Structure study of pyrolysis fuel oil in (Ras Lanuf Oil & Gas Processing Company) RASCO- LIBYA

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Abstract— Study of the composition and stability of the pyrolysis fuel oil produced in Ras Lanof oil & gas company- Libya. The stability of the pyrolysis fuel oil was firstly studied. Four samples (250ml) of pyrolysis fuel oil were placed in round flasks, two at room temperature and another two at 80ºC for four weeks. The fractions of pyrolysis fuel oil were injected into the GC-M equipment, the obtained results showed that the pyrolysis fuel oil consist of six classes of 152 compounds, aliphatic olefin compounds, cyclo olefinic compounds, alkylated aromatic compounds, aromatic compounds with styrene structure, compounds with indene structures and high condense aromatic compounds. It is known that the formation of deposits in the fuel oil system is due to the polymerization of olefins mixture.
The polymerization of olefin compounds can occur under specific conditions (temperature, presence of oxygen, presence of impurities). Therefore, the polymer formation observed in the fuel piping system may be due to very high temperature or another process condition.
The blending of the pyrolysis of fuel oil with the fuel oil produced from the refinery was also studied. The blend ratio of the pyrolysis fuel oil to refinery 1:96 was chosen to match the production ratio per day in the plant from both products (The production of pyrolysis fuel oil in ethylene plant is 120-130 ton/day and the production of fuel oil in refinery plant is 12963 ton/day). The physical properties of the mixture were tested immediately after blending and three weeks later. From the obtained results, it is clear that the addition of the pyrolysis fuel oil to the refinery fuel oil in the above mentioned ratio does not affect the specific gravity of the refinery fuel oil so much.
The change was in the third digit. The same behavior was observed for the API gravity, total sulfur, pour point, heat combustion unit and density. All these properties have been changed for the refinery fuel oil after the addition of the pyrolysis fuel oil only in the third digit for each value. A relatively slight change was observed in the flash point of the blend. A slightly increase in the viscosity of the blend (from 90.46 to 93.36) at 82.2ºC was also recorded. The carbon residue in the blend is remarkable higher than in the refinery fuel oil. The ash content of the refinery fuel oil 0.005 wt. % is very low compared to the ash content of the pyrolysis fuel oil 4.07 wt.%.

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1 INTRODUCTION

Steam cracking process or pyrolysis, has been utilized to crack many of hydrocarbon feed stocks into olefins. It includes a pyrolysis furnace where the feedstock typically crude or a fraction optionally desalted, and then heated at appropriate temperature to lead to thermal decomposition of the larger hydrocarbon molecules. Steam is added to the pyrolysis furnace to reduce hydrocarbon partial pressure and control residence time which help minimize coke formation. The desired products was obtained from the furnace include light olefins such as ethylene, propylene, and butylenes [1,2,3]. Pyrolysis process also produces high molecular weight materials identified as pyrolysis fuel oil or steam cracked tar ("SCT"). Normally tar and steam cracked gas oil ("SCGO") are obtained as bottoms product in the first fractionator after the steam cracker. These are the least valuable products obtained from the effluent of a pyrolysis furnace. Higher aromatic materials feedstocks ("heavy feeds") produce larger quantities of pyrolysis fuel oil or SCT.

Pyrolysis fuel oil or SCT is unwanted product of pyrolysis because of the few uses of them. SCT are incompatible with other "virgin", which means that they have not undergone any hydrocarbon conversion process, such as Fluid Catalytic Cracking (FCC). A very important reason for such incompatibility is the presence of (very high molecular weight) asphaltenes, which lead to precipitate out when blended even in

small amounts into other materials, such as fuel oil streams.

The more use of less quality crude feeds to the refinery, i.e., heavier, and more aromatic and/or higher sulfur feeds, can increase the amount of tar produced. When higher sulfur feeds used, the disposing of tar is more complicated. One of the ways to avoid production of SCT is to limit conversion of the pyrolysis feed; however this also reduces the amount of valuable products such as light olefins. Another way is to "flux" or dilute SCT with absence asphaltenes stocks, but this also lead to consume higher economic value products in other useful purposes. Some improved methods of tar have been suggested in the prior art, as in the report, U.S. 4,207,168 [4].

