Refining of Crude and its Corrosion Control using Distributed Control System

[1]RAMRAJ SANKARAN[2]ANANDARAJCHINNASAMY

[1]Department of Electronics and Instrumentation Engineering
[2]Department of Electrical and Electronics Engineering
Thiruvalluvar College of Engineering and Technology
Vandavasi, Tamil Nadu
INDIA
[1]itzrara@gmail.com[2]chinnaanand1979@gmail.com

Abstract - Distillation separates compounds by the variation in how effortlessly they vaporize. The two main types of standard distillation comprise unremitting distillation and batch distillation. Unremitting distillation, as the name says, unremittingly takes a feed and separates it into two or more products. Batch distillation takes on lot (or batch) at a time of feed and splits it into products by selectively removing the more unstable fractions over time. Other ways to categorize distillation are by the equipment type (trays, packing), process configuration (distillation, absorption, stripping, isotropic, extractive, complex), or process type (refining, petrochemical, compound, gas treating). Many industries use distillation for critical separations in making useful products. These industries include petroleum distillation, beverages, compound processing, petrochemicals, and natural gas processing. The general distillation column element is comprises feed device, Random packing and support grid.

Keywords: - DCS, Distillation, Corrosion control, Catalytic cracking Utility boilers, polymerization, Sulfur recovery.

1 Introduction

Distillation separates compounds by the difference in how easily they vaporize. The two major types of classical distillation include unremitting distillation and batch distillation. Unremitting distillation, as the name says, unremittingly takes a feed and separates it into two or more products. Batch distillation takes on lot (or batch) at a time of feed and splits it into products by selectively removing the more volatile fractions over time.The general distillation column component is shown below. The picture shows the inner sections of the distillation column. Distillation is the application and removal of heat to separate hydrocarbons by their relative volatility or boiling points. This necessary addition of heat normally in the feed stream or at the tower bottoms via a re-boiler can also lead to unwanted consequences such as polymerization, corrosion and reverse solubility.The elimination of heat can lead to sedimentation, solubility effects, deterioration and precipitation. The concentration of certain constituents by the distillation process can cause corrosion, polymerization, sediment fouling and flow phenomena effects.A accurately designed distillation column can decrease the effects of these consequences, but in convinced applications the polymerization, corrosion and other effects are very prominent leading to reduced separation efficiency in the column.This reduced separation efficiency increases the need for column preservation and unit down time. In these applications a review of tower internal design and process compound treatments should be initiated.

2 Distributed Control System

In large industry where several parameters are to be controlled and varied is implemented with DCS. Though it can control large amount of loops for shelter loops PLC were used. This technique is useful in simplifying the controlling of process. A distributed control system (DCS) refers to a control system usually of a manufacturing system, process or any kind of dynamic system, in which the controller elements are not central in position but are distributed throughout the system with each component sub-system controlled by one or more controllers. The entire system of controllers is connected by networks for communication and monitoring. DCS is a very broad term used in a variety of industries, to monitor and control distributed equipment. A DCS typically uses custom designed processors as controllers and uses both proprietary interconnections and communications practice for communication. The processor receives information from input modules and sends information to output modules. The input modules receive information from input instruments in the process (or field) and transmit instructions to the output instruments in the field. CENTUM is the generic name of Yokogawa's distributed

control systems (referred to as "DCS") for small- and medium-scale plants (CENTUM CS 1000), and for large scale plants (CENTUM CS 3000). The redundancy architecture of the CPU is referred to as a synchronous hot standby system, which is the primarily same as that of the CENTUM CS, the only difference being the addition of the new error detection and protection functions. These functions set write protected areas in each CPU card to protect the program and database areas against illegal address writing instruction from the other CPU card, and thereby prevents both card from failing due to illegal accesses caused by malfunctions in MPU. Other newly added functions include the memory management unit (MMU) and engrave protection which ensure data veracity, the parity check of addresses and data, the ECC memory, and a two wire signal self-checker. The hardware architecture of CENTUM CS 1000 has been shown in figure 2.1. The description of CENTUM CS 1000 has been given after subdividing it in some smaller areas as CPU, Battery Units, Power supply units, I/O Modules, communication cards, Human interface system (HIS).Several compounds have elevated boiling point temperatures as well as being air perceptive. A simple laboratory vacuum distillation glassware set-up can be used, in which the vacuum can be replaced with an inert gas after the distillation is complete. However, this is not a completely satisfactory system if it is desired to collect fractions under a reduced pressure. For better results or for very air sensitive compounds, either a Perkin triangle distillation set-up or a short-path distillation set-up can be used.
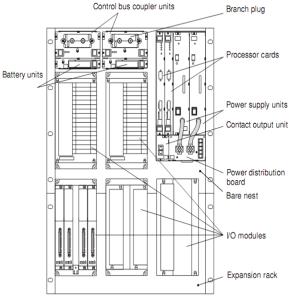

