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THE CHARACTERIZATION MOTOR FUELS IN YEMEN AND COMPARE THEM WITH INTERNATIONAL FUELS SPECIFICATIONS.

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Abstract

The main purpose of this search is to characterize our local Motor Fuels and compare them with international fuels aiming to contribute in finding a solution to improve their quality.

Fuels affected by legislation include gasoline, diesel and heavy fuel oil, this trend is now spreading to other regions of the world, wherever similar clean fuels regulations are being planned and implemented.

The paper deals with the current specifications for local market and ways to meet international requirements. Analysis for the produced Motor gasoline and diesel fuel in Yemen Refining Companies were done and proposed changes for the qualities and technological processes are suggested

Introduction

Specifications for petroleum products are based ideally on functional requirements, which need periodically to be reviewed and upgraded to comply with the increasing environmental and health restrictions on automotive emissions [1-4].

Modern gasoline specification aim to reduce the emissions of volatile organic compounds, toxic and nitrogen oxides, and limit the ceiling of RVP value, benzene, aromatics and sulphur contents. Gasoline must have a maximum content of 40% vol. of aromatics and 1% vol. of benzene.

The World market share of leaded gasoline is steadily declining as that portion of new cars fitted with exhausted catalyst increases [5-7].

Leaded gasoline is produced and consumed in Yemen with no alterations taken until now. It seems that it is time to review our local petroleum products specifications and alter them in view of changes in the international market and environmental requirement. Additional cost and may be new investment is to be raised.

Diesel fuel is used for personal transportation in Yemen and owing to the high efficiency of diesel engines and reasonable price of diesel; its demand in Yemen is increasing steadily.

The product specifications of diesel fuel concerns sulphur content, density, Poly-Aromatic Hydrocarbons (PAH) content, cetane number & 95% ASTM distillation point. Process technologies currently being selected to meet diesel specifications include: Hydro-cracking, Hydro-treating and aromatics saturation [9-11].

Alternative gaseous fuels especially – compressed natural gas (CNG) and liquefied petroleum gases (LPG), represent the most technologically mature and abundant alternative fuels for utilization in the transportation sector [9], comparison with conventional fuels (gasoline and diesel) has largely concentrated on emissions from the exhaust pipe, although more attention is now being paid to the total energy chain

Work Done

To characterize the Motor Fuels (Gasoline and Diesel) that produced in Yemen, data relating its production was compiled through the last seven years and representative samples were analyzed.

A comparison was done between the Yemeni specification and those in Middle East, European Commission. The comparison was concentrated on the most harmful stuffs.

Experimental

The motor gasoline components were analyzed under similar conditions with a gas chromatograph fitted with a flame ionization detector (ASTM D 5443 – 93). The standard method Multi-Dimensional Gas Chromatography determines paraffins, naphthenes and aromatics by carbon number in low olefin hydrocarbon streams having final boiling points of 200 °C or less.

Characterization of the light gas oil is performed according to standard testing methods beside to urea techniques and chromatography for determination of the hydrocarbon groups.

The basic exhaust emissions from diesel, CNG & LPG were measured in a standard way using commercial analysers – NDIR for CO and CO_2 and chemiluminescence's analyser for NO_x. The exhaust was sampled through micro-

porous filter to trap particulate matter (PM), the quantity of which was then determined by weight. The experiments were performed with heavy duty engines of the kind used in city busses.

Results and Discussion

Motor gasoline is a complex mixture of relatively volatile hydrocarbons that vary widely in their physical and chemical properties. The fuel properties must be balanced to give satisfactory engine performance over an extremely wide range of operating conditions.

Modern motor gasoline represents a mixture of components, which are obtained as a result of various technological processes of the petroleum. Depending on the type of the gasoline, gasoline is obtained from atmospheric distillation, catalytic and thermal cracking, catalytic reforming, visbreaking, isomerization, and polymerization and oxygenates.

In Yemen, gasoline is formulated by blending certain quantities of light gasoline, straight run gasoline and reformat, in addition to limited quantities of tetraethyl lead (T.E.L.), which boosts the research octane number (R.O.N.) to the required value.

