *In re Colonial Stores, Inc.*, 394 F.2d 549, 551, 157 USPQ 382, 384 (C.C.P.A. 1968); *In re Shutts*, 217 USPQ 363, 364-65 (TTAB 1983)); *In re Positec Grp. Ltd.*, 108 USPQ2d 1161, 1162-63 (TTAB 2013).

In this case, both the individual components and the composite result are descriptive of applicant’s goods and/or services and do not create a unique, incongruous, or nondescriptive meaning in relation to the goods and/or services. Specifically, the term "OIL" modifies the term "REFINING" to create a congruous, descriptive meaning that applicant provides perfected petroleum as a good as well as services pertaining to perfecting petroleum.

Ultimately, when purchasers encounter applicant’s goods and services using the mark **OIL REFINING**, they will immediately understand the mark as indicating a feature and characteristics of the goods and services, and not an indication that applicant is the source of the goods and services. Therefore, the mark is merely descriptive, and registration is refused pursuant to Section 2(e)(1) of the Trademark Act.

Advisory Regarding Mark Appearing To Be Generic

In addition to being merely descriptive, the applied-for mark appears to be generic in connection with the identified goods and/or services. “A generic mark, being the ‘ultimate in descriptiveness,’ cannot acquire distinctiveness” and thus is not entitled to registration on either the Principal or Supplemental Register under any circumstances. *In re La. Fish Fry Prods., Ltd.*, 797 F.3d 1332, 1336, 116 USPQ2d 1262, 1264 (Fed. Cir. 2015) (quoting *H. Marvin Ginn Corp. v. Int’l Ass’n of Fire Chiefs, Inc.*, 782 F.2d 987, 989, 228 USPQ 528, 530 (Fed. Cir. 1986)); *see* TMEP §§1209.01(c) *et seq.*, 1209.02(a). Therefore, the trademark examining attorney cannot recommend that applicant amend the application to proceed under Trademark Act Section 2(f) or on the Supplemental Register as possible response options to this refusal. *See* TMEP §1209.01(c).

Response Options to Refusals

Although applicant’s mark has been refused registration, applicant may respond to the refusal(s) by submitting evidence and arguments in support of registration. However, if applicant responds to the refusal(s), applicant must also respond to the requirement(s) set forth below.

Drawing Amendment Not Accepted Due to Material Alteration - Original Drawing Remains

Operative

Applicant has requested to amend the mark in the application. The USPTO cannot accept the proposed changes because they would materially alter the mark in the drawing filed with the original application. 37 C.F.R. §2.72(a)(2), (b)(2); TMEP §807.14. Accordingly, the proposed amendment will not be entered; the previous drawing of the mark will remain operative. *See* TMEP §807.17.

The original drawing shows the mark as **OIL REFINING**. The proposed amended drawing shows the mark as **CHP+ADU**.

The USPTO cannot accept an amendment to a mark if it will materially alter the mark in the drawing filed with the original application. 37 C.F.R. §2.72(a)(2), (b)(2); TMEP §807.14. An amendment to the mark is material when the USPTO would need to republish the mark with the change in the USPTO *Trademark Official Gazette* to fairly present the mark to the public. *In re Thrifty, Inc.*, 274 F.3d 1349, 1352, 61 USPQ2d 1121, 1123-24 (Fed. Cir. 2001) (citing *In re Hacot-Columbier*, 105 F.3d 616, 620, 41 USPQ2d 1523, 1526 (Fed. Cir. 1997)); TMEP §807.14.

That is, an amendment is material if the altered mark does not retain "the essence of the original mark" or if the new and old forms do not "create the impression of being essentially the same mark." *In re Hacot-Columbier*, 105 F.3d at 620, 41 USPQ2d at 1526 (quoting *Visa Int'l Serv. Ass'n v. Life-Code Sys., Inc.*, 220 USPQ 740, 743-44 (TTAB 1983)); *see, e.g.*, *In re Who? Vision Sys., Inc.*, 57 USPQ2d 1211, 1218 (TTAB 2000) (amendment from "TACILESENSE" to "TACTILESENSE" a material alteration); *In re CTB Inc.*, 52 USPQ2d 1471, 1475 (TTAB 1999) (amendment of TURBO with a design to just the typed word TURBO without design a material alteration).

When determining materiality, the addition of any element that would require a further search of the USPTO database for conflicting marks is also relevant. *In re Guitar Straps Online LLC*, 103 USPQ2d 1745, 1747 (TTAB 2012) (citing *In re Pierce Foods Corp.*, 230 USPQ 307, 308-09 (TTAB 1986)); *In re Who? Vision Sys. Inc.*, 57 USPQ2d at 1218-19; TMEP §807.14.

In the present case, applicant's proposed amendment would materially alter the mark in the drawing filed with the original application because the marks are not the same; that is, the originally submitted mark and the amended mark look and sound differently and have different commercial impressions. Specifically, the commercial impression of **OIL REFINING** pertains to goods and services relating to refining oil; whereas, the commercial impression of **CHP+ADU** is that of an acronym, a formula, or an abbreviation. Because the marks looks and sound differently and have different commercial impressions, the amended drawing is considered a material alteration and is not accepted.

To avoid the application from abandoning, applicant must respond to this issue. TMEP §807.17. Applicant may respond by (1) withdrawing the request to amend the drawing, or (2) arguing that the proposed amendment is not a material alteration of the mark.

For more information about changes to the mark in the drawing after the application filing date, please go to the Drawing webpage.

Entity Type Mismatch - Amendment Required

The name of an individual person appears in the section of the application intended for the trademark owner's name; however, the legal entity is set forth as a limited liability company. Applicant must clarify this inconsistency. *See* 37 C.F.R. §§2.32(a)(2), (a)(3)(i)-(ii), 2.61(b); TMEP §803.02(a).

Specifically, the owner of the mark is listed as "Randy C. Stubbs", but the entity type is listed as a Texas "limited liability company". Applicant must resolve this discrepancy.

If applicant is an individual, applicant should simply request that the legal entity be amended to “individual” and must indicate his/her country of citizenship for the record. 37 C.F.R. §2.32(a)(3)(i); TMEP §803.03(a). Alternatively, if applicant is a limited liability company, applicant must provide the correct name of the limited liability company and the U.S. state or foreign country of incorporation or organization. 37 C.F.R. §2.32(a)(3)(ii); TMEP §803.03(h).

If, in response to the above request, applicant provides information indicating that it is not the owner of the mark, registration may be refused because the application was void as filed. *See* 37 C.F.R. §2.71(d); TMEP §§803.06, 1201.02(b). An application must be filed by the party who owns or is entitled to use the mark as of the application filing date. *See* 37 C.F.R. §2.71(d); TMEP §1201.02(b).

Response guidelines. For this application to proceed, applicant must explicitly address each refusal and/or requirement in this Office action. For a refusal, applicant may provide written arguments and evidence against the refusal, and may have other response options if specified above. For a requirement, applicant should set forth the changes or statements. Please see “Responding to Office Actions” and the informational video “Response to Office Action” for more information and tips on responding.

Please call or email the assigned trademark examining attorney with questions about this Office action. Although an examining attorney cannot provide legal advice, the examining attorney can provide additional explanation about the refusal(s) and/or requirement(s) in this Office action. *See* TMEP §§705.02, 709.06.