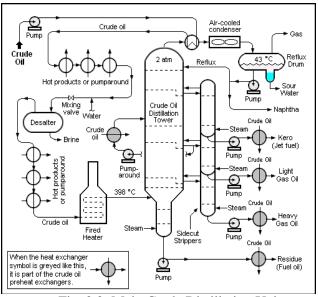Fig. 2.1: Architecture of DCS (CENTUM CS 1000)

Fig. 2.2: Main Crude Distillation Unit

The performance which is in existence consumes hefty amount of energy to separate each of the residues. The proposed model is shown in figure 2.2.Here the outlet steam is left as it is. They do not use the steam for preheating the crude oil.

3 Modeling of System

In the technique which we propose uses the steam leaving out from the stripper unit is reused for preheating the crude oil and for maintaining the temperature in the main fractional catalytic cracking unit or distillation column. We also control the corrosion occurring in the distillation column by adding the catalyst in the column. It reduces the maintenance cost by $40,000 per year which would be a great saving in cost and also increase in the productivity.Vacuum distillation of moderately air/water-sensitive fluid can be done using standard Schlenk-line techniques. When assembling the set-up apparatus, all of the connecting lines are clamped so that they cannot pop off. Once the apparatus is assembled, and the liquid to be distilled is in the still pot, the desired vacuum is recognized in the scheme by using the vacuum connection on the short-path distillation head. Care is taken to prevent potential "bumping" as the liquid in the still pot Degases. While establishing the vacuum, the flow of coolant is started through the short-path distillation head. Once the desired vacuum is established, heat is applied to the still pot. If needed, the first portion of distillate can be discarded by purging with inert gas and changing out the distillate receiver. When the distillation is complete: the heat is removed, the vacuum connection

is closed, and inert gas is purged through the distillation head and the distillate receiver.
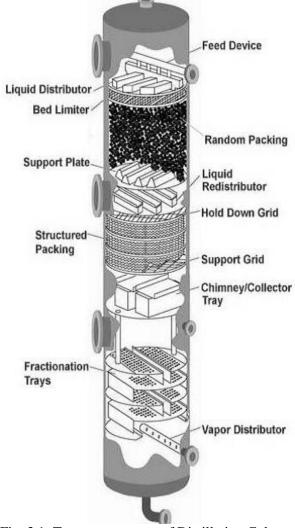

Fig. 3.1: Tray arrangement of Distillation Column

While under the inert gas purge, eliminate the distillate receiver and cap it with an air-tight cap. The distillate receiver can be stored under vacuum or under inert gas by using the side-arm on the distillation container.

4 Formation of Crude

Oil was formed from the remains of animals and plants that lived millions of years ago in a marine (water) environment before the dinosaurs. Over the years, the remains were covered by layers of sludge. Heat and pressure from these layers helped the remains turn into what we today call crude oil. The declaration "petroleum"

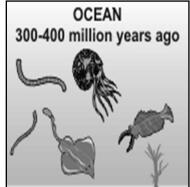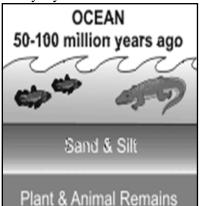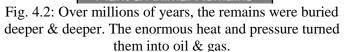means "rock oil" or "oil from the earth." The diagram which shows the crude formation is shown below.
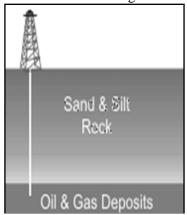

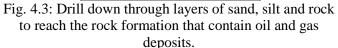Fig. 4.1: Tiny Sea plants and animals died and were buried on the ocean floor. Over time, they were covered by layers of silt and sand

Fig. 4.2: Over millions of years, the remains were buried deeper & deeper. The enormous heat and pressure turned them into oil & gas.

