ENGINEERING PRACTICE

VOLUME 5 NUMBER 18

JULY 2019

SPECIAL FEATURES

Reaching Profitability in the Downstream Industry – Refining Configurations

Process Design Considerations for Instrument Air Systems

High Rate Downflow Filtration for Industrial Use

IACPE

INTERNATIONAL ASSOCIATION OF CERTIFIED PRACTICING ENGINEERS

Z Z Z 1DFSHFR P #

ENGINEERING PRACTICE

VOLUME 5
NUMBER 18
JULY 2019

ABOUT

International Association of Certified Practicing Engineers provides a standard of professional competence and ethics. Identifies and recognizes those individuals that have meet the standard. And requires our members to participate in continuing education programs for personal and professional development.

In additional to insuring a professional level of competency and ethics the IACPE focuses on three major areas of development for our members: Personal, Professional, and Networking.

HISTORY

The International Association of Certified Practicing Engineers concept was formulated by the many young professionals and students we meet during our careers working in the field, running training courses, and lecturing at universities.

During question and answer sessions we found the single most common question was: What else can I do to further my career?

We found, depending on the persons avail able time and finances, and very often dependent on the country in which the person was from, the options to further ones career were not equal.

Many times we found the options available to our students in developing countries were too costly and or provided too little of value in an expanding global business environment.

The reality is that most of our founders come from countries that require rigorous academic standards at four year universities in order to achieve an engineering degree. Then, after obtaining this degree, they complete even stricter government and state examinations to obtain their professional licenses in order to join professional organizations. They have been afforded the opportunity to continue their personal and professional development with many affordable schools, programs, and professional organizations. The IACPE did not see those same opportunities for everyone in every country.

So we set out to design and build an association dedicated to supporting those engineers in developing in emerging economies.

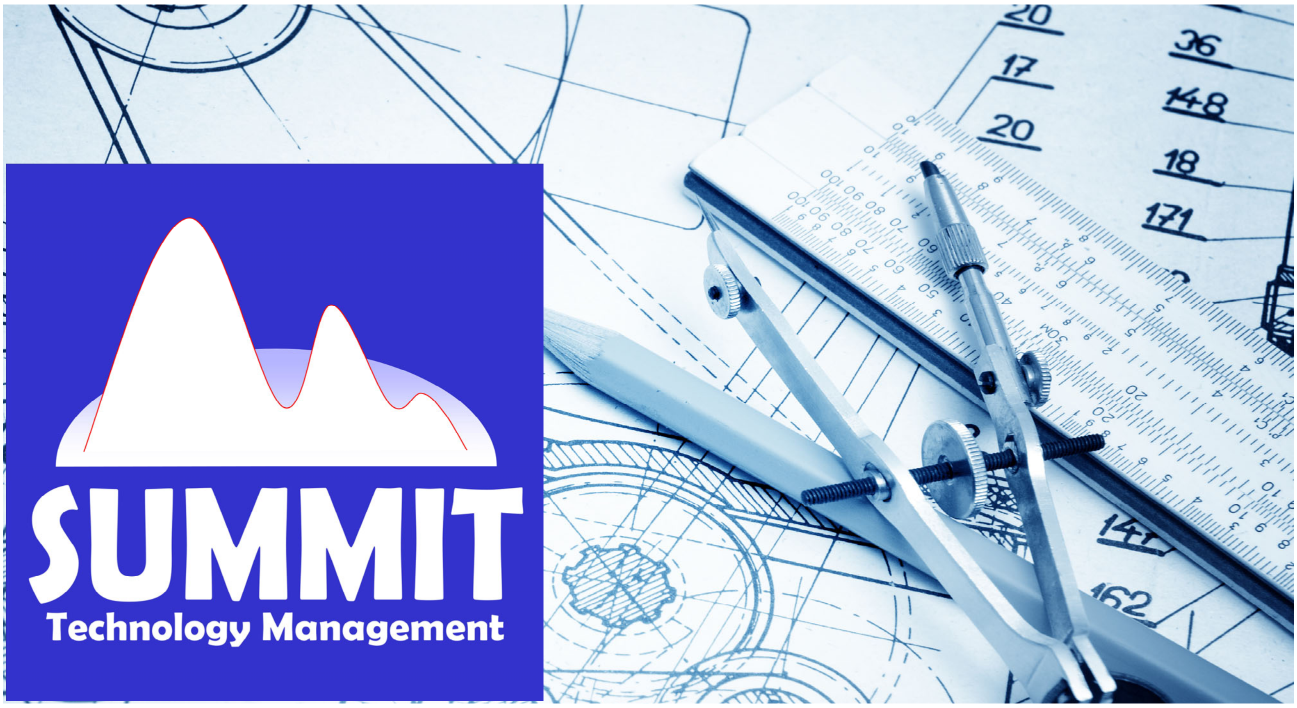
The IACPE took input from industry leaders, academic professors, and students from Indonesia, Malaysia, and the Philippines. The goal was to build an organization that would validate a candidates engineering fundamentals, prove their individuals skills, and enhance their networking ability. We wanted to do this in a way that was cost effective, time conscience, and utilized the latest technologies.

MISSION

Based on engineering first principles and practical real world applications our curriculum has been vetted by academic and industry professionals. Through rigorous study and examination, candidates are able to prove their knowledge and experience. This body of certified professionals engineers will become a network of industry professionals leading continuous improvement and education with improved ethics.

VISION

To become a globally recognized association for certification of professional engineers.



Partners to the Top

Summit Technology Management is a technical consultancy group, providing specialized services and training to improve process plant operational efficiency, profitability and safety. We provide engineering solutions by offering training, technical services, best practices, and equipment to meet the specific needs of our partner clients.

- **Basic Design Packages**
- **Detailed Design Packages**
- **Commissioning of Process Units**
- **Process Engineering Studies**
- **Bench Marking of Process Units**
- **Regional Training Conferences & In-House Training**
- **Singapore & Malaysia Company Registration & Set Up**
- **Specialty Equipment: Distillation Equipment, Filter Skid Packages, Compressor Knockout/Scrubber Skid Packages, Mercury Removal Skid Packages**

www.summit-tech-mtg.com

LETTER FROM THE PRESIDENT

KARL KOLMETZ

Great Blooms Along Your Path

I have tried to grow some fruit trees and flowers on the farm for a few years. I have had some good luck and some bad luck. I did not have much luck with commercial roses. Several springs I try to plant some and they do not make it through the second year.

There is a place on the farm where a trailer was parked. The people in the trailer had some roses. They were a kind of a local Texas rose. The were just growing wild in the area where the trailer was parked.

The roses had survived several droughts and freezes. I decided to move some of them up by the farm house. They survived the move. I bought a small support trellis for them and began to care for them providing regular food and water. As one might expect, they did much better than in the wild. As they began to grow we built a larger trellis for them. And they began to blossom.

Almost amazing the difference. I think they are called the Seven Sisters Roses. What is the difference? Same rose, same area, same soil, same sun. The major differences are more water, more food and structure. There are some of the roses that can still bloom in the wild, but it is rare. They tend to be blocked from blooming by grass and weeds. All of these roses have the same capacity to bloom.

As I look at these roses I think about people, especially children. Some have no blooms, some have a few small blooms, and some have seven large blooms. What makes the difference in these children? I know this is a simplistic answer, but it is water, food, structure and removing obstacles. If we are going to have a better world in the future we are going to have to help children and adults bloom.

1. Life's Basics
We understand we need clean water and healthy food. It seems strange to me, the wealthier we become the more unhealthy our food becomes. We need to assure our children are given healthy food. The problem is that unhealthy food is easily found and is lower cost.

2. Structure
Most children and adults tend to function better in structured environments. There are some rare people who do well in any environment, but many cannot bloom in the wild. We are experimenting in less structured environments, and less punishment. I would really like to believe that with less structure and less punishment we get more blooms.

Unfortunately, in my 60+ years on earth I have yet to see this correlation. When children and adults see no consequences for their bad behaviors, they seem to only continue with more and deepening bad behaviors.

3. Removing Obstacles
All of us have some advantages and disadvantages. Some have good looks; some not so good looks. Some are athletic; some not so athletic. Some are very smart; some aren't the smartest. Whatever our advantages and disadvantages are, we need to try and help children and adults bloom by removing obstacles that are holding them back from blooming. Sometimes this is just someone believing in them and helping them through the day-to-day struggles.