The USPTO does not accept emails as responses to Office actions; however, emails can be used for informal communications and are included in the application record. *See* 37 C.F.R. §§2.62(c), 2.191; TMEP §§304.01-.02, 709.04-.05.

Advisory Regarding Hiring a Trademark Attorney

Because of the legal technicalities and strict deadlines of the trademark application process, applicant is encouraged to hire a private attorney who specializes in trademark matters to assist in this process. The assigned trademark examining attorney can provide only limited assistance explaining the content of an Office action and the application process. USPTO staff cannot provide legal advice or statements about an applicant’s legal rights. TMEP §§705.02, 709.06. See Hiring a U.S.-licensed trademark attorney for more information.

How to respond. Click to file a response to this nonfinal Office action.

/Nabeela Abid/
Nabeela Abid
Trademark Examining Attorney
Law Office 301
(571) 270-3828
nabeela.abid@uspto.gov

RESPONSE GUIDANCE

- **Missing the response deadline to this letter will cause the application to abandon.** The response must be received by the USPTO before midnight **Eastern Time** of the last day of the response period. TEAS maintenance or unforeseen circumstances could affect an applicant's ability to timely respond.

- **Responses signed by an unauthorized party** are not accepted and can **cause the application to abandon**. If applicant does not have an attorney, the response must be signed by the individual applicant, all joint applicants, or someone with legal authority to bind a juristic applicant. If applicant has an attorney, the response must be signed by the attorney.

- If needed, **find contact information for the supervisor** of the office or unit listed in the signature block.

oil noun, often attributive

Save Word

\ ˈȯi(-ə)l \

Definition of *oil* (Entry 1 of 2)

1 a : any of numerous unctuous combustible substances that are liquid or can be liquefied easily on warming, are soluble in ether but not in water, and leave a greasy stain on paper or cloth

b (1) : PETROLEUM

(2) : the petroleum industry

2 : a substance (such as a cosmetic preparation) of oily consistency
// bath *oil*

3 a : an oil color used by an artist

b : a painting done in oil colors

4 : unctuous or flattering speech

WORD OF THE DAY

abrogate

See Definitions and Examples »

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4 : unctuous or flattering speech

oil verb

oiled; **oiling**; **oils**

Definition of *oil* (Entry 2 of 2)

transitive verb

: to smear, rub over, furnish, or lubricate with oil

intransitive verb

: to take on fuel oil

oil the hand *or* **oil the palm**

: BRIBE, TIP

Synonyms

More Example Sentences

↓ Phrases Containing *oil*

↓ Learn More About *oil*

Synonyms for *oil*

Synonyms: Noun

canvas (*also* canvass), oil painting, painting

Synonyms: Verb

grease, lubricate, slick, wax

Visit the Thesaurus for More

Examples of *oil* in a Sentence

Noun

// The price of crude *oil* is expected to rise.

// We heat our house with *oil*.

// A little bit of *oil* will help lubricate the chain.

See More

Recent Examples on the Web: Noun

// The chef uses many of the same flavors in the Chongqing noodles but adjusts the ratios to give the chili *oil* more room to roam, perfect for those who seek heat even in the dog days of summer.
— Tim Carman, *Washington Post*, 15 Aug. 2022

// Along with equities, commodities are also down premarket with *oil* leading the way, off by nearly 5%.
— Jj Kinahan, *Forbes*, 15 Aug. 2022

// China consumes about 15% of the world's *oil*, imports more crude than any other country and consumes more than half of refined copper globally.
— Jason Douglas, *WSJ*, 15 Aug. 2022

See More

These example sentences are selected automatically from various online news sources to reflect current usage of the word 'oil.' Views expressed in the examples do not represent the opinion of Merriam-Webster or its editors. Send us feedback.

Phrases Containing *oil*

a/the squeaky wheel gets the grease/oil	arachis oil	banana oil
castor oil	castor-oil plant	canola oil
cod-liver oil	coconut oil	coal oil

See More

First Known Use of *oil*

Noun

Noun
13th century, in the meaning defined at sense 1a

Verb
15th century, in the meaning defined at transitive sense

History and Etymology for *oil*

Noun
Middle English *oile*, from Anglo-French, from Latin *oleum* olive oil, from Greek *elaion*, from *elaia* olive

Learn More About *oil*

Share *oil*

Time Traveler for *oil*

The first known use of *oil* was in the 13th century

See more words from the same century

Dictionary Entries Near *oil*

Statistics for *oil*

Oikopleura
oil
oil and gas lease

See More Nearby Entries

Last Updated
17 Aug 2022

Look-up Popularity
Top 4% of words

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"Oil." *Merriam-Webster.com Dictionary*, Merriam-Webster, https://www.merriam-webster.com/dictionary/oil. Accessed 23 Aug. 2022.

Style: MLA

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KaitlynAnnPyrcioch · 12 September, 2013

I have a project on it i science.

Reply · 8 1 · Share

ItzYahya · 2 March, 2016

knowing about oil will make things easy for every one

Reply · 1 · Share

More Definitions for *oil*

oil noun

\ ˈȯil \

Kids Definition of *oil* (Entry 1 of 2)

1 **:** any of numerous greasy usually liquid substances from plant, animal, or mineral sources that do not dissolve in water and are used especially as lubricants, fuels, and food

2 **:** PETROLEUM

3 **:** paint made of pigments and oil

4 **:** a painting done in oils

oil *verb*

oiled; **oiling**

Kids Definition of *oil* (Entry 2 of 2)

: to rub on or lubricate with a greasy substance

---

oil *noun*

\ ˈȯi(ə)l \

Medical Definition of *oil*

1 **:** any of numerous unctuous combustible substances that are liquid or can be liquefied easily on warming, are soluble in ether but not in water, and leave a greasy stain on paper or cloth

— see ESSENTIAL OIL, FATTY OIL, VOLATILE OIL

2 **:** a substance (as a cosmetic preparation) of oily consistency

// bath *oil*

Other Words from *oil*

oil *adjective*

More from Merriam-Webster on *oil*

Nglish: Translation of *oil* for Spanish Speakers

Britannica English: Translation of *oil* for Arabic Speakers

Britannica.com: Encyclopedia article about *oil*

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WORDS AT PLAY

'Dunderhead' and Other 'Nicer' Ways to Say Stupid

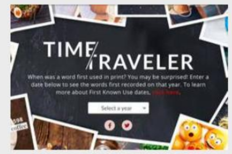
As illustrated by some very smart pups

10 Words from Place Names

Bikini, bourbon, and badminton were places first

'Pride': The Word That Went From Vice to Strength

Do you take pride in Pride?



When Were Words First Used?

Look up any year to find out

ASK THE EDITORS

Literally

How to use a word that (literally) drives some pe...

'All Intensive Purposes' or 'All Intents and Purposes'?

We're intent on clearing it up

Lay vs. Lie

Editor Emily Brewster clarifies the difference.

Hot Mess

"The public is a hot mess"

WORD GAMES

What Are You Wearing?

Roll up your sleeves and identify these garments

TAKE THE QUIZ >

Name That Animal: Volume 2

Can you tell a meerkat from a wombat?

TAKE THE QUIZ >

Spell It

Can you spell these 10 commonly misspelled words?

TAKE THE QUIZ >

Spelling Bee Quiz

Can you outdo past winners of the National Spelli...