In the report of U.S. 4,309,271[4], after hydrogenation of hydrocarbons; the liquid fraction is cracked and fractionated. A polymer free fraction of the residue is sent back to the feedstock and to the hydrogenation stage, heavy residues of the initial liquid fraction are partially oxidized with the residue.

In the report of GB 2 014 605[4], the produced pyrolysis fuel oil is treated during the production of olefins by thermal cracking. The treated material is believed to show "essential differences" from asphaltenes obtained from petroleum fractions. The polymer-free portion constitutes a material supposed to be useful as a fuel oil. The polymeric components, precipitated in solid form can be used in the road construction. The GB 2 104 544 report stated that [4], treatment of pyrolysis

tar gained from the ethylene production by naphtha feeds is done by steam cracking, firstly, by heating the feedstock with hydrogen to saturate polynuclear aromatic compounds, then hydrocracking the hydrogenated compounds in a cracking area to obtain an effluent from the cracking area which may be separated into a gaseous and liquid product.

Pyrolysis fuel oil is the heaviest by-product in the ethylene production plant. Plants consuming naphtha as feedstock, yield about 10-20% of ethylene production, the fuel oil produced by using gas oil as crude, is high however, using vacuum gas oil is higher. The instability of pyrolysis fuel oil is a known globally problem in many ethylene plants, that is because of the high content of olefin compounds. Moreover, ethylene plants feed stocks are naturally low in sulfur, which is less than 1 %(w/w).

The low content of sulfur and high content of condense aromatics of pyrolysis fuel oils are good feed stocks, that producing carbon black and needle coke. The composition of pyrolysis fuel oil in the ethylene plants depends on the composition of the raw materials used and the cracking process conditions. Usually, the disposal way for this product is by burning it in boilers or large process heaters with a minimum intermediate storage. This way is not favorable due to the formation of polymer precipitations in the piping systems, causing blockage of the system.

2 MATERIAL AND METHODS

2.1 Equipments

- Atomic absorption spectroscopy (AAS) for determination of metals, Pye-unicam.
- Gas chromatography-mass spectrometry (GC-MS) for compositional study of the fuel oil, Pye-unicam.
- Hydrometer for determination of specific gravity and API gravity, Stanhope-Seta.
- Test jar for pour point determination.
- Centrifuge equipment for bottom sediments and water determination, Stanhope-Seta.
- Distillation apparatus for determination of water by distillation, Electro-mantel ME.
- Pesky-Martens Closed tester for flash point determination.

- Spectroscopy by IR (LECO) equipment for combustion and determination of sulfur content.

2.2 Sampling:

The pyrolysis fuel oil sample is collected from the ethylene plant. Sample connection   SC-26, and the fuel oil produced from the refinery was collected from the sample connection FT-1.

2.3 Physical properties experiments

Specific gravity, API gravity, flash point, viscosity, ash content, carbon residue, pour point, water and sediments, total sulfur, water content are determined according to the ASTM methods. Nickel, Sodium and Vanadium are determined using flame atomic absorption technique. The pyrolysis fuel oil

sample was distilled into three fractions before injection into the GC-MS.

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2.4 Density, Relative Density (Specific Gravity), or API Gravity by Hydrometer Method [5]

The sample is brought to a specified temperature and a test portion is transferred to a hydrometer cylinder that has been brought to approximately the same temperature. After temperature equilibrium has been reached, the hydrometer scale is read, and the temperature of the test portion is taken.

2.5 Sulfur in petroleum products high- temperature method [6]

This test method is applicable to samples boiling above 177oC and detection limit is 0.06wt % sulfur. The existence of sulfur compounds in petroleum products leads to corrosiveness in the used equipment and environment pollution. The combustion of sulfur compounds in petroleum produces sulfur oxides, which react with water or humidity producing a very corrosive sulfuric acid.