Try to Help Others Bloom Along Your Path,

Karl Kolmetz

Reaching Profitability in the Downstream Industry – Refining Configurations

Dr. Marcio Wagner da Silva

Introduction

Just like any other business, the central objective of the crude oil refining industry is to maximize profitability, to achieve this objective the refiners need to ensure meeting quality requirements and, mainly, compliance of environmental regulations.

Refineries conception or refining scheme adopted by refiners depends on the market that will be attended aim to define what derivative will be maximized (diesel, gasoline, lubricants, etc.) as well as quality and environmental requirements that these derivatives need meet and, of course, the crude oil which will be processed. As generally known, heavier crude oils need a higher conversion and treating levels, raising the processing costs.

The comparison between different refineries is a hard task given that each operational unit attends distinct markets and different specifications, however, some standard refining schemes were defined over the years in the sense to allow the comparative studies. Refining scheme is the sequence of process units through the crude oil is submitted aim to produce desired derivatives meeting the quality and environmental requirements.

Refining Configurations

The crude oil refining scheme considered basic is called Topping, in this case, are applied only separation process as atmospheric distillation. Figure I presents a basic process flow to a typical topping refinery.

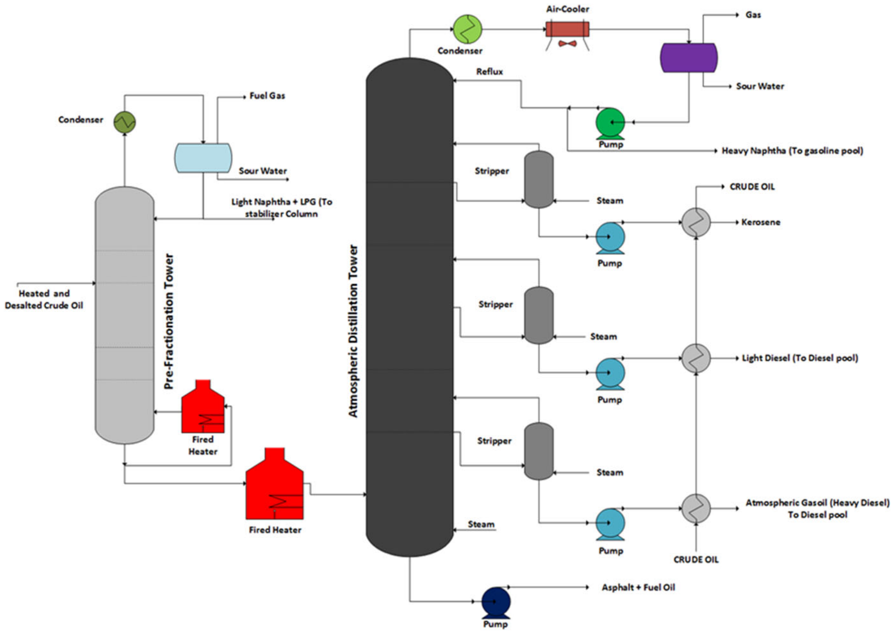


Figure I – Typical Scheme for a Topping

PROCESS
ENGINEERING ASSOCIATES, LLC

"Excellence in Applied Chemical Engineering"

Process Engineering Associates, LLC
Process Engineering International, LLC

We provide engineering services exclusively via highly qualified chemical engineers and we specialize only in process engineering. Our industrial process design and plant operations experience are extensive. Our companies provide only Chemical Engineering process design and process safety services and currently employ over 50 highly qualified, full-time chemical engineers.

Our services are provided to most industrial process markets including chemical / petro-chemicals, petroleum refining, alternative fuels, power generation, metals/mineral processing industries, foods, pharmaceuticals, and more.

PROCESS' personnel are experienced, highly-motivated Chemical Engineers with track records of significant achievement in the process engineering field.

PROCESS has experience in providing exceptional process design services for the development of conceptual and detail process design, process modeling and simulation, and operations support. Typical services include process option screening studies/evaluations, preliminary process designs (FEL & FEED), comprehensive Schedule A process design packages, detail engineering process support, process construction oversight, startup assistance, and more.

Corporate Office

700 South Illinois Ave.
Suite A-202
Oak Ridge, TN 37830

Phone: +1 (865) 220-8722

Overview of Services

We specialize in process chemical engineering, process design, and process safety.

- Process Design
- Process Modeling/Simulation (CHEMCAD / AspenPlus / HYSYS / etc.)
- Operations Support
- Process Safety Management
- Safety Instrumented Systems / ISA Compliance
- Additional Capabilities

Please visit our websites at http://www.ProcessEngr.com and http://www.ProcessEngr-Intl.com.

Nowadays, this refining scheme is impracticable once purely physical processes are applied and difficultly achieve crude oil conversions sufficiently attractive economically, furthermore, the derivatives produced have high contaminant content, mainly nitrogen and sulfur, making prohibitive the commercialization of these products without break currently environmental regulations.

Another problem with this refining configuration is the large quantity of asphalt and fuel oil produced, these products have low added value and a restrict market, for this reasons the Topping refining scheme make the refinery poor economically uncompetitive, it´s uncommon to find a Topping refinery currently.

The Hydroskimming configuration aggregate conversion and treating processes to the refining scheme, making the refinery operation more profitable and raising the derivatives quality. Figure 2 shows a block diagram for a typical refinery operating under Hydroskimming configuration.

The inclusion of conversion units as Catalytic Reforming and treating like Hydrotreatment raise the derivatives quality and make these products more friendly to the environment, improving the added value and allowing his commercialization according to current environmental regulations, however, the Hydroskimming configuration still show a limited conversion and a large production of low added value products like fuel oil and asphalt.

Cracking configuration adds to the refining scheme process units capable to raise the derivatives recovery from crude oil and units capable to convert residual streams into high-quality derivatives. A Cracking refinery has, beyond the units of Hydroskimming configuration, vacuum distillation unit, Fluid Catalytic Cracking (FCC), Alkylation unit, visbreaking (nowadays, deasphalting units are more common) and MTBE production process (nowadays in disuse too), the last was applied to raise the octane number of the final gasoline.

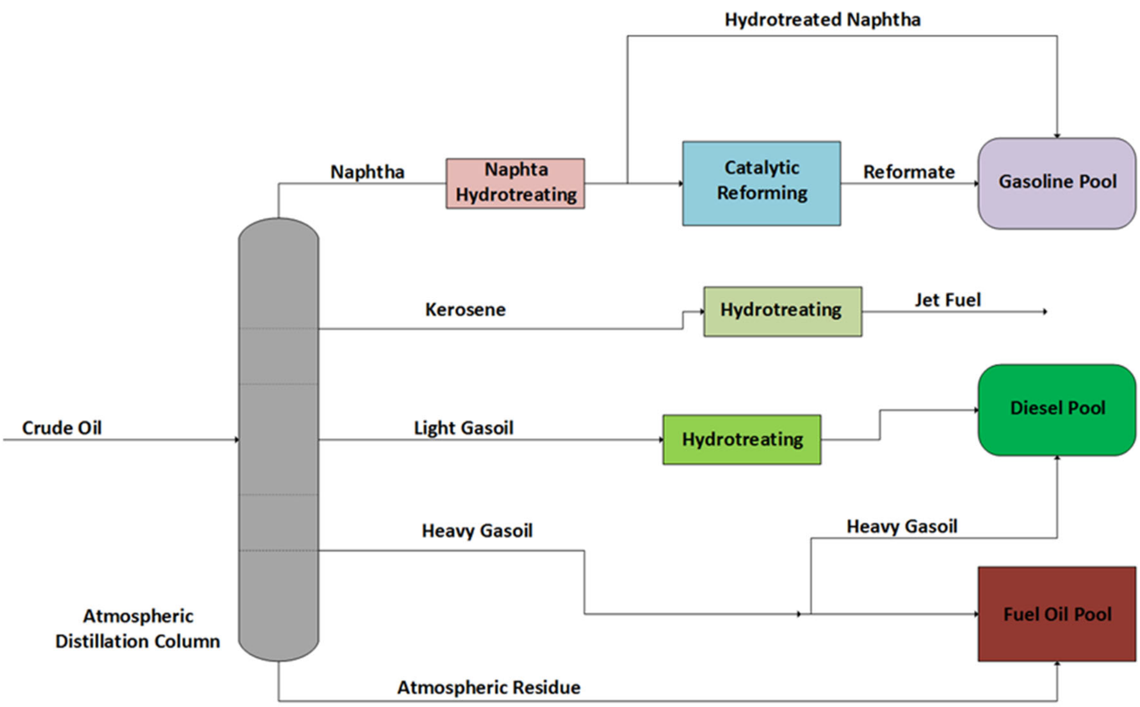


Figure 2 – Block Diagram for a Typical Hydroskimming Refinery

Figure 3 presents a block diagram for a typical refinery operating under cracking refining configuration.