Fig. 4.3: Drill down through layers of sand, silt and rock to reach the rock formation that contain oil and gas deposits.

Crude distillation is the first major process in are finery. All crude oil entering the refinery passes through the atmospheric distillation on the way to be further processed in downstream process units to improve fuel

properties, increase the Yields of the distillate products and meet environmental specifications. Any process upset situation has an effect on the downstream processes serious upsets may shut down the entire refinery. Crude oil is primary washed in desalting to eradicate salts metals and other impurities that would cause corrosion in atmospheric distillation and catalyst deactivation in downstream catalytic process units. After desalting the feed is preheated in a series of heat exchangers and heated to the process temperature in a heater. Feed enters to the distillation column at2 - 5 bars and about 380 °C. Light vapors rise to the top of the column and heavier liquid hydrocarbons fall to the bottom. Hydrocarbon fractions are drawn from the tower according to the specific boiling temperatures. Stripping steam at the column bottom improves the separation of lighter boiling components. The vapors are condensed at the overhead cooling and recycled back to the column as reflux. Circulating reflux (pump around) and side stripping with vapor improve the separation of different fractions. Column bottom heavy residue is sent to vacuum unit to recover more distillates. The capacity of the presented crude distillation is 200000bbl/day (~10 million tons/year) with fuel utilization of about 10000 MMBtu/day.

5 Corrosion Control

Corrosion is a major issue in distillation equipment flat with suitable designs. Several factors can interact and create corrosive attack. With the current run length of plants between maintenance outages approaching five years, corrosion control is a must to maintain distillation efficiency and recovery.Areas of corrosion in distillation comprise; crude distillation, vacuum distillation, and solvent extraction. Proper metallurgy selection and then proper compound treatment is essential to prevent corrosion in the distillation equipment for hydrocarbon and compounds processing. Corrosion treatment compounds include neutralizers, filmers, and other corrosion inhibitors. These compound can prevent or mitigate damage from galvanic bi-metallic, aqueous acidic, and under-deposit corrosion, as well as pitting. Crude Distillation Corrosion in refinery crude distillation units is a common industry problem. Acids or salts present in the distillation column overhead system may cause corrosion when the right conditions exist. For this reason, it is common practice to inject corrosion inhibitors, neutralizer compounds, or in some instances wash water to control corrosion in the column overhead system. Crude Distillation Unit overhead corrosion

diminishes unit reliability and operation in a number of ways. Some effects of overhead corrosion include equipment replacement and repair, lost throughput, reprocessing costs, off spec products, and downstream unit fouling. The two most common causes of overhead corrosion, acid corrosion and under salt corrosion stem from the presence of hydrochloric acid (HCl). Acid corrosion occurs when a condensed water phase is present and is most often characterized by a general metal thinning over a wide area of the equipment.The most problematic form of acid corrosion occurs when a pipe wall or other surface operates at a temperature just cool enough for water to form. HCl in the vapors forms an acidic zoetrope with water, leading to potentially very low pH droplets of water. Here are some pictures from an atmospheric tower of a Reside Hydrocracker Unit. The trays were of model metallurgy and in operation for eight years. They were inspected in October 2006 and found to be acceptable. Until 2005 the corrosion protection treatment was a combination of filming inhibitor and neutralizer. In 2005 the refiner decided to stop the neutralizer to save cost. This was the inspection product in March 2008.Under-salt corrosion occurs when corrosive salts form before a water phase is present. The strong acid HCL reacts with ammonia (NH3) and neutralizing amines—both weak bases—to form salts that deposit on process surfaces. These salts are acidic and also readily absorb water from the vapor stream.
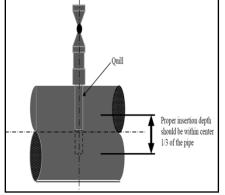

