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IACPE
INTERNATIONAL ASSOCIATION OF CERTIFIED PRACTICING ENGINEERS
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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.

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KNOWLEDGE. CERTIFICATION. NETWORKING

LETTER FROM THE PRESIDENT

KARL KOLMETZ

HONOR YOUR ENGINEERING MENTOR AND FRIENDS

Dear Friends,

We hope that 2018 is shaping up to be a great year for you. We are honored and very thankful that the International Association of Certified Practicing Engineers (IACPE) is being well received all over the world. We are thrilled at the formation of partnerships with prestigious individuals and universities.

Engineering Practice Magazine is full of articles by knowledgeable authors and we are truly thankful to all the authors who have submitted articles. The kind words and comments we receive from readers like you about the magazine make publishing it a joy.

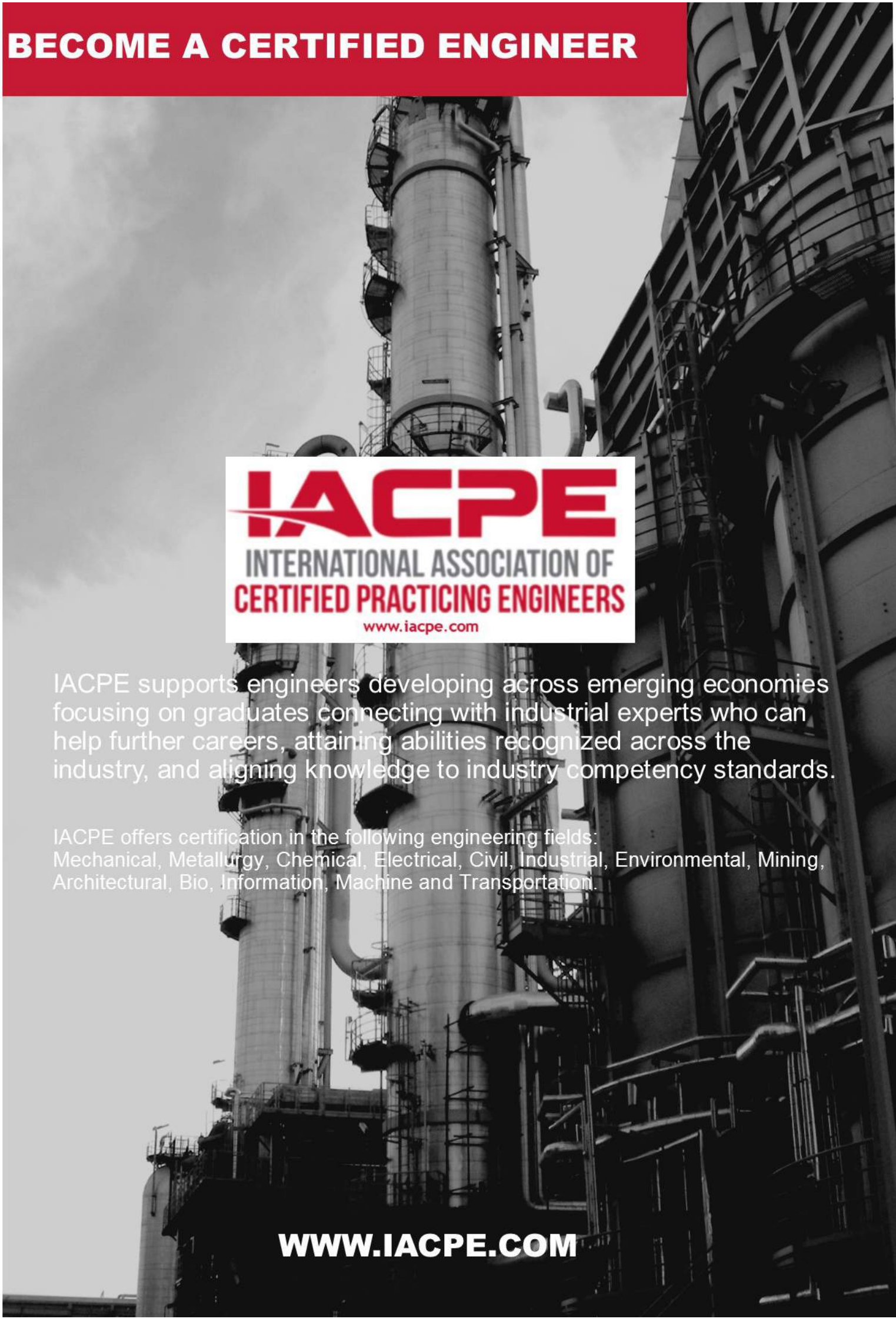
It is time to once again nominate your engineering mentor and friends for the Distinguished Practicing Engineering Award. Far too many times we fail to honor those that have assisted our engineering careers and personal lives. I have many friends and colleagues that have assisted my engineering career and personal life. I try to let them know that I appreciate their help.

In 2017 we had a great group of nominees and award winners. To honor those great people who are impeccable mentors and cherished friends we are now asking for the 2018 nominees. We ask you to submit nominations of people you believe embody this award.

In the July Engineering Practice Magazine, we will select the top three nominees from each division and in the October Engineering Practice Magazine we will recognize the 2018 group of awardees.

All the best in your career and life,

Karl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Guidelines for Ethylene Quench Towers

Karl Kolmetz
Timothy M. Zygula

Abstract

Ethylene quench oil and quench water towers may have the highest failure rates in fractional distillation due to the rigorous service that these towers perform. Almost all the challenge areas of distillation are concentrated into one column system; high temperature, solids, fouling potential, oxygenates, polymerization potential, heat removal by pump arounds, and a mixture of hydrogen, steam, and C1 to C20s. Given this combination, the guidelines for designing this column must be flexible yet sturdy to handle each of the challenges.

One of the most reliable designs has been the one developed in 1998 (1). These designs have run continually for eight years, with previous designs in these revamped columns having less than one year run length. Motivated by Kister and Schwartz's concluding remarks that good engineering judgment is needed in evaluating quench towers (2), the authors will examine the history of quench oil and quench water tower's successful and not successful case studies and lessons than can be learned from each of the cases.

Introduction of Quench Towers

There are many process unit quench towers including; Fluidized Catalytic Cracking Units, Vinyl Chloride Monomer Units, Ethylene Oxide, Ethylene Glycol and Ethylene Pyrolysis Cracking Units. The reactor effluent from the process requires cooling for further fractionation and therefore the temperature is reduced or quenched.

Typically quench towers utilize one or more heat transfer sections or pump rounds to remove heat from the column. The use of heat transfer sections or pump rounds results in a better distribution of tower loads than would be the case if all the heat were removed in the tower overhead. Additional benefits include reduced tower diameter at the column upper sections and the recovery of heat at a higher temperature. This higher level of heat can then be utilized in the process for improved energy recovery and higher overall plant efficiency, sometime called specific energy consumption.

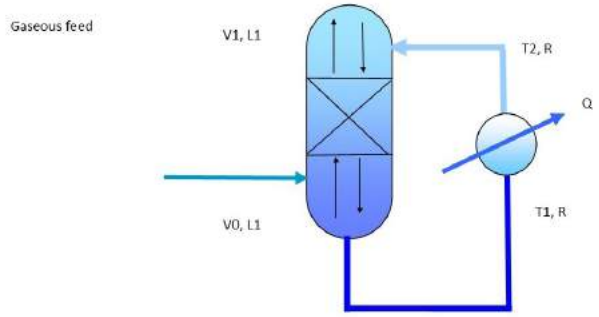

Fig. 1. Example of a Typical Pump Around Section.

The amount of heat that is removed in the external pump around circuit of a heat transfer section in a column is equal to the exchanger duty Q. The exchanger reduces the pump around liquid temperature from the draw off temperature T1 to the return temperature T2. In a typical design, Q and T1 are usually set by the heat and material balances and the engineer must select appropriate values of T2 and the pump around rate R.

These variables are related by the following equation:

$$Q = M\ CP\ \Delta T \quad (1)$$

$$Q = MPA\ CPL\ (T1 - T2) \quad (2)$$

where:

Q =Exchanger duty
MPA =Pump around liquid rate
CPL =Specific heat capacity of liquid
T1 = Pump around liquid draw off temperature
T2 = Pump around liquid return temperature

Quench Tower Theory

A reactor produces a hot intense mixture of feed, reactants, inerts and co products. The mixture need to be cooled and separated. In an ethylene plant the mixture is partially cooled by heat exchanger and then in a quench tower. The quench tower has heat transfer sections that remove the heat at different levels.

The heat is removed in the heat transfer section by re-circulating liquid against the ascending vapor that enters the tower bottoms. At the bottom of the pump around section the liquid is removed, externally cooled and then returned to the top of the heat transfer section. The challenge of designing the heat transfer sections involves the simultaneous solution of heat and mass transfer equations in which the actual temperature driving force is difficult to evaluate, leading to cases where the number of trays or the height of the packing has been undersized.

The industry method for designing and rating heat transfer section is to utilize a heat transfer unit (HTU). This method is like the mass transfer unit (NTU or HETP) approach to fractionation efficiency, where NTU is number of transfer units and HETP is height equivalent per theoretical plate. The number of trays or the height of packing for heat transfer can be determined based on heat duty, tower loadings, temperature driving forces and tower area once the mass transfer unit has been established. The mass transfer units are typically established by a process simulator such as PROII or ASPEN.

In 1985 Kulbe, Hoppe and Keller (3) reviewed load flexibility, heat transfer and condensation in packed beds. They address then need to review the vapor flow in each bed separately and / or the need to possibly section the tower for calculation of heat transfer. They used the term tower load profile. The tower sectioning will depend on the relative amounts of latent and sensible heat transferred in each section, followed by separate heat transfer calculations for each section. Sectioning a tower is to obtain realistic temperature driving forces for heat transfer. In general, different values of temperature driving forces are obtained for each tower section.

In 1995 Spiegel, Bomio and Hunkeler (4) developed and published a method for designing or rating direct contact heat transfer sections with packing. The number of overall transfer units for the gas phase NTUOG was calculated based on the enthalpy difference on the gas side assuming no mass transfer resistance on the liquid side.

$$NTU_{OG} = \int_{btm}^{top} \frac{dh_G}{h_G - h_I} \qquad (3)$$

with

hG - enthalpy of the bulk gas phase
hI - enthalpy of the gas phase at the interface

The number of overall transfer units per meter NTUMOG can be calculated by

$$NTUM_{OG} = NTU_{OG}/Z \qquad (4)$$

With Z being the packing height.

The $NTUM_{OG}$ depends on the gas and the liquid loads. For a system that is gas side controlled a dependence on the gas load would be expected. The influence of the liquid load may be attributed to the effective interfacial area which depends on the liquid load being in acceptable ranges. The influence of the liquid load on the effective interfacial area is proportional to the velocity of the liquid phase.

aI,eff proportional to vL0.2

where

aI,eff is the effective interfacial area
vL is the superficial velocity of the liquid phase

This has to be compared to random packing where a much stronger dependence on vL is found. This may be due to the fact that aI,eff of random packing depends more on the liquid load than structured packing. If one utilizes the air/water system, the overall heat transfer coefficient U can be calculated from the NTUMOG.

$$U = \frac{NTUM_{OG} \cdot \rho_G \cdot v_G \cdot c_{P,G}}{a_{I,eff}} \qquad (5)$$

with

vG superficial velocity of the gas phase
ρ_G gas density
$c_{P,G}$ specific heat capacity of the gas

Combining this data the U correlation for 250 X structured packing can be modeled as

U = 97.7 FV0.8 (6)

With U in W/m2K, vL in m/s and FV in Pa0.5. The exponent 0.8 of the gas load Fv factor is typical for gas side controlled systems.

In 1970, before structured packing entered the industrial market, Nemunaitis, Eckert, Foote, and Rollison (5) used pilot scale data to correlate the following equation for heat transfer coefficient using random packing (2-inch polypropylene rings):

U = C'Tp Lon Gom (7)

where

C'Tp system constants
Lo liquid rate
Go Gas rate

n = 0.68 (for dehumidification) or 0.82 (humidification)

m = 1.0 (for dehumidification) or 0.5 (humidification)

The overall heat transfer coefficient is calculated using the theory of tubular heat exchangers.

$$U = \frac{Q}{A \cdot \Delta T_{LM}} \quad (8)$$

with

Q heat flow

A heat transfer area of the packing

ΔT_{LM} mean logarithmic temperature difference

Analysis of two sets of laboratory data suggest a relationship of the following dependence of the overall heat transfer coefficient

U proportional to vG0.8

When the overall heat transfer coefficient U is plotted against the gas side Reynolds number

$$Re_G = \frac{\rho_G v_G d_h}{\mu_G \cos(\gamma)} \quad (9)$$

with

dh hydraulic diameter of packing

μ_G dynamic viscosity of gas phase

γ corrugation angle of packing

and the data is regressed, an overall heat transfer correlation is developed.

$$U = 0.0925 Re_G^{0.8} \quad (10)$$

The physical properties of fluids in industrial applications are very different from air/water system. To make a possible comparison of the heat transfer data a dimensionless parameter such as the Nusselt number for forced convection must be utilized (6).

$$\frac{Nu_G}{Pr_G^{1/3}} \text{ proportional } Re_G^{0.8} \quad (11)$$

with

Nu_G Nusselt number = 4U/(alkG)
U Overall heat transfer coefficient
kG thermal conductivity
PrG Prandtl number (=)

The abscissa in the Nusselt diagram is NuG/PrG1/3, the ordinate is ReG.

With these correlations with lab and field data a graph can be constructed of the model and actual field data in Fig. 2 (4).