The vacuum distillation unit allows raise derivatives recovery from crude oil, the gas oil produced is fed to a fluid catalytic cracking unit producing cracked naphtha that is incorporated into the gasoline pool, currently, this stream pass through a specific hydrotreatment unit (Cracked Naphtha Hydrotreating Unit) aim to control the contaminants content in the automotive gasoline.

Vacuum residue is fed to visbreaking unit, as aforementioned, in the modern refining schemes is more common the installation of Solvent Deasphalting Units. LPG fractions from FCC unit can be sent to catalytic alkylation and MTBE production units aiming to produce streams capable to raise the octane number of the final produced gasoline.

Diesel production is also elevated in this case through the addition of Light Cycle Oil (LCO) stream into diesel pool, the gas oil produced in the visbreaking unit it's also added to diesel pool, however, currently, it's necessary prior treatment of these streams before the addition to the diesel pool. Another great advantage of the Cracking configuration is the presence of flexible process units like FCC and Catalytic Reforming that can be optimized to maximize the production of petrochemical intermediates in detriment of transportation fuels, allowing a closer integration with the petrochemical sector in according to the current trend of the downstream market.

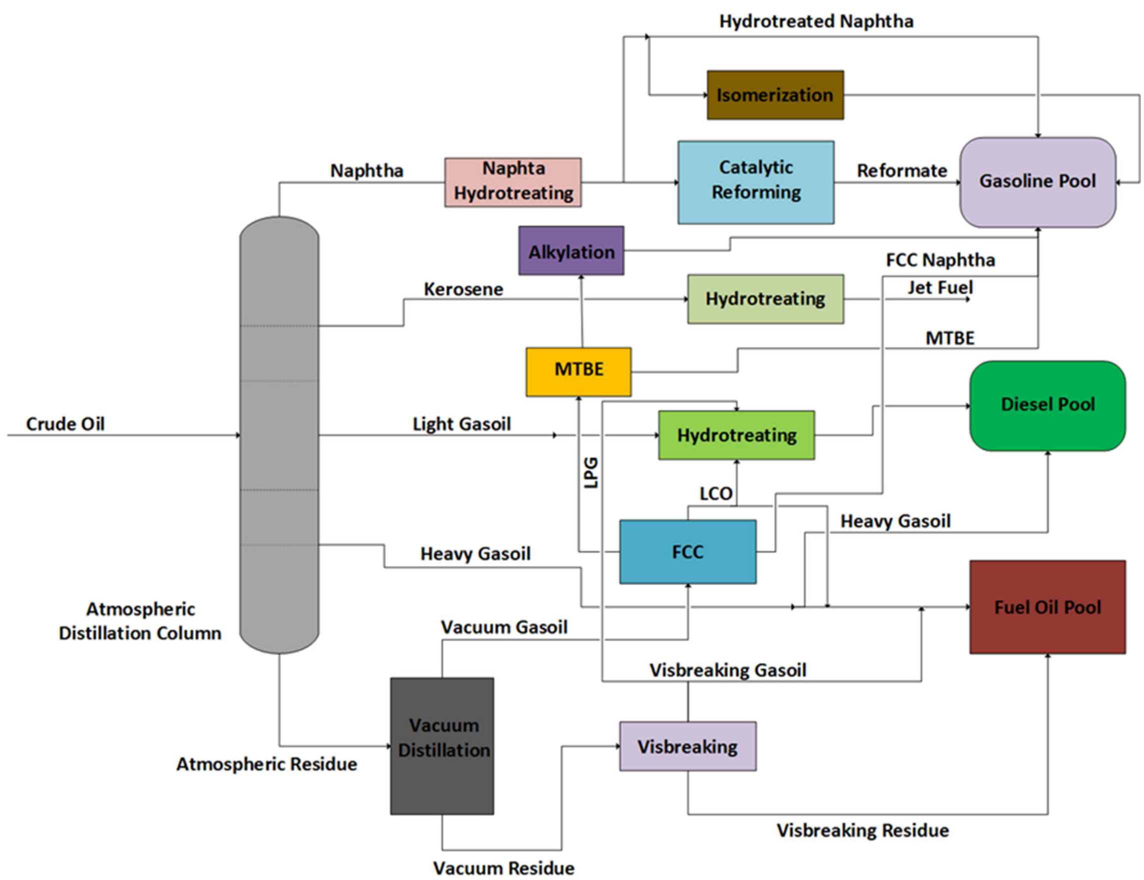


Figure 3 – Typical Process Arrangement to Cracking Refinery Configuration

Despite representing a great evolution when compared with the Hydroskimming configuration, the Cracking refining scheme still conducts production of a large amount of fuel oil, to reduce the low added value derivatives production it's necessary the installation of bottom barrel conversion units, capable to destroy residual streams and convert them into light and middle derivatives, the Coking/ Hydrocracking refining configuration present these characteristics, as presented in Figure 4.

In the case of Coking/Hydrocracking refining scheme, fuel oil production is reduced to the minimum necessary to attend the consumer market, delayed coking and hydrocracking units raise the production of high added value products, like naphtha, diesel and Jet fuel, leading to a significant rise in the refiner profitability.

The improving in the refinery conversion grade rise the complexity of the refining scheme and, despite improve the profitability, operational costs also are higher to more complex refineries, however, the higher volume and better quality of the produced derivatives produces sufficient elevation in the refining margin to cover this additional costs.

Refineries considered high conversion can include in the refining scheme gasification units to consume the coke produced in delayed coking units, these units can be associated to Power generation unit, and an example is the FLEXICOKING™ technology, licensed by ExxonMobil Company.

There are variations of the presented refining configurations, an example is the combination of Fluid Catalytic Cracking and Hydrocracking in the

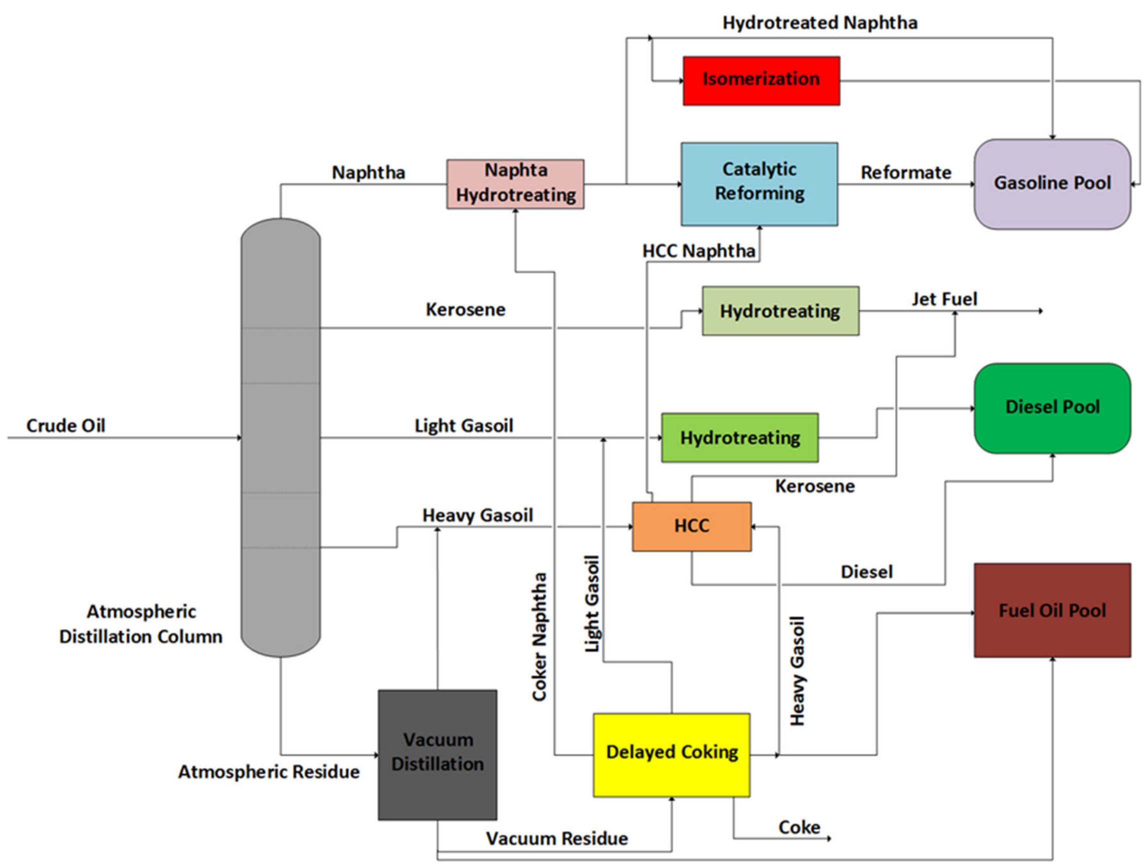


Figure 4 – Process Arrangement to a Refinery Operating Under Coking/Hydrocracking Configuration

same refining scheme, in high conversion units its possible sent the unconverted residue from FCC to Hydrocracking unit, also are common refining schemes that combine catalytic cracking and delayed cocking technologies. The refining schemes showed in this technical note are optimized to produce automotive fuels, some refiners direct part of the derivatives to petrochemical intermediates market due the high profitability and necessity to attend a specific consumer market.