TAKE THE QUIZ >

refine verb

Save Word

re·fine | \ ri-ˈfīn \
refined; **refining**

Definition of *refine*

transitive verb

1 **:** to free (something, such as metal, sugar, or oil) from impurities or unwanted material

2 **:** to free from moral imperfection **:** ELEVATE

3 **:** to improve or perfect by pruning or polishing
// *refine* a poetic style

4 **:** to reduce in vigor or intensity

5 **:** to free from what is coarse, vulgar, or uncouth

WORD OF THE DAY
abrogate
See Definitions and Examples »
Get Word of the Day daily email!

intransitive verb

1 **:** to become pure or perfected

2 **:** to make improvement by introducing subtleties or distinctions

Other Words from *refine*

Synonyms & Antonyms

More Example Sentences

Learn More About *refine*

Other Words from *refine*

refiner *noun*

Synonyms & Antonyms for *refine*

Synonyms

ameliorate, amend, better, enhance, enrich, help, improve, meliorate, perfect, upgrade

Antonyms

worsen

Visit the Thesaurus for More

Examples of *refine* in a Sentence

// The inventor of the machine spent years *refining* the design.

// The class is meant to help you *refine* your writing style.

Recent Examples on the Web

// They will be used to *refine* electric-vehicle performance technology that will be applied to future N offerings.
— Dan Edmunds, *Car and Driver*, 15 July 2022

// During the war, as buyers for Urals crude dwindled, Russia attempted, quite

literally, to sweeten the deal, making its Urals blend lighter and less sour, and therefore easier to *refine*.
— Samanth Subramanian, *Quartz*, 15 July 2022

// The only way to *refine* an image DALL-E produces currently is to rewrite the prompt or crop the image and use it as the prompt for a new set of ideas.
— *Wired*, 14 July 2022

See More

These example sentences are selected automatically from various online news sources to reflect current usage of the word 'refine.' Views expressed in the examples do not represent the opinion of Merriam-Webster or its editors. Send us feedback.

First Known Use of *refine*

1582, in the meaning defined at transitive sense 1

Learn More About *refine*

Share *refine*

Time Traveler for *refine*

The first known use of *refine* was in 1582

See more words from the same year

Dictionary Entries Near *refine*

refind

refine

refined

See More Nearby Entries

Statistics for *refine*

Last Updated

13 Aug 2022

Look-up Popularity

Top 2% of words

Cite this Entry

“Refine.” *Merriam-Webster.com Dictionary*, Merriam-Webster, https://www.merriam-webster.com/dictionary/refine. Accessed 23 Aug. 2022.

Style: MLA

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People are talking about

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CeciliaDinkelmanNel · 27 September, 2012

Refine me, O Lord, God of heaven and earth, for YOUR glory to reflect on me!

Reply · 12 · Share

MayaImerlishvili · 27 December, 2011

the word of the LORD is refine

Reply · 8 · Share

1 reply

PatriciaJohnson455 · 4 February, 2013

learning more words that relate to the understanding of God, and refine is a good word for me.

Reply · 6 · Share

Show More Comments

More Definitions for *refine*

refine verb

re·fine | \ ri-ˈfīn \

refined; **refining**

Kids Definition of *refine*

1 **:** to bring to a pure state

// *refine* sugar

2 **:** to make better **:** IMPROVE

// He's *refining* his recipe.

refine *transitive verb*

re·fine | \ ri-ˈfīn \

refined; **refining**

Medical Definition of *refine*

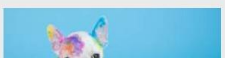
: to free (as sugar or oil) from impurities or unwanted material

More from Merriam-Webster on *refine*

Nglish: Translation of *refine* for Spanish Speakers

Britannica English: Translation of *refine* for Arabic Speakers

WORDS AT PLAY



'Dunderhead' and Other 'Nicer' Ways to Say Stupid

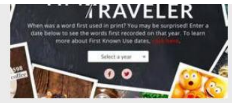
As illustrated by some very smart pups

10 Words from Place Names

Bikini, bourbon, and badminton were places first

'Pride': The Word That Went From Vice to Strength

Do you take pride in Pride?



When Were Words First Used?

Look up any year to find out

ASK THE EDITORS

What Are You Wearing?

Roll up your sleeves and identify these garments

TAKE THE QUIZ >

Name That Animal: Volume 2

Can you tell a meerkat from a wombat?

TAKE THE QUIZ >

Spell It

Can you spell these 10 commonly misspelled words?

TAKE THE QUIZ >

Spelling Bee Quiz

Can you outdo past winners of the National Spelli...

TAKE THE QUIZ >

Oil Refining

Refining oil in that decisive phase of the industry meant turn crude oil that comes out of the ground into kerosene.

From: Risk Management in the Oil and Gas Industry, 2021

Related terms:

Natural Gas, Biofuel, Power Generation, Biodiesel, Biomass, Hydrogen, Feedstocks, Sulfur, Oil Company

View all Topics

Carbon Capture

Zhien Zhang, ... Muftah H. El-Naas, in Exergetic, Energetic and Environmental Dimensions, 2018

4.4 Oil Refinery

Oil refining is an essential process for transforming crude oil into marketable products such as fuels, lubricants, and kerosene. A typical oil-refining process consists of several processing units such as distillation, cracking, coking, reforming, and posttreatment and refining of the products. The operation of these processes requires large amounts of thermal energy and results in the release of

Finance

Robert Bruce Hey, in Performance Management for the Oil, Gas, and Process Industries, 2017

21.9 Profit and Investment

In oil refining terms, gross margin is the difference between the raw material price and the selling price per barrel of oil. Net margin, or profit per barrel of oil, is the gross margin minus the operating expense. Box 21.4 discusses the effect of the type of crude on profit, based on the products a refinery can extract using its existing assets.

Box 21.4

significant amounts of CO_2 from different sources in the refinery, as shown in Table 6.

Table 6. CO_2 Emission Sources in Typical Refinery [81,102]

Emission Source	Description	Share of CO_2 Emissions (%)	CO_2 Concentration in Off-Gas Flow (Vol. %)
Process furnaces	Combustion of fossil fuels for heat generation for distillation columns and reactors	30–60	8–10
Steam generators	Combustion of fossil fuels to generate process steam	20–50	4–15
Catalytic crackers	Burn-up of petroleum coke	20–50	10–20
Hydrogen production	Reforming of hydrocarbons to H_2 and CO_2	5–20	20–99

In general, petroleum refineries generate about 1 billion tons of CO_2 annually, which represents around 4% of global CO_2 emissions. Depending on the complexity of the refinery, around 1.5%–8% of the fuel is used in the refining process. A typical refinery generates about 0.8–4.2 million tons of CO_2 per year [102].

Several strategies could be employed to reduce CO_2 emissions by the oil-refining process; the most economical way is to reduce energy consumption. However, the nature of the refining processes implies that a refinery will still consume a substantial amount of energy, which in turn would result in the production of a considerable amount of CO_2 emissions. Thus, CCS as per the approaches described in the previous sections is the best strategy to avoid significant CO_2 emissions [102].

Refining Margins Example—Crack Spread[5]

Crack spread is a term used in the oil industry and futures trading for the differential between the price of crude oil and petroleum products extracted from it—that is, the profit margin that an oil refinery can expect to make by "cracking" crude oil (breaking its long-chain hydrocarbons into useful shorter-chain petroleum products).