Iodate detection system – The sample is burned in a stream of oxygen at a sufficiently high temperature to convert about 97 % of the sulfur to sulfur dioxide. A standardization factor is employed to obtain accurate results. The combustion products are paced into an absorber containing an acid solution of potassium iodide and starch indicator. A faint blue color is developed in the absorber solution by the addition of standard potassium iodate solution. As combustion proceeds, bleaching the blue color, more iodate is added.

The amount of standard iodate consumed during the combustion is a measure of the sulfur content of the sample.

This test method provides a means of monitoring the sulfur level of various petroleum products and additives. The knowledge can be used to predict performance, handing, or processing properties. In some cases the presence of sulfur compounds is beneficial to the product and monitoring the depletion of sulfur can provide useful information. In the other cases the presence of sulfur compounds is detrimental to the processing or use of the product.

2.6 Flash-Point by Pensky-Martens Closed Cup Test [7]

A 75-mL test specimen is heated at a slow constant rate with continual stirring in a brass test cup of specified dimensions with a cover of specified dimensions. An ignition source is directed into the test cup at regular intervals with simultaneous interruption of the stirring.

The flash point temperature is one measure of the tendency of the test and used in shipping and safety regulations [9].

2.7 Kinematic viscosity & dynamic viscosity)[8]

Many petroleum products, and some non-petroleum materials, are used as lubricants, and the correct operation of the equipment depends upon the appropriate viscosity of the liquid being used. The viscosity of many petroleum fuels is important for the estimation of optimum storage, handling, and operational conditions [10].

2.8 Pour point of petroleum products [9]

This test method is intended for any petroleum product. A procedure suitable for black specimens, cylinder stock, and no

distillate fuel oil, and used for testing the fluidity of a residual fuel oil at a specified temperature. The pour point of a petroleum specimen is an index of the lowest temperature of its utility for certain application [13].

After preliminary heating the sample is cooled at a specified rate and examined at intervals of 3oC for low characteristics. The lowest temperature at which movement of the specimen is observed is recorded as the pour point.

2.9 Water by distillation [10]

This test method covers the determination of water in the range from 0 to 25 % volume in petroleum products by the distillation method. Volatile water-soluble material, if present, may be measured as water.

The material to be tested is heated under reflux with a water-immiscible solvent, which co-distills with the water in the sample. Condensed solvent and water are continuously separated in a trap, the water settling in the graduated section of the trap and the solvent returning to the still. The amount of water as determined by this test method (to the nearest 0.05 volume %) may be used to correct the volume involved in the custody transfer of petroleum products and bituminous materials.

2.10 Ash content from petroleum products [11]

This test method covers the determination of ash in the range 0.001- 0,180 mass%, from distillate and residual fuels, gas turbine fuels, crude oils, lubricating oils, waxes, and other petroleum products, in which any ash-forming materials present are normally considered to be undesirable impurities or contaminants.

The sample contained in a suitable vessel is ignited and allowed to burn until only ash and carbon remain. The carbonaceous residue is reduced to an ash by heating in a muffle furnace at 775oC, cooled and weighed.

2.11 Conradson carbon residue [12]

This test method covers the determination of the amount of carbon residue left after evaporation and pyrolysis of an oil, and is intended to provide some indication of relative coke-forming propensities.

A weighed quantity of sample is placed in a crucible and subjected to destructive distillation. The residue undergoes cracking and coking reactions during a fixed period of severe heating. At the end of the specified heating period, the test crucible containing the carbonaceous residue is cooled in desiccator and weighed. The residue remaining is calculated as a percentage of the original sample, and reported as Conradson carbon residue.

2.12 Heat combustion [13]

This test method covers the estimation of the gross and net heat of combustion in SI units, mega joules per kilogram, of hydrocarbon fuels and blend stocks from the fuel density and sulfur, water, and ash contents.