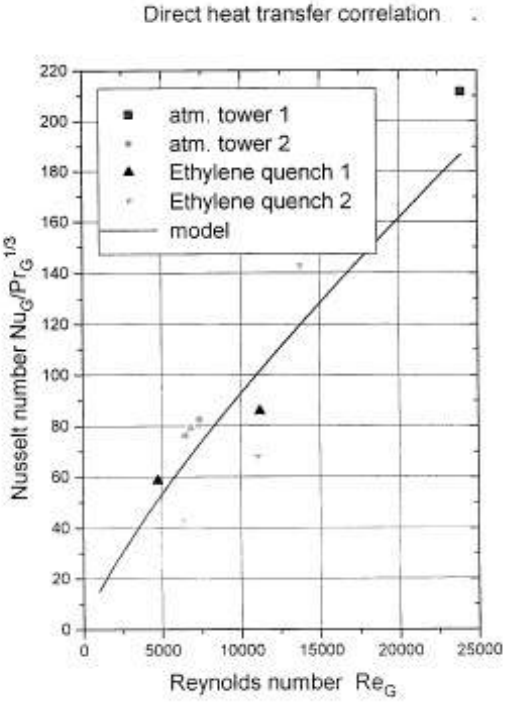

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Fig. 2. Test of the heat transfer model by operating data of industrial applications

Utilizing this model which matches the field data one can calculate the heat transfer limits of pump around sections. Utilizing a simulator such as PRO II one can then calculate the equilibrium limits and confirm the design of heat transfer pump around sections.

Quench Tower Fractionation Device Selection

In non fouling services most fractionation devices can be utilized for heat transfer sections. Typically trays cost less than other fractionation devices and would be the first choice. In a revamp where higher capacity is required structured packing can be utilized. Packing is best when low pressure drop is desired, while still providing good heat transfer and efficiency. Compared to grid, beds heights can be lower with packing to achieve the same separation.

Fouling services are where the fluids contain solids such as coke, catalyst or scale, and other components that might lead to solid, crystallization or polymer formation. (7) In fouling service, the order of preference would be grids, trays, structured packing, and last random packing. The disadvantage of random packing in fouling service is that occasionally one of the random packing will be vertical and the liquid on the horizontal section will have a high residence time leading to fouling. Once the fouling starts it will grow and eventually block the vapor and liquid flows.

Grids are preferred over trays when low pressure drop is desired, entrainment needs to be reduced, and when coking or fouling potential is high due to their low liquid hold up and resident times. Grids have seen excellent service in many quench towers.

Several fouling phenomena can be experienced in quench towers and quench systems; solid fouling, polymer fouling, and coke fouling. Typically quench oil fouling is lowered by the to the following process conditions.

1. There is 30% steam in the quench oil column therefore fouling will be reduced by this inert.

2. There is a high percentage of hydrogen which will reduce the fouling potential, and

3. Many of the fouling components are in the vapor phase.

Fouling still does occur in quench oil columns due to the rigorous conditions of the feed stream and designs that increase resident time in the columns. In 2002 Gondolfe and Mueller noted that poor column design is the main reason for quench oil tower fouling. (8)

Solid Fouling

1. Solid Fouling can be seen in quench water towers by naphthalene. Naphthalene is an aromatic compound with a chemical formula of C10H8 and a molecular weight of 128.2. Physical properties include a normal boiling point of 218°C and a specific gravity of 1.02. Naphthalene can form a white crystal solid at temperature below its boiling point and may cause fouling in the Quench Water System. Mostly is found in the Quench Water Loop because the Specific Gravity of Naphthalene is close to water, so it preferentially goes with the water phase. Sometimes white solid naphthalene crystals can be found in the suction of quench water pump. This can be remedied by a small stream of pyrolysis gasoline to the system.

Polymer Fouling

1. Polymer fouling can be seen in quench system by polystyrene, many times not in the quench towers, but the adjacent equipment such as the Dilution Steam Generator.

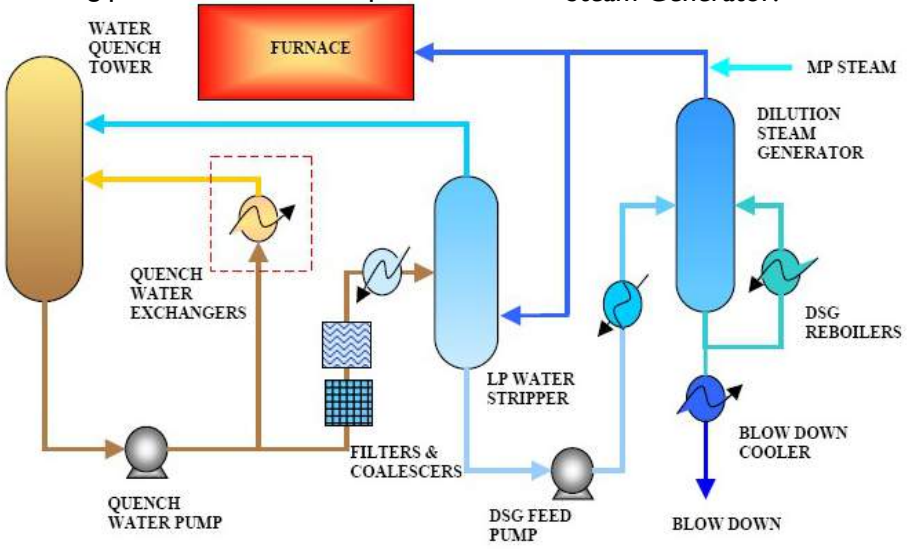

Fig. 3. Process flow diagram of water quench tower and dilution steam generator.

A dilution steam generator was revamped from pan distributors and random packing in 1999 (1). Previously the system was cleaned yearly and after the revamp to low resident time fouling resistant notched distributor and grids, the system is still in service today – 8 eight years later.

Styrene fouling is typically brown to black in color and very hard formations. Polystyrene usually occurs at high temperature with Ferric Oxide as Catalyst. It can be minimized by avoiding hot vapor contact directly to packing with no liquid reflux.

Styrene should not be found in a DSG. If the quench water system pH is not controlled, an emulsion will form and carry the styrene and other hydrocarbon with the water to the DSG, where the polymerization will occur.

2. Polymer fouling can be seen in quench oil towers by polyindene if the residence time is high. It is a yellowish color powder and can accumulate in trays and packing. It can be minimized by maintain the gasoline reflux and prevent oxygen and oxygenates from entering into system.

Coke Fouling

1. Coke is a co product of olefin production. It is caused by a catalytic reaction with the Fe in the furnace tubes. The coke will partially condense on the furnace tube and partially be swept with the feed and steam mixture to the quench system. The coke will then collect in the any collection system such as pan distributors and random packing. It will also settle into low resident time areas such at the tower bottoms. Some of the coke is removed in the quench oil circulation pump filters.

Olefin Plant Quench Water Systems

In olefins plants, the potential for significant fouling exists in the quench columns that are used to cool the hot process gas from the pyrolysis cracking furnaces. The pyrolysis furnace effluent is a full range mixture of hydrogen, hydrocarbons and steam. Coke fines from the cracking furnaces are entrained with the gas to the first column in the quench unit. This first column will be an oil quench primary fractionator in a liquid cracker or a water quench column in a gas cracker.

In many ethylene units because of the coke fines, the column section above the cracked gas inlet will often utilize open-type baffle trays such as angle trays, disk and donut trays or splash decks depending on the licensor. In light naphtha units dual flow ripple trays have been successful, but in heavy naphtha units there have been some issues with dual flow trays. Some units will use a grid style packing in this section or a combination bed of grid packing with structured packing or trays. Some units still utilize random packing and pan distributors even though they have been shown to be problematic.

As the vapor cools and the worst coke fouling is eliminated, the packing type can be changed to a higher efficiency style. As a result of the additional packing efficiency, the liquid outlet temperature from the column can be increased, resulting in greater heat recovery from the ethylene quench unit. In the upper section of these columns, where fouling is less of a concern, high performance structured packing or trays can be utilized to provide greater efficiency for increased cooling of the process gas.

With the coke fines being removed from the process vapor by the pump around liquid, the liquid at the bottom of the quench column is usually heavy in solids. The pump around liquid is re-circulated to the tower after filtering and heat removal. The filtered re-circulating pump around liquid still contains some fouling material and requires a fouling resistant liquid distributor design such as a larger size spray nozzle distributor or a v-notched weir trough distributor.

The quench water decanter settler can have emulsification problems when the pH of the water is not neutral. This results in the circulation of hydrocarbons back to the quench water tower with what should be water circulation and to the DSG System. This can be the primary source of fouling.

The water pump around circuits are sometimes integrated with a dilution steam generator (DSG). The DSG performance can impact the quench column operation and styrene fouling can be developed. Some olefins plant has removed the tower internals of the DSG System, but environmentally this is not a good option as one of the DSG functions is to remove phenol from the excess DSG water that is sent to waste water treatment for final disposal.

Case One Example - US Gulf Coast Quench Water Tower

An ethylene water quench tower was commissioned in 1992 at a US Gulf Coast ethane gas cracker. The original design of the tower had

random packing in the top bed and structure packing in the bottom bed. The tower was upset during start-up and both beds collapsed.

The tower was then hot tapped and spray nozzles were inserted through ring of hot taps around the top of the tower. With the ring of hot taps and spray nozzles, the unit was able to run at full rates, however, the tower's top temperature was higher than design, about 115 to 120 °F compared to a design of 105°F. This led to increase energy consumption in the compressor. The temperature in the bottom of the column was 140 to 160 °F, instead of the design of 180°F. The led to a loss of heat transfer causing increased energy usage per ton of product.

The commissioning of quench water towers can be challenging. The tower is designed to have condensables (steam) and non condensables (cracked gas). During the unit and furnace commissioning there are times when few non condensables are in the furnace effluent, this is called decoking or hot steam stand by. Steam is fed to the furnace to remove the heat in the coils while the furnace is being brought to operating temperatures.

This condensable steam can cause a vacuum in the quench water tower if no non condensables are added. The tower bottoms is kept at 180°F, if the pressure is allowed to drop into a vacuum, the water in the tower bottoms can flash, leading to damage to the structured or random packed bed.

The quench water tower is equipped with a vacuum breaker. It is normally methane or nitrogen that is added by a regulator. If the regulator is inadvertently left blocked in during a start up, and a vacuum is created inside the tower, damage to the tower internals can occur.

A second challenge of vacuum breakers is the location. If the vacuum breaker is placed on the tower outlet, the outlet which is the compressor suction, can still be a positive pressure, while the tower bottoms can be flashing. The vacuum breaker of a quench tower should be placed on the tower inlet to always maintain positive pressure at the tower bottoms.

Due to this flashing phenomenon the tower should be designed with additional mechanical strength. The tray and internals uplift rating should be increased. Normal tray designs up lift is 0.1 lbs per square foot. Heavy duty design is 1.0 lbs per square foot. The designs that were installed by the authors had 2.0 lbs per square foot rating.

This also tends to point toward utilizing baffle trays and grids in the tower bottoms, because they can withstand the flashing phenomenon better than packing or trays.

In 1995 the tower was revised with random packing in the top and a draw pan for spray circulation in the tower bottom. The draw pan was upset during start up. Later inspection found hold-down clamps were not properly installed and bolts were missing. The ring of spray nozzles was reinstalled.

In 2000 the circulation rate was suddenly reduced, as if a line plugged overnight. The tower was shut down for inspection and a loose vapor riser hat from the draw pan was found in circulation draw. The vapor riser hats were welded in place improving the previous bolting design.

In September 2003 the tower was converted to v-notch liquid distributors and grid packing. The tower is still performing with lower pressure drop and improved heat transfer capacity than the original design.

Case Two Example - US Gulf Coast Quench Water Tower

An ethylene water quench tower was commissioned in 1997 at a US Gulf Coast ethane/propane gas cracker. (11) Because the unit was designed to crack E/P only, an oil quench column was not installed. The water quench tower had a combination of spray nozzles and random packing.

The column was configured with two beds of packing. The top bed of packing used nominal 2" random packing with a spray nozzle distributor for liquid irrigation of the primary quench water feed. A deck type re-distributor was used to collect liquid from the upper bed and redistribute it to the lower bed. A secondary water quench was introduced over the lower packing bed via a spray nozzle distributor, which was located below the deck re-distributor.

The bulk of the bottom bed was packed with a nominal 3" random packing plus a small section of grid style packing for higher fouling resistance.

This column had a history of pressure drop problems. The pressure drop in this column typically ranged from 1 psi to 1.5 psi while the calculated pressure drop at design conditions was approximately 0.3 psi. The hydraulic capacity ratings of the packing were less than 70% at the design conditions. The column was kept in service despite continued pressure drop problems and attempts

to mitigate the fouling by modifying the unit operations and maintenance practices.

In 2000, the quench tower was starting to show signs of reduced heat transfer capacity.

Additionally, the three pound pressure drop increase is a very large operating cost due to the fact that the pyrolysis furnace reactor yields are much higher with lower pressure.

The high quench tower pressure drop increases the reactor pressure and greatly reduces the net yield of the plant.

Table 1. Comparison of operating data before and after revamp.

	2000 Operating Data Prior to Revamp	2005 Operating Data After Revamp
Cracked Gas Flow, Lb/Hr	100% of original design	121% of original design rates
Quench Water Bed 1, GPM	2197	2294
Quench Water Bed 2, GPM	1850	1668
Total Quench Water, GPM	4047	3962
Top Temperature Approach, °F	2.3	0.4
Overhead Vapor Temperature, °F	101	95.3
Bottom Water Temperature, °F	186	179.4
Column Temp Delta, °F	85	84
Overhead Pressure, psig	13.2	16.9
Column Pressure Drop, psi	3.0	0.23
Number of Heat Transfer Units developed per Bed	-	6.7 top / 3.3 bottom
Total Number of Stages	-	4 top / 2-3 bottom

Case Three - Light Naphtha Crackers

Two identical light naphtha crackers were commissioned in South East Asia. The first unit was commissioned in 1995 and the second in 1999. These crackers were designed for a feed stock of heart-cut naphtha with about 80 to 85% paraffins. A second option for designing naphtha crackers may be to what is called an "open spec" naphtha which has higher end points and 60% paraffins. A third option is to design for gas oil cracking which has much higher feed stock end point and much lower paraffins.

These light naphtha crackers had quench oil and quench water columns with dual flow ripple trays. There was no feed inlet device, baffle trays or middle draw on the quench oil tower. These columns have performed very well on light naphtha service but would be challenged on open spec or gas oil feed stocks.

An open spec Naphtha Cracker in South East Asia has been performing well with shed decks in the tower bottoms, followed by spray nozzles, random packing and pan distributors. Several points of operation are beneficial to South East Asia tower operations and they may not be representative of other regions.

1) There was a government mandated shutdown every 24 - 36 months for the first few years of operations. A shutdown and system cleaning every three years can eliminate many of the potential fouling precursors. The challenge is the 4 and 5 years of tower operation.