Laboratory analysis of the gasoline produced in Yemen for the last seven years (table 1) reveals that the average values for aromatics & benzene were 17.8% and 3.3% vol. respectively. These values in comparison with International specifications (table 2) show that the local has low aromatics content and moderate percentages of benzene.

Table 1: Structure of motor gasoline produced in Yemen by carbon number and hydrocarbon group, vol. %.

Carbon number	Paraffin's	Naphthenes	Aromatics
C_4	0.8	0	0
C_5	6.6	0	0
C_6	21.2	4.2	3.3
C_7	20.8	3.5	7.6
C_8	13.5	2.1	5.5
C_9	5.9	1.8	1.3
C_{10}	1.0	0.4	0.1
Total	69.8	12.0	17.8

Low aromatics content in the gasoline is a reason for its low octane number. To enhance the gasoline RON certain quantities of (T.E.L.) is added, these quantities are different but closely submit to a specified specification that limits the ceiling of the addition. Lead is a hazardous stuff and its elimination from gasoline is favorable.

Actual sulphur content in distributed gasoline in Yemen is far below the specification and better than the planned in the year 2005 in Europe. This returns to the processing of Mareb crude oil which sulphur content is very low.

Table 2: Reformulated Gasoline Specification

Property	Local Gasoline		European Specification	
	Distributed	Specification	2002	2005
Sulphur, wt. ppm	20	2000	150	50
Aromatics, vol.%	17.8	No spec.	42	35
Benzene, vol.%	3.3	No spec.	5	1
Lead, g/l	0.41	0.55	-	-

Average lead addition in Yemen for the last seven years is illustrated in (fig.1).

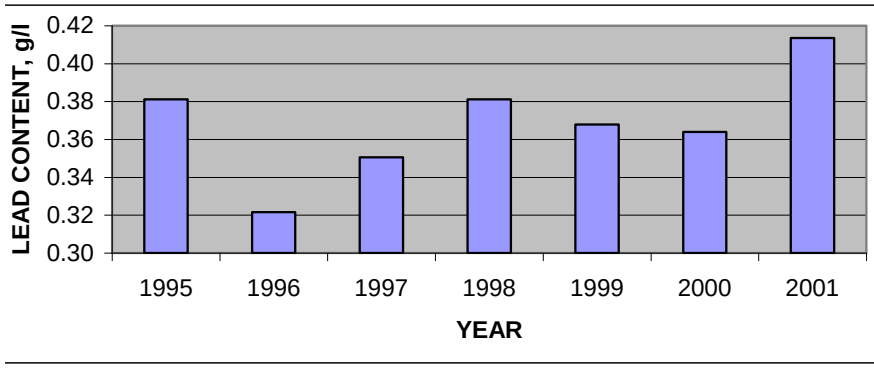

Fig.1: Annual levels of lead content in gasoline in Yemen.

These rates are significant and Lead accumulation carries a lot of threat to the living organism. Lead phase-out is a necessary step towards clean environment. Compensation of the effect of Lead in gasoline needs new technologies to be introduced that produce high octane components. Investments in FCC and Alkylation's units must be done.

Principal physical and chemical properties of the straight run gas oil drawn from atmospheric distillation of Mareb crude oil (Mareb is Town in East of Yemen) in comparison with Middle East gas oil are shown in (table 3). The two gas oils are of paraffin type as can be seen from the high cetane index. Mareb gas oil is distinguished by its low sulphur content.