This test method is purely empirical. It was derived using liquid hydrocarbon fuels produced by normal refining processes from conventional crude oil that conform to the requirements of specifications for petroleum fuels as described in Note . This test method is valid for those fuels in the density range from 750 kg/m3 to 1000 kg/m3 and those that do not contain an unusually high aromatic content.

2.13 Water and sediment by the centrifuge method [14]

This test method describes the laboratory determination of water and sediment in fuel oil in the range from 0 to 30% volume by means of the centrifuge procedure.

Equal volumes of fuel oil and water saturated toluene are placed in each of two cone-shaped centrifuge tubes. After centrifugation, the volume of the higher density water and sediment layer at the bottom of the tube is read.

The water and sediment content of fuel oil is significant because it can cause corrosion of equipment and problems in processing.

2.14 Vanadium, Nickel, Sodium [15]

The (AAS)method is used to analyze a sample diluted with an organic solvent for the determination of Ni, V, and Na. This test method uses oil-soluble metals for calibration to determine dissolved metals and does not purport to quantitatively determine nor detect insoluble particulates. Hence, this test method may underestimate the metal content, especially sodium, present as inorganic sodium salts.

Thus, these test methods can be used to help in determining the quality and value of the pyrolysis fuel oil.

2.15 Stability test method

The stability of the pyrolysis fuel oil was studied by taking two samples (250ml) of pyrolysis fuel oil in round flasks. One sample was kept at room temperature and another one at 80oC, for four weeks. A formation of deposits in both samples was noticed to know. No formation of deposits in both samples in one month time was considered as stable nature of pyrolysis fuel oil under normal conditions.

3 RESULTS AND DISCUSSION

The physical and chemical analysis, stability and chemical composition of the residual oil mixture have been studied to find out its further utilization way as a quality fuel by blending it with refineries fuel oil. A comparative study between the properties of blending oil with the residual oils has been also studied. By blending, less desirable cracked residual oil can be made more attractive as fuel oil. This is accomplished by adding to a given quantity of residual oil a small amount of lighter distillate fuel oil. Oil fuel engine is a very efficient power plant; it does have a higher degree of sensitivity to specific fuel properties and contaminants than does the steam boiler. Therefore, we have determined the following important physical and chemical analysis data *viz*. density, specific gravity, API gravity, Flash point, viscosity, pour point, heat combustion value, water content, bottom sediments, ash content, carbon residue, total sulfur and trace metals- vanadium, nickel and sodium, of the two samples of pyrolysis fuel oil (residual **oil) and blended pyrolysis fuel oil with refinery fuel oil. Phys**ical and chemical analysis data are given in Table 1 & 2 for pyrolysis heavy fuel oil samples A1 &2; for refinery light fuel oil samples C1 & C2 are given in Table 3 & 4 and for Blended oil

(sample A1+ sample C1) are given in Table 5. A comparison of the physical and chemical analysis data of pyrolysis heavy fuel oil (sample A1) and refinery light fuel oil (sample C1) are gien in Table-6

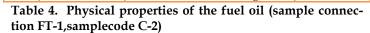| S/N	Method	Test	Sample A-1
1	ASTM D-1298	Specific gravity at 15.6 ºC	1.0409
2		API gravity	4.4401
3	ASTM D-1552	Total sulfur wt%	0.006
4	ASTM D-93	Flash point ºC	86.0
5	ASTM D-445	Viscosity at 37.8ºC Cst	15.69
6	ASTM D-97	Pour point ºC	+ 17
7	ASTM D-95	Water by distillation vol%	Trace
8	ASTM D-482	Ash content wt%	4.07
9	ASTM D-189	Carbon residue wt%	15.22
10	ASTM D-4868	Heat combustion kcal/kg	9595.50
11	ASTM D-1298	Density at 15.0 ºC	1.0405
12	ASTM D-1796	Bottom sediment and water vol%	0.10
13	ASTM D-5863	Vanadium mg/l	Nil
14	ASTM D-5863	Nickel mg/l	Nil
15	ASTM D-5863	Sodium mg/l	10.22

Table1. Physical properties of the pyrolysis fuel oil (sample connection SC-26, sample code A-1)