Fig. 5.1: Proper insertion of the catalytic tube

The water acts as the electrolyte to enable these acid salts to corrode the surface. Pitting typically occurs beneath these salts. The principal agent causing overhead corrosion is hydrochloric acid, although amine hydro-chlorides, hydrogen sulfide, organic acids, sulfur oxy-acids, and carbon dioxide can also contribute to overhead corrosion. Oxygen, introduced through poorly managed water wash systems can make corrosion worse. Hydrochloric acid induced overhead corrosion is

primarily controlled by chloride management in the incoming crude oil and secondarily controlled by the use of supplemental injection of organic neutralizers and corrosion inhibitors in the overhead system. Chloride management consists of good crude tank handling, desalting, and then polishing/neutralizing with aqueous sodium hydroxide, which is commonly called caustic. Refinery crude feeds contain water and inorganic salts (sodium, magnesium, and calcium chloride). Hydrolysis of calcium and magnesium chlorides (MgCl2 and CaCl2) occurs when crude oil is heated in the pre-heat exchangers and fired heaters. Many refiners inject caustic into the crude feed to the crude unit distillation tower to control condensation of hydrochloric acid downstream of the distillation tower in the overhead line. Caustic injection is vigilantly balanced with chloride levels measured in the overhead receiver. Typically, operators specify chloride levels to be between 10 and 30 ppm. The lower limit is set to avoid over-treatment with caustic. Over treatment with caustic can result in contamination of the heavy products from the crude distillation tower with sodium, which can affect downstream units such as cokers, visbreaker, and Fluid Catalytic Cracking (FCC) Units. One best practice limits sodium to 25 ppm in the visbreaker feed.

6 Simulated Output

The simulated output shows the complete process of the explained paper. The output gives an clear idea on the overall process. The vacuum over the sample is then replaced with an inert gas (such as nitrogen or argon) and the distillate receiver can then be stopper and removed from the system.All refineries utilize some form of desecrate water treatment so water effluents can securely bare turned to the environment or reused in the refinery. The design of waste water treatment plants is complicated by the diversity of refinery pollutants, including oil, phenols, sulfides, dissolved solids, and toxic compounds. Although the treatment processes employed by refineries vary greatly, they generally include neutralizers, oil/water separators, settling chambers, clarifiers, dissolved air flotation systems, coagulators, aerated lagoons, and activated sludge ponds. Refinery water effluents are collected from various processing units and are conveyed through sewers and ditches to the treatment plant.
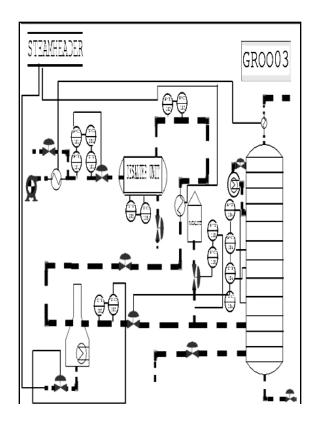

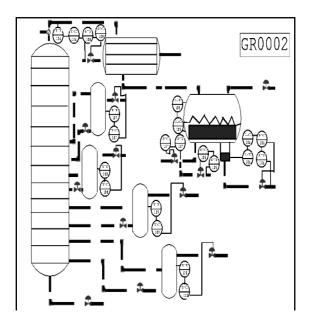Fig. 6.1: Simulated layout of Refining and Corrosion Control
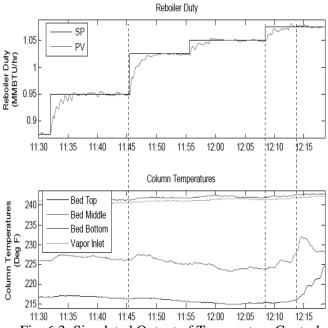

Fig. 6.2: Control Loops in the refining process

Fig. 6.3: Simulated Output of Temperature Control

There are thirteen control loops in the overall process of refining of crude and its corrosion control. The control loops are Desalting drum temperature control, Desalting in control, Desalting out control, Furnace temperature control, and Distillation column control, Reflux drum in control, Reflux drum out control, condenser unit control, catalyst flow control and Striper unit control. For an effective refining of crude we need to eliminate salt contents and impurities from crude. So here for carrying the desalting process we need to maintain the desalting drum temperature. The furnace temperature is to be controlled to main the temperature of the crude at 350° – 390°. So we need to control the temperature by controlling the steam flow. The distillation column pressure and temperature is to be maintained to separate the residues at appropriate trays. The pressure here is maintained at one bar and the temperature at 390°.
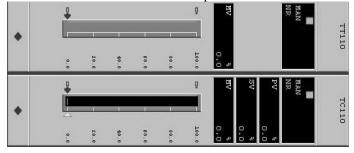