Conclusion

As aforementioned, the choice of the adequate refining scheme depends on the assumptions that were adopted in the refinery concept step, main production focus (fuels or lubricants, for example) and the consumer market that will be attended. More complexes refining schemes improve the refinery competitiveness once makes it more flexible in relation to crude oil which will be processed, these are strategic characteristics to the current scenario of the refining industry. A higher conversion capacity of bottom barrel streams is fundamental to refiners in the short term scenario of the downstream sector once new regulations like IMO 2020 will require a drastic reduction in the sulfur content of bunker (marine fuel oil), in this sense the refiners with low conversion capacity, inevitably, will lose competitiveness and market share in the short term.

About the Author

Dr. Marcio Wagner da Silva is Process Engineer and Project Manager focusing on Crude Oil Refining Industry based in São José dos Campos, Brazil. Bachelor in Chemical Engineering from University of Maringa (UEM), Brazil and PhD. in Chemical Engineering from University of Campinas (UNICAMP), Brazil. Has extensive experience in research, design and construction to oil and gas industry including developing and coordinating projects to operational improvements and debottlenecking to bottom barrel units, moreover Dr. Marcio Wagner have MBA in Project Management from Federal University of Rio de Janeiro (UFRJ) and is certified in Business from Getulio Vargas Foundation (FGV).

References:

ROBINSON, P.R.; HSU, C.S. Handbook of Petroleum Technology. 1a ed. Springer, 2017.

FAHIM, M.A.; AL-SAHHAF, T.A.; ELKILANI, A.S. Fundamentals of Petroleum Refining. 1st ed. Elsevier Press, 2010.

GARY, J. H.; HANDWERK, G. E. Petroleum Refining – Technology and Economics. 4thed. Marcel Dekker., 2001.

Process Design Considerations for Instrument Air Systems

Jayanthi Vijay Sarathy, M.E, CEng

Abstract

Industrial process facilities consist of a wide variety of pneumatically operated equipment which needs to be provided with a motive force for operation. Towards this, ambient air is one of the commonly used motive fluids to operate.

In an Oil & Gas project, the primary step is to assess the number of elements that need instrument air (IA) and capacities of each element (e.g., Control valve) to determine the required instrument air system capacity. The following article focuses on sizing an IA air receiver vessel as well as some of the design considerations to made for an IA system.

Typical Layout & Operation of Instrument Air (IA) System

A typical layout of an Instrument Air system is shown below,

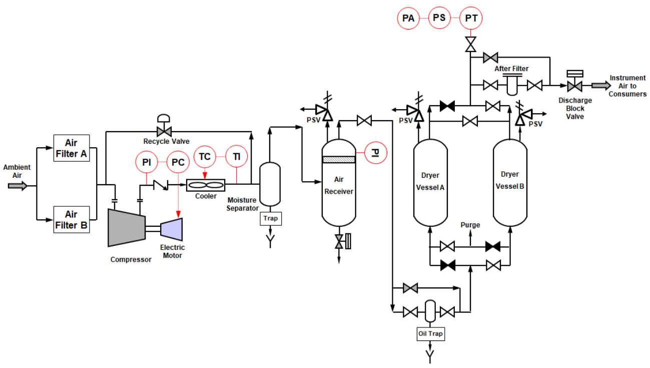


Figure 1. Schematic of Compression System

The main components of an instrument air system consist of an inlet air filter to decontaminate the atmospheric air of dust and debris, an air compressor to produce instrument air at the required pressure, a cooler to cool the hot air from the compressor discharge, a moisture separator to remove any condensates from the compressed air, an air receiver that stores the compressed air, a set of molecular sieve air dryers that act as a desiccant to dry the instrument air to the required dew point. Air dryers are operated in cycles whereby when one dryer is under operation, the other dryer is regenerated by removing water vapour using a pressure swing adsorption (PSA) process.

IA Receiver Design Considerations

A key component of the Instrument Air System is the Air Receiving Vessel. The IA Receiver when designed must consider the following factors

1. ***Minimize Pressure Fluctuations*** – To meet IA consumers' demands and during emergency shutdown scenarios, it becomes a necessity to reduce pressure fluctuations. This also means that sufficient pressure at a steady rate must always be available for processes that use IA and is measured in units of time (minutes).
2. ***Short Term Air Demand*** – In process facilities often the demand for instrument air (IA) can fluctuate sometimes reaching a peak. This needs to be accounted for in the air compressor capacity estimates along with sufficient storage volume in the associated IA receiver to accommodate the peak demand IA flow rates.
3. ***Energy Savings*** – Instrument Air Systems run frequently consuming power & it becomes imperative to achieve power savings by operating (loading/unloading) the air compressor only as and when required. When the pressure in the IA Receiver drops below a threshold, the IA compressor is loaded to achieve the required pressure in the IA Receiver. Sizing the IA Receiver for longer cycles enables to cut own on power consumption while providing a steady flow of IA to the end users.

Instrument Air System Design

To evaluate the process data of an instrument air unit, a example case study is used to explain. An Instrument air package is to be designed to deliver 600 ACFM of dry air at 8 barg to pneumatic device users. The ambient location is 20^{0}C, with a relative humidity (RH) of 60%. The barometric pressure is 1.01325 bara. The IA delivered to the IA receiver is required to be ~30^{0}C. The IA Receiver is charged/discharged through a 10 sec cycle & the operating pressure band between lower and upper pressure of the IA vessel is 10 psi. From Steam Tables, moisture content in free air is as follows,

Table 1. Mass of H_2O in Air (kg.H_2O/m^3 Free Sat. Air)

Tempera-ture	Pressure	
[°C]	0 barg	8 barg
0	0.0045	0.00051
20	0.018	0.0019
40	0.059	0.0062
60	0.18	0.017
80	0.65	0.041

Water Condensation in IA Receiver

To estimate the amount of water that condenses in the wet air IA Receiver, the mass of water in air at 100% RH is taken from Table 1.

Water Content in saturated air [100% RH] entering compressor [0 barg] = 0.018 kg H_2O/m^3

Water Content in IA compressor suction at 60% RH = RH x Water Content at 100% RH = 0.6 x 0.018 = 0.0108 kg H_2O/m^3 Air

Water Content at IA Comp. Discharge [100% RH] at 8 barg = 0.00341 kg H_2O/m^3 Air [Table 1]

Water extracted from compressed air discharge and drained via IA Receiver Liquid Outlet = 0.0108 – 0.00341 = 0.00739 kg H_2O/m^3

Water drain rate in IA Wet Receiver = 0.00739 x (600 x 0.0283168) x 60 = 7.5 kg.H_2O/h

Relative Humidity [RH] of Air Leaving the IA Receiver to Air Dryer = 0.00341/0.018 = 19%

Pressure Dew Point in IA Inlet & IA Receiver

The pressure dew point of the instrument air processed at the IA compressor inlet and IA Receiver Exit can be calculated using Arden-Buck equation as follows,

$$\gamma_m[T,RH] = ln\left[\frac{RH}{100}e^{\left(b-\frac{T}{d}\right)\left(\frac{T}{c+T}\right)}\right]$$

(1)

$$T_{Dew\ Point} = \left[\frac{c\times\gamma_m[T,RH]}{b-\gamma_m[T,RH]}\right]$$

(2)

