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# ASSESSMENT OF GASOLINE MAJOR QUALITY PARAMETERS

***Dhuha kadhim Ismayyir* and Lamyaa M. Dawood*****

***MSc. Candidate, **Assist. Prof.**

**(IE Division)/ Production Eng. and Metallurgy Dept. / UOT Iraq. Baghdad**

**E- mails:* eng_lady_1987@yahoo.com**

***lamya_alkazaai@yahoo.com**

## ABSTRACT

Gasoline is the key profit generator and the quality of gasoline is importance, since it determines the gasoline price. Four major quality parameters were investigated in this research these are; Research Octane Number (RON), Raid Vapor Pressure (RVP), Sulphur content, and Lead content. 90 samples of different Iraqi gasoline blends at Al-Daura refinery were collected over five consecutive months to perform this research. X bar and R statistical control charts were performed to assess gasoline production process .Results revealed that although gasoline production is rather stable but there are variations between samples RON , RVP values and that of Iraqi specifications that needs to be improved. Also these results show an improvement towards fewer values of Lead and Sulphur parameters. Therefore, gasoline does not conform Iraqi marketing standards and it is essential to improve the production quality and tighten up quality parameters so as to pace the international standards.

**Keywords**: Quality, Gasoline, Parameter RON, RVP, Sulphur, Lead, $\bar{X}$ control chart, *R* control chart, Histogram, Performance characteristics.

## INTRODUCTION

The common goal of all refiners is to provide safe, profitable, and products of high quality. (Pelham, R. and C. Pharris, 1996).Gasoline is the key profit generator for petroleum refining industry where it represents 70% of refinery profit.Gasoline is a hydrocarbon complex mixture of liquid, formedfrom crude oil by the distillation. Gasoline is volatile and inflammable petroleum-derived compounds. Other terms for gasoline are petrol and less commonly, motor spirit **(**A.Singh,et.al,2000**)**.

Most refiners produce and market more than one grade of motor gasoline; it is classified by octane ratings minimum (conventional, oxygenated and reformulated) into three main grades regular, midgrade and Premium **(**Mohamed A. Fahim**,** et.al, 2010)**.** Gasoline blends can vary widely in composition; even those having the same octane number can be quite different. The various properties of gasoline depend on the types and relative proportions of each of their constituents (Andreas A. Kardamakis, et.al, 2007).

Gasoline is used in vehicles propelled by internal combustion engines – automobiles, buses, planes, boats, etc. Gasoline is also, used as a diluents, finishing agent, and industrial solvent (Sittig, M. 1984). The issue of the quality of gasoline is importance, since the price gasoline is generally determined by the quality as the process of producing quality fuels requires the employment of the most advanced and hence rather costly technologies (Rigby, B**,** et.al, 1995 and Matijošius J., 2009). It is a crucial procedure, as gasoline must conform quality standards for local markets, meeting the requirements of car engines and with minimum possible damage to the environment. There is an increasing requirements related to engine performance, safety and environmental impact (Rigby, B**,** et.al, 1995**,**Pasadakis N., 2006, **-**Moreira LS, D´ Avila LA, and Azevedo DA. 2003). Typical commercial gasoline is produced by mixing refinery different streams at predefined concentration levels in order to meet quality market standards. The composition of gasoline has changed significantly (Cody A. Anderson,2010).Quality is the result of a process, and it can achieve by only one way, that is, by setting the process correct. Product qualities are predicted through correlations that depend on the quantities and the properties of the blended components (Mohamed A. Fahim**,** et.al, 2000 andVinay A. Kulkarni , and AnandK. Bewoor,2009).The purpose of this study is to investigate major gasoline quality parameters are RON, sulphur, R.V.P and lead, so as to monitor, control, and improve process performance over time. Utilizing quality control tools such as;$\bar{X}$, R and histogram charts, Minitab 16 software is performed to reveal these charts. Also the conformity with Iraqi and of the international standards is verified.