For simplicity, most refiners wishing to hedge their price exposures have used a crack ratio usually expressed as X:Y:Z where X represents a number of barrels of crude oil, Y represents a number of barrels of gasoline, and Z represents a number of barrels of distillate fuel oil, subject to the constraint that X = Y + Z. This crack ratio is used for hedging purposes by buying X barrels of crude oil and selling Y barrels of gasoline and Z barrels of distillate in the futures market.

Widely used crack spreads have included 3:2:1, 5:3:2, and 2:1:1. As the 3:2:1 crack spread is the most popular of these, widely quoted crack spread benchmarks are the "Gulf Coast 3:2:1" and the "Chicago 3:2:1."

Further to discussion in Section 2.7, Integration, large integrated complexes that extend the supply chain tend to be more profitable. As the profits pour in, the tendency is to reinvest further down the supply chain.

Some integrated complexes can convert low-grade crude oil into highly profitable products such as gasoline and diesel, as well as various petrochemicals.

Box 21.5 gives an example of extraordinary gross margins and continuing investment.

Feedstock types and properties

James G. Speight, in The Refinery of the Future (Second Edition), 2020

Abstract

Crude oil refining has grown increasingly complex in the last 20 years. Lower quality crude oil (such as heavy crude oil, extra heavy oil, and tar sand bitumen), crude oil price volatility, and environmental regulations that require cleaner manufacturing processes and higher performance products present new challenges to the refining industry. Improving processes and increasing the efficiency of energy use with technology research and development are keys to meeting the challenges and maintaining the viability of the refining industry in the United States and the production of the hydrocarbon fuels upon which the modern world is dependent.

It is the purpose of this chapter to present a general description of the types of feedstocks that are currently accepted by refineries and to illustrate the evolution of the acceptance of these feedstocks from the original conventional crude oil for which the refineries were constructed.

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Algae fuel for future

S.C. Bhatia, in Advanced Renewable Energy Systems, 2014

24.11 Straight vegetable oil (SVO)

The algal-oil feedstock that is used to produce biodiesel can also be used for fuel directly as 'straight vegetable oil' (SVO). The benefit of

Box 21.5

Reliance Refinery—Profits and Investment[6]

Reliance Refinery, in India, is the largest integrated refinery in the world (as at the time of writing) and is owned by Reliance Industries Limited (RIL). Profits are high, relative to industry norms. Reliance Refinery is among a handful of global refiners with the ability to process low-grade crude into high-value products and switch between fuels depending on market prices.

The following is an extract of the gross refinery margins over nine quarters:

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However, the company continues to expand its petrochemical production. As of early 2016, RIL is investing $16 billion in expanding petrochemical production. Of this, $4.6 billion is for a project to convert captive petcoke to synthetic gas; $4.5 billion for a refinery off-gas cracker to extract ethane, ethylene, propylene, butanes, and propanes; $5 billion to expand polyester production; and $1.5 billion to import ethane from the United States to replace costly propane imports and naphtha. See also Box 27.7, Reliance Refinery Benchmarking Performance.

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FEEDBACK

using the oil in this manner is that it does not require the additional energy needed for transesterification (processing the oil with an alcohol and a catalyst to produce biodiesel). The drawback is that it does require modifications to a normal diesel engine. Transesterified biodiesel can be run in an unmodified modern diesel engine, provided the engine is designed to use ultra-low sulphur diesel, which, as of 2006, is the new diesel fuel standard in the United States.

24.11.1 Hydrocracking to traditional transport fuels

Vegetable oil refining and green crude vegetable oil can be used as feedstock for an oil refinery where methods like hydrocracking or hydrogenation can be used to transform the vegetable oil into standard fuels like gasoline and diesel.

24.11.2 Jet fuel

Rising jet fuel prices are putting severe pressure on airline companies, creating an incentive for algal jet fuel research. The International Air Transport Association (IATA), for example, supports research, development and deployment of algal fuels. IATA's goal is for its members to be using 10 per cent alternative fuels by 2017.

On January 8, 2009, Continental Airlines ran the first test for the first flight of an algae-fueled jet. The test was done using a twin-engine commercial jet consuming a 50/50 blend of biofuel and normal aircraft fuel. It was the first flight by a US carrier to use an alternative fuel source on this specific type of aircraft. The flight from Houston's Bush International Airport completed a circuit over the Gulf of Mexico. The pilots on-board, executed a series of tests at 38,000 ft. (11.6 km), including a mid-flight engine shutdown. Larry Kellner, chief executive of Continental Airlines, said they had tested a drop-in fuel which meant that no modification to the engine was required. The fuel was praised for having a low flashpoint and sufficiently low freezing point, issues that have been problematic for other biofuels.

Sources of hydrocarbons

FEEDBACK

James G. Speight PhD, DSc, PhD, in Handbook of Industrial Hydrocarbon Processes (Second Edition), 2020

2.1.6 Crude oil refining

Crude oil refining is the separation of recovered crude oil into fractions and the subsequent treating of these fractions to yield marketable products (Table 2.3) (Speight, 2014a, 2019a). In fact, refining is the means by which hydrocarbon derivatives are separated or produced from crude oil. A refinery is essentially a group of manufacturing plants which vary in number with the variety of products produced (Parkash, 2003; Gary et al., 2007; Speight, 2014a, 2017a; Hsu and Robinson, 2017). As the basic elements of crude oil, hydrogen and carbon form the main input into a refinery, combining into thousands of individual constituents and the economic recovery of these constituents varies with the individual crude oil according to its particular individual qualities, and the processing facilities of a particular refinery. In general, crude oil, once refined, yields three basic groupings of products that are produced when it is broken down into cuts or fractions (Speight, 2014a, 2017a). The complexity of crude oil is emphasized insofar as the actual proportions of low-boiling, medium-boiling, and high-boiling fractions vary significantly from one crude oil to another.

FEEDBACK

Table 2.3. Fractions obtained from crude petroleum by distillation.

	Boiling range[a]	
Fraction	°C	°F
Low-boiling naphtha	−1–150	30–300
Gasoline	−1–180	30–355

24.11.3 Algae cultivation

Algae can produce 15–300 times more oil per acre than conventional crops, such as rapeseed, palms, soyabeans or jatropha, and they have a harvesting cycle of 1–10 days, which permits several harvests in a very short time frame, increasing the total yield. Algae can also be grown on land that is not suitable for other established crops, for instance, arid land, land with excessively saline soil, and drought-stricken land. This minimises the issue of taking away pieces of land from the cultivation of food crops. They can grow 20 to 30 times faster than food crops.

Not only does algae produce biofuel, it also helps with reducing CO_2 emissions. Algae, like other fuels, releases carbon dioxide when it is burned. Fortunately, algae takes in CO_2 and replaces it with oxygen during the process of photosynthesis. Ultimately, its net emissions are zero because the CO_2 released in burning is the same amount that was absorbed initially. The hard part about algae production is growing the algae in a controlled way and harvesting it efficiently.

24.11.4 Photobioreactors

Most companies pursuing algae as a source of biofuels are pumping nutrient-laden water through plastic tubes (called bioreactors) that are exposed to sunlight (and so-called photobioreactors or PBR). Running a PBR is more difficult than an open pond, and more costly.