Where,

Constant 'b' = 18.678 ; Constant 'c' = 257.14 ^{0}C ;

Constant 'd' = 234.50 ^{0}C ; RH = Relative Humidity

Therefore, the pressure dew point at IA Compressor Inlet is,

$$\gamma_m[20^0C,60\%] = ln\left[\frac{60}{100}e^{\left(18.678-\frac{20}{234.5}\right)\left(\frac{20}{257.14+20}\right)}\right]$$

(3)

$$\gamma_m[20^0C,60\%] = 0.831$$

(4)

$$T_{Dew\ Point} = \left[\frac{257.14\times0.831}{18.678-0.831}\right] \approx 12^0C$$

(5)

The pressure dew point at the air leaving the IA Receiver is computed as,

$$\gamma_m[30^0C,19\%] = ln\left[\frac{19}{100}e^{\left(18.678-\frac{30}{234.5}\right)\left(\frac{30}{257.14+30}\right)}\right]$$

(6)

$$\gamma_m[30^0C,19\%] = 0.274$$

(7)

$$T_{Dew\ Point} = \left[\frac{257.14\times0.274}{18.678-0.274}\right] \approx 3.8^0C$$

(8)

Instrument Air Receiver Size

The Instrument Air Receiver which collects the compressed gas is sized based on the principle of excess pressure in the IA receiver volume in which the quantity of stored compressed air is above the facility's requirements. Using the actual volume flow rate flowing into the IA Receiver, the storage volume, taking into account the time cycle for charging/discharging, pressure band & barometric pressure, can be computed as,

$$V_{IA\ Receiver} = \left[\frac{Q_c\times f\times P_a}{(P_U-P_L)}\right]$$

(9)

Where,

Q_c = Instrument Air Capacity [ACFM]

f = Charge/Discharge per IA Receiver Cycle [sec]

$P_U – P_L$ = Pressure band of IA Receiver [psia]

P_a = Barometric Pressure at Location [psia]

Therefore, the volume of the IA receiver is computed as,

$$V_{IA\ Receiver} = \left[\frac{600\times10\times14.7}{60\times10}\right] = 147\ ft^3$$

(10)

Or, $V_{IA\ Receiver} \approx 4.2\ m^3$

(11)

IA Dew Point at Atmospheric Pressure

The performance guarantee parameter for most industrial IA systems is based on a typical dew point requirement of -40°C at atmospheric pressure at the outlet of the air dryer. In the current undertaking, no calculations are shown for air dryer unit, however taking the IA receiver process conditions, it can be estimated, what should be the air dryer's pressure dew point (i.e., at 8 barg) to achieve a performance guarantee dew point of -40°C at 1 atm at the air dryer outlet.

To estimate the dew point at atmospheric pressure, the following dew point graph between atmospheric pressure & indicated pressure is used.

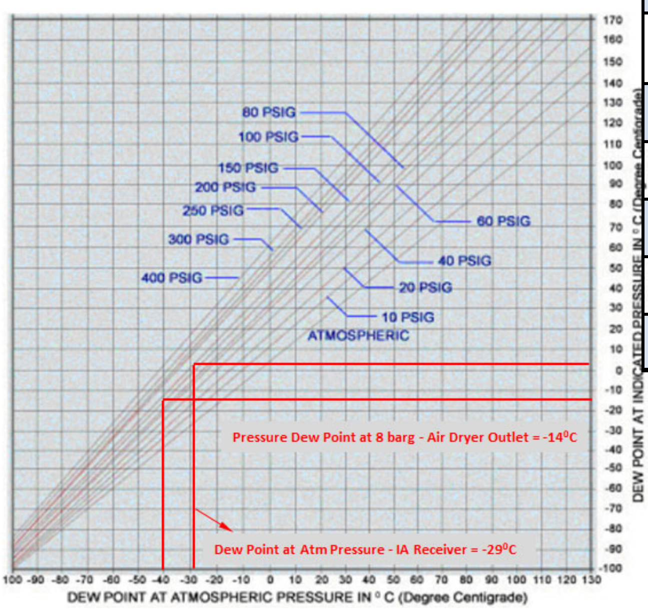


Figure 2. Air Dew Point Conversion Chart

From Fig. 2, for a pressure dew point of 3.8°C at 8 barg in IA Receiver, the dew point at 1atm is -29°C. Therefore for achieving an atmospheric dew point of -40°C at the air dryer outlet, the pressure dew point temperature should be -14°C at the air dryer outlet. To estimate the relative humidity [RH] at air dryer outlet for an atmospheric dew point of -40°C, Eq. (1) and Eq. (2) can be re-arranged as,

$$\gamma_m[T,RH] = \left[\frac{b\times T_{DP}}{c+T_{DP}}\right]$$

(12)

$$RH = \left[\frac{e^{\gamma_m[T,RH]}}{e^{\left(b-\frac{T}{d}\right)\left(\frac{T}{c+T}\right)}}\right]\times 100$$

(13)

Assuming the temperature rise in the air dryer is 40°C, the RH of the IA exiting the air dryer is,

$$\gamma_m[T,RH] = \left[\frac{18.678\times(-14)}{257.14+(-14)}\right] = -1.075$$

(14)

$$RH = \left[\frac{e^{-1.705}}{e^{\left(18.678-\frac{40}{234.5}\right)\left(\frac{40}{257.14+40}\right)}}\right]\times 100 = 2.8\%$$

(15)

Table 2. IA System Results Summary

Parameter	Value	Units
H_2O Extracted in IA Receiver	0.0074	$kg.H_2O/m^3$
H_2O Condensate in IA Receiver	7.5	$kg.H_2O/h$
Air RH leaving IA Receiver	19	%
$T_{Pressure\ Dew\ Point}$ - IA Comp. Inlet	12.0	°C
$T_{Pressure\ Dew\ Point}$ - IA Receiver	3.8	°C
$T_{Pressure\ Dew\ Point}$ – Air Dryer Exit	-14.0	°C
Instrument Air Receiver Size	4.2	m^3

IA System Design Considerations

1. In process facilities, it is prudent to install IA systems with a 1W + 1S configuration. The standby IA system can be diesel driven or steam driven, subjected to the utility available.
2. For most utility applications, nominal instrument air line pressure for the utility industry should be ~690 kPa (100 psi).
3. Since most industrial facilities operate with IA air at about 7 barg to 8 barg, the set pressure of the relief valve (RV) must be set higher accordingly but must not exceed the vessel design pressure.
4. The IA distribution lines must be sized such that the line pressure drop is not more than 1 bar between the air dryer outlet and the farthest user of IA. Typically, a user can be considered to use 0.015 m3 (0.5 SCF) of air per minute.
5. Air dryer regeneration methods are of two types – Air purge regeneration & Heater regeneration. Air purge regeneration is a commonly used method where the packed column of molecular sieves is dried by diverting a fraction of the dry air from the active air dryer vessel enabling adsorption of the moisture and expelling via a purge line. Whereas in heater regeneration methods, a heater-blower setup is installed in the regeneration line that heats ambient air & routes the heated air through the regenerating dryer. The hot air heats the regenerated dryer till the moisture reaches boiling point and is subsequently expelled through the purge line.
6. The regeneration time of each air dryer shall not be more than 6 hours as per IPS–G-IN-200 (2). The recommended cycle time between regeneration cycles for normal operation is 6 hours for regeneration and 2 hours of standby. The maximum allowable cycle time between regeneration cycles is 6 hours for regeneration and 4 hours standby. Hence the air dryers must be designed to be capable of drying for at least 10 hours without increase in dew point.
7. The air dryer adsorption operation is exothermic & causes the dried air to reach as high as 60^0C. If its temperature is not expected to cool to ~40^0C, additional after-coolers would be required at the air dryer outlet.
8. After coolers can be air-cooled type or water-cooled type. Water-cooled aftercoolers are usually sized to cool outlet air to within ~5°C to 8°C of the inlet cooling water temperature. to leakage from particulate scoring.