2) There is a shortage of propylene in the region and the units have low cracking severity to produce more propylene. Lower cracking severity produces less tar, coke and other co products.

3) Due to overcapacity in the region the units have ran at about design rates during 2000 to 2003 time period. Higher rates challenge the towers more than design rates.

Guidelines for Increased run length include

1. Restrict the use of pan distributors and random packing in fouling services. (7) Quench Oil and Water towers can experience coke fine, particles and flashing. Pan distributors and random packing serve as excellent collectors for the coke and other solids. These designs have a few successes and many not successful operations. In 2002 Kister and Schwartz presented their findings on differences between shed decks and packings in quench towers. (2)

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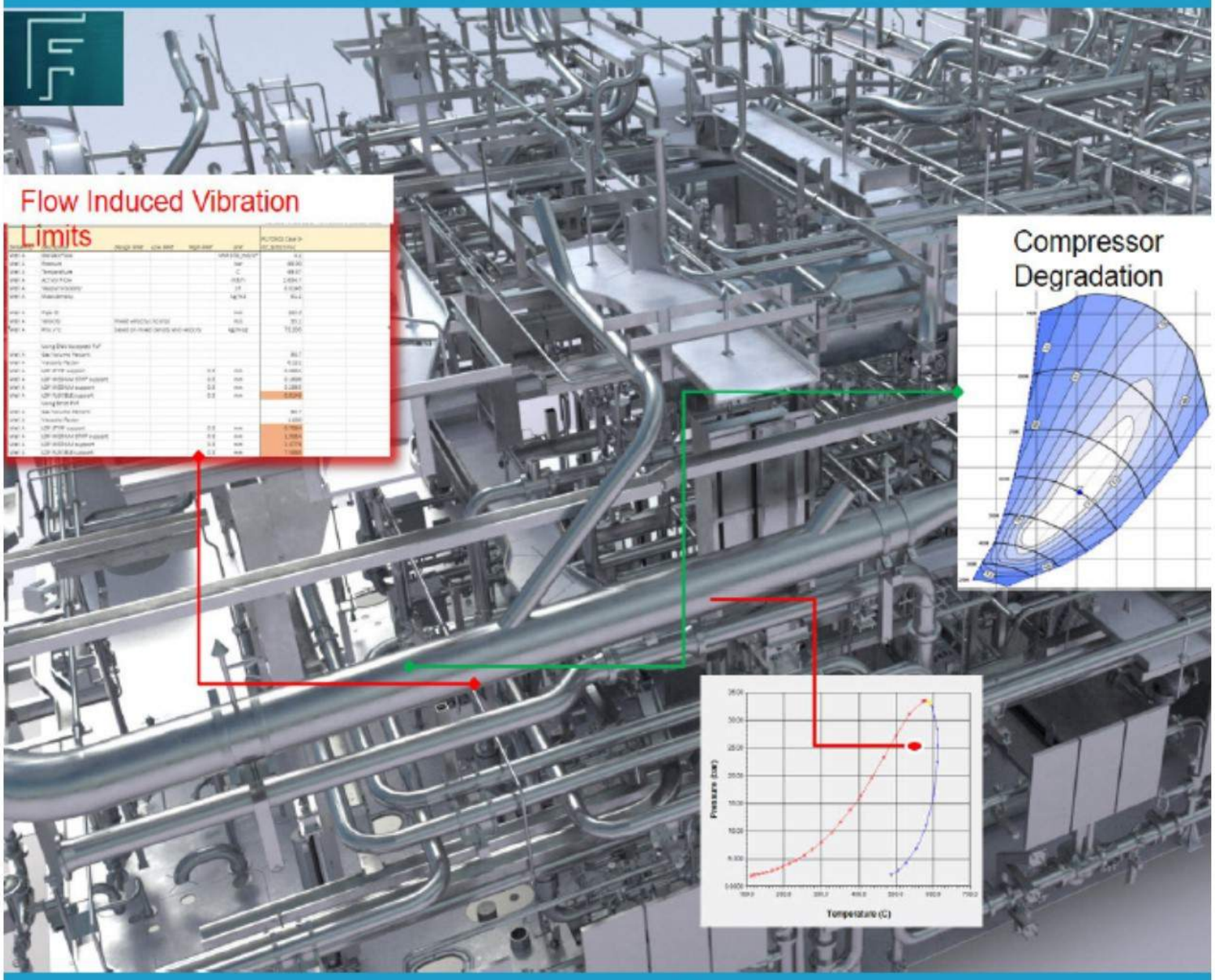

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2. Restrict the use of movable valve trays in fouling services. Dual flow trays or fixed valves trays that direct the flow across the tray are a better choice. Consider utilizing devices like push valves that eliminate the high residence time areas of cross flow trays. Stepped outlet weirs can be utilized, but are not required in the upper section of the columns.

3. Be cautious of component trapping in quench oil towers. Some species of hydrocarbon are too light to exit out the bottoms and too heavy to be removed in the overhead and can even be concentrated if the quench oil tower has a middle draw pan.

When component trapping occurs a very high residence time can be encountered, partially in conventional or dual flow trays, leading to fouling on the tray. Pictures of up to 18 inches (450 mm) of fouled material on a tray were presented in a conference in 2001. (9) Restrict the use of pan distributors, conventional trays or dual flow trays in high residence and fouling areas of the tower.

4. Utilize low residence time devices in high fouling areas. Residence time and efficiency are inversely proportional. The best devices for fouling are baffle trays and grids. They have lower efficiency but 5+ years run length versus 1 year run length or in one case 45 days.

5. The most reliable designs have baffle trays, followed by grids, then other devices can be utilized above the grids such as dual flow ripple trays or conventional cross flow trays. This configuration has less efficiency than other configurations but will have a very good run length. In the upper section the choice between ripple trays and cross flow trays can be the vendor's choice.

6. In quench water towers structured packing has been used in the top sections successfully, but there is mixed results for structured packing in quench oil towers and very poor results for most random packing in each service. But some quench oil towers have good results even with random packing, because on these towers the fouling potential is low. If the unit fouling potential is low, structured packing can be utilized on the top of the quench oil tower, but trays are a safer choice.

The fouling potential is a function of feed stocks, cracking severity and design capacity. If the unit processes light naphtha feed stocks, maintains cracking severity low to produce propylene and keeps the capacity about the rated design, then fouling potential is reduced.

7. Consider heavy duty designs in quench towers. The potential exist for flashing to occur if the quench water tower is allowed to condense into a vacuum. The authors have recommended and utilized a 2 lb per square foot uplift design.

Conclusions

The optimum number of heat transfer trays or packed height is based on an economic study involving tower height and diameter, external heat exchanger size, pump and power costs and tower reliability. By far the largest economic driver is reliability. Many quench towers run lengths are measured in days due to lack of understanding of the basic principles

One definition of insanity is to repeat the same experiment and expect different results. If a design has had multiple failures, one should consider modifying the design or expect continued failures. Practical engineering is an ongoing learning experience from past successes and failures. If you have had no failures, you have not been working hard enough, but it is very important to be learning from your mistakes and the mistakes of others.

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Fluid Catalytic Cracking Technologies – Higher Operational Flexibility and Better Refining Margin

Dr. Marcio Wagner da Silva

Introduction

Fluid Catalytic Cracking (FCC) is one of the main processes which give higher operational flexibility and profitability to refiners. The catalytic cracking process was widely studied over last decades and became the principal and most employed process dedicated to converting heavy oil fractions in higher economic value streams.

The installation of catalytic cracking units allows the refiners to process heavier crude oils and consequently cheaper, raising the refining margin, mainly in higher crude oil prices scenario or in geopolitics crises that can become difficult the access to light oils. The typical Catalytic Cracking Unit feed stream is gas oils from vacuum distillation process. However, some variations are found in some refineries, like sending heavy coker naphtha, coker gas oils and deasphalted oils from deasphalting units to processing in the FCC unit.

The catalyst normally employed in fluid catalytic cracking units is a solid constituted by small particles of alumina (Al2O3) and silica (SiO2) (zeolite). By the catalyst characteristics and the operational conditions in the catalytic cracking process (temperature higher than 500 oC), the process is inefficient to cracking aromatic compounds, therefore, how much more paraffinic is the feed stream, higher is the unit conversion. Figure 1 presents a process scheme for a typical Fluid Catalytic Cracking Unit (FCCU).

Process Arrangement

In a conventional scheme, the catalyst regeneration process consists in the carbon partial burning deposited over the catalyst, according to chemical reaction below:

$$C + ½\ O2 \rightarrow CO$$

The carbon monoxide is burned in a boiler capable of generating higher pressure steam that supplies others process units in the refinery.

The principal operational variables in a fluid catalytic cracking unit are reaction temperature, normally considered the temperature in the top of the reactor (called riser), feed stream temperature, feed stream quality (mainly carbon residue), feed stream flow rate and catalyst quality.

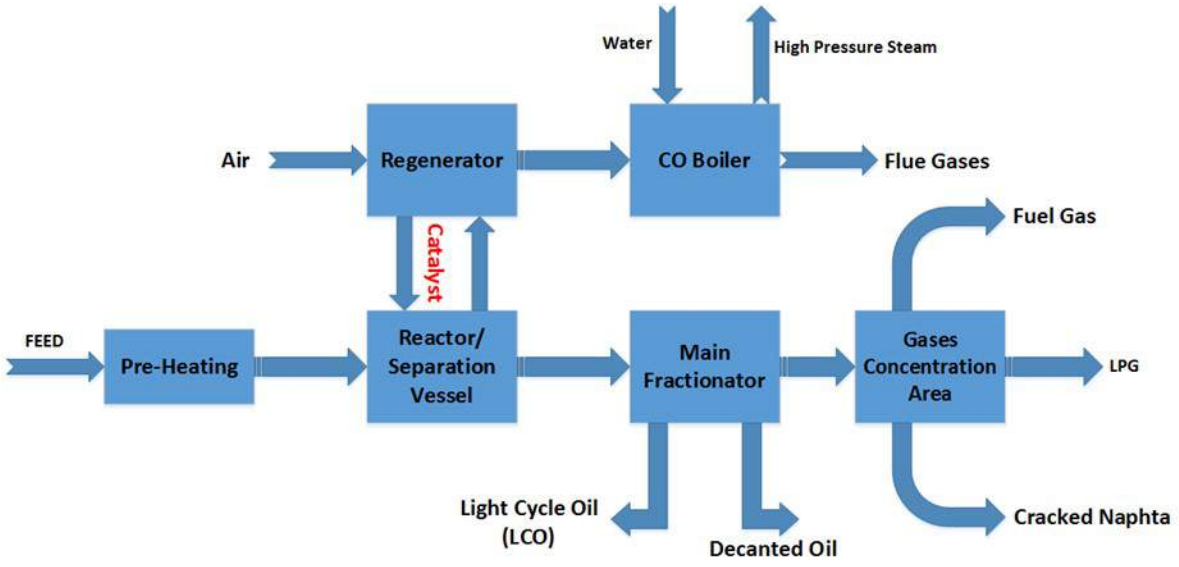

Figure 1 – Schematic Process Flow for a Typical Fluid Catalytic Cracking Process Unit (FCCU)

Feedstock quality is especially relevant, but this variable is a function of the crude oil processed by the refinery, so is difficultly can be changed, but for example, aromatic feedstock's with high metals content are refractory to cracking and conducting to a quick catalyst deactivation.

An important variation of the fluid catalytic cracking technology is the residue fluid catalytic cracking unit (RFCC). In this case, the feedstock to the process is basically residue from atmospheric distillation column, due to the high carbon residue and contaminants (metals, sulphur, nitrogen, etc.) are necessary some adaptations in the unit like catalyst with higher resistance to metals and nitrogen and catalyst coolers furthermore, it's necessary apply materials with most noble metallurgy due the higher temperatures reached in the catalyst regeneration step (due the higher coke quantity deposited on the catalyst), that raises significantly the capital investment to the unit installation. Nitrogen is a strong contaminant to the FCC catalyst because they neutralize the acid sites of the catalyst which are responsible for the cracking reactions.

When the residue has high contaminants content, is common the feed stream treatment in hydrotreating units to reduce the metals and heteroatoms concentration to protect the FCC catalyst.

Typically, the average yield in fluid catalytic cracking units is 55% in volume in cracked naphtha and 30 % in LPG. Figure 2 presents a scheme for the main fractionator of the FCC unit with the principal product streams.

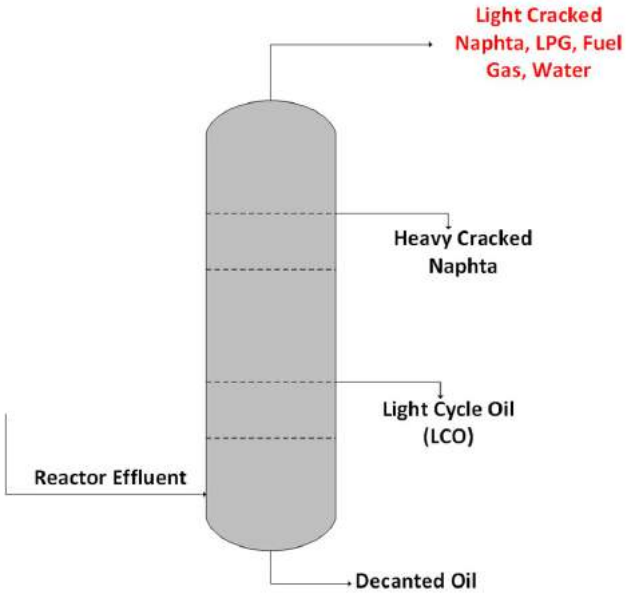

Figure 2 – Main Fractionator Scheme for a Typical

The decanted oil stream contain the heavier products and have high aromatic content, is common that this product are contaminated with catalyst fines and normally this stream is directed to use like fuel oil diluent, but in some refineries, this stream can be used to produce black carbon.

Light Cycle Oil (LCO) has a distillation range close to diesel and normally this stream is directed to treatment in severe hydrotreating units (due to the high aromaticity), after this treatment the LCO is sent to the refinery diesel pool.

Heavy cracked naphtha is normally directed to refinery gasoline pool, however, in scenarios where the objective is to raise the production of middle distillates, this stream can be sent to hydrotreating units for further diesel production.