Table 3: The Main Properties of Mareb and Middle East Gas Oil

Property	Mareb Gas Oil	Middle East Gas Oil
Density @ 15 °C, g/cm^3	0.8472	0.8430
Distillation temperatures, °C		
Initial Boiling Point	227	188
10% recovery	251	-
50% recovery	290	296
90% recovery	358	-
Final Boiling Point	>370	> 370
Colour (ASTM)	< 1	-
Pour point, , °C	+ 5	-
Flash point, °C	102	-
Total sulphur, %wt	0.08	1.30
Viscosity @ 40 °C, cSt	4.2	-
Cetane Index	55.3	55.1
Aromatics, %wt	36.1	32.1

Analysis of the straight run light gas oil from Mareb crude oil using urea adduction method followed by gas chromatography shows (table 4) that it contains a significant quantity of n-alkanes (48.6 wt. %). These n-alkanes comprise a large portion of high melting point components C_{19}+ (21.9 wt. % of the gas oil fraction), which is reflected in the relatively high pour point temperature (+5 °C). To reduce the pour point temperature a quantity of valuable lighter product (kerosene) is to be added, other economical practice, which is not adopted yet in Yemen to add special additives “depressants”.

Table 4: Carbon number distribution in Urea adductables and Light Gas Oil from Mareb Crude Oil

Carbon No	Concentration Relative Weight %	
(Alkanes)	Urea Adductables	Light Gas Oil
C_{13}	1.3	0.6
C_{14}	4.6	2.3
C_{l5}	10.9	5.3
C_{16}	16.0	7.8
C_{17}	12.2	5.8
C_{18}	10.0	4.9
C_{19}	11.4	5.5
C_{20}	9.2	4.5
C_{21}	7.7	3.8
C_{22}	5.4	2.6
C_{23}	5.0	2.4
C_{24}	3.5	1.7
C_{25}	1.5	0.7
C_{26}	0.6	0.3
C_{27}	0.4	0.2
C_{28}	0.2	0.1
C_{29}	0.1	0.1
Total	100.0	48.6

Further analysis of the gas oil cut using liquid-solid chromatography reveals that it contains 63.9 wt. % of saturated components (alkanes + cycloalkanes) and 36.1 wt. % aromatics distributed into monoaromatics, diaromatic and polyaromatic in percentages 1.8, 18.1 and 16.2 respectively (table 5). The hydrocarbon groups of the light gas oil were identified using refractometer. The results are shown in (table 5).

Table 5: hydrocarbon groups distribution in light gas oil from Mareb crude oil.

Compound type	Weight %	Refractive Index @ 20 °C
Saturates	63.9	1.4480 – 1.4554
Monoaromatics	1.8	1.5051
Diaromatics	18.1	1.5407 – 1.5471
Polyaromatics	16.2	> 1.55

The diesel oil frequently distributed in the local market in comparison with the local and European Specifications is shown in (table 6).

Table 6: Local gas oil (diesel) production and specification in comparison with European specification.

Property	Local Gas Oil		European Specification	
	Distributed	Specification	2000	2005
Sulphur, wt. ppm	100 - 900	1000	350	50
Cetane number	54.0	51	51	54
Polyaromatics, wt.%	14.0	11	11	6
Density @ 15°C, g/cm^3	0.845	0.82 - 0.86	0.845	0.845
Distillation T-95, °C	> 360	> 360	> 360	> 360

Although local specification for sulphur indicates a limit of 1000 wt.ppm, actual distributed diesel has sulphur far below this limit (100 - 900 wt.ppm).

Processing of low sulphur Mareb crude oil participate significantly in reducing sulphur content in diesel but the quantities are not sufficient to satisfy the increasing local market demand due to unplanned shifting from gasoline to diesel engines. The balance quantity is covered through imported Middle East gas oils with relatively high sulphur content.

To meet the increasing demand in diesel it is anticipated to raise the processing quantities of Mareb crude oil or to introduce new technologies such as hydro-cracking, which is a way to increase middle distillates resources.

New international specifications trend to reduce sulphur limit (table 6) down to 50 wt. ppm by 2005 and it is planning in 2010 to 10-20 wt.ppm .

To reach such margins a radical change in processing policy should be adopted by introducing new operational processes namely hydro-treating. This process also should reduce the concentration of poly-aromatics in distributed local diesel which is relatively high (14 wt. %) compared to present European Union specification (11.0 wt. %).

Reduction of polyaromatic hydrocarbons will help also to reduce smoke and particulates in road vehicles tail gas as a result of incomplete burning of the fuel.