   Whereas Air-cooled aftercoolers are usually sized to cool outlet air to within 14°C to 17° C of the ambient air temperature
9. Compression increases the partial pressure of the water vapour present. If the water vapour partial pressure is increased to the saturation water vapour pressure, condensation occurs. If the saturation water vapour pressure is reduced to the partial pressure of the water vapour present, water or ice will result. Therefore, moisture removal is a major consideration of instrument air treatment systems. Water droplets entrained in the air can initiate the formation of rust or other corrosion products which block internal passageways of electric to pneumatic converters resulting in sticking and/or binding of moving parts. Water droplets can also obstruct the discharge ports on solenoid air pilot valves thus reducing their ability to function properly. Therefore an automatic drain (e.g., timer drain, float drain or an electronic drain) with a manual bypass should be located near the bottom of the air receiver to dispose of the condensate.
10. In cold climates, water extracted from the atmospheric air accumulates at the low points in the IA system. Hence, in such cold climates, insulation and steam tracing should be provided to both piping as well as up to a sufficient height from the bottom portion of the air receiver.
11. For the design and construction of the vessels, ASME Boiler and Pressure Vessel Code, Section VIII, Div. 1 or any other approved standard of equivalent authority is acceptable. For design, fabrication, erection and testing of piping ASME B16.5 and ASME B31.3 are acceptable.
12. In IA distribution systems, commonly used types of valves are globe valves, gate valves & ball valves. Globe valves provide the advantage of regulating system flow rates & provide tight shut-off. On the down side, they cause reduced flow rates, increased pressure loss, and allow places for particulates to collect causing valve leakages. Gate valves & Globe valves are used for On/Off isolation & provide full, line-size port for air flow with minimal pressure drop and are conducive to internal cleaning. The disadvantages of gate valves are that they allow particulates to collect in disc guides, and valve discs can separate from their stems. The disadvantage of ball valves is that they are more expensive than comparably-sized globe or gate valves, and their sealing surfaces are

ANNEXURE A: Saturation Vapour Pressure at Dew Point & Actual Vapour Pressure

The saturation vapour pressure of air at its dew point can be calculated as,

$$P_1 = 6.1078 \times 10^{\left[\frac{7.5 \times T_{Dew\ Point} \times 14.7}{T_{Dew\ Point} + 237.3}\right]}$$

(16)

Actual vapour pressure is, $P_v = P_1 \times RH$

(17)

For air leaving IA receiver at T_{DP} of 3.8^{0}C & 19% RH

$$P_1 = 6.1078 \times 10^{\left[\frac{7.5 \times 3.8 \times 14.7}{3.8 + 237.3}\right]} = 8\ hPa$$

(18)

$$P_v = 8 \times 0.19 = 1.59\ hPa$$

(19)

References

ANSI/ISA-7.0.01-1996, "*Quality Standard for Instrument Air*", 12th Nov 1996

IPS-G-IN-200(2), "*General Standard For instrument Air Systems*", 2nd Edition, Feb 2016

Engineering ToolBox, (2008), Compressed Air and Water Content

https://www.omnicalculator.com/physics/air-density

http://www.nationalcompressedair.com/dat/files/600.pdf

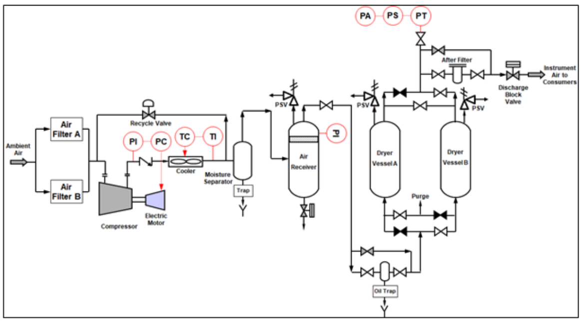
ANNEXURE B: MS Excel Calculation Sheet

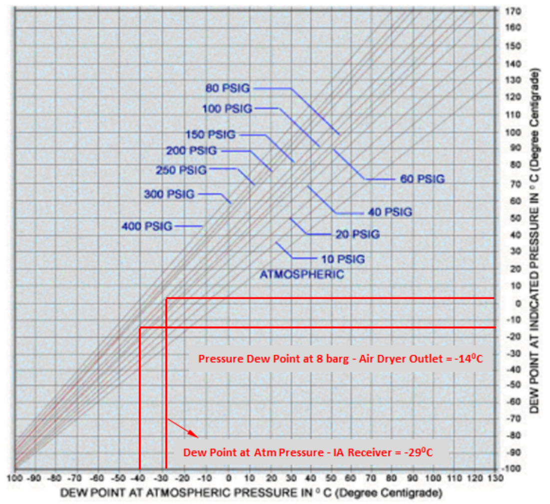
Plant Instrument Air Receiver - Process Design Tool

Standard Pressure [P_S]	1.01325	[bara]
Standard Temperature [T_S]	273.15	[K]
Ambient Pressure [P_1]	0	[barg]
IA Compressor Suction Temperature [T_1]	20	[°C]
Ambient Air Relative Humidity [RH]	60	[%]
IA Compressor Discharge Pressure [Saturated] [P_2]	8	[barg]
IA Compressor Cooler Temperature [Saturated] [T_2]	30	[°C]
Compressor Flow Capacity [Q_C]	4973	[SCFM]
	600	[ACFM]
	0.2832	[Am^3/s]
Water Content at 100% RH [Atmospheric Conditions]	0.0180	[$kg.H_2O/m^3$ free air]
Water Content in IA Compressor Suction [60% RH]	0.0108	[$kg.H_2O/m^3$ free air]
Water Content in IA Compressor Discharge [100% RH]	0.0034	[$kg.H_2O/m^3$ free air]
Water Extracted inIA Receiver & Sent to Drain	**0.0074**	[$kg.H_2O/m^3$ free air]
	0.690	[$g.H_2O$/kg free air]
Water in Air Leaving the IA Receiver	**0.318**	[$g.H_2O$/kg free air]
Water Drain Rate in Wet Air IA Receiver	**7.5**	[$kg.H_2O/h$]
Air Relative Humidity [RH] - IA Receiver Exit to Air Dryer	**19**	[%]
Dew Point Calculation [Arden-Buck Method]		
Constant 'a'	6.1121	[mbar]
Constant 'b'	18.678	[-]
Constant 'c'	257.14	[°C]
Constant 'd'	234.5	[°C]
γ(T, RH) at IA Compressor Inlet	0.831	[-]
Pressure Dew Point [$T_{Pressure\ Dew\ point}$] at IA Compressor Inlet	**12.0**	[°C]
γ(T, RH) at IA Receiver Exit	0.274	[-]
Pressure Dew Point [$T_{Pressure\ Dew\ point}$] at IA Receiver Exit	**3.8**	[°C]
Instrument Air Receiver Size		
IA Compressor Capacity [Q_C]	**600**	[ACFM]
Charge/Discharge per IA Receiver Cycle [f]	10	[sec]
Pressure Band of IA Receiver [P_U-P_L]	10	[psi]
Instrument Air (IA) Receiver Size [$V_{Receiver}$]	**147**	[ft^3]
	4.16	[m^3]
Air Dryer Process Design		
Required Dew Point at 1 atm Pressure at Air Dryer Outlet	-40.0	°C
Temperature Rise in Air Dryer	40.0	[°C]
Pressure DP required at Air Dryer Outlet [8 barg] for -40C Atm DP [DP Conv. Graph]	-14.0	[°C]
γ(T, RH) at IA Air Dryer Outlet	-1.075	[-]
Relative Humidity [RH] Required at Air Dryer Outlet for -40C Atm DP	**2.82**	[%]
SUMMARY		
Water Extracted & Sent to IA Receiver Drain	**0.00739**	[kg H_2O/m^3]
Water Drain Rate in Wet Air IA Receiver	**7.5**	[kg H_2O/h]
$T_{Pressure\ Dew\ point}$ at IA Comp. Inlet	**12.0**	[°C]
$T_{Pressure\ Dew\ point}$ at IA Receiver Exit	**3.8**	[°C]
$T_{Pressure\ Dew\ point}$ Required at Air Dryer Outlet	**-14.0**	[°C]
Instrument Air (IA) Receiver Size [$V_{Receiver}$]	**4.16**	[m^3]

Mass of Water in Air (kg.H_2O/m^3 free saturated air)

Temperature (°C)	Pressure (barg) 0	2	4	6	8
0	0.0045	0.0015	0.00091	0.00065	0.00051
20	0.018	0.0058	0.0035	0.0025	0.0019
40	0.059	0.019	0.011	0.0079	0.0062
60	0.18	0.053	0.031	0.022	0.017
80	0.65	0.14	0.078	0.054	0.041
100	-	0.38	0.19	0.13	0.094
120	-	-	0.49	0.29	0.21





Density of Air [Based on RH]

Saturation Vapour Pressure at Dew point [p_1]	8.0	[hPa]
Actual Vapour Pressure [p_v]	1.52	[hPa]
Pressure of Dry Air [p_d] at IA Receiver Exit	9012	[hPa]
Density of Air [ρ_{Air}] at IA Receiver Exit	**10.71**	[kg/m^3]

About the Author

Vijay Sarathy holds a Master's Degree in Chemical Engineering from Birla Institute of Technology & Science (BITS), Pilani, India and is a Chartered Engineer from the Institution of Chemical Engineers, UK. His expertise over 12 years of professional experience covers Front End Engineering, Process Dynamic Simulation and Subsea/Onshore pipeline flow assurance in the Oil and Gas industry. Vijay has worked as an Upstream Process Engineer with major conglomerates of General Electric, ENI Saipem and Shell.