Algae can also grow on marginal lands, such as in desert areas where the groundwater is saline, rather than utilise freshwater. The difficulties in efficient biodiesel production from algae lie in finding an algal strain with a high lipid content and fast growth rate that isn't too difficult to harvest, and a cost-effective cultivation system (i.e. type of photobioreactor) that is best suited to that strain. There is also a need to provide concentrated CO_2 to turbocharge the production.

24.11.5 Closed loop system

Another obstacle preventing widespread mass production of algae for

Heavy naphtha	150–205	300–400
Kerosene	205–260	400–500
Low-boiling gas oil	260–315	400–600
Heavy gas oil	315–425	600–800
Lubricating oil	>400	>750
Vacuum gas oil	425–600	800–1100
Residuum	>510	>950

a

For convenience, boiling ranges are converted to the nearest 5°.

Naphtha, a precursor to gasoline and solvents, is extracted from both the low-boiling and middle range of distillate cuts and is also used as a feedstock for the petrochemical industry. The middle distillates refer to hydrocarbon products from the middle boiling range of crude oil and include kerosene, diesel fuel, distillate fuel oil, and low-boiling gas oil. Waxy distillate and lower boiling lubricating oils are sometimes included in the middle distillates. The remainder of the crude oil includes the higher boiling lubricating oil fractions, gas oil, and residuum (the nonvolatile fraction of the crude oil). The residuum can also produce high-boiling lubricating oils and waxes but is more often used for asphalt production.

Refinery processes must be selected and products manufactured to give a balanced operation in which crude oil is converted into a variety of products in amounts that are in accord with the demand for each (Chapter 3). For example, the manufacture of hydrocarbon products from the lower-boiling portion of crude oil automatically produces a certain amount of higher-boiling hydrocarbon components. If the latter cannot be sold as, say, high-boiling fuel oil, these products will accumulate until refinery storage facilities are full. To prevent the occurrence of such a situation, the refinery must be flexible and be able to change operations as needed. This usually means more processes: thermal processes to change an excess of high-boiling fuel oil into more gasoline with coke as the residual biofuel production has been the equipment and structures needed to begin growing algae in large quantities. Maximum use of existing agriculture processes and hardware is the goal.

In a closed system (not exposed to open air) there is not the problem of contamination by other organisms blown in by the air. The problem for a closed system is finding a cheap source of sterile carbon dioxide (CO_2). Several experimenters have found the CO_2 from a smokestack works well for growing algae. To be economical, some experts think that algae farming for biofuels will have to be done next to power plants, where they can also help soak up the pollution.

24.11.6 Open pond

Open pond systems for the most part have been given up for the cultivation of algae with high-oil content. Many believe that a major flaw of the Aquatic Species Program was the decision to focus their efforts exclusively on open ponds; this makes the entire effort dependent upon the hardiness of the strain chosen, requiring it to be unnecessarily resilient in order to withstand wide swings in temperature and pH, and competition from invasive algae and bacteria. Open systems using a monoculture are also vulnerable to viral infection. The energy that a high-oil strain invests into the production of oil is energy that is not invested into the production of proteins or carbohydrates, usually resulting in the species being less hardy or having a slower growth rate. Algal species with a lower oil content, not having to divert their energies away from growth, have an easier time in the harsher conditions of an open system. Some open sewage ponds trial production has been done in Marlborough, New Zealand.

24.11.7 Nutrients

Nutrients like nitrogen (N), phosphorus (P), and potassium (K), are important for plant growth and are essential parts of fertiliser. Silica

product, or a vacuum distillation process to separate the heavy oil into lubricating oil stocks and asphalt.

The refining industry has been the subject of the four major forces that affect most industries and which have hastened the development of new crude oil refining processes: (i) the demand for hydrocarbon products such as gasoline, diesel, fuel oil, and jet fuel, (ii) feedstock supply, specifically the changing quality of crude oil and geopolitics between different countries and the emergence of alternate feed supplies such as bitumen from tar sand, natural gas, and coal, (iii) environmental regulations that include more stringent regulations in relation to sulfur in gasoline and diesel, and (iv) technology development such as new catalysts and processes to produce more hydrocarbon derivatives from the barrel of oil.

In the early days of the 20th century, refining processes were developed to extract kerosene for lamps. Any other products were considered to be unusable and were usually discarded. Thus, first refining processes were developed to purify, stabilize, and improve the quality of kerosene. However, the invention of the internal combustion engine led (at approximately the time of World War I) to a demand for gasoline for use in increasing quantities as motor fuel for cars and trucks. This demand on the lower boiling products increased, particularly when the market for aviation fuel developed. Thereafter, refining methods had to be constantly adapted and improved to meet the quality requirements and needs of car and aircraft engines.

Since then, the general trend throughout refining has been to produce more products from each barrel of crude oil and to process those products in different ways to meet the product specifications for use in modern engines. Overall, the demand for gasoline has rapidly expanded and demand has also developed for gas oils and fuels for domestic central heating, and fuel oil for power generation, and iron, as well as several trace elements, may also be considered important marine nutrients as the lack of one can limit the growth of or productivity in an area. One company, green star products, announced their development of a micronutrient formula to increase the growth rate of algae. According to the company, its formula can increase the daily growth rate by 34 per cent and can double the amount of algae produced in one growth cycle.

24.11.8 Waste water

A possible nutrient source is waste-water from the treatment of sewage, agricultural or flood plain run-off, all currently major pollutants and health risks. However, this waste water cannot feed algae directly and must first be processed by bacteria, through anaerobic digestion. If waste-water is not processed before it reaches the algae, it will contaminate the algae in the reactor, and at the very least, kill much of the desired algae strain. In biogas facilities, organic waste is often converted to a mixture of carbon dioxide, methane, and organic fertiliser. Organic fertiliser that comes out of digester is liquid, and nearly suitable for algae growth, but it must first be cleaned and sterilised.

The utilisation of waste-water and ocean water instead of freshwater is strongly advocated due to the continuing depletion of freshwater resources. However, heavy metals, trace metals, and other contaminants in waste-water can decrease the ability of cells to produce lipids biosynthetically and also impact various other workings in the machinery of cells.

The same is true for ocean water, but the contaminants are found in different concentrations. Thus, agricultural-grade fertiliser is the preferred source of nutrients, but heavy metals are again a problem, especially for strains of algae that are susceptible to these metals. In open pond systems the use of strains of algae that can deal with high concentrations of heavy metals could prevent other organisms from infesting these systems.

as well as for low-boiling distillates and other inputs, derived from crude oil, for the petrochemical industries.

As the need for the lower boiling products developed, crude oil yielding the desired quantities of the lower boiling products became less available and refineries had to introduce conversion processes to produce greater quantities of lower boiling products from the higher boiling fractions. The means by which a refinery operates in terms of producing the relevant products depends not only on the nature of the crude oil feedstock but also on its configuration (i.e., the number of types of the processes that are employed to produce the desired product slate) and the refinery configuration is, therefore, influenced by the specific demands of a market. Therefore, refineries need to be constantly adapted and upgraded to remain viable and responsive to ever changing patterns of crude supply and product market demands. As a result, refineries have been introducing increasingly complex and expensive processes to gain higher yields of lower boiling products from the higher boiling fractions and residua. To convert crude oil into desired products in an economically feasible and environmentally acceptable manner. Refinery process for crude oil are generally divided into three categories: (i) separation processes, of which distillation is the prime example, (ii) conversion processes, of which coking and catalytic cracking are prime examples, and (iii) finishing processes, of which hydrotreating to remove sulfur is a prime example (Speight, 2014a, 2017a).