**LITERATURE REVIW**

The quality of gasoline is one of the key factors having an impact upon the operational performance of the engine. In recent years it became increasingly important for both technical and financial reasons. Gasoline blend may be composed of different components,these components are mixed , the types and amount of components in gasoline blending can be adjusted for a number of reasons, such as improving engine performance or reducing emissions (Matijošius J. and Sokolovskij E, 2009**,**B. K. BhaskaraRao, 1990**,** Reese E. and Renate D. Kimbrough.1993). Gasoline quality is defined in terms of a range of quality parameters. The properties of gasoline as other fuels may be classified into three categories; operational properties such as fuel octane number properties determining the durability and chemical stability or the chemical composition of fuels such as fuel Octane Number (ON) (Reese E. and Renate D. Kimbrough.1993**-** Mata, T. M.; Smith, 2002). Gasoline performance characteristics are significantly influenced by the ON, RVP; lead content, sulphur content, existent gums and stability**(**Matijošius J. and Sokolovskij E., 2009**,** Wiedemann LSM, D´ Avila LA, and Azevedo DA. 2005,andCarlos R. Kaiser,et.al 2010**)**. Among other parameters, fuel performance characteristics are also significantly influenced by (ON) and evaporation characteristics(Rigby, B., Lasdon, L. S., & Waren, A. D.1995).

Extensive work has been done concerning the role of the gasoline characteristics on the actual performance of the engines and mainly its impact on vehicle emissions (Price, M.J. 2002**,**andS.Kalligeros,et.al, 2003).

Methyl Tertiary Butyl Ether (MTBE) is generally blended by refiners as a substitute to using aromatics to achieve gasoline octane specifications. This is result in a significant aromatic reduction in the gasoline therefore, additional CO reduction(Cody A. Anderson.2010). Safety related properties within transportation and storage such as flash point. And properties which appear to be the largest properties related to environmental requirements such as Sulphur content. The sulfur content of gasoline can be lowered using low-sulfur crude oil, treating gasoline with hydrogen or by both(Rigby, B., et.al,1995, Syed M. JavaidZaidi . 1995, Mata, T. M,et.al, 2002, and ASTM D86-99a. 1987). The impact of gasoline on the environment is directly related to its composition and properties. Particular consideration in updating the standards of quality is driven by the environmental performance of fuels including properties as Sulphur content, polycyclic aromatic hydrocarbons and other contaminants in gasoline (Rigby, B., et.al,1995).

Since quality control of gasoline generates a great quantity of data and involves several characteristics (variables)therefore, the equipment's, control and analysis procedures should be compromised (LuizBueno da Silva, 2006), and it is performed everywhere in the world by refineries, distribution companies and government inspection departments (Wiedemann LSM,et.al, 2005, and Moreira LS, D´ Avila LA,and Azevedo DA, 2003). Statistical Process Control (SPC) tools such as $\bar{X}$, R charts are widely used to monitor various industrial processes. These charts are useful tool in detecting the deviation from process mean and process variability. $\bar{X}$ chart is used to indicate the process means changes over time. While R chart plot the range, thus monitoring process variability and indicating whether it changes over time (Vinay A. Kulkarni , and Anand K. Bewoor .2009,andDale H. Besterfield.2009).Generally, quality control of gasoline is ensured through the establishment of technical specifications, which vary in different of the world. Table 1 shows gasoline worldwide standards. These specifications' is improved and modified inadvertently or different from the standard quality mainly through inadequate transport, handling, and storage or through adulteration with some substances (Teixeira, L. S. Get.al, 2008,de Oliveira,et.al, 2004, and G. V. Shuvalov,et.al, 2004).Changes in gasoline specifications are developing with the time, as regulations for environmental protection concerning production, storage and use of engines gasoline (J. Hancsoket.al, 2003, and Xuan li, B.E, 2000).