The overhead products from main fractionator are still in gaseous phase and are sent to the gas separation section. The fuel gas is sent to the refinery fuel gas ring, after treatment to remove H2S, where will be burned in fired heaters while the LPG is directed to treatment (MEROX) and further commercialization. The LPG produced by FCC unit have a high content of light olefins (mainly Propylene) so, in some refineries, the LPG stream is processed in a Propylene separation unit to recovery the propylene that has higher added value than LPG.

Cracked naphtha is usually sent to refinery gasoline pool which is formed by naphtha produced by other process units like straight run naphtha, naphtha from the catalytic reforming unit, etc. Due to the production process (deep conversion of residues), the cracked naphtha has high sulfur content and to attend the currently environmental legislation this stream needs to be processed to reducing the contaminants content, mainly sulfur.

Available Technologies

The cracked naphtha sulfur removing is a great technology challenge because it's necessary to remove the sulfur components without molecules saturation that gives high octane number for gasoline (mainly olefins).

Over the last decades some technology licensers had developed new processes aiming to reduce the sulfur content in the cracked naphtha with minimum octane number loss, some of the main technologies dedicated for this purpose are technology PRIME G+ ™ from Axens, the processes

OCTAGAIN ™ and SCANfining ™ from Exxon Mobil, the process S-Zorb™ from ConocoPhillips and ISAL™ technology from UOP.

Usually, catalytic cracking units are optimized to aiming the production of fuels (mainly gasoline), however, some process units are optimized to maximize the light olefins production (propylene and ethylene). Process units dedicated for this purpose have his project and operational conditions significantly changed once the process severity is strongly raised in this case.

The reaction temperature reaches 600 oC and higher catalyst circulation rate raises the gases production, which requires a scaling up of gas separation section. Figure 3 presents a typical scheme for a gas separation section for a fluid catalytic cracking unit.

Conclusion

Despite the great operational flexibility which fluid catalytic cracking technology give for the refineries, some new projects have dismissed these units in the refining scheme, mainly when the new refinery objective is to maximize middle distillates products (Diesel and Jet Fuel) once this is not the focus of the fluid catalytic cracking unit. Despite specific cases, as cited above, Fluid Catalytic Cracking still a very attractive technology, especially to refiners inserted in markets with great demand for gasoline and light olefins, in these cases, the FCC process is fundamental to guarantee the adequate refining margin and the economic sustainability in the crude oil refining business.

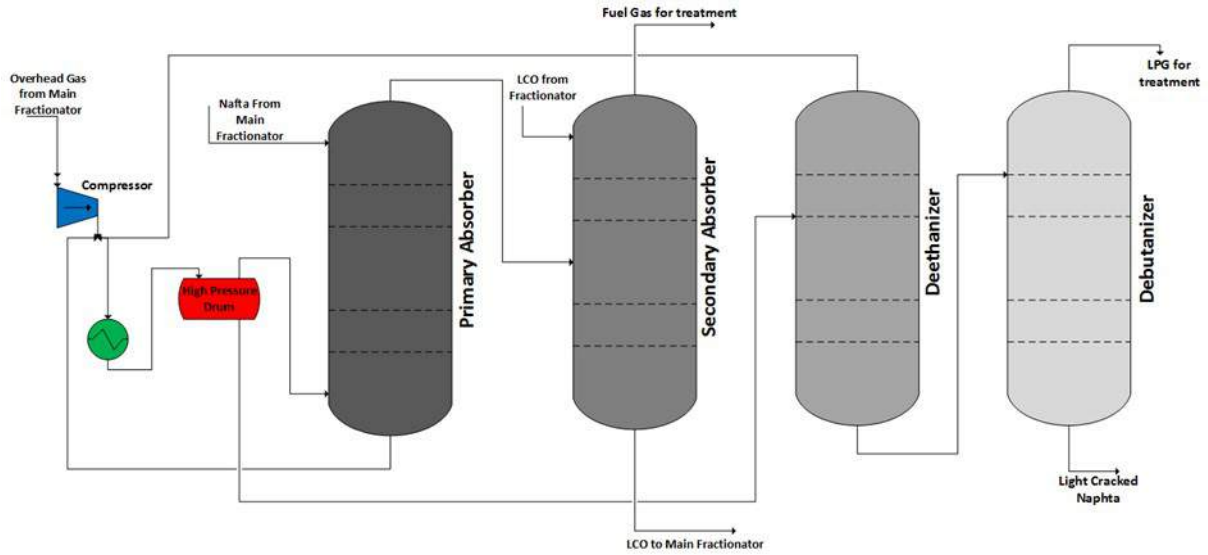

Figure 3 – Basic Process Flow Diagram for a Typical Gas Separation Section from FCC Unit

In several cases, due the higher heat necessity of the unit is advantageous to operate the regenerator with the total combustion of the coke deposited on the catalyst, this arrangement changes significantly the thermal balance of the refinery once it's no longer possible to resort the steam produced by the CO boiler.

Over last decades, the fluid catalytic cracking technology was intensively studied aiming mainly the development of units capable of producing light olefins (Deep Catalytic Cracking) and to process heavier feedstocks. The main licensers for fluid catalytic cracking technology nowadays are the companies KBR, UOP, STONE & WEBSTER, AXENS, CB&I and FOSTER WHEELER (with partners).

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Quarterly Safety Connector

For Engineers; Because Safety Is Part Of The Process!

By: Chris Palmisano, MESH, IFSAC **April 2018**

An Introduction to Process Safety Management

Safety Planning, Considering The "What Ifs'"

Process safety is an OSHA requirement. It's a fusion of engineering and management, focusing on preventing conflagration or catastrophic incidents. The last thing we want is the unanticipated release of toxic, reactive materials, or flammable liquids and/or vapors. Regardless of the industry that uses these highly hazardous chemicals, there is a potential for an accidental release if proper controls and plans are not in place.

Some of the basic elements of concerns are:

- Failure or Collapse or Structural Components
- Uncontrolled Reactions
- Fire and Explosions
- Environmental Chemical Releases/Spills/or Vapor Clouds

So, what industries do the OSHA rules cover? The OSHA standards for process safety apply mainly to manufacturing industries, particularly those pertaining to chemicals, transportation equipment, and fabricated metal products. Other affected sectors include those involved with natural gas liquids; farm product warehousing; food processing, electric, gas, and sanitary services; and wholesale trade. The standard also applies to pyrotechnics and explosives manufacturers. It has special provisions for contractors working in covered facilities.

The standard contains requirements for the safe management of hazards associated with processes using, storing, manufacturing, handling, or moving highly hazardous chemicals onsite. It emphasizes the management of hazards through an established comprehensive program that integrates technologies, procedures, and management practices.

Prevention starts with proper training and certifications in process safety and the implementation of a formalized Process Safety Committee (PSC). The members of your team should have a good mix of industry experienced people and include professional compliance specialists that know how to interpret the standards.

Generally process safety considers how most hazards should be assessed and controlled. Effective process safety management should eliminate risks by considering potential accidents that can occur in production, construction, maintenance and/or retro fit.

To help ensure safe and healthful workplaces, OSHA has issued the Process Safety Management Standards for Highly Hazardous Chemicals §29 CFR 1910.119, which contains requirements for the management of hazards associated with processes using highly hazardous chemicals.

OSHA's standards emphasize the management of hazards associated with highly hazardous chemicals so you can establish a comprehensive management program, which integrates technologies, procedures, and management practices.

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They provide four elements of information to help you:

1. The Standards - Process Safety Management (PSM) is addressed in specific standards for General Industry and Construction.

2. Hazard Recognition - Provides references that help begin a process hazard analysis by recognizing process hazards.

3. Evaluation and Control - Provides references that may aid in evaluating and controlling process hazards in the workplace.

4. Additional Resources - Provides links and references to additional resources related to process safety management.

Because engineering environments are dynamic, there are no fixed answers to process safety planning and procedure but generally your plan should consist of:

- "What-if" analyses
  - Checklist methods
  - Hazard and operability studies
  - Failure modes and effects analyses
  - Fault-tree analyses
  - Prioritizing and Identifying needs
  - Review statistics or other know industry incidents
  - Consider the professional input of all your team members
  - Do you have enough time and/or funding for the process
  - Do you have the right people?
  - Review all technical input from the stakeholders
  - Above all, it's important to know the properties of the chemical/s involved

OSHA provides a list of the chemical materials they consider highly hazardous and other information that can assist you in designing your safety programs and process flowcharts. https://www.osha.gov/SLTC/processsafetymanagement/standards.html

It's important to remember that OSHA doesn't have a specific standard to cover every operation or situation. They recognize what they call Consensus Standards. These are Industry and other organizational standards that they view as industry gospel and therefore, this means that if OSHA doesn't have a standard that covers your particular situation, then they may view one the following industry standards as the Law.

American National Standards Institute (ANSI)/ American Petroleum Institute (API)

- 2015-1994, Safe Entry and Cleaning of Petroleum Storage Tanks, Planning and Managing Tank Entry from Decommissioning Through Recommissioning, Fifth Edition
- 500-1992, Classification of Locations for Electrical Installations at Petroleum Facilities, First Edition
- 510-1992, Pressure Vessel Inspection Code: Maintenance Inspection, Rating, Repair, and Alteration, Seventh Edition. Includes Supplement 1 and Supplement 2.

American Petroleum Institute (API)

- 598, Valve Inspection and Testing, Seventh Edition
- 653, Tank Inspection, Repair, Alteration, and Reconstruction, Second Edition. Includes Addendum 1.
- API Recommended Practices

  o RP 574-1992, Inspection of Pressure Relieving Devices, First Edition

  o RP 520-1-1992, Sizing, Selection, and Installation of Pressure-Relieving Devices in Refineries Part I, "Sizing and Selection," Sixth Edition

  o RP 752, Management of Hazards Associated With Location of Process Plant Buildings, CMA Manager's Guide, First Edition

  o RP 2003, Protection Against Ignitions Arising Out of Static, Lightning, and Stray Currents, Fifth Edition

  o RP 574-1992, Inspection of Piping, Tubing, Valves, and Fittings, First Edition

- RP 55, Conducting Oil and Gas Producing and Gas Processing Plant Operations Involving Hydrogen Sulfide, Second Edition

- RP 2220, Improving Owner and Contractor Safety Performance, First Edition

- RP 750, Management of Process Hazards, First Edition

- RP 521-1992, Guide for Pressure-Relieving and Depressuring Systems, Third Edition

National Fire Protection Association (NFPA)

The NFPA mission is to reduce the worldwide burden of fire and other hazards on the quality of life by providing and advocating scientifically-based consensus codes and standards, research, training, and education.

- 495, Explosive Materials Code. Covers the manufacture, transportation, storage, sale, and use of explosive materials.
- 77, Recommended Practice on Static Electricity
- 780, Standard for the Installation of Lightning Protection Systems

In conclusion process safety should be part of your standard operating procedures when you work with hazardous materials. Never minimize the importance of this program, failing to do so can result in disaster.

Chris is a Professional Risk Management Consultant, a former Philadelphia Fire Department Lieutenant and former OSHA Compliance Officer. He is the creator of the InSite GHS Hazcom Workplace Labeling System for Secondary Chemical Containers. For questions about this article or his workplace chemical labeling system to meet the OSHA GHS June 2016 requirement, you can reach Chris at: ChrisAPal@aol.com or at LinkedIn https://www.linkedin.com/in/chris-palmisano-696b3b6/

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Variable Speed Drives For Gas Compressor Operations

Jayanthi Vijay Sarathy, M.E, CEng

Abstract

Historically the Oil & Gas industry has been dominated by mechanical prime movers like gas turbines or steam turbines to drive centrifugal gas compressors for large industrial applications. With time, these prime mover operations have become difficult to maintain, considering the Environmental Protection Agency (EPA) regulations that mandate strict emission compliance. A good alternative to combat emission concerns is to use electric motors as a prime mover in modern times with regards to their high rates of efficiencies of the order of 80% to 90% in addition to the absence of hydrocarbon emissions from electric motors. Electric Motors can be operated in two modes, namely, Fixed Speed Drive (FSD) Mode where the prime mover's speed cannot be altered during operation & Variable Speed Drive (VSD) Mode where the prime mover's speed can be altered by altering the frequency of the current fed to the electric motor. The following article is written to explore the power requirement implications for gas compressor operation when employing these modes of operation.

Introduction

The standard procedure employed by engineers to perform gas compressor design can be found quoted in literature such as GPSA, JM Campbell to name a few with Industry Standards, for example, API 617, to conveniently customize centrifugal gas compressors as per customer's requirements. However Chemical Engineers need to work beyond the standard practice of estimating steady state process parameters to avoid under-estimating power requirements for an effective compressor start-up & restart. This is so, since steady state calculations only provide information on the 'Absorbed Power' which can be defined as the power required to sustain the gas compressor at the required operating conditions during continuous operation. The power required to start a gas compressor will always be higher than the steady state absorbed power since, the electric motor (EM) has to overcome the inertia of the entire gas compressor system to bring it to normal operating conditions.

To understand by how much, excess power required during start-up varies, requires a transient state set of calculations including steady state calculations. With the advent of engineering software, such studies can be made and the Author uses Aspentech's HYSYS 2006.5 to investigate the power requirements for a gas compressor start-up based on a case study.

Keywords: Gas Compressor, Start-up Power, Fixed speed drives, Variable speed drives

Case Study

To understand the effects of VSD and FSD mode of operation on gas compressor start-up, a case study is made. Based on a certain gas compressor performance curves, the following process conditions are employed.

Table 1. Gas Compressor Process Parameters

Parameter	Value
Operating Capacity	8,100 m^3/h
Suction Flange Pressure	0.2 barg
Discharge Flange Temperature	25 ^0C
Discharge Flange Pressure	2.7 barg
Gas MW	18.38
Compressor Speed [100% Curve]	3,000 rpm

The Performance Curves (Polytropic Head vs. Actual Flow & Polytropic Efficiency vs. Actual Flow) used for the study is shown below.