The simplest refinery configuration is the *topping refinery*, which is designed to prepare feedstocks for petrochemical manufacture or for production of industrial fuels in remote oil-production areas. The topping refinery consists of tankage, a distillation unit, recovery facilities for gases and low-boiling hydrocarbon derivatives, and the necessary utility systems (steam, power, and water-treatment plants). Topping refineries produce large quantities of unfinished oils and are

At the Woods Hole Oceanographic Institution and the Harbour Branch Oceanographic Institution the waste-water from domestic and industrial sources contain rich organic compounds that are being used to accelerate the growth of algae. Also the Department of Biological and Agricultural Engineering of the University of Georgia is exploring microalgal biomass production using industrial waste-water.

Algaewheel, based in Indianapolis, Indiana, presented a proposal to build a facility in Cedar Lake, Indiana that uses algae to treat municipal waste-water and uses the sludge by-product to produce biofuel.

24.11.9 Investment

There is always uncertainty about the success of new products and investors have to consider carefully the proper energy sources in which to invest. A drop in fossil fuel oil prices might make consumers and therefore investors lose interest in renewable energy. Algal fuel companies are learning that investors have different expectations about returns and length of investments. AlgaePro Systems found in its talks with investors that while one wants at least 5 times the returns on their investment, others would only be willing to invest in a profitable operation over the long-term. Every investor has its own unique stipulations that are obstacles to further algae fuel development.

Transportation, Processing, and Refining Operations

highly dependent on local markets, but the addition of hydrotreating and reforming units to this basic configuration results in a more flexible *hydroskimming refinery*, which can also produce desulfurized distillate fuels and high-octane gasoline. These refineries may produce up to half of their output as residual fuel oil, and they face increasing market loss as the demand for low-sulfur (even no-sulfur) and high-sulfur fuel oil increases.

The most versatile refinery configuration today is known as the *conversion refinery*, which incorporates all the basic units found in both the topping and hydroskimming refineries, but it also features gas oil conversion plants such as catalytic cracking and hydrocracking units, olefin conversion plants such as alkylation or polymerization units, and, frequently, coking units for sharply reducing or eliminating the production of residual fuels. Modern conversion refineries may produce two-thirds of their output as unleaded gasoline, with the balance distributed between liquefied crude oil gas, jet fuel, diesel fuel, and a small quantity of coke. Many such refineries also incorporate solvent extraction processes for manufacturing lubricants and petrochemical units with which to recover propylene, benzene, toluene, and xylenes for further processing into polymers.

Finally, the yields and quality of refined crude oil products produced by the configuration of refineries may vary from refinery to refinery. Some refineries may be more oriented toward the production of gasoline (large reforming and/or catalytic cracking) whereas the configuration of other refineries may be more oriented toward the production of middle distillates such as jet fuel and gas oil.

The gas and gasoline fractions form the lower boiling products and are usually more valuable than the higher boiling fractions and provide hydrocarbon gas (liquefied petroleum gas, LPG) and hydrocarbon fractions such as naphtha, kerosene, aviation fuel, fuel

M. Ibrahim Khan, M.R. Islam, in The Petroleum Engineering Handbook: Sustainable Operations, 2007

8.5.7 Green inputs

In the oil refining process, the quality of the crude will affect the quality of the refined products. Using "cleaner crude oil" containing less sulfur and fewer metals will prevent pollution. Less effort and treatment will be needed to remove impurities, and smaller amounts of pollutants will enter the environment through refining and the use or disposal of products. Also, practically all steps of crude oil refining and subsequent synthesis (e.g., making of plastics) must be overhauled. It is possible that by using proper environmental science, the process can be reversed to create "good" final products that are environmentally-friendly (Rahbar and Islam 2005).

It is important to note that the "greening" of a process cannot be accomplished unless every item is checked for sustainability. Sustainability can be only assured by using natural materials (Chhetri and Islam 2006a). In this process, the role of catalysts and other additives cannot be ignored. Proper analysis of such roles requires the knowledge of the science of intangibles, something that cannot be detected using a conventional detector. For instance, catalysts have been known for the longest time to be environmentally benign because they would not release any appreciable amount. "Appreciable" here relates to what can be detected. It turns out that any catalyst would release some amount, which would end up with the end user.

Because most of the gas or oil is actually burned while the rest of them are exposed to slow oxidation, any molecule of a toxic catalyst will end up being oxidized, releasing harmful products. Similarly, heat sources should also be checked for sustainability. Whenever there are alternate and more natural forms of energy available, they should be used. For instance, there is no reason why a sunny site

oil, and feedstocks for the petrochemical industry (Speight, 2014a, 2017a; 2019a).

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Maintenance

FEEDBACK

Heinz P. Bloch, in Petrochemical Machinery Insights, 2017

Distinguishing Benchmarks

Some petrochemical and oil refining companies make a distinction between repairs and failures. This was alluded to in what one engineer wrote:

I have a philosophical question around the classification of repairs vs. failures when tracking rotating equipment reliability. As I see it, there are basically two structures or philosophies:

- Asset philosophy
- Component philosophy

In the world of *asset philosophy*, one views the equipment train as a singularity, and this is how it's being done here, where I work. A motor and pump combination is a single asset. We observe if the asset as a whole continues to perform its intended duty, that is, pumping product. As long as the asset moves fluid, the asset has not failed. In other words, if a particular component fails and needs to be replaced, the asset has not failed. If, as an example, a seal leaks, the action to correct the leaking seal is logged in as a repair. After all, the asset continues to perform its intended function. In this view, all seal leaks are considered repairs. If—and only if—the seal leak causes the asset to shut down (e.g., the seal blows out), this situation is classified as an asset failure.

FEEDBACK

should be used. For instance, there is no reason why a sunny site should not use solar heating. Such a process can generate sufficient heat to provide us with a cheap and environmentally-friendly alternative to electrical or combustion heating. Note, however, that the solar energy has to be direct. Recently, Khan and Islam (2007) have introduced a series of such processes that are highly efficient, inexpensive, and most importantly, environmentally-friendly.

Similarly, during the polymerization process, if no toxic chemical is added and synthesis of materials takes place under natural environmental conditions, the plastic that will be produced will be environmentally-friendly. It is important in this process not to introduce any toxic chemical throughout the process, as tested by the Khan and Islam (2006e) criterion. Polymers produced with this process will remain environmentally-friendly and can be used in numerous applications, such as packages, paintings, hard composites, etc.

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Analysis of oil from tight formations

James Speight, in Shale Oil and Gas Production Processes, 2020

4.2.1 Boiling point distribution

In the crude oil refining industry, boiling range distribution data are used (i) to assess crude oil crude quality before purchase, (ii) to monitor crude oil quality during transportation, (iii) to evaluate crude oil for refining, and (iv) to provide information for the optimization of refinery processes.