The need to produce “clean fuels” is spreading around the world, requiring refiners to review their options for meeting the new demands. Produced motor gasoline must comply with the increasing environmental and health restrictions on automotive emissions.

In 1998, the EU adopted regulations to reduce gasoline and diesel vehicle emissions by 60-70% by the year 2005 as well as taking the first steps towards much more stringent specifications for gasoline and diesel fuel for 2005.

Reduction of sulphur is a result of hydro-treating processes, which are widely introduced in petroleum industry. Such technologies are bounded with massive investments with the scope of enlarging the refineries capabilities in processing sour crude oils.

The experimental data obtained shows that the combustion of gaseous fuels in heavy duty engines (HDE) results in a decrease of CO and NO_x emissions (Fig. 2) and especially the emission of PM (Fig. 3).

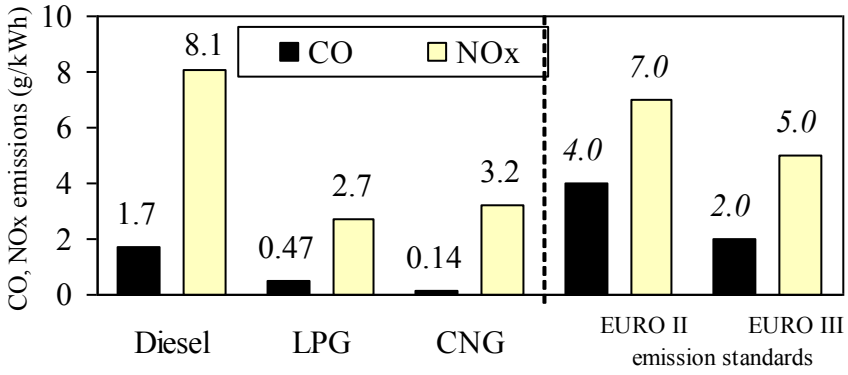

Figure 2: Comparison of CO and NO_x emissions

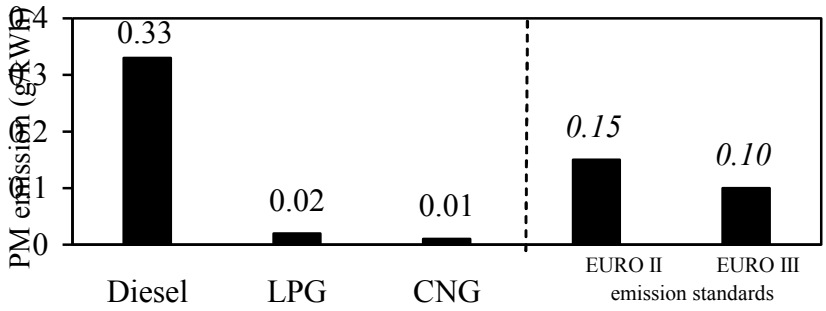

Figure 3: Comparison of PM emissions.

Conclusions

1. Local Motor Fuel specification should be reviewed to cope with the international regulations regarding the harmful stuffs such as lead, sulphur & polyaromatics content etc.

2. To cope with international specifications, satisfying the local market demand of petroleum products and enhancing the economics of the local refineries new processing technologies such as hydrocracking, hydrotreatment and reforming using modern catalysts are methods to improve the quality and quantity.

3. Analysis of local gasoline produced in Yemen shows that it complies with international specification regarding sulphur, benzene and total aromatics

concentration but out of date regarding octane number and use of lead alkyl additive.

4. Diesel fuel polyaromatic content is slightly above the current European Union specifications, but the difference will be higher in the year 2005.

5. Introducing of new automotive fuels such as Autogas (CNG, LPG), oxygenated gasoline and will significantly improve air quality by reducing levels of contamination by carbon oxides, lead, particulate matters-PM, hydrocarbon vapors and other smoke.

6. The utilization of CNG or LPG as a fuel for heavy duty engines represents a way of reducing the negative impact of transportation on the environment, mainly in density populated cities. The combustion of gaseous fuels results in a significant decrease of CO, NO_x as well as PM exhaust emissions compared with the combustion of diesel fuel

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