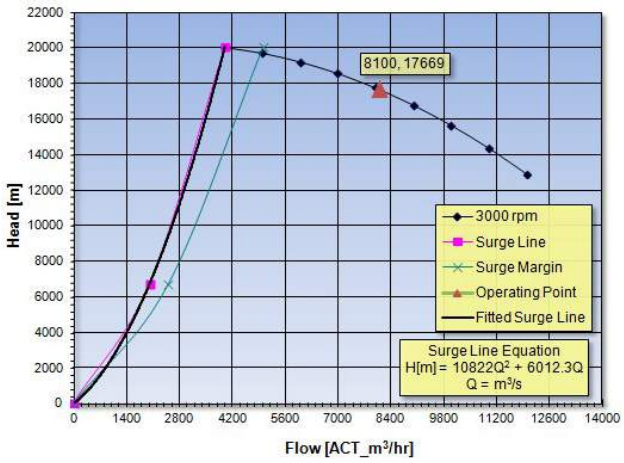

Figure 1. Polytropic Head vs. Actual Volume Flow

Since no information is available on the actual location of the surge line, the surge margin is assumed as 10% on the actual volume flow. The polytropic efficiency vs. flow rate curves is shown below as,

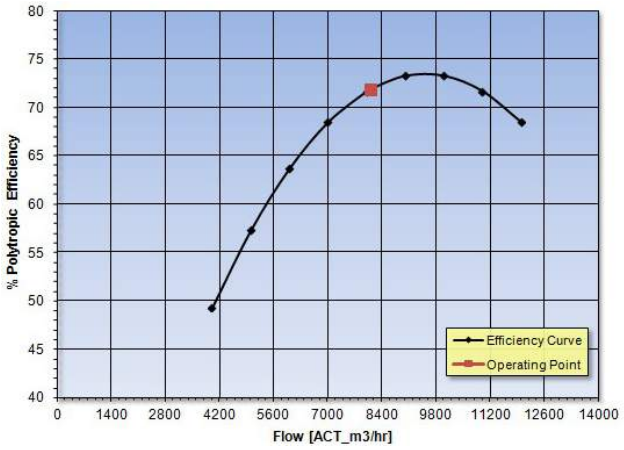

Figure 2. Polytropic Efficiency vs. Actual Volume Flow

To drive the compressor, an asynchronous electric motor is chosen. The slippage in the electric motor can vary even up to 5% during start-up depending on its design. However for this exercise, a value of 1% is assumed. Note that, the EM is rated at 600 kW & the start-up power required would be higher than 600 kW. The power absorbed during operating conditions is 496 kW. In addition to the VSD and FSD cases, the case of suction throttling with an FSD is also investigated.

Table 2. Electric Motor Configuration

Parameter	Value
Electric Motor Type	Asynchronous Induction
Motor Rating	600 kW
Number of Poles	4
Frequency	50 Hz
Motor Slip	1%
Rated Speed	1500 rpm [With Gearbox]

The EM is also characterized by a Speed vs. Torque curve enabling to compute the power and torque required to be generated.

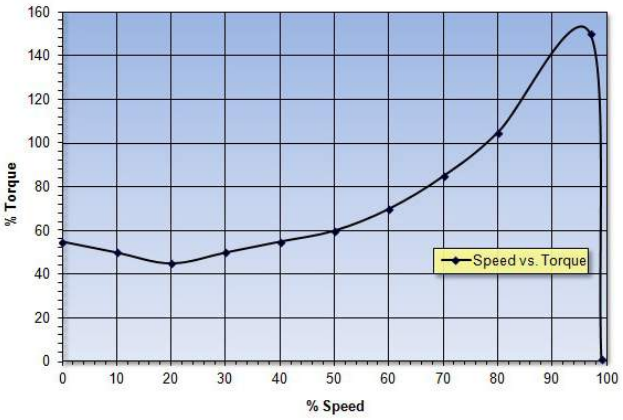

Figure 3. EM Speed vs. Torque Characteristics

Design Methodology & Approach

Prior to performing a transient study for power requirements, the gas compressor's remaining piping & equipment system details needs to be available. The general design approach consists of performing steady state calculations, i.e., heat & mass balance as well as sizing the equipment, valves & lines based on customer's needs and layout. However in the current undertaking, since no layout information is available, an approach is proposed based on the Author's experience for preliminary volumes to avoid surge during start-up & shutdown. This is followed by shaping these volumes into detailed piping & equipment estimates. A general schematic of the compressor loop envisaged is shown below.

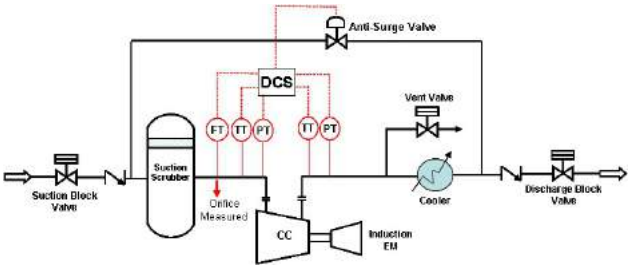

Figure 4. Gas Compressor Proposed Layout

Equipment Sizing

Equipment Volumes

The main equipment in addition to piping that contributes to the compressor loop volumes are suction scrubber and discharge cooler. In situations where gas condensation occurs after the discharge side air cooler, an additional discharge scrubber is installed to knock out any liquids. The discharge side volumes particularly affect the response time of anti-surge system. Excessive discharge side volumes result in a delay in recycling discharge gas. Hence discharge side volumes are to be kept as minimum as possible.

It must be ensured that the anti-surge take-off point before the discharge side check valve and air cooler is chosen, such that the setup is not too close to the compressor discharge flange (which can cause the anti-surge valve to rattle) inducing noise related issues. If the anti-surge line tap off point is too far, then it increases the surge response time. The rate at which the compressor coast down, i.e., speed decay occurs, also determines the size of the anti-surge valve that regulates the amount of the recycle flow. Based on the above considerations, the equipment volumes are calculated as described in the next section.

Suction Side Volume

Based on the Author's experience, the suction side volume can be calculated initially for twice the rated volume flow. Therefore,

$$V_{Suction,Prelim} = Q_{Suction\,Scruuber} \times Margin \quad (1)$$

Or,

$$V_{Suction,Prelim} = \frac{8100}{3600} \times 2 = 4.5\ m^3 \quad (2)$$

Therefore on the suction side, a preliminary volume of 4.5 m^3 is taken. This is a preliminary estimate that is subjected to change depending on heat & material balance, equipment sizing & transient study results for start-up & shutdown scenarios.

Discharge Side Volume

The discharge side volume is predicted for the worst case of surge & this can happen during an emergency shutdown (ESD) which is dependent on the decay rate of the compressor speed as well as the recycle flow rate through the anti-surge valve (ASV). Based on the Author's experience, the discharge side volume can be taken as approximately, 1/3rd of the suction volume.

$$V_{Discharge,Prelim} = V_{Suction\,Scruuber} \times \frac{1}{3} \quad (3)$$

Or,

$$V_{Discharge,Prelim} = \frac{1}{3} \times 4.5 = 1.5\ m^3 \quad (4)$$

Therefore, the discharge volume is taken as 1.5 m^3.

Anti-surge Valve (ASV) Size

To estimate the anti-surge valve (ASV) C_v, the ASV inlet & outlet pressure is required. The compressor vendor would provide performance curves as a plot of discharge pressure vs. flow rate from which the discharge line losses is added to the compressor discharge pressure to arrive at the ASV's upstream pressure & the ASV's downstream pressure is the sum of suction side line losses and compressor suction pressure. Considering the maximum possible flow through the compressor is at the stonewall region, the ASV can be sized for this flow. However, to avoid equipment operation at its limits, a margin of 10% to 15% on the stonewall flow at 3000 rpm is taken to ensure that the ASV does not recycle excess fluid back to the suction side. Based on a maximum allowable compressor suction flow of 10,440 m^3/h, the ASV C_v size is taken as 980 as per ANSI/ ISA 75.01-1985 standard estimation.

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Start-up Operations

The compressor loop is checked for stability in terms of surge and power adequacy for different start-up modes. This is applied to

1. Fixed Speed Gearbox coupled Electric Motor (EM) + Centrifugal Compressor (CC) configuration
2. Variable Frequency Drive (VFD/VSD) + Electric Motor (EM) configuration.
3. In addition to VFD and FSD configurations, the case of using a suction throttle valve at 100% ASV opening is also studied.

Suction throttling methods involve the use of a globe valve or a butterfly valve at the suction line of the CC to cool the gas thereby increasing gas density. This operation reduces the power required to compress the incoming gas i.e., compressor start-up power is also decreased. However, a limitation exists on the suction throttling operation while reducing the suction flow rate, because it results in the operating point moving closer to the surge line during start-up. Hence the throttling valve operation must be regulated.

Table 3. Gas Compressor Start-up Cases

Start-up Case No.	Electric Motor Configuration		Anti-surge Valve (ASV) Position		Fixed Speed & Fixed ASV opening with / without Suction Throttling
	Fixed Speed	Variable Speed	Fixed ASV	Variable ASV	
1	Ö		Ö		
2	Ö			Ö	
3		Ö	Ö		
4		Ö		Ö	
5	Ö				Ö
6		Ö			Ö

Results & Discussions

Case 1: Fixed Speed with Fixed ASV at Start up

For Case 1, based on the simulations, the following plot shows the operating point migration. For the volumes & ASV size used, no surging occurs & the compressor reaches the rated point of 8,100 m^3/h & 2.7 barg.

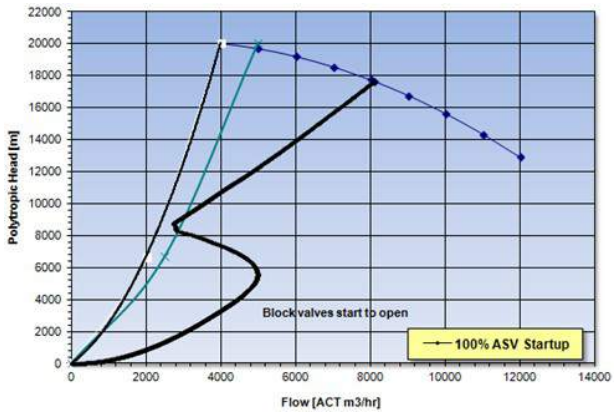

Figure 5. Case 1: Operating Point Migration

Case 2: Fixed Speed with Variable ASV Start up

For Case 2, based on the simulations, the following plot shows the operating point migration. For the volumes & ASV size used, no surging occurs & the compressor reaches the rated point of 8,100 m^3/h and 2.7 barg.

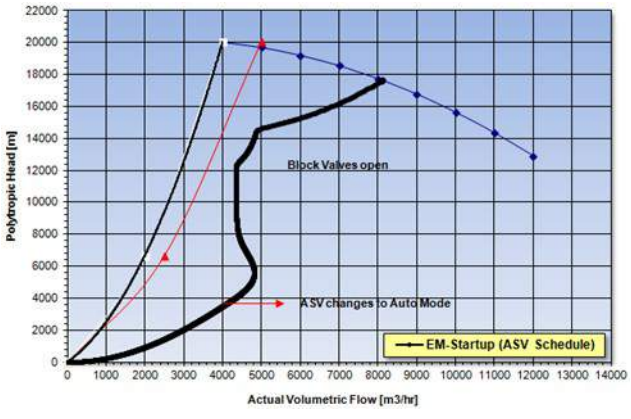

Figure 6. Case 2: Operating Point Migration

Case 3: Variable Speed with Fixed ASV Start up

Variable frequency drives (VFD) are particularly useful when a variation in speed is required, to control gas throughput during production changes. VFD's also offer the advantage of lowering compressor speed during turndown conditions thereby avoiding gas recycling that causes energy wastage. During start-up, the EM speed ramp-up rate is achieved by altering the frequency of the current passing through the EM which thereby raises the CC speed gradually. In Case 3, for the volumes & ASV size used, no surging occurs & the compressor reaches the rated point of 8,100 m^3/h and 2.7 barg discharge pressure.

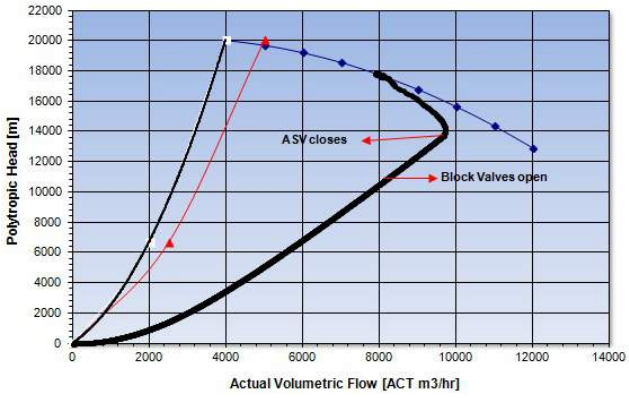

Figure 7. Case 3: Operating Point Migration

Case 4: Variable Speed with Variable ASV Start

The variable ASV position is achieved by using an Anti-surge controller (ASC). In Case 4, no surging occurs & the compressor reaches the rated point of 8,100 m^3/h and 2.7 barg discharge pressure.

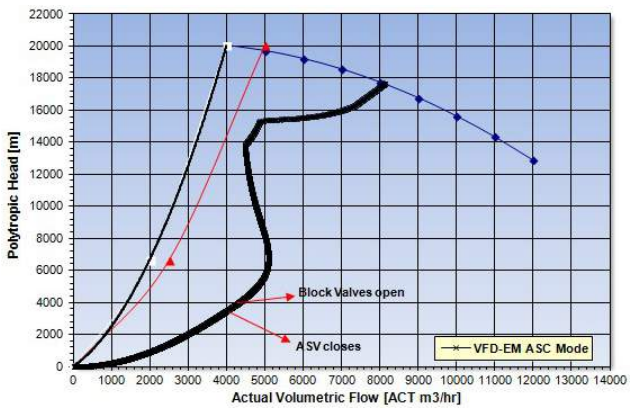

Figure 8. Case 4: Operating Point Migration

Case 5: Fixed Speed with Suction Throttling

For Case 5, with fixed speed drive, 100% ASV opening and suction throttling, suction throttling causes the operating point to closer to the surge line but does not cross. Based on the simulations, the following plot shows the migration of operating point. For the volumes & ASV size used, no surging occurs & the compressor reaches the rated point of 8,100 m^3/h and 2.7 barg discharge pressure.

