“Crude distillation overhead system”: Corrosion and Control.

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Abstract-
Corrosion problem has been a major challenge in the crude distillation overhead system of the petrochemical industry. It affects every part of the metallic structures of the crude distillation overhead system due to contaminants from crude oil. As a result of this, lots of revenue are been incurred to tackle it. This review therefore discussed the definition of a crude distillation overhead system, its working principle, the structural material for constructing crude distillation overhead system, the types of corrosion that occurs in crude distillation overhead system, the economic cost, the prevention and control methods employed in crude distillation overhead system. Also, the review showed that materials used for crude distillation overhead system, such as carbon steels, are mostly affected by pitting corrosion, intergranular corrosion and general corrosion. In addition, the review showed that the use of material selection, inhibitors, protective coating and cathodic protection are the common prevention and control methods usually employed in crude distillation overhead system. However, the review stated that the use of inhibitor is the most trusted and time tested as the proven method of prevention and control in crude distillation overhead system. This will help to reduce the huge economic cost incurred on corrosion effect in petrochemical industry, especially in the crude distillation overhead system.

Key words: Corrosion, crude distillation overhead system, inhibitor, material selection.

1. Introduction
The petrochemical industry has always been faced with different challenges among which corrosion happens to be a major [1]. Corrosion occurs at every part of the petrochemical industry but our focus in this review is on crude distillation overhead system. Crude distillation overhead system is constructed with metallic materials, such as carbon steel, which are naturally prone to corrosion effects [2]. Corrosion sets in to those metallic materials when they get in contact with crude oil contaminants such as acid, chlorides, saline solutions etc. Research has shown that until these metallic structures are protected [3], corrosion is inevitable to them. Crude distillation overhead system is the compartment of a refinery where the separation of crude oil into their diverse fractions take place. It is known in the petrochemical industry as the starting point of production of crude oil [4]. The crude oil constituents are separated by the crude distillation overhead system portion by portion through their boiling points. The lighter ones first before the heavy ones. The temperature runs as low as from 20°C to separate the lighter ones and can go as high as increase as 400°C [5]. The crude distillation overhead system is made up of the desalter, furnace, atmospheric distillation column, pre-flash drum, vacuum distillation column [6,7].
The economic effect of corrosion in the petrochemical industry has revealed that corrosion must be addressed in order to save cost and to have a sustainable industry. Great number of researches has shown that lots of revenue are spent on corrosion maintenance, management, and control in the petrochemical industry. Some of these researches are discussed below. Report from Ramraj and Anandaraj [8], showed that crude distillation overhead system consumes $40,000 yearly on maintenance. Another research revealed that from 2004 up to 2008, about $2.5 million was consumed for corrosion maintenance and control in the petrochemical industry [9]. Also, report captured Nigeria, the largest oil producing country in Africa, that about $765 million are usually spent yearly for corrosion maintenance and control [9]. NACE reported that $1.4 billion dollars was reserved for corrosion control of the upstream sector in the petrochemical industry by the Americans [10]. Furthermore, $7 billion was spent on maintenance, replacement and repairs of corrosion in oil industry, increasing in cost every year. All the above showed few of the cost implications of the effect of corrosion especially in the oil and gas industry. This is the reason why research on corrosion effect in the oil and gas industry cannot be neglected.

2. Corrosion and crude distillation concept

The process Crude distillation overhead system is affected with different prevalent types of corrosion due to the presence of contaminants in the crude oil. Some of these corrosions’ types are discussed below.

General corrosion: This happens when there is electron lose from a metal as a result of flow of electron to the cathode of the same metal. Research by Groysman [11] revealed that the presence of acid is a major cause of general corrosion occurrence in crude distillation overhead system. General corrosion also occurs when chlorides, sulphide and carbon dioxide are available in the crude distillation overhead system [12]. Furthermore, ammonia and amines cause increase the level of general corrosion in crude distillation overhead system [13]. General corrosion occurs in crude distillation overhead system when made with carbon steel as a result of sulfides and chlorides in the presence of dissolved in water [14]. Most times, general corrosion attack makes the metallic structure of the crude distillation overhead system to reduce in thickness, thereby causing sudden disaster to the system.

Pitting corrosion: Research by Humooudi et al. [15] showed that salt content from crude oil causes pitting corrosion on the metallic structure of the crude distillation overhead system. The presence of hydrochloric acid in crude distillation overhead system also causes pitting corrosion to occur [16]. Report by Slavcheva et al. [17] revealed that when alloy steel is used for the construction of crude distillation overhead system, pitting corrosion occurs especially at the temperature of about 338°C. crude distillation overhead system also experiences pitting corrosion when temperature of the operation is more than 310 °C and that is usually severe [18]. Schempp et al. [19] showed that whenever corrosive salts come in contact with crude distillation overhead system, pitting corrosion occurs causing serious damage to the system. Pitting corrosion also occur in crude distillation overhead system during production process of the crude oil, due to the presence of sulfide and chloride [20].