High Rate Downflow Filtration for Industrial Use

Robert Thomas

Introduction

High rate downflow single or multi-media filters can operate at a hydraulic service flowrate through the bed of between 5 to 25 gpm/Sq.Ft. (ft2). The filter vessels can be either vertical or horizontal in configuration.

This type of filter can be utilized as a single vessel or can be grouped on a skid with each vessel typically handling 100% flow rate, 50% flowrate or 33% flowrate etc.

When 2-100% units are included one is in service and one in standby, if 3-50% units are included two units are in service and one in standby, and if 4-33% units are included the three units are in service and one is in standby. The service cycles are staggered so that there is no interruption when one unit reaches its end point and must come out of service to be cleaned, and the standby unit then goes into service.

Typical Filter Operating Technique

Typical Operating and Cleaning Sequence

STP.	SEQUENCE	MINUTES
1	In Service	1440
2	Out of Service	1
3	Draindown (vent open)	6 (approx.)
4	Air scour	3
5	Slow backwash	1
6	Fast backwash	3
7	Pause	1
8	Draindown (vent open)	5
9	Air Scour	3
10	Slow backwash	1
11	Fast backwash	3
12	Pause for bed settling	1
13	Rinse	3
14	Ready for Service	

The flow during the in service step is in the downward direction through the filter bed. The filter remains in service until a predetermined run time has elapsed, the differential pressure through the bed is reached or the turbidity of the effluent is out of range. Once any one of these predetermined points have been reached the filter is taken out od service either manually or automatically using a programmable controller mounted in a system control panel. At this time the unit will be out od service and subjected to a cleaning cycle.

Filter Internals

Inlet Distribution – The inlet distribution system is located at the top of the filter and can be a simple splash plate or an efficient hydraulically balance header lateral system with either slotted laterals or laterals equipped with spray nozzles. The header lateral system allows for even distribution of water across the entire cross section of the filter bed below, which helps to combat any water channeling at the top of the bed, which if allowed will lead to inefficient operation and a short service cycle.

Outlet Collection System – The effluent collection system is located at the bottom of the filter within the supporting bed of the active filtration bed. The most efficient collection system is a header lateral system similar to the inlet distribution system. This system has two functions, one to collect the effluent from the filter and direct it to the downstream piping and the other is to act as the backwash water distribution system to distribute the backwash water evenly across the bed area so that the bed is lifted evenly during the backwash cycle.

Materials of Construction and Design – Both the inlet and outlet systems can be constructed of various materials, with the most common being PVC or stainless steel. Regardless of the material used adequate support must is required to ensure that the distributers are not stressed during either the service or cleaning cycles. The design of both must be such so that the loss of bed material is minimized during any operation, service or cleaning. PVC material is slotted with slot size to prevent media loss and stainless steel is usually wedge wire wrapped sized to prevent media loss.

Filter Operating Range

The High Rate Downflow Filter has an inlet water operating range of from 1.0 ppm to 100 ppm of suspended solids and from 2.0 ppm to 50 ppm of free oil or grease. With the correct selection of the filter size, media and operating chemicals these filters will produce very good effluent water characteristics.

Typical Applications

Plant Make-Up – Typically river water, where the expected suspended solids may be anything from organics to clay in the range of 10-300 ppm. If the solids loading exceeds 100 ppm, pretreatment such as clarification should be considered.

The maximum flux rate for these filters can be between 5-25 gpm/ft.2 depending on the inlet water solids loading.

With proper design an effluent quality water with 85-90% of particulate ≥ 10 micron (μ) removed can be achieved without chemical assistance.

City Water Make-Up – The expected suspended solids are usually 10 - 2 ppm.

The flux rate for these filters can be between 10-25 gpm/ft.2

The effluent quality water achieved can be 95-98% of particulate ≥ 2-5 micron (μ) removed which can be achieved without chemical assistance.

Oily Water Ponds – Extreme conditions may be as high as free oil of 50ppm with suspended solids as high as 250 ppm.

Filter flux should be in the range of 8-12 gpm/ft.2

The effluent quality for free oil, depending on location and country can range from15 ppm to 29 ppm.

Cooling Towers – Generally the filtration sizing is based on percent of the side stream rate of the total flow, anywhere from 5-10% of the total cooling tower flow.

The flux rate for the cooling tower filter can be up to 25 gpm/ft.2 maximum for a service run of 10-12 hours.

With proper design an effluent quality water with 85-90% of particulate ≥ 10 micron (μ) removed can be achieved without chemical assistance.

Industrial Wastewater – This type of waster water may contain oil, grease, chemicals, solvents suspended solids as well as organic and inorganic material. The companies producing this kind of water waste range from a large range of manufacturer's, food , textiles, petroleum chemicals and plastics to name a few.

The filter applications for this type of water need to be evaluated on a case by case basis to determine flux rates, run times and the chemicals that may be required to achieve the necessary effluent quality.

Filtering Mechanisms

When using a graded bed of granular media to capture suspended solids (TSS) or free oil several different mechanisms can be used to achieve the goal of TSS or oil removal.

Surface Straining – The particulate is larger than the interstices (Pores) between the media and therefore cannot enter the bed. In this case the particulate accumulates on the beds surface which soon blinds over the bed surface creating a high Delta P (ΔP) and a short run length.

Particle Bridging – Several particles cling together and bridge an interstice thereby blocking further flow through the passage.

Interstitial Straining – As particulate proceeds deeper into the bed they may encounter reduced space between the media, the interstitial space, if the pore diameter is smaller than the particulate, potentially straining out the particulate, causing carry over to the bed below.

Adsorption - Can occur when the particulate to be filtered has an electrostatic charge which opposes the charge of the media. This can cause the particulate to become attached to the media as it flows downward and will cause service run time and channeling in the media bed.

Chemical Assistance – A polyelectrolyte can

HEAT TRANSFER TECHNOLOGY

PT. WARU TEKNIKATAMA

Waru Teknikatama designs and fabricates heat exchangers, pressure vessels and other equipment to accomplish highest degree of client satisfaction.

Products | Air Cooled Heat Exchangers | Shell & Tube Heat Exchangers | Pressure Vessels | Plate Heat Exchangers | Other Equipment

Services | Heat transfer related calculation, design and development & troubleshooting | Detail Design Packages : Mechanical, Civil, Electrical Engineering design of plant | After Sales Services by providing spare parts and special tools for heat exchangers

Codes & Standards

Pressure Vessel : ASME Sec VIII Div 1&2, PD 550
ACHE : API 661, ASME Sec VIII Div 1
STHE : TEMA, API 660, ASME Sec VIII Div 1&2
Storage Tank : API 650, API 620, AWWA D100
Piping System : ASME Sec I, ASME B31.3, B31.4, B31.8
Condenser : HEI (Heat Exchanger Institute)
LP Heater
HP Heater
Deaerator

Certifications

ASME U, U2, S
The National Board of Boiler and Pressure Vessel Inspectors (NB & R)
ISO 9001 : 2008
HTRI Member

Head Office
Unimas Garden Regency
Jl. Imermotors F-18
Waru, Sidoarjo 61256 – Indonesia
Phone : +62 (0) 31 853 3643,
853 3591, 854 9184
Fax : +62 (0) 31 853 3591
www.waruteknikatama.com
waru@waruteknikatama

Workshop
Desa Domas. Km 11, Trowulan, Mojokerto, East Java, Indonesia

Cert.No. JKT 6006851

ASME - S AND U Stamp

enhance the charge of either the particulate or the media.

Coagulation - Using a polyelectrolyte will cause smaller particulate to agglomerate allowing the interstitial and surface straining mechanisms to operate more effectively.