## EXPERMENTAL PROCEDURE

At al- Daura Refinery, gasoline blends are produced in one grade that is regular RON 85 from three different types of Iraqi crude oils(of different API values and constituents) and different components that are blended(of different RON value) these components are; Light Straight Run Naphtha (LSRN)RON 63, reformate RON 88.5 from reforming a mixture of30%LSRN, 70% Heavy Straight Run Naphtha (HSRN)], and the last component is power formateRON87.

150 samples of blended gasoline were collected through out five consecutive months, so as to analyze and verify gasoline production performance process. The sample size is determined according to different blending tanks. To quantify gasoline quality, statistical quality control tools " $\bar{X}$ - R charts where utilized.These charts are useful tools in detecting the deviation from process mean and process variability. "X bar chart" indicates how the process means changes over time. While "R chart" plot the range of each sample. Thus monitoring the process variability and checking its changes over time. Good control can be described as that which has no out-of-control points. Therefore, no long runs on either side of the central line, and no unusual patterns of variations. The central values for the $\bar{X}$- R charts are obtained using the following equations(Vinay A. Kulkarni , and Anand K. Bewoor .2009,andDale H. Besterfield.2009):

$$\bar{\bar{X}} = \sum_{j=1}^{m} \bar{X}_j / m \quad (1)$$

$$\bar{R} = \sum_{j=1}^{m} R_j / m \quad (2)$$

Where $\bar{\bar{X}}$ = mean or average of the subgroup means.

$\bar{X}_j$ = mean of the *j*th subgroup.

$m$ = number of subgroup.

$\bar{R}$ = mean or average of the subgroup ranges.

$R_j$ = range of the *j*th subgroup.

The control limits for the charts are calculated at ±3 standard deviations from the central value depending on theformulas(Vinay A. Kulkarni , and Anand K. Bewoor .2009,andDale H. Besterfield.2009):

$$UCL_{\bar{x}} = \bar{\bar{x}} + A_2\bar{R} \quad (3)$$

$$LCL_{\bar{x}} = \bar{\bar{X}} - A_2\bar{R} \quad (4)$$

$$UCL_R = D_4\bar{R} \quad (5)$$

$$LCL_R = D_3\bar{R} \quad (6)$$

Where UCL: upper control limit, and LCL: is the lower control limit.

*A2, D3* and *D4 are* factors that vary with subgroup size and are determined according to sample size(n=3)(Vinay A. Kulkarni ,and Anand K.Bewoor .2009,andDale H. Besterfield.2009):

Minitab 16 software is used to reveal the results of $\bar{X}$ chart, or R chart for each major gasoline parameters; RON, RVP, Sulphur and lead. These data are collected and consolidated in total of 21 blends (samples) as shown in Fig.1 to Fig.4 respectively for each parameter.

**RESULTS AND DISCUSSION**

Fig. 1 shows R-chart for RON, that reflects that the variability of gasoline blending process where there is no (sample) out of control limits. Percentage of out-of-control limits subgroups for the whole five months is 14.29 % on the $\bar{x}$chart.That is caused due to assignable causes. To improve gasoline quality and meet performance requirements the octane number should be raised by some additives such as oxygenates ethers ,alcohol of high octane components can be added. Or by introducing new reforming production units, that can raise of octane value.

The results of RVP property in of gasoline is shown in Fig. 2.The observed samples showed that value of RVP should be less. Reduction of RVP is crucial and depends primarily on the reduction of light components such as butanes. Replacing alcohols with the corresponding ethers will also decrease RVP value. In Fig. 3 Sulphur content of gasoline is shown where three samples are out of control limits in $\bar{X}$ bar chart, on the other hand R chart shows process variability for is not stable. The total percentage of out _of_ control limits for the whole five months is14.29%.Sulphur content in Iraqi gasoline blends is a high compared with other international standards. This is because Iraqi crude oils have high Sulphur contents therefore, requiring additional sulfur reduction process. Currently Lead is added to gasoline as a low cost octane enhancer. If lead is not added to gasoline, it is necessary to: modify the refinery process, raise octane level of the unleaded gasoline pool, and add alternative octane enhancing additives such as ethers and alcohols hence help to compensate for octane shortfall, or reduce vehicle octane requirements. In most countries, mixture of the first two approaches is used. Results obtained for analyzing lead content of gasoline are depicted in Fig. 4. Where, there are no samples out of control limit so the process is stable, but doesn't conform to Iraqi standards. It could be noticed from this fig. that the lead values descend near the lower control limit showing an indication of improvement in the quality of this parameter. The total tested results of the five months Iraqi specification is verified in histogram chart ( Fig.5.).From this fig it could be noticed that:-