S/N	Method	Test	Sample A-2
1	ASTM D-1298	Specific gravity at 15.6 ºC	1.0408
2		API gravity	4.4531
3	ASTM D-1552	Totalsulfur wt%	0.006
4	ASTM D-93	Flash point ºC	86.0
5	ASTM D-445	Viscosity at 37.8ºC Cst	15.80
6	ASTM D-97	Pour point ºC	+ 17
7	ASTM D-95	Water by distillation vol%	Trace
8	ASTM D-482	Ash content wt%	4.23
9	ASTM D-189	Carbon residue wt%	14.62
10	ASTM D-4868	Heat combustion kcal/kg	9594.50
11	ASTM D-1298	Density at 15.0 ºC	1.0404
12	ASTM D-1796	Bottom sediment and water vol%	0.10
13	ASTM D-5863	Vanadium mg/l	Nil
14	ASTM D-5863	Nickel mg/l	Nil
15	ASTM D-5863	Sodium mg/l	9.89

Table 2. Physical properties of the pyrolysis fuel oil (sample connection SC-26, sample code A-2)

S/N	Method	Test	
1	ASTM D-1298	Specific gravity at 15.6 ºC	0.9040
2		API gravity	25.03
3	ASTM D-1552	Totalsulfur wt%	0.21
4	ASTM D-93	Flash point ºC	118.0
5	ASTM D-445	Viscosity at 50.8v ºC Cst	90.46
6		Viscosity at 82.2 ºC Cst	22.56
7	ASTM D-97	Pour point ºC	+38
8	ASTM D-95	Water by distillation vol%	Trace
9	ASTM D-482	Ash content wt%	0.005
10	ASTM D-189	Carbon residue wt%	4.30
11	ASTM D-4868	Heat combustion kcal/kg	10037
12	ASTM D-1298	Density at 15.0 ºC	0.9035
13	ASTM D-1796	Bottom sediment and water vol%	0.10
14	ASTM D-5863	Vanadium mg/l	<0,10
15	ASTM D-5863	Nickel mg/l	5.50
16	ASTM D-5863	Sodium mg/l	10.0

Table 3. Physical properties of the fuel oil (sample connection FT-1, sample code C-1)

S/N	Method	Test	Sample C-2
1	ASTM D-1298	Specificgravity at 15.6 ºC	0.9039
2		API gravity	25.04
3	ASTM D-1552	Total sulfur wt%	0.23
4	ASTM D-93	Flash point ºC	117.0
5	ASTM D-445	Viscosity at 50.8 ºC Cst	90.41
6		Viscosity at 82.2 ºC Cst	22.50
7	ASTM D-97	Pour point ºC	+38
8	ASTM D-95	Water by distillation vol%	Trace
9	ASTM D-482	Ash content wt%	0.004
10	ASTM D-189	Carbon residue wt%	4.11
11	ASTM D-4868	Heat combustion kcal/kg	10034
12	ASTM D-1298	Density at 15.0 ºC	0.9034
13	ASTM D-1796	Bottom sediment & water vol%	0.10
14	ASTM D-5863	Vanadium mg/l	<0,10
15	ASTM D-5863	Nickel mg/l	5.12
16	ASTM D-5863	Sodium mg/l	9.45

Table 4. Physical properties of the fuel oil (sample connection FT-1,samplecode C-2)