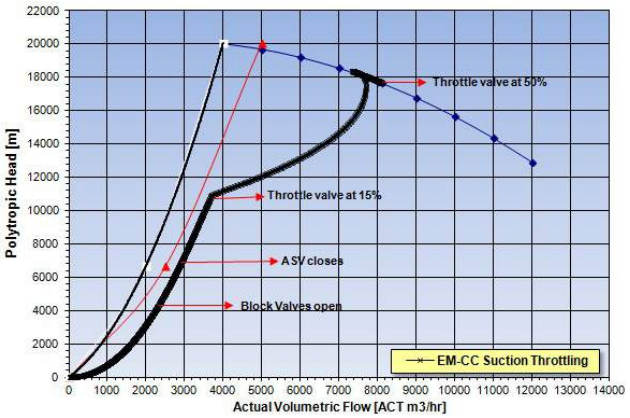

Figure 9. Case 5: Operating Point Migration

Case 6: Variable Speed with Suction Throttling

For Case 6, with variable speed drive, 100% ASV opening and suction throttling, based on the simulations, the following plot shows the migration of operating point. For the volumes & ASV size used, no surging occurs & the compressor reaches the rated point of 8,100 m^3/h and 2.7 barg. Between cases 5 & 6, the peak absorbed power is 865 kW and 666 kW respectively which can be attributed to the use of variable ASV position during start-up.

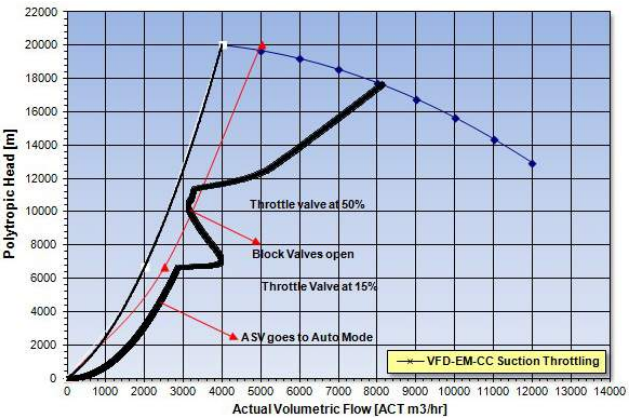

Figure 10. Case 6: Operating Point Migration

Start-Up Power Results

From the 6 cases simulated for start-up power requirements, a plot of the power absorbed vs. Time for a start-up time of 180 sec (~3 min) for cases that have VFD provision and is shown below.

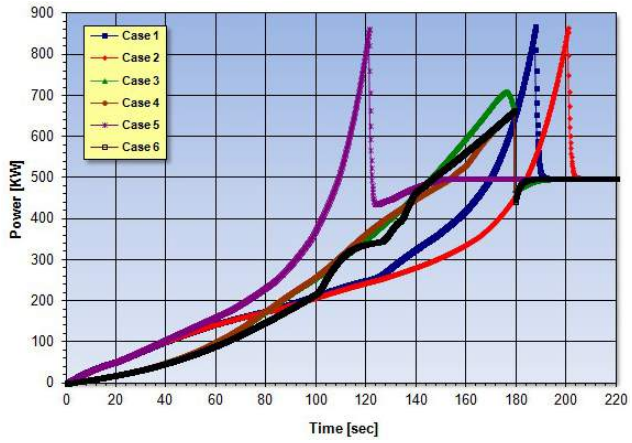

Figure 11. Compressor Start-up Power – All Cases

The compressor speed variation during start-up is also plotted and shown below.

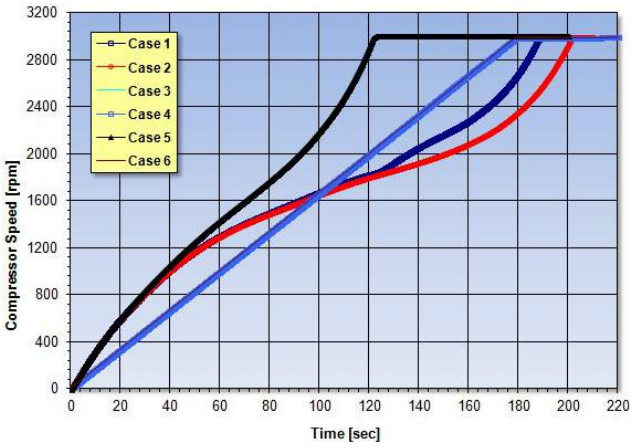

Figure 12. Compressor Speed vs. Time – All Cases

A comparison of the peak absorbed power for all the start-up cases is shown below.

Table 4. Start-up Power Comparison

Case	Peak Absorbed Power [kW]	% Power Savings [w.r.t Case 1]
1 (Base Case)	869	0
2	866	0.3
3	711	18.2
4	666	23.4
5	865	0.5
6	666	23.4

From the above table, it is seen that for cases 1, 2 & 5 which use an fixed speed induction motor coupled CC with Gearbox arrangement, the start-up power is higher while for cases 3, 4 & 6 which use a VFD, the start-up power is lower by ~23% w.r.t case 1. Cases 1, 2 & 5 are fixed speed EM operation cases and show that the peak power absorbed is higher since the EM has to reach breakdown torque threshold of ~150%. In case 2, using a variable ASV position for a fixed speed operation during start-up, does not help in energy reduction.

Conclusions

From the study made, it can be inferred that,

1. VFD's show a significant reduction in start-up peak power when compared to FSD operation. In oil & gas applications, with varying production rates, VFD's are better equipped to alter the speed of the centrifugal gas compressor to match production demands to give energy savings & operational savings.
2. Electric motor's speed vs. Torque curves are designed for a higher break-down torque, sometimes as much as 200%. This means during start-up with an FSD, there are chances that the electric motor would reach the break down torque but can still fail to bring the compressor online to match the required process conditions. In such cases, VFD's are an alternative.
3. With FSD's, there is no provision for speed control. Hence during a stat-up if the ramp up rate is too fast, a sluggish anti-surge controller would struggle to recycle sufficient flow to the compressor suction to prevent surge. Use of VSD's help slowing down the start-up ramp up rate of the electric motor, enough to allow the anti-surge controller to respond & ensure sufficient recycle gas flows to the compressor suction to prevent a compressor surge.

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Author Biography

Vijay Sarathy holds a Master 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 10 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.

Complaint Management

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Synopsis
Complaint as risk that happened in the business transaction. Manufacture companies, service or commercial has similar risk potentials. During this a response of the company toward a complaint tend to be negative, mainly the negative connotation from this complain self. Customer give a claim or complain6 assessed as annoying customer then this felt as an unnecessary annoyance to be handled positively.

Concerned with customer's complaint, the company often overlooked an iceberg phenomenon. What is seen over the surface as negative thing that burdening the company operational oftentimes it is the way to positive things on the contrary support the success of the company. Latest study show that one of the reasons customer left a company because the it does not indicate a seriousness in complaint handling. Whereas complaint handled good, will afford customer's satisfaction and frequently arise intention to make re-transaction with the company. In this case, focus on customer satisfaction is crucial to be paid attention by each company.

Understanding of customer complaints begins with an understanding of the customer satisfaction. Obligations that every company has in business is ability to fulfill customer's needs, where when the need is met, satisfaction will be realized. Understanding about this things will avoid a company from customers complaints.

Complaints as correction of service imperfection of the company in the eyes of the customers. Customer as a party who determined whether to return to business with a company or leave the company and choose business with another one. This book written as manual fro businessmen or managers to anticipating complaint by providing service as good as possible to customers. In addition, this book also served as motivator for readers to respond a complaint wisely and make complaint as trigger of the company success, not as burden or accidental that should be respond as antipathy,

"Why customers leave a company, because the company does not handle their complaints properly"

In this book, the writer uses some terms to mentioned buyer, among them consumer, buyer, customer. While in international trading, the writer give examples of complaint management that conducted several companies in effort to minimize complaint of the customer.

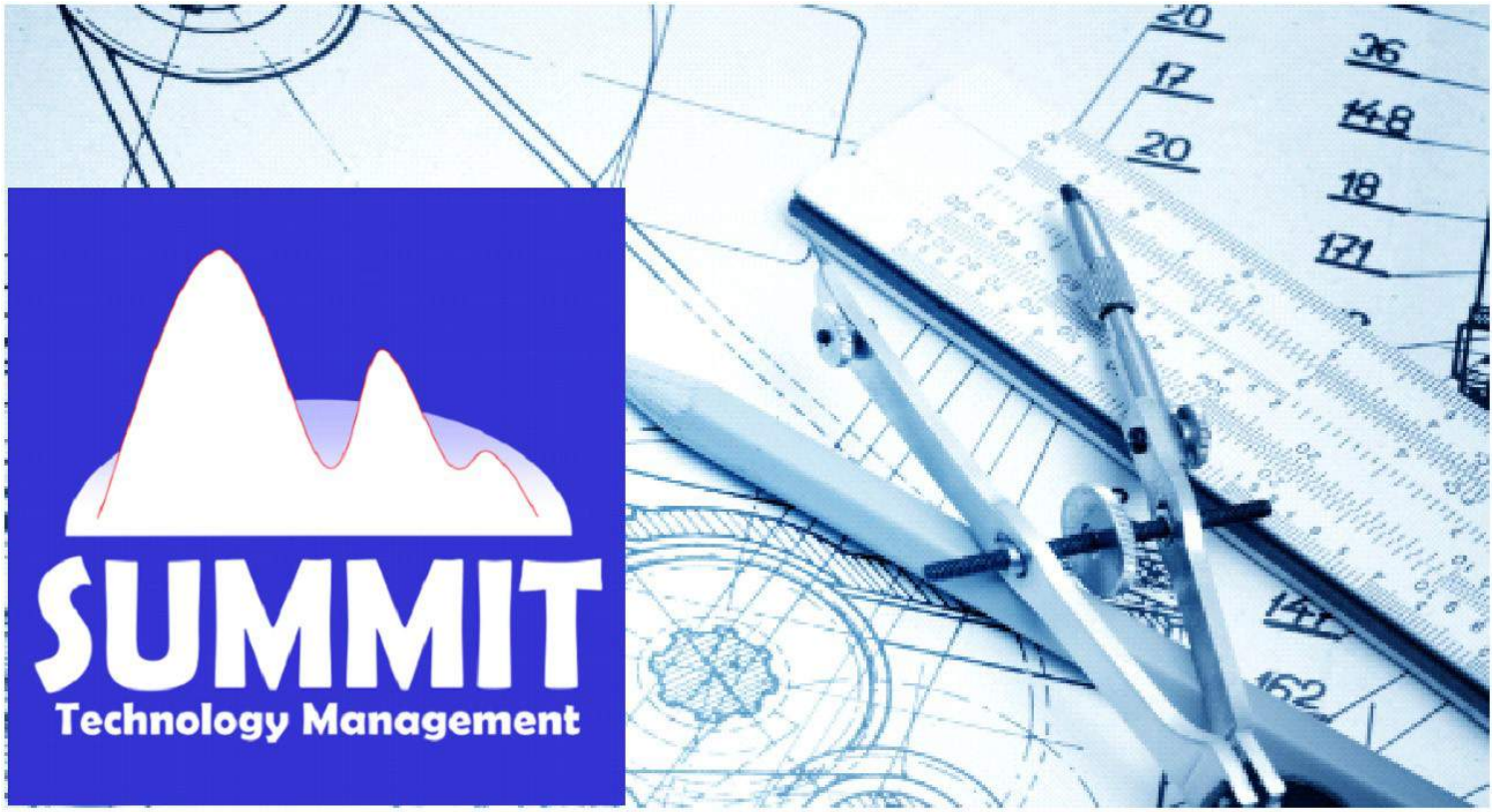
Thanks for Mr. Ir. H. Bagus Andris Lesmana who inspired topic writing of this book from workshop titled "Received Your Claim for Success" delivered in even semester Selecta Capita in Ciputra University. Hereby thanks for Mr. Budhi Wibowo who has sharing claim solving tips from oversea customer as his experiences for years in frozen shrimp export to various country.

Relationship of Service Quality and Price to Customer Satisfaction

Fact that customer satisfaction is strategic things that must be achieved, as something in common known by the companies, either local or international company. However, essentially customer satisfaction is an abstract concept. It is because the process of customer satisfaction accomplishment so multiple diverge, begin from simple process to complex. In this case, the company need to identify anything that able to give significant effect on customer satisfaction.

Money as exchange tool is universal nature has high value in the eyes of human. In majority of transaction, money as one thing that must be sacrificed by consumer to get goods or services. Can be said that money is "price" that must be paid by consumer to get value of the goods or services. When the price paid by the consumer regarded as correspond with received value, consumer tend to be satisfied. Otherwise, when not correspond with it, then will be dissatisfaction.

Another factor determines customer satisfaction is service quality (Bitner, 1990, Bolton & Drew,



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1991b, Wang & Shieh, 2006, and Mosahab, Mahamad, & Ramayah, 2010). Argument that given the company service done beyond customer's expectation or hope. This is come out satisfaction. Consumer make perception that his expectation fulfilled or even exceed it, then consumer will say that company service is qualified.

Service quality concept first coined by Parasuraman, Zeithaml, and Berry (1985). They has argument that service quality uneasy to caught by consumer, particularly self-service characteristics are unformed, heterogen, and instantly consumed. Unlike product quality is measurable (for example features or durability), service quality keep abstract.

Numerous literature try to define service quality in general. Parasuraman, Zeithaml, and Berry (1985) expressed that service quality as comparison between perceived service by customer with the expected service. Tjiptono (2007, p. 59) adds that service quality is an excellence level and control to the excellence level self, in meeting the customer's expectation. This both definitions has similarity that is emphasizes on consumer.

Good or poor of the service quality undeterminable by service provider. Consumer has power to determined whether service that he or she accept is compatible, surpass or incompatible with her or his expectation. In this case, it is important for the company identify consumer's expectations on the company's service. When consumer's expectation fulfilled or surpassed, then service quality can be said good.

On progress, service quality become inseparable from company's operational. Company engaged in the manufacture field, trade, and especially service will be pertinent with this concept. An automotive factory will keep try to provide best service for their customer, either distributor or supplier. Retail supermarket should be obliged to pay attention service quality of the workers to the consumers. Then can be drawn a conclusion that service quality is absolute thing owned every company.

Chapter 2 provide understanding on service quality also its dimensions in relation with customer satisfaction. In addition, customer satisfaction will be explored more in related to the service. In the final of this chapter, will be show the important own qualified service and precisely price strategy to get customer satisfaction.

A. Price

The price is the amount of money that a consumer is willing to pay for certain item or service. This is created when demand happen over the item and available supply for such item. The higher demand happen, the price will increase, chiefly whenever wanted item supply unable to fulfill the demand.