Media Selection

High Suspended Solids without Free Oil or Grease Present – Maximum TSS loading is 100 ppm. Use a coarse media for holding capacity and a fine media to achieve better clarity. This is achieved by using a dual or tri-media media bed.

High/Low Suspended Solids with Free Oil Present – Never use sand when free oil is present. Use anthracite and garnet when oil is present. With the use of chemicals, and testing at reasonable intervals, removal efficiencies of as high as 98% can be achieved.

Cleaning Techniques

Air Scour – Air scouring helps reduce the backwash water volume required in the cleaning cycle. The air bubbles essentially help to create a void by moving the media particles aside. This void progressively collapses as the bubbles pass up through the bed causing a collision of the particulate which helps to release the attached particulate and or oil droplets. This allows the backwash water to more easily carry them out of the filter.

Note that when there is a presence of hydrocarbons that safety issues may be created if air is mixed with the hydrocarbon vapor. In these cases, gas should be used for the air scour step rather than air.

Backwash – The backwash rate in gpm/ft.2 is determined by the media used and the backwash water temperature. These parameters must be used to ensure that the bed expansion desired is achieved for proper cleaning of the media.

Surfactant Wash – When oil is present, gas for the air scour and a surfactant wash should be used for effective removal of the free oil from the media.

Filter Freeboard

Th height between the top of the filter bed and the lowest internal point at which the water is discharged from the filter.

Filter Sizing

Filter Loading and Bed Holding Capacity – The maximum suspended solids loading, for design to consider for each filter is 100 ppm. The dirt loading capacity to be considered is between 1-4 pounds per square foot of media bed surface area.

Conclusion

It should be noted that many people now promote the use of membrane filtration over conventional media filtration. This is fine when very low micron size particulate need to be removed, such as upstream of a reverse osmosis system. Further, walnut shell media is now used for many free oil applications.

However, for more conventional applications as discussed here, media or multi-media filtration is more than adequate for the applications discussed, and has worked well for any application that requires particulate removal of up to 98% removal of ≤ 2 micron, in many cases without the necessity of chemical usage. The operation of these units, and the upkeep and maintenance required of these systems is much less rigorous that that required for membrane filtration systems.

About the Author

Bob Thomas has been in the water treatment business since 1967. He attended the evening division of Widener University. The basis for this article is a design guide he did for Serck Baker. He has been Vice President of several companies, most notably Modular Production Equipment where he was not only the V.P of Business Development but also the engineering manager, President of his own companies, Fluid technologies, and has worked for and as a consultant to many OEM Water Treatment companies, EPC's and major oil companies. Fluid Technologies will be pleased to help you solve any water treatment problems you may have, whether Boiler Feedwater Systems, Produced Water Systems, Sea Water Injection Systems, Sulphate Removal Systems or Injection Systems which require Low Salinity effluent for EOR. We hope you find this article interesting and we look forward to publishing more articles on all types of water treatment systems as well as design information on both the systems and their specific equipment.

Quarterly Safety Connector

For Engineers; Because Safety Is Part Of The Process! By: Chris Palmisano, MESH, IFSAC June 2019

Golf Carts, Not Just for Golf!

Golf carts have become popular in private industry. These breezy little vehicles are affordable, easy to operate, and a convenient way to transport people, tools, equipment and supplies around a refinery.

Safety is important for any kind of vehicle, and golf carts are no exception. While golf carts travel at low speeds, they typically lack seat belts, lighting and other safety features typically found on road vehicles and, they can cause serious accidents, fire and or injuries.

About 13,000 people each year are treated in the U.S. for injuries caused by golf cart accidents. To maximize safety, it's imperative to have a policy for golf cart use that follows general safety principles, manufacture's guidelines and requires all drivers to be trained in their operation.
The recommendations to be considered are many throughout development of your organization's golf cart safety plan.

Safety Plans & Recommendations

Require a driver's license. While it may be legal to **operate a golf cart without a driver's license in many states, consider limiting golf cart driving privileges, ONLY to experienced, licensed drivers.**

Set a speed limit. Golf cart speed can often be mechanically governed. They typically are set at approx. 16 miles an hour, but some golf carts can go up to 25 miles an hour. Consider setting speed limits and/or governing speed settings.

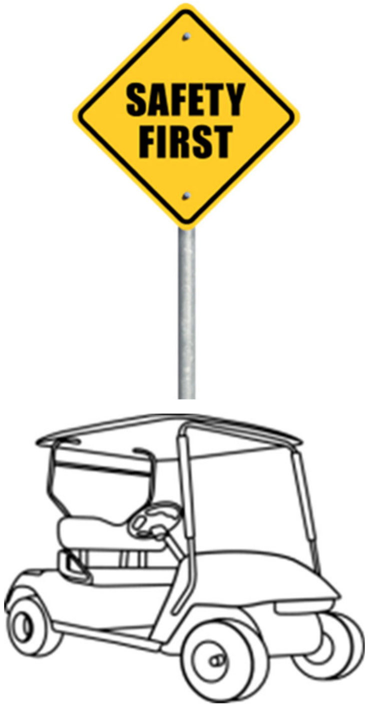
Establish cart paths. Golf carts are designed for smooth surface travel. Setting out a distinct cart path can help keep passengers safe and prolong the life of your carts. Driving paths should be relatively, smooth, flat and dry without sharp turns.

Be careful in parking lots. Roaming Golf Carts and Pedestrians make for a maze of potential hazards for Vehicle Operators. Cart Drivers should take care when moving through active parking areas, always yielding to pedestrians and automobiles.

Reduce Distractions. Discourage the use of radios, cell phones, side conversations, and eating or drinking while driving.

Follow Manufacturer Guidelines. Golf carts come with instructional manuals that deal with safety issues. Follow the manufacturers' safety guidelines, especially for fire and operator safety.

Golf Cart Safety



Operational Procedures

List your procedures for safe golf cart operations. Use the examples below as a guide and add your own organization specific procedures to help meet your needs.

- Golf carts must be operated only by those employees whose duties makes it necessary for them to operate over significant distances or to move equipment that is difficult to move by hand. Designate which employees are authorized to operate golf carts.
- Employees may not operate golf carts until they have been fully trained and authorized. Contract employees, trainees, and visitors should be prohibited from operating your organization's golf carts until they have been properly trained.
- Golf carts can generate sparks, which can ignite flammable vapors. They can also be a source of deadly CO. Only carts approved for indoor use should be used within your facilities.
- Golf carts should be kept clean and well maintained, and never operated with lose tools or other objects that can fall or interfere with the brakes or other operating controls.

Possible Hazards

1. Consider restricting inexperienced or untrained drivers from using golf carts.
2. No after dark driving without proper lights.
3. If crossing vehicle roads, always use the same caution you'd use in a car or truck.
4. To increase cart visibility, mark carts with reflective tape and/or use a canopy.
5. Don't use golf carts in flammable atmospheres.

Operator Training

To prevent workplace accidents, all employees who operate golf carts must be trained before using the vehicles. This training should include the proper procedures for operating and maintaining golf carts in conjunction with the golf carts' operational manuals.

- To protect your company from allegations of negligence in golf cart accidents/ injury cases or litigations involving golf carts, it is important to assure that operators have successfully completed golf cart training prior to operating golf carts. Employee training documentation should include the trainee's name, title, department, date of training, and supervisor's signature and should be placed in the employee's file.
- Do not stand or operate with feet, arms or legs hanging outside of the cart.
- Any Employee who observes an Operator driving a golf cart in an unsafe manner, should be encouraged to report the safety violation to a Supervisor.
- When the golf cart is not in use, the operator should place the golf cart in the "neutral" position, brake on and remove the key.
- Do not allow the use of steering wheel speed handles (common known as suicide knobs) Turning a golf cart too quickly can cause it flip over, causing serious injuries or death as well as cause premature wear of the unit's tires and steering components.
- Any injuries, accidents or damage caused by golf carts, should be reported immediately.

KLM Technology Group is a technical consultancy group, providing specialized services and training to improve process plant operational efficiency, profitability and safety. We provide engineering solutions by offering training, technical services, best practices, and engineering designs to meet the specific needs of our partner clients. Since 1997, KLM Technology Group has been providing engineering, operations, and maintenance support for the hydrocarbon processing industry.

WWW.KLMTECHGROUP.COM

Engineering Solutions, Standards, and Software

KLM Technology Group

IACPE

INTERNATIONAL ASSOCIATION OF

CERTIFIED PRACTICING ENGINEERS

Www.iacpe.com