S/N	Method	Test	SampleC-1

S/N	Method	Blend Test		after mixing	9 days	21days
1	ASTM D-1298	Specific gravity at	15.6 ºC	0.9051	0.9055	0.9031
2		API gravity		24.84	24.76	25.18
3	ASTM D-1552	Total sulfur	wt%	0.20	0.20	0.20
4	ASTM D-93	Flash point	ºC	114.0	123.0	124.0
5	ASTM D-445	Viscosity at	50.8 ºC Cst	97.18	95.43	93.37
6		Viscosity at	82.2 ºC Cst	21.29	21.91	22.33
7	ASTM D-97	Pour point ºC		+37	+37	+39
8	ASTM D-95	Water by distillation	vol%	trace	trace	Trace
9	ASTM D-482	Ash content	wt%	3.51	3.90	3.77
10	ASTM D-189	Carbon residue	wt%	15.0	14.23	13.99
11	ASTM D-4868	Heat combustion	kcal/kg	10038	10035	10044
12	ASTM D-1298	Density at	15.0 ºC	0.9046	0.9050	0.9026
13	ASTM D-1796	Bottom sediment and water vol%		0.1	0.1	0.05
14	ASTM D-5863	Vanadium	mg/l	Nil	Nil	Nil
15	ASTM D-5863	Nickel	mg/l	5.4	5.12	4.43
16	ASTM D-5863	Sodium	mg/l	10.10	9.56	8.69

Table 5. Physical properties of the Blend (Pyrolysis fuel oil with fuel oil from refinery)

S/N	Method	Test		A-1 Pyrol	C-1 Fuel	Blend after mixing	Blend after 9 days	Blend after 21days
1	ASTM D-1298	Specific gravity at	15.6 ºC	1.0409	0.9040	0.9051	0.9055	0.9031
2		API gravity		4.44	25.03	24.84	24.76	25.18
3	ASTM D-1552	Total sulfur	wt%	0.006	0.21	0.20	0.20	0.20
4	ASTM D-93	Flash point	ºC	86.0	118.0	114.0	123.0	124.0
5	ASTM D-445	Viscosity at	50.8 ºC Cst	15.7at37.8ºC	90.46	97.18	95.43	93.37
6		Viscosity at	82.2 ºC Cst		22.56	21.29	21.91	22.33
7	ASTM D-97	Pour point	ºC	+17	+38	+37	+37	+39
8	ASTM D-95	Water by distillation	vol%	trace	trace	trace	trace	trace
9	ASTM D-482	Ash content	wt%	4.07	0.005	3.51	3.90	3.77
10	ASTM D-189	Carbon residue	wt%	15.22	4.30	15.0	14.23	13.99
11	ASTM D-4868	Heat combustion	kcal/kg	9595.5	10037	10038	10035	10044
12	ASTM D-1298	Density at	15.0 ºC	1.0405	0.9035	0.9046	0.9050	0.9026
13	ASTM D-1796	Bottom sediment and water vol%		0.1	0.1	0.1	0.1	0.05
14	ASTM D-5863	Vanadium	mg/l	Nil	<0.1	nil	nil	Nil
15	ASTM D-5863	Nickel	mg/l	Nil	5.50	5.4	5.12	4.43
16	ASTM D-5863	Sodium	mg/l	10.22	10.0	10.10	9.56	8.69

Table 6. Comparative data of the physical properties of Pyrolysis fuel oil A-1, Fuel oil from refinery C-1 and Blend)

MS ANALYSIS OF THE PYROLYSIS COMPOSITION:

To improve the separation of the compounds in the GC capillary column the pyrolysis fuel oil was distilled under vacuum into three fractions. The fractions were injected into the GC-MS equipment. The obtained results showed that the pyrolysis fuel oil consists of six classes of compounds viz. aliphatic olefinic compounds, cyclo-olefinic compounds, alkylated aromatic compounds; aromatic compounds with styrene structure, compounds with indene structures and high condense aromatic compounds.

The identified aliphatic olefins and cyclo-olefins are conjugated olefins. The type of olefins is unstable and easy to polymerize. Their presence in the fuel oil is the main reason for the gum formation. The GC-MS analysis showed that,

fraction consists mainly of substituted trienes and substituted cyclo-pentadienes. The GC peaks of the fuel sample indicate the small concentration of these compounds in the mixture.

Other classes of compounds with small amount in the mixture are the di and tri-substituted aromatic compounds (appendix, compounds 10 to 30). This type of compounds has good solvent properties for polymers.