Traditionally, boiling range distributions of the various fractions have been determined by distillation. Yield-on-crude data are still widely

In the sphere of *component philosophy*, an asset is seen as a composite unit consisting of multiple and various components (i.e., motor shaft, motor bearings, pump shaft, pump bearings, impeller, wear rings, coupling, throttle bushing, seal, seal pot, etc.). Each of these has its own failure mode. While it is true that a particular component may cease to perform its intended function and not prevent the asset as a whole from functioning (i.e., a small seal leaking does not stop the pump from pumping), the asset must still be taken off-line to repair the defective component. So, in essence, there will be an asset repair due to a component failure.

I believe the component philosophy is the superior form of equipment classification as it pertains to rotating equipment reliability. It gives my plant the ability to classify both asset and components in their respective statistics or catalog. Moreover, it provides the benefit of seeing issues down to the component level. The component strategy is helpful in identifying what particular items are causing all the problems.

What the reader stated may look interesting; however, it also shows how we can play up one side or the other, even with apparently valid statistics. It is not possible to compare statistics based on narrow definitions with statistics based on much broader definitions. Sensible MTBF statistics aim for simplicity. Therefore, some reliability engineers or professionals see merit in making comparisons as long as they do not involve the judgmental ingredient of questioning if and how a particular component defect *could have* caused the asset to shut down.

It must be stated that, for years, many of the best organizations have called it a failure event whenever a component was being replaced. When first collecting relevant statistics many years ago, these companies decided that only two preventive/predictive action steps, data taking and/or performing scheduled oil changes, would escape been determined by distillation. Yield-on-crude data are still widely reported in the crude oil assay literature, providing information on the yield of specific fractions obtained by distillation. To some extent in the laboratory, atmospheric and vacuum distillation techniques have largely been replaced by *simulated* distillation methods, which use low resolution gas chromatography and correlate retention times to hydrocarbon boiling points.

The distillation tests give an indication of the types of products and the quality of the products that can be obtained from the crude oil and the tests are used to compare different crude oil through the yield and quality of the 300 °C (570 °F) residuum fraction. For example, the waxiness or viscosity of this fraction gives an indication of the amount, types, and quality of the residual fuel that can be obtained from the crude oil. In this respect, the determination of the aniline point (ASTM D611, IP 2) can be used to determine the aromatic or aliphatic character of crude oil. Although not necessarily the same as the wax content, correlative relationships can be derived from the data.

The basic method of distillation (ASTM D86) is one of the oldest methods in use since the distillation characteristics of hydrocarbon derivatives have an important effect on safety and performance, especially in the case of fuels and solvents. The boiling range gives information on the composition, the properties, and the behavior of crude oil and derived products during storage and use. Volatility is the major determinant of the tendency of a hydrocarbon mixture to produce potentially explosive vapors. Several methods are available to define the distillation characteristics of crude oil and its various crude oil products. In addition to these physical methods, other test methods based on gas chromatography are also used to derive the boiling point distribution of a sample (ASTM D2887, ASTM D3710, ASTM D6352).

In the preliminary assay of crude oil the method of distillation is

data taking and/or performing scheduled oil changes, would escape being called an equipment failure event. The main aim of the reliability professionals in those organizations was to facilitate comparisons based on facts, not on assumptions or projections. These best practices organizations wanted to steer clear of guessing or speculating if leaving a flawed component in place would have, or would not have, led to an asset shutdown.

Reactions of hydrocarbons

James G. Speight PhD, DSc, PhD, in Handbook of Industrial Hydrocarbon Processes (Second Edition), 2020

2.3 Thermal reforming

Thermal reforming is a crude oil refining process using heat (but no catalyst) to effect molecular rearrangement of a low-octane naphtha to form high-octane motor gasoline. The process is carried out at higher temperature when noncyclic hydrocarbon derivatives are converted to high octane number olefin derivatives and aromatic hydrocarbon derivatives.

In the process, a feedstock, such as 200°C (390°F) end-point naphtha is heated to 510–595°C (950–1100°F) in a furnace much the same as a thermal decomposition furnace, with pressures from 400 to 1000 psi. As the heated naphtha leaves the furnace, it is cooled or quenched by the addition of cold naphtha. The quenched, reformed material then enters a fractional distillation tower where any heavy products are separated. The remainder of the reformed material leaves the top of the tower to be separated into gases and reformate. The higher octane number of the product (*reformate*) is due primarily often used to give a rough indication of the boiling range of the crude (ASTM D2892, IP 123). The test method is used for the distillation of stabilized (gases-removed) crude oil to a final cut temperature of up to 400 °C (750 °F) *atmospheric equivalent temperature* (AET). The crude oil is heated and separated by the distillation column into lower-boiling products such as; naphtha and kerosene. The distillate and the residuum can be further examined by tests such as specific gravity (ASTM D1298, IP 160), sulfur content (ASTM D129, IP 61) and viscosity (ASTM D445, IP 71). In fact using a method (ASTM D2569) developed for the determining the distillation characteristics of pitch allows further detailed examination of residua.

In addition to the whole crude oil tests performed as part of the inspection assay, a comprehensive or full assay requires that the crude be fractionally distilled and the fractions characterized by the relevant tests. Fractionation of the crude oil begins with a true boiling point (TBP) distillation employing a fractionating column having an efficiency of 14–18 theoretical plates and operated at a reflux ratio of 5: 1 (ASTM D2892). The TBP distillation may be used for all fractions up to a maximum cut point of about 350 °C atmospheric equivalent temperature (AET) but or low residence time in the still (or reduced pressure) is needed to minimize cracking.

It is often useful to extend the boiling point data to higher temperatures than are possible in the fractionating distillation method previously described, and for this purpose a vacuum distillation in a simple still, with no fractionating column (ASTM D1160) can be carried out. This distillation, which is done under fractionating conditions equivalent to one theoretical plate, allows the boiling point data to be extended to approximately 600 °C (1,110 °F) with many crude oils. This method gives useful comparative and reproducible results that are often accurate enough for refinery purposes, provided significant cracking does not occur.

to the thermal decomposition of higher molecular weight paraffin derivatives into higher-octane olefin derivatives.

Thermal reforming is in general less effective than catalytic processes and has been largely supplanted. As it was practiced, a single-pass operation was employed at temperatures in the range of 540–760°C (1000–1140°F) and pressures in the range 500–1000 psi. Octane number improvement depended on the extent of conversion but was not directly proportional to the extent of thermal decomposition-per-pass.

The amount and quality of *reformate* are dependent on the temperature. A general rule is the higher the reforming temperature, the higher the octane number of the product but the yield of reformate is relatively low. For example, naphtha with an octane number of 35 when reformed at 515°C (960°F) yields 92.4% of 56 octane reformate; when reformed at 555°C (1,030°F) the yield is 68.7% of 83 octane reformate. However, high conversion is not always effective since coke production and gas production usually increase.

Modifications of the thermal reforming process due to the inclusion of hydrocarbon gases with the feedstock are known as *gas reversion* and *polyforming*. Thus, olefinic gases produced by thermal decomposition and reforming can be converted into liquids boiling in the gasoline range by heating them under high pressure. Since the resulting liquids (polymers) have high octane numbers, they increase the overall quantity and quality of gasoline produced in a refinery.