Fig. 6.4: Face plate of distillation unit
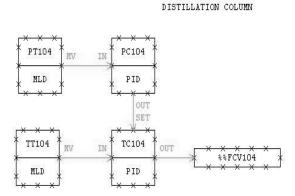

Fig. 6.5: Control blocks of Valve action

Fig. 6.5: Distillation Column Control

The loop used here is cascade loop. Cascade control is defined as the control loop with two controllers' namely primary controller and secondary controller in which the output of primary controller is given as set point to the secondary controller.

7 Conclusion

All the accessible techniques do not use catalyst for corrosion control and they do not distill the crude ably by reusing the gas impending out from the distillation column.By using the method which we proposed here we could make a plant efficient and also reduce the maintenance cost by $20,000 P.M. The corrosion control not only reduces the maintenance cost but also increases the productivity as there is no need of stopping the plant every two weeks.We use DCS instead of PLC as the amount of loops present here are more in number. Though weuse DCS for safety loops we use PLC in order to acquirehastyreaction.

References:

[1] B. G. Liptak, Instrument Engineers' Handbook: *Process Control and Optimization*, 4 Ed: CRC Press, 2005.

[2] D. E. Seborg, T. F. Edgar, and D. A. Mellichamp, *Process Dynamics And Control*: John Wiley & Sons, 2004.

[3] Educational Services, "Delta V Digital: *Automation System*,"Emerson Process Management.

[4] Educational Services, "*Course 7009 Delta V : Operate Implementation I*," Emerson Process Management, 2007

[5] K. J. Astrom and T. Hagglund, " *Tuning of simple regulators with Specifications on phase and amplitude margin*s" Automatic, vol. 20, pp. 645-651, 1984.

[6] B. Linnhoff, E. Hindmarsh, 1983, *The pinch design method of heat exchanger networks*, ChemEngSci, 38, 745-763

[7] F. Friedler, 2010, *Process integration, modelling and optimisation for energy saving and pollution reduction*, ApplThermEng, 30, 2270-2280.

[8] M. Gadalla, M. Jobson, R. Smith, 2003, *Shortcut models for retrofit design of distillation columns*, Trans IChemE, 81, Part A, 971-986

9] M. Gadalla, Ž. Olujić, M. Jobson, R. Smith, 2006, *Estimation and reduction of CO2 emissions from crude oil distillation units*, Energy, 31, 2398-2408

[10] N. Zhang, R. Smith, I. Bulatov, J. Klemeš, 2013, *sustaining high energy efficiency in existing processes with advanced process integration technology*, Applied Energy, 101, 26-32

[11] Tolliver T. L. and McCune L. C., "*Distillation Column Control Design Based On Steady State Simulation*", ISA Transactions, Vol. 17, No. 3, 1978, Pages 3-10

[12] Roat S. D., Moore C. F., and Downs J. J., "*A Steady State Distillation Column Control System Sensitivity Analysis Technique*", 1988, Proceedings IEEE Southeast Con, Pages 296-300

[13] Skogestad S., "*Dynamics and Control of Distillation Columns - A Critical Survey", Preprints IFAC Symposium, DYCORD + 92*, College Park, MD, USA, Pages 1-25

[14]Luyben W. L., "*Steady-State Energy Conservation Aspects of Distillation Column Control Design", I&E.C., Fundam.,* Vol. 14, No. 4, 1975, Pages 321-325

[15]Chien I-L and Fruehauf P. S., "*Consider IMC Tuning to Improve Controller Performance"*, C.E.P., Vol. 86, No. 10, October 1990, Pages 33-41.

[16] Khin Nway Oo, Zaw Min Naing, Hla Myo Tun *"Implementation of Distributed Control System in Process Control Management"* International journal of Scientific & Technology Research Volume 3, Issue 6, June 2014, 149-154