I. RON parameter(in blue color) is stable throughout the five months but still less than Iraqi specification, therefore RON improvement should be considered, and increasing gasoline verities.

II. For RVP parameter (in red color) is rather stable but at the higher values of Iraqi standards. It is necessary to improve this specification even to lower values since it affects engine performance

III. For Sulphur (in green color),and Lead (in violate color) specifications values are improved towards lower values indicating an important improvement in the gasoline quality towards the performance and environment directions. Therefore, this development should be continued and controlled further so as to tighten more these two specifications and limit their effect.

## CONCLUSIONS AND FUTURE RECOMMENDATIONS

# To meet engine requirements and save the environment specifications of the refinery have to consider various options as; increase RON value, reduction of RVP value, and Sulphur content .This could improve efficiency / life of catalytic converter, phasing out of Lead from gasoline to meet requirement of catalyst fitted vehicles and to meet environment requirements.

# Motor gasoline produced in Iraqi refineries does not conform to international standard specifications except that of Sulphur content where it British Standards(BS-II).

# It is crucial to improve gasoline quality so as to increase gasoline varieties and refinery outcome, also to catch to the international standards and to save the environment.

Since the fuels quality are ever developing. It is essential that gasoline blending process is controlled so that the quality of supplied gasoline is better controlled. Therefore, it is recommended that blending process should be integrated, communicated and have continuous data feedback from quality control department. This may enhance gasoline blending process by defining the required components constitutes from different crude oils' batches and compounds, catches certain faults therefore improving gasoline quality and refinery target profit.

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**NOMENCLATURE**

API: American Petroleum Institute Value.

PPM: Part Per Million.

Vol. %: Volume Percent.

BS: British Standard.

Euro: European Standard.

WFC: World Fuel Charter Standard.

Table1.  Gasoline specifications according to different standards (Anurag A. Gupta. 2009)

| Standards | BS-II | Euro III | Euro IV | WFC | Iraqi * |
|---|---|---|---|---|---|
| Year of Implementation | 2000-2001 | 2005 | 2010 | | (2000) |
| Sulphur, PPM | 500 | 150 | 50 | 10 | 500 |
| RON, Min | 88 | 91 | 91 | | 85 |
| MON, Min | - | 81 | 81 | | - |
| Benzene, Max. , Vol. % | 5/3 | 1 | 1 | | - |
| Aromatics, Max. Vol. % | - | 42 | 35 | | - |
| Olefin, Max. , Vol. % | - | 21 | 21 | 10 | - |
| RVP, KPa. | 35-60 | 60 Max. | 60 Max. | | 44-82.5 |