1. Value

In a transaction, goods or service wanted by consumer has a value. This value will perceived by a consumer when consumption process happen. Consumer of the tangible product will feel the product value in adequate period until the goods is perish or obsolete, while service consumed instantly then the value will be perceived in relatively brief duration.

2. Sacrifice

Like mentioned above, price can be said as one of consumer's sacrifice to afford goods or service. In this case, the value context or value of goods and service become abstract, particularly except if each consumer has difference expectation and standards. What is feel worth by someone but uncertain has same value for someone else.

For example, a person who has travelling hobby will be willing to sacrifice time, effort, and money to travel to a country. In this case, he is willing to spend a lot of money to consuming various goods or services in the country he visited so that from the demand appears supply from tour & travel bureaus or other related companies such as hotels or restaurants.

What should be a concern for these companies is the desire to travel each individual is not the same. There are people who prefer to travel by backpacking, where they will plan their own journey and tend to spend a long time in a country. However, there are also people who rely on tour and travel companies to organize their trips because they are not willing to sacrifice their time and effort to plan. They tend to have a willingness to sacrifice more money for this. In this case, there are two groups that have similar demand, but they have different standards.

B. Price Influence on Customer Satisfaction

One of the factors of customer satisfaction can be obtained through proper pricing. Price is one of the most important elements of marketing and influences the customer's decision to buy. Price can indicate the brand quality of a product, where the customer has the assumption that the expensive price usually have good quality. The higher price, the higher perception of quality. Customers have a positive relationship between the price and quality of a product, then they will compare between one product with another product, as a basis to buy a product or service.

Price is often used as an indicator of value, especially if the price is associated with perceived benefits to a goods or service. Values can be defined as the ratio between perceived benefits to prices. At a certain price level, if perceived benefits increase, then the value will increase as well. If the perceived value of customers is high, it will create maximum satisfaction.

Price becomes one of the factors that affect the demand of goods or services, accompanied by the ability to buy at a certain price level or condition. Yoeti (2009, p. 109) argues that demand is the amount of goods or services that are economic goods, which the customer will buy at a certain price within a certain time or period.

The law of demand reads, "the lower the price of a goods , the more demand for it." On the contrary, "the higher the price of a goods , the less demand for it" (Sukirno, 2005 p. The demand for goods or services generally depends on the customer's income and the price of the goods or services offered. An increase in the price of goods will cause a decrease in the quantity of goods demand, this is because rising prices will cause a decrease in customer purchasing power which will result in reduced demand. As a result, customers will find replacement goods that are cheaper.

The pricing of a product or service is absolutely done by a company. Appropriate pricing results from knowledge of what is going on and where it is sold. The cost of the product or service must match what the customer perceives. A person with a high level of satisfaction will show a positive attitude towards the product or service offered, while the dissatisfied will show a negative attitude. They will not be loyal to the products or services offered, because they do not get satisfaction as expected.

Price becomes one of the factors forming customer satisfaction. In his study, Vossetal (1998) states that customer satisfaction is formed from the function of price, performance, and expectations. In contrast to performance, price policy becomes the most dominant determinant of customer satisfaction. The results show that when the perceived price matches what the customer expected, it will have an impact on the level of customer satisfaction.

Price is related to customer satisfaction. Price perceived by the customer through the level of fairness, conformity, affordability, and price competitiveness. Customer perception is a reference to compare the price of a company's goods with a competitor company, as well as a basis of reference to buy the goods. Price also has a relationship with customer satisfaction, where the correlation results obtained shows a strong relationship between price and satisfaction.

Rahman, Kalam, Abdullah, and Rahman (2012) research on *The Influence of Service Quality and Price on Customer Satisfaction : An Empirical Study on Restaurant Service in Khulna Division* states that pricing affects customer satisfaction. Consumers tend to consider relationship between prices and expectations, to form customer satisfaction. Consumers compare between the price offered and the previous experience or the customer's actual expectations.

Price and customer expectations must be compatible with the performance of the products or services they buy. If the customer's perception of performance exceeds their expectations, then they will perceive the price offered well. Therefore, the magnitude of linkage and the influence of prices on the creation of a customer satisfaction needs to be considered. Appropriate pricing is one of the company's strategy to be able to create customer satisfaction. So in this case, the company is required to create customer satisfaction. One way is to adjust the pricing and expectations of consumers.

C. Principles of Service Quality

An understanding of the service quality concept is crucial before applying it. According to Tjiptono (2007), there are several principles contained in achieving service quality expected:

a. Planning
   Good service quality does not happen by itself. Consumer expectations for a product or service must be known by the company. This is what will become a blue print of quality that must be achieved. In this case, strategic planning should include quality as expected and how it will be measured. Planning is what will be a guide in directing the company to achieve the expected quality.

b. Leadership
   Commitment from top management to achieve expected service quality is vital to a company. In the operational process of a company, leaders are individuals who play a role to direct the workers in improving service quality. Although effective, a plan that is not accompanied by adequate leadership, then quality services achievement will not have a major impact on the company.

c. Review
   The review process is the only effective tool for management to change organizational behavior. This process is a mechanism that

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ensures and constant attention and continually to afford the quality. In this case, both top management and workers under them will always refer to planning document as a tool to gauge whether the services provided are now in accordance with the goals or not.

d. Communication

Implementation of the quality strategy in each worker is influenced by the communication process within the company. Well-planned quality will not be achieved without participation from each individual in a company. Frequently good quality planning does not work because workers do not know what to do to achieve that quality. In this case, communication becomes an important and irreplaceable instrument. The information system built should be easily accessible and learned by every employee in order to be understood well.

e. Awards and Measurements

The rewards are compensated for workers who are trying to realize a planned quality goal or strategy. This has a positive impact, because it can motivate other workers to provide better quality services. However, it should be noted that rewards can be given if the quality of a worker's service can be measured. Several methods of measuring service quality will be discussed in subsequent chapters.

f. Education

All company personnel from top management to operational workers must obtain quality education. Aspects that need to be emphasized on education include quality concepts such as a business, quality strategy implementation techniques, and executive planning in the implementation of quality strategies.

D. Service Quality Dimension

Parasuraman, Zeithaml, and Berry (1985) used a gap model to define service quality. The conclusion taken is the service quality is a gap between consumer perceptions toward service and expectations that received by the consumers. From the results of the research shows that there are 10 dimensions of service quality, including; (i) Reliability, (ii) Responsiveness, (iii) Competence, (iv) Access, (v) Courtesy, (vi) Communication (vii) Credibility, (viii) Security, (ix) Understanding / knowing the Customers, and (ii) Competence, (x) Tangibles.

In its progress, these dimensions are reduced to 5 dimensions (Parasuraman, Zeithaml, & Berry, 1988). This dimension become quality measuring basis on service and keeps used today. The dimensions are as follows :

a) Physical products (Tangibles)

Physical facilities, equipment, tools, means of communication, and others are essential to the service process. This element is a means to realize the service directly as required in a transaction of goods or services. The means should be realized in an attractive, informative, and convenient form for the consumer so that later these means will support service delivery process to the consumer.

b) Reliability

Reliability is the ability to deliver accurately, dependability, and on time services without any error. This dimension of reliability involves skill mastery level of service providers (services) as well as service products. For example, cooks in the culinary business, service technicians on machine maintenance services, therapists on beauty treatments, and so forth.

c) Responsiveness

Responsiveness is the willingness or desire of the workers to help and provide services required by customers. Consumers who are purchasing or selecting a product expect its existence to be recognized by the seller. In this case, the consumer expects that the seller is able to provide information, help, and a positive response. It should be noted that being responsive is not the same as being aggressive. This should be avoided, especially at the time of the purchase process. At the time of the buying process, the consumer wants no kind of coercion from the seller, because aggressive attitude shown by a salesperson.

d). Assurance

Assurances include knowledge, abilities, friendliness, courtesy, and trustworthiness. This can be obtained from direct contact between seller and buyer. With the assurance, the buyer will not hesitate and free from danger and risk.

e) Empathy

Empathy includes the contact attitude of personnel and companies in understanding the customer's needs or difficulties. Good communication and attentive, will provide convenience in communication or relationships. Empathy can also be manifested in a series of attitudes so that customers feel comfortable and not awkward. Sense of alien and awkward levels make customers become sensitive and tend to make uncomfortable. The most appropriate way to overcome this is to try

to become familiar and make customers comfortable so that customers feel the place is not strange for her.

Measurements based on these service quality dimensions will be further elaborated "into questionnaires containing 22 question items, where the basis of the question is consumer expectations and perceptions. This instrument is better known as Service Quality or SERVQUAL. The SERVQUAL application in service quality achievement that leads to customer satisfaction achievement will be discussed in the second part of this book.

Measurement of service quality is growing up to now. One of the different measurement methods proposed by Cronin & Taylor (1992) is called performance-based service quality or SERVPERF. The instruments used are still based on service quality dimensions, but SERVPERF eliminates the expectation element. The argument is that consumer perceptions of a service are important to note, given primary focus of the service is the consumer. Good service performance will be achieved if the consumer's perception of a service is also good.

Apart from SERVQUAL and SERVPERF, an instrument that measures the specific industry of restaurants with the name DINESERV (Stevens, Knutson & Patton, 1995). However, these instruments are still based on service quality dimensions. It's just that in this instrument, the question items that have been adapted are specific to the restaurant industry.

E. Effect of Service Quality on Customer Satisfaction

Customer satisfaction is also influenced by service quality factor. Good service quality is often said to be one of the important factors in the business success. Parasuraman, Zeithaml, and Berry (1985) show that the service quality provided should be in compatible with what is expected by the customer. All actions, treatment, or ways of serving others must fulfill their needs and wants. This means the service quality provided should be consistent with customer expectations. The conformity level between expectations of the service quality provided by the company, is a sign of the creation of a maximum value of satisfaction.

The service quality concept related to satisfaction is determined by five dimensions, commonly known as tangible, reliability, responsiveness, empathy, and assurance. The service quality concepts was created to shape attitudes and behaviors of service development in providing a strong and basic service form, in order to be assessed according to the service quality received. The essence of the service quality concept here is to show all forms of actualization of service activities that satisfy the service recipients suitable for the responsive, to generate the assurance that show tangible proof that supports the service to feel the attitude awareness (empathy) from people who provide services in accordance with its reliability, and run the overall service provided by consequence to satisfy the customer. In other words, service quality is created to avoid the gap between reality and customer's expectation of the service received so as to create the customer satisfaction level.

Kaihatu (2008) argues that the service quality is the basis of the service marketing, because the core product marketed is a performance (quality). This performance is purchased by the customer, therefore the performance of the service quality as the basis for marketing services. Jasfar (2005 p.19) suggests that in a service system, service providers and customers as service users must have a very close relationship, where the customer is an active participant in the formation of service processes. Concept of good service will provide an opportunity for companies to compete in seizing customers. Good performance (quality) of a service concept will lead to a competitive situation, where it can be implemented through strategies to convince customers, reinforce brand image, advertising, sales, and pricing.

However, when companies are faced with increasingly fierce competition (ie, when increasing number of competitors in offering products or services with better service quality), in this case the customer is faced many choices of products or services replacement. It requires the company to always pay attention to the customer’s needs and desires and trying to meet their expectations by providing a more satisfactory service than by the competitors.

Companies should continue to strive to provide good service, with the aim to meet the needs and expectations of service users in general, and customers in particular. If a company has been able to improve its service quality, then automatically the company will meet customer expectations. If the company meets the expectations of a customer, then there will be satisfaction for the customer.

In an earlier study, the writer examined the gap of service quality and customer satisfaction. In the study, the writer verify that the service quality has a positive effect on customer satisfaction. That is, the higher the service quality, the higher the customer satisfaction. Service Quality affects customer

satisfaction, because it provides an impetus to customers to undergo strong ties with the company. In the long term, this bond allows the company to understand carefully the expectations of customers and their needs.

For the sake of creating customer satisfaction, companies must be able to maximize a pleasant customer experience and minimize unpleasant experiences. Keys decision of the customer is one of them related to customer satisfaction on the assessment of service quality provided by the company. So understanding the needs, desires, and expectations of customers on the service quality in accordance with its expectations will affect a customer satisfaction. So only companies with high quality that can compete and dominate the market. From this it can be seen that customer satisfaction is influenced by customer expectation and perception to company performance, that is service quality.

A. How to Face and Complete Complaints Positively

The focus of this chapter is the curative part of complaints management, which is how to handle complaints positively. It has been mentioned that as good as any planning has been made, complaints will still emerge. The development of the characteristics or attitude of consumers in general tend to be unpredictable, especially because many factors that influence it, such as changes in taste and changes in purchasing power. Therefore, the step to handling complaints is very important for each company.

Skills in handling complaints from customers is not trivial and easy to do. This requires a technique of its own and necessary steps in taking appropriate and correct action. Furthermore, consumers tend to demand rapid handling. If the handling is not done properly, correctly, and quickly, most likely consumers will become dissatisfied and decide to switch brands. However, it should be noted that quick handling does not mean hurry. The prescribed procedure must be kept to ensure that satisfaction does not only occur on the consumer side, but also on the company side.

A. Stages in Receiving and Resolving Complaints of the Customer

When a complaint arises, the handling of the complaint may vary. Typically, a company has Standard Operational Procedure (SOP) in handling complaints, and these SOPs differ from each other. However, the implementation of these SOPs is often ineffective, especially since the big picture of complaint handling is not understood either by front line workers or a company's customer service. An outline of the complaint handling can be divided into 6 phases which are described below.

Stage 1: Listening and Understanding

The key to dealing with customers is "listening". Listening becomes a basic attitude to capture what anxiety and customer needs are. In this case, "listening" can be many things, depending on the media in which the complaint is delivered.

Companies in the service sector tend to be in direct contact with customers who complain. Therefore, "listening" can be taken literally. When complaints occur, front line workers are obliged to listen to complaints from customers in order to establish perceptions about the complaint. The main focus of the listening process is to explore the source of the complained problem until a proper understanding of the complaint finally occurs. Frontline workers are expected not to be defensive or interrupted when a complaint is submitted, but may still ask the right questions at the right time, in accordance with existing SOPs (e.g., when, what causes, how can happen).