Intergranular corrosion: Intergranular corrosion occurs on metals at the inner and grain boundaries of the metal [21]. It is a destructive corrosion which damages the inner surface of metals by affecting the cross-sectional area, causing reduction of the metal [22]. Research by Loto and Loto [23] revealed that during industrial applications, steel structures are affected by intergranular corrosion. In crude distillation overhead system, intergranular corrosion occurs
when sulfide and acid are presence, causing metallic fracture failure [24]. The presence of hydrogen, amine, acids and water, also causes intergranular corrosion in crude distillation overhead system [25]. Furthermore, corrosive agents such as, oxygen and hydrochloric acid are the major causes of intergranular corrosion in crude distillation overhead system [11].

The crude distillation overhead system works based on the principle of evaporation and condensation. The mixture is below the columns with several condensers leaving at different high levels. The column is heated at high temperature (very hot) at the bottom of the distillation system and cools off when it gets to the top to separate its self [21]. The products with the high boiling points get condensed at the bottom and the ones with the low boiling points get condensed at the top due to their different boiling points. The crude oil moves into the storage tank regularly by transporting through the pipeline for distillation process. The desalter treats the crude oil to remove the salts after it has been prepared by settling process or means. Then the crude oil is heated in the furnaces, and the resultant liquid-vapor mixture flows through a transfer line to the flash part of the pre-flash drum [21]. This then passes through the furnace, and the liquid crude enters into atmospheric distillation column. The atmospheric distillation column is the main organ of any crude distillation system where crude is distilled and different petroleum products are derived. Also, each subunit has its functions and it moves from one stage to the other. It separates the crude oil into its individual constituents, such as butane, petrol, naphtha, kerosene, and diesel and recovers light materials [26-28].

![Figure 1: Showing the boiling temperature range of the crude distillation overhead system.](image-url)[29]
3. Material and Control Mechanism

The material used in petrochemical industry and the oil and gas industry etc, are very important because of the kind of chemicals and contaminants they face. Carbon steel is a type of material used for constructing refinery equipment [31, 32]. Stainless steel material is used for constructing crude distillation overhead system especially when sulfur content is present [33, 34]. Kahar [35] revealed that non-alloyed carbon steel is used as construction material for crude distillation overhead system. Crude distillation overhead system is also constructed with corrosion resistant high strength alloy 945 materials [36].

In crude distillation overhead system prevention and control of corrosion is highly necessary in order to minimize huge cost of corrosion incurred from time to time. Research by Groysman [6] stated that the process called physicochemical is the basic treatment for corrosion in crude distillation overhead system. Below are some of the prevention and control methods used in crude distillation overhead system.

Ameh et al. [37] stated that the control of corrosion in petrochemical equipment is done by selecting high corrosive resistant materials and it is the core method of control. Another method is the protective coatings and this helps to cover the layers of the steel materials used for crude distillation overhead system [38]. Sometimes, the steel layers are painted or coated in order to form a metallic lining or covering on the steel [21]. Bio-corrosion effect in petrochemical equipment are also prevented by protective coatings [39]. Cathodic Protection as described by Papavinasam [21] showed that reduction of corrosion in petrochemical equipment occurs by minimizing the potentials difference across its cathode and anode. In addition, Hasan et al. [40] showed that corrosion inhibitor is a chemical used in reducing the rate of corrosion occurrence on materials used for crude distillation overhead system. Corrosion inhibition forms film
protection on surface of metallic structures of crude distillation overhead system [41]. This confirms that corrosion inhibition on crude distillation overhead system is the most trusted, proven and time-tested application in petrochemical industries.

4. Conclusion
The effect of corrosion in crude distillation overhead system has been reviewed pointing out that contaminants from crude oil, such as chlorides, carbon dioxide, acids and sulfides etc, are the main cause. The review showed that carbon steel and stainless steel are most used materials for constructing crude distillation overhead system. As a result of these, they are exposed to contaminants which causes damage to them by reducing their life span over time. Pitting, intergranular and general corrosion were recorded as the major prevalent corrosion type that occurs in crude distillation overhead system. Furthermore, the review stated that the separation temperature starts from as low as 20°C to as high as more than 400°C. Finally, the review also showed that different methods of prevention and control of corrosion are usually used for crude distillation overhead system. Among which are material selection, protective coating, cathodic protection and use of inhibitor. Material selection showed great control measure over long period of time, while the use of inhibitor turned out to be the most reliable and time tested in crude distillation overhead system.

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