*  Marketing Specifications of Iraqi Petroleum  Products

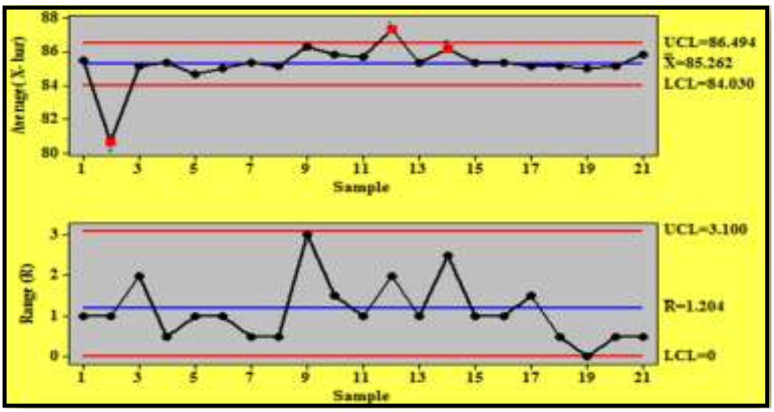


Fig.1. X̄and R charts for RON property of gasoline

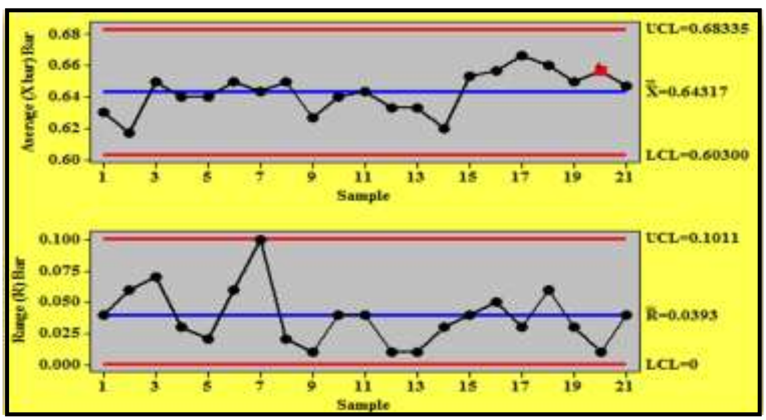


Fig.2. X̄and R charts Sample for RVP property of gasoline

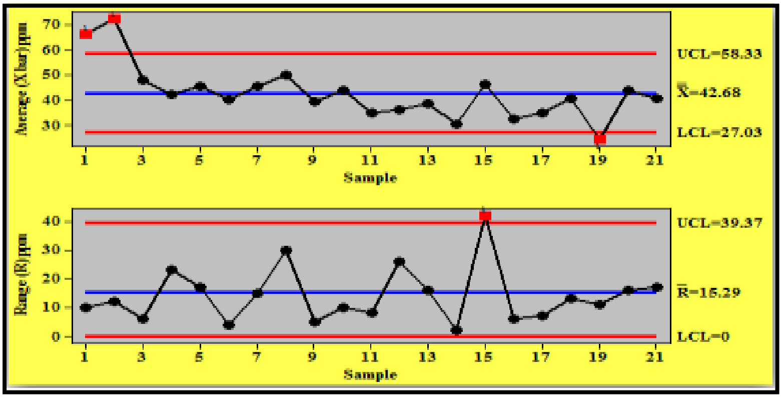


Fig.3. $\bar{X}$ and R charts Sample for Sulphur content of gasoline

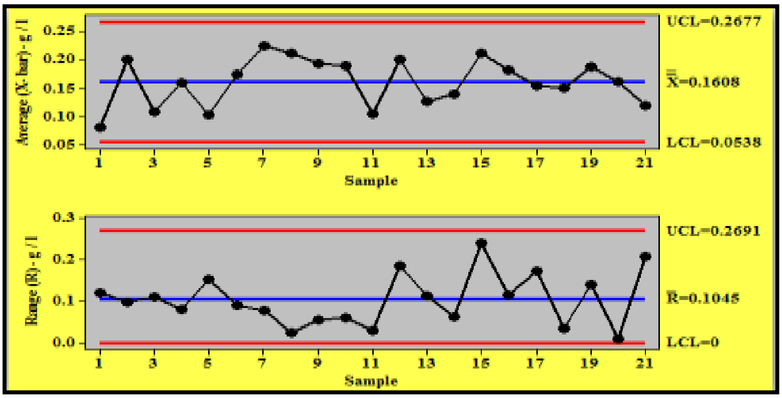


Fig.4. $\bar{X}$ and R charts for Lead content of gasoline


Fig.5. Changes in Iraqi gasoline blends' specifications