On the other hand, companies engaged in manufacturing and trade usually have a customer service division that specifically serves customers directly. Typically, complaints are conveyed to this division either by email, letter, telephone, or face-to-face. In this case, "listening" can be taken literally when the media of complaint submission is telephone or face-to-face. So, what the customer service division should do is similar to what has been described in the previous paragraph. However, if the complaint is made via email or letter, then the company concerned must understand the root of the problem in writing. The positive side of this is the time for discussion within the customer service team to understand the root cause of a complaint. The negative side of this is the unread of the customer's emotion when filing the complaint so that the urgency level of the complaint is less readable.

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Stage 2: Clarification and Perception of Equipment

The clarification process is a continuation of the listening and understanding process. When the company, whether the front line worker or customer service division has a perception of the complaint posted, this perception must be clarified once again on the customer who filed the complaint. This is to prevent corporate error in handling complaints.

Often, this stage is not done in the complaint settlement process. However, this stage is still important. As a result of the lack of clarification is the complaint is not handled in accordance with the consumer's wish. In this case, the worst possible customer will switch brands and spread the story about the poor complaints handling of the company. This means that consumers will experience twice dissatisfaction, namely dissatisfaction of consumption and dissatisfaction over the complaints handling.

In the process of clarification, what needs attention is the discussion. Front line workers and customer service workers are required to have a courteous attitude in this process, especially since the grievance process is usually accompanied by consumer emotions. Instead, the employee explains that this process is to ensure that those who are captured by the workers are correct and will be processed according to the existing SOP. In case of written complaint, the expected language is formal containing clarification and explanation of why this letter or email replies were written, i.e. again to ensure that the company has properly understood the complaint from the customer.

Stage 3: Explanation and Apology

The next step in the complaint handling process is explanation and apology. The company explains the cause of consumer dissatisfaction from the company perspective. It should be noted that once again, this process requires a diplomatic discussion. In explaining the source and cause of customer dissatisfaction until the complaint filed, the front line officer or customer service division should not blame the company, company system, other related divisions, or the customer itself.

As a result of the explanation that is blaming the company, both workers, systems, or certain divisions, will result in very fatal. Customers may be satisfied with the explanation, but the word of mouth that is created remains negative, i.e. the company has a flop within the system and its workers. What is targeted is the satisfaction of handling complaints and a positive word of mouth as well.

The explanation process is usually followed by a company apology. Once again, diplomacy is indispensable in this regard. A good apology is an apology for the situation, not an apology for a corporate fault. Of course, there are exceptions to this, that corporate fault is undeniable. For example, when a company makes a shipping mistake, nothing can be done except to acknowledge the company's fault. However, if there is a defect in one or two products, there are still many possibilities that the fault is not on the part of the company. In this case, the apology is done for the situation.

Stage 4: Solution and Taking Action

Often solutions in complaint handling are related to existing SOPs. When a complaint is conveyed, understood, and clarified with the customer concerned, usually the complaint will be categorized. This complaint category varies, depending on the company policy. One example of complaint categorization process is from mild, middle, to a fatal complaint. Indicators of each category are usually created and agreed upon by the team or consultant that a company uses.

The solutions offered to customers are usually beneficial to the customer. However, not all solutions will be directly agreed by the customer. In this case, the front line workers and customer service division must have negotiation ability so that consumers feel benefited and the company is not harmed. Of course, a given solution must be approved by the customer who filed a complaint.

Submission of this agreement is also often a problem for the company, mainly because of the negotiation process. Front line workers and customer service divisions are often blamed for providing solutions that are slightly incompatible with existing SOPs. It should be understood that each customer is a different individual with the purpose of a different complaint. Therefore, the company should provide more flexibility to workers who intersect directly with consumers. Nevertheless, it is necessary to set certain restrictions in the provision of solutions so that the company is not too disadvantaged. For example, a restaurant customer's complaint about an undercooked steak can be solved with an apology and a compensation of a glass of wine. If no set restrictions, then it could be the wine given as compensation is first class wine. However, it can be defined that the wine given must be part of

wine first class.

Stage 5: Follow Up

The final stage of complaint handling is the follow-up phase, which is the stage that is often forgotten or deliberately forgotten by the company. This is mainly because the company must once again deal with customers who have filed a complaint, even though the complaint has been dealt with. However, the follow-up phase is a very important step because it involves building a good relationship with the customer who has filed a complaint.

The follow-up phase should be done by workers with managerial level, either the leader of the customer service division, the leaders of the marketing division, or the operational concerned. This will make the customer feel that he is an important person for the company, increasing the opportunity to make the customer not only satisfied, but also loyal.

B. Use of Standard Operational Procedure in Receiving Complaints

Procedure of receiving complaints in a company is required to be written as part of the overall Standard Operational Procedure (SOP) of the company. In this case, the SOP of complaint handling serves as a framework or grid that should be understood by front line workers and customer service divisions. This SOP, which usually takes the steps outlined above, should be translated into what is called a work flow or action plan.

The action plan should consider that the focus of complaint handling is to provide the best service and solution to customer complaints. Examples of action plans are as follows:

a) Prepare every staff to deal with customer complaints by using positive words like "sorry", "thank you", and so forth, so that the customer is satisfied with the service provided.

b) Print an existing action plan, give it to the customer service division to stick to the back office so that the workers always remember and be able to implement the action plan well.

c) Print product specifications to be given on the customer service so that the workers have a good product knowledge.

C. Some Advices in Facing a Complaint

After identifying steps of complaint handling, it should be noted that the strategy will not work without any party related to the operation, either front line worker or customer service division. Training on complaints handling should be done to improve workers' skills in the face of customers.

Here are some suggestions that can be practiced directly by front line workers and customer service divisions:

a) Identify key points. This can be done by observing the intonation of sentence pronunciation from the complaining customer. Customers tend to emphasize certain parts of the sentence to express dissatisfaction. Words such as "how is possible", "I am very dissatisfied", "incompetent company", and the like implies that the sentence is at the core of the customer's problem.
b) Sympathize and acknowledge verbally and action if something goes wrong.
c) Accept customers to take the time to tell what happened. Isolate customers when submitting a complaint, for example invite sit and receive it at the customer service desk, so that what is delivered not heard by others and did not happen intervention other party.
d) Explain in detail what the company will do

When customer service deals with customer complaints that should not be done:
a) Saying "it's not my fault".
b) Saying phrases like "You are the fifth person to declare such complaints today".
c) Disrupt guest comfort.
d) Go straight to conclusion regardless of what the background of the guest's complaint is.
e) It is only responsible when we are sure that the cause of the guest complaint is really the customer service division's own fault.
f) Turning patronizing or teaching a guest who is experiencing a complaint. If the complaint is not understood how to use the product, then politely inform the customer not to be embarrassed.
g) Do not deny all allegations against the complaint. Defensive attitude tends to make the consumer more angry.
h) Do not scold customers who are complaining
i)Do not blame others for the customer's complaints.

This also applies to other divisions. Attitude of blame other division indirectly recognize that the company already made a fatal mistake.

Use of appropriate language

Note the selected language in performing the task as customer service:

Allowable :
a) "I'm sure you'll be happy with this"
b) Use the word "please"
c) Use the word "sure"
d) "I will return to you for completion"
e) "I will finish as soon as possible"

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Disallowable words :
a) "I try" (not convincing).
b) "Okay" (less assertive) better use "yes" or "good".
c) "busy" (as if it does not matter).
d) "maybe" (hesitate impression)

D. The example Stages Application in Receiving and Resolving Complaints

The following is a case study on receiving and resolving the complaints to clarify the application phases of complaints acceptance. It has been mentioned that each company tends to have different standards in the complaint settlement, but still follows the pattern described above. One application of the above step comes from an international trade practitioner who is engaged in seafood, namely Budhi Wibowo. Here are the company's procedures for receiving and handling complaints (Wibowo & Kusrianto, 2010) :

Complaint detail, look for the real problem

Often complaints by customers are unclear and not detailed. Words are often generalized, for example :
a) Your product is poor
b) problematic goods
c) I am disappointed with the quality

To find out the real problem, we must breakdown the problem by describing the existing product specifications / features. The trick is to repeat ask one by one to the customer about the specifications/features of our products. Which specifications or features are problematic and which one are not.
For example, a frozen shrimp exporter company receives complaints from its buyers abroad. The buyer is actually a buyer who has long bought frozen shrimp products from the exporter earlier. However, this time the buyer was disappointed because there was a problem with the product. The complaint sentence received from the buyer is that the product is poor, without further explanation. To face the problem, the exporter should ask the buyer where the problem lies, for example ask 5 main features related to the quality of frozen shrimp as follows.

Is there a problem with:
a.Packing? (carton, plastic etc.)
b.What size is correct?
c.Freshness is in accordance with the standards?
d.How about the color?
e.What net weight is enough?

The more detailed the problem being asked will be better, so the problem becomes clearer.

Reduce Existing Problems with Reducing Techniques

From the above example, the answer of the five questions asked is that there is only one problem, for example just a matter of weight. Thus, problems 1 to 4 can be eliminated from the problem list. The technique is called the reducing technique that diminish or eliminate some of the existing problems.

Reduce Problems More with Split Techniques

Once we get a real problem that is the core or the source of the complaint, we can ask again to the buyer, whether the short weight is on all the goods in 1 (one) container or partly?

Usually buyers will tell the truth, that not everything weighs less. The buyer will acknowledge that it weighs less than about 10% of the total amount of goods. The technique is an example illustration of Split Technique, which means from the rest of the problems that exist, we split again the number so that the real problematic stuff to stay a little.

It should be noted, however, that the company has rights to request the proof of complaints to avoid fraud, if the customer discloses that all containers have a severe shortage, samples from the containers are required, for example, 5 out of 25 containers. If the weight is not in accordance with the standards, then the company needs to follow up the complaint.

Multiply the Company Advantages

In this case, it can be said that the problem only exists on the weight, and the amount is not too much. Can be added that other main features no problem. Remind the buyer, that he has bought in large quantities to us without any problems. However, it must be admitted that this last delivery may indeed be a problem, although the problem is not too large. When compared to existing problems with the last shipment with which we have been sent so far, this problem is not very meaningful. In essence, this technique is to multiply all our advantages over the years, and compare with the existing problems so that the impression will arise the problem becomes very small and meaningless.

Give Resolution

All complaints must be addressed and resolved. We must examine the truth of the complaint and treat it honestly. Talk to the customer about how to settle the complaint. There are several alternative solutions, for example:
a)Repair damaged goods.
b)Replace damaged goods.
c)Provide price discount.
d)Provide special rates for future purchases.
e)Provides compensation.
to the complaint for handling and settlement.

If the problem is not too serious, usually the buyer complains with a purpose just to tell us the problems that exist. The buyer is quite satisfied if we listen to his complaints and try to fix them in the future. Most of them do not compensate as long as we can deal with their complaints well and sympathetically. However, in certain cases, we can provide reasonable compensation to reduce the disappointment of the buyer. The compensation can be in the form of price discount or pay back some of what they have paid to us.

Give Special Gift
Even if the customer has agreed to the settlement of the complaint we give, we must prevent them from spreading bad news about us to others. For that, it takes additional special gift that can treat his disappointment, for example :

a)Souvenirs.
b)Gift.
c)Additional goods.
d)Discount card.

Keep in touch
After settlement of the complaint, keep in touch with the buyer. We must show them that we are very serious about responding to complaints and have tried our best to solve the problems. The positive impression of the buyer is very beneficial for further relationship between us and the buyer.

"If the problem is not too serious, usually the buyer complains with the purpose to tell us the problems that exist. They are quite satisfied if we listen to his complaints and try to fix them in the future ".

Create Report to Internal Management
After knowing the real problem, make a report to internal management about the complaint. Management must examine the existing problem, why it can happen and how to fix it to prevent the same complaint in the future.

E. Prevention of Complaint in the Future
The things mentioned above are something that a seller needs to do in facing the complaints. More broadly, the things that the seller's company needs to do are as follows:

Develop a Corporate Culture Not See Complain Negatively
Many consider complaints to be a scary and inconvenient business. The opinion is clearly not quite right. Complaints are very useful for the company, which is as information back from the buyer. Therefore, everyone in the company should take a positive view of the complaint and not be afraid or hesitate to face it.

The existence of complaints can be used to make improvements to products sold by a company. A complaint is a direct sound from the user of the product. Through complaints, we can know the weaknesses of our products so that it can be done improvements in the future.

The complaint also indicates that there are still concerns from potential buyers. Still good buyers are willing to give complaints to us, than the buyer is no longer want to talk to us, because very disappointed. And it would be even worse if the buyer spread our badness to everyone.

Give a Way for the Buyer to Submit a Complaint and Dissatisfaction
Companies do not being closed to complaints. Companies should make it easy for buyers to complain. Must be made / held a special section to receive complaints from buyers. To receive complaints, can be done by the customer service or by the seller of the product. Media for complaint submission should also be considered more. If via email or mailbox is available, then the contents of the email or letter must be read.

Create Standard Reporting Procedures and Complaint Handling
The company should make standard reporting procedures and complaints handling. Division who receives the complaint directly from the buyer must have a complaint form to be filled by the buyer. The complaint information from the buyer must be promptly communicated to other division relating Good SOP for complaint handling is a SOP that takes into account the details of each event. The form must include name, time, event details, and name of the recipient of the complaint. The ability of workers or complaint handling officers to understand the essence of a complaint will be very instrumental in filling complaints. In other words, this form is one of the tools in the complaint handling phase.

Creating Standard Time of Complaint Settlement
Buyers who complain can not wait long about the certainty of the complaints settlement. The company must establish a standard how long it will take to handle a complaint. All divisions related to complaint handling must comply with the time standard so as not to disappoint the buyer who complains. Management must also strictly control that complaint handling is carried out in accordance with the procedure and within the specified time standard. In addition, the time standard must be informed to the customer who filed a complaint. What should be considered the company is "under promise over deliver". Application of this is

resolved within 3 days, but in fact the company can resolve the complaint within 2 days. This will make customers feel that they are important to create satisfaction over complaints handling.

Finding the Roots of the Complaints Problem and Repairing So the Similar Incident Not Happen Anymore

The main purpose of handling complaints other than to treat dissatisfied buyers, also to find out the root of the problem why such complaints can occur. It should be studied in detail about the problems that caused the complaint and made repairs so that such incidents will not happen again. This step can be applied in existing SOP updates, as well as adding data in a complaint database that belongs to a company.

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