The gases most susceptible to conversion to liquid products are olefin derivatives with three and four carbon atoms. These are propylene ($CH_3CH{=}CH_2$), which is associated with propane in the C_3 fraction, and butylene ($CH_3CH_2CH{=}CH_2$ and/or $CH_3CH{=}CHCH_3$) and *iso*-butylene [$(CH_3)_2C{=}CH_2$], which are associated with butane ($CH_3CH_2CH_2CH_3$) and *iso*-butane [$(CH_3)_2CHCH_3$] in the C_4 fraction.

Usually seven fractions provide the basis for a reasonably thorough evaluation of the distillation properties of the feedstock: (i) gas, boiling range: <l5.6 °C/60 °F, (ii) gasoline (low-boiling naphtha), boiling range: l5.6 to l50 °C/60 to 300 °F, (iii) kerosene (medium naphtha), boiling range: 150–230 °C/300 to 450 °F, (iv) gas oil, boiling range: 230–345 °C/450 to 650 °F, (v) low-boiling vacuum gas oil boiling range: 345–370 °C/650 to 700 °F, (vi) high-boiling vacuum gas oil, boiling range: 370–565 °C/700 to 1050 °F, and (vii) residuum, boiling range: >565 °C/1050 °F. From five to fifty liters of crude oil are necessary to complete a full assay, depending on the number of cuts to be taken and the tests to be performed on the fractions.

A more recent test method (ASTM D5236) is seeing increasingly more use and appears to be the method of choice for crude assay vacuum distillations. The method employs a vacuum pot still with a low pressure drop entrainment separator operated under total takeoff conditions. The reduced pressure allows volatilization at a lower temperature than under atmospheric conditions, thus allowing temperatures up to 565 °C (1050 °F) for most samples and which avoids thermal decomposition (cracking) of the oil (caused by prolonged exposure to temperatures in excess of above 350 °C, 650 °F). The test method applies to the higher boiling fractions of crude oil that are in the gas oil and lubricating oil range as well as heavy crude oils and residua.

ASTM D2887 (Standard Test Method for Boiling Range Distribution of Crude oil Fractions by Gas Chromatography) and ASTM D3710 (Standard Test Method for Boiling Range Distribution of Gasoline and Gasoline Fractions by Gas Chromatography) use external standards composed of n-alkanes. ASTM D5307 (Standard Test Method for Determination of Boiling Range Distribution of Crude Petroleum oil by Gas Chromatography) is very similar to ASTM D2887 but requires two determinations to be made with each

When the C_3 and C_4 fractions are subjected to the temperature and pressure conditions used in thermal reforming, they undergo chemical reactions that result in a small yield of gasoline. When the C_3 and C_4 fractions are passed through a thermal reformer in admixture with naphtha, the process is called *naphtha-gas reversion* or *naphtha polyforming*.

These processes are essentially the same but differ in the manner in which the gases and naphtha are passed through the heating furnace. In gas reversion, the naphtha and gases flow through separate lines in the furnace and are heated independently of one another. Before leaving the furnace, both lines join to form a common soaking section where the reforming, polymerization, and other reactions take place. In naphtha reforming, the C_3 and C_4 gases are premixed with the naphtha and pass together through the furnace. Except for the gaseous components in the feedstock, both processes operate in much the same manner as thermal reforming and produce similar products.

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Utilization of coal in IGCC systems

Sarma V. Pisupati, Vijayaragavan Krishnamoorthy, in Integrated Gasification Combined Cycle (IGCC) Technologies, 2017

2.8.2 Petcoke

Petcoke is a byproduct of the oil refining industry. Petcoke is an attractive fuel for its high heating value and lower costs. Lee et al. studied the gasification characteristics of petcoke in a 1-ton per day atmospheric-pressure entrained-flow reactor at about 1873K as the sample, one of which uses an internal standard. The amount of material boiling above 540 °C (above 1000 °F) (reported as residue) is calculated from the differences between the two determinations.

Wiped-wall or thin-film molecular stills can also be used to separate the higher boiling fractions under conditions that minimize cracking. In these units, however, cut points cannot be directly selected, because vapor temperature in the distillation column cannot be measured accurately under operating conditions. Instead, the wall (film) temperature, pressure, and feed rate that will produce a fraction with a given end point are determined from in-house correlations developed by matching yields between the wiped-wall distillation and the conventional distillation (ASTM D1160, ASTM D5236). And wiped-wall stills are often used because they allow higher end points and can easily provide sufficient quantities of the fractions for characterization purposes.

From the point of view of crude oil and crude oil product analysis for environmental purposes, boiling range distributions provide an indication of volatility and component distribution. In addition, boiling range distribution data is also useful for the development of equations for predicting evaporative loss (Speight, 2005; Speight and Arjoon, 2012).

peak temperature (Lee et al., 2010). The results showed that carbon conversion of petcoke with char recycle can reach about 80% (for O_2/fuel ratio = 1) with corresponding cold gas efficiency slightly above 40% (Lee et al., 2010). The amount of oxygen has to be increased to achieve nearly 100% conversion. A higher amount of oxygen means lower coal gas efficiency. The petcoke was fed into the gasifier as a slurry. In another study where the gasifier was operated at slightly higher pressure of 4.2 bar, the carbon conversion was found to be 86% with a cold gas efficiency of ~63% (Shen et al., 2012). The relatively higher cold gas efficiency can be attributed to dry feeding of the petcoke to the gasifier. Besides the kind of feeding into the gasifier, increased pressure is expected to increase the residence time of the particles within the reactor, contributing to increased conversion at higher pressure. In industrial gasifiers, recycling of petcoke char is expected to increase the overall carbon conversion.

Cold gas efficiency for petcoke is typically lower than that of coal, which is due to its lower reactivity (Shen et al., 2012). The lower reactivity of petcoke in an entrained-flow gasifier is due to limited porosity generation during devolatilization (Sun et al., 2012). It is important to recognize that petcoke gasification in an entrained-flow gasifier is pore-diffusion limited. Limited porosity affects carbon conversion and consequently affects the cold gas efficiency.

Petcoke gasification is also not complete in a Winkler fluidized-bed gasifier, with overall conversion ranging between 57–88% (Yan et al., 1998). Lower conversion means a higher feed rate and lower thermal output of the gasifier. For substantial utilization of petcoke, more gasifiers have to be installed for the same thermal output, and this increases the overall investment cost.

Utilization of petcoke in slagging entrained-flow gasifiers can have other problems. The inorganic product from petcoke utilization is

V_2O_3. V_2O_3 has unfavorable slag flow characteristics due to its high melting temperature, requiring the use of higher amounts of fluxants. Moreover, operating at a very high temperature to melt V_2O_3 can increase oxygen consumption and reduce cold gas efficiency (NETL, 2013). In addition, V_2O_3 is very corrosive on the refractory and reduces the service time. All these problems can lead to higher maintenance costs. To have a good slag flow characteristic, fluxing agents are usually added. A more detailed discussion of petcoke as a feedstock for IGCC is presented in Chapter 3, Petroleum coke and refinery residues.

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FEEDBACK

FEEDBACK

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3	*r{v:2}{"fph":2}{v:2}n*[bi,ti] not dead[ld]	6607	0	0	0	0:03
4	2 and 3	28	0	28	28	0:02
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9	8 and "004"[cc]	745	0	388	388	0:01
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11	"Randy C. Stubbs"[on]	0	0	0	0	0:00
12	"Randy C Stubbs"[on]	2	1	1	1	0:00
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