The aromatic compounds with styrene and indene analog structures are also separated and identified (appendix, compounds 31 to 82). These types of compounds are easy to polymerize compared to another olefin types. This might be due to the conjugation of the double bond to the ring system. Divinyl benzene compounds were also found in the mixture. These compounds are good precursor for polymer networks which are insoluble in the solvents and acids. Therefore, in case of formation of such networks in the piping system their

removal could only be carried out mechanically. Acetylene and di-acetylene compounds are also identified in this region. The group of substituted di, tri and poly-aromatic compounds were isolated from the mixture and identified (appendix, compounds 83 to 152). These types of compounds are a good precursor for carbon black production.

Condense aromatic compounds could not identified using GC-MS. This might be due to their thermal decomposition on the column.

FUEL STABILITY

The stability of the pyrolysis fuel oil was studied at room temperature and at 80ºC after four week. A formation of deposits in both samples was not observed during the time. Undoubtedly the results indicate that the pyrolysis fuel oil produced in RASCO ethylene plant is stable under normal conditions as well as at temperature 80ºC for four week. These obtained results were found contradictory with those observed in the plant. The production department of the ethylene plant reported about continuously fouling formation in the piping system of fuel oil.

It is known that the formation of deposits in the fuel oil system is due to the polymerization of olefins. The polymerization of olefin compounds can occur under specific conditions (temperature, presence of oxygen, presence of impurities). Therefore, the polymer formation observed in the fuel piping system is might be due to very high temperature or another process condition which must be discussed in details with production department.

The blending of the pyrolysis of fuel oil with the fuel oil produced from the refinery was also studied. The blend ratio of the pyrolysis fuel oil to refinery was chosen to match the production ratio per day in the plant from both products i.e 1 ; 96.

COMPARATIVE STUDY

The physical and chemical characteristics of the mixture of pyrolysis fuel oil and refinery fuel oil (blended) were determined immediately after blending as well as after three weeks of blending. The obtained results are illustrated in tables 5 and 6. It is apparent from the comparative data that the addition of the pyrolysis fuel oil to the refinery fuel oil in the above mentioned ratio affects very slight change in values of the specific gravity, API gravity, density, total S, pour point, heat of combustion of the refinery fuel oil. The change was found in the third digit of values. A relatively slight change was observed in the flash point of the blend.

An insignificant increase in the viscosity of the blend (from 90.46 to 93.36) at 82.2 ºC was also recorded.

The carbon residue in the blend is remarkable higher than in the refinery fuel oil. That is due to the high content of condense aromatic in pyrolysis fuel oil. The ash content of the refinery fuel oil 0.005 wt% is very low compared to the ash content of the pyrolysis fuel oil 4.07 wt%.

Ash content 3.77 wt% of blend fuel oil remain unchanged during three week of time, which is the maximum storage time for the refinery fuel oil before exporting. Table also revealed that there are no significant changes of physical and chemical data observed which may not affect the significant level of quality of blended oil.

CONCLUSIONS AND RECOMMENDATIONS

- The study of the stability of the pyrolysis fuel oil showed that this product is not so unstable. By exposure it to the air at room temperature and at 80ºC for three weeks no fouling formation was observed.
- To explain the reason of the deposit formation in the pyrolysis fuel oil system in the plant, an information exchange among laboratory and production department is required.
- If RASCO is interested to avoid the problem of fouling in the pyrolysis fuel system especially in boilers using this product a blend of this product with refinery fuel oil is possible.
- The addition of pyrolysis fuel oil to the refinery fuel oil in the ratio of 1: 96 does not affect the final specifications of the refinery fuel oil in one month storage time. All slightly changed properties are found under the specification range.
- The details structure study of the fuel oil composition showed that this product consist of aliphatic and aromatic olefins and condense aromatic compounds.
- Due to relative high content of aromatic olefins the pyrolysis fuel oil could be polymerized with radical initiator and addition of fillers. This polymerization reaction can produce hard materials for special uses like protection of car bodies.
- It was found that the pyrolysis fuel oil contains high quantity of tri and poly- aromatic compounds which makes it as good precursor for the carbon black production

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