Developing a Database System for the Laboratory Tests

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ABSTRACT

The objective of this research was to develop a database to store results of laboratory tests of crude oil and this will lead to improve the quality of Petroleum products and to reduce operating cost in the same time. Statistical process control give many tools including the seven quality tools which can be used to determine if the manufacturing process within control limits of crude oil specification and to detect any problem. Using Microsoft Access 2007 program offers many possibilities such as developing database, using statistical tools, building form, query, generating reports, importing and exporting data to statistical program such as Microsoft Excel 2007. Therefore the development of a database with Microsoft Access 2007 will provide electronic data store and using statistical control tools and this will leads to diagnosis problems in production process and improve the quality of petroleum products.

Keywords: Quality Control, American Society for Testing and Materials, Statistical Process Control, American Petroleum Institute, Microsoft Access 2007.

تطوير نظام قاعدة بيانات للفحوصات المختبرية

الخلاصة

الغرض من هذا البحث هوتطوير قاعدة بيانات لحفظ نتائج فحوصات النفط الخام المختبرية و سوف يقودنا هذا الى تحسين جودة المنتوجات النفطية وتقليل كلفة التشغيل بنفس الوقت.يغطي موضوع سيطرة العملية الأحصائية أستخدام عدة أدوات ومن بينها أدوات الجودة السبعة التي يمكن أستخدامها لمعرفة أذاما كانت العملية الأنتاجية تحت السيطرة أم لا ولتحديد وجود أي مشكلة.يوفر برنامج الأكسس 2007 أمكانية بناء قاعدة بيانات وكذلك يوفر أمكانيات أستخدام الوسائل الأحصائية وبناء الواجهات والأستعلام وتوليد التقارير وأستيراد و تصدير البيانات الى برامج أحصائية مثل برنامج مايكروسوفت الأكسل 2007.لذا فأن بناء قاعدة بيانات مع برنامج مايكروسوفت الأكسس 2007 يوفر الخزن الألكتروني للبيانات وأستخدام وسائل السيطرة الأحصائية مما يقودنا الى تشخيص المشاكل في العملية الأنتاجية وتجسين جودة المنتوجات النفطية.

الكلمات المرشدة :السيطرة النوعية،الجمعية الأمريكية للأختبارات و المواد،سيطرة العمليات الأحصائية،معهد البترول الأمريكي،مايكروسوفت أكسس 2007.

INTRODUCTION

Quality control (QC) is a set of planned activities which include procedures and tests to achieve a specific specification of final products. Quality control is required on the whole path of manufacturing process and includes the required tests for raw material and intermediate products, and then for final products .In petroleum Oil industry these tests consider supporting procedures and conducted according to global standard such as American Society for Testing Materials(ASTM)[1] ,of course the type of required testing will depend on the type of product, some of these tests are take place daily three times while others according to needed system work, also there is additional test in case of emergency and operational problems. Test result will be written on notebook paper, this accumulation paperwork vulnerable to loss, damage and lack of regulation as well as you can't see the comprehensively. Consequently there is a lack of observations and foreseen conclusions. For the purpose of upgrading quality work one could use the statistical process control (SPC) [2] to organize results collection and creating notes after that data analysis for building effective conclusions to assess the performance of operating units. Access program from Microsoft office 2007 can be used for building a database to save results of laboratory tests, then displaying stored data with reports and statistical tools like process control charts.

THEORETICAL CONCEPT

A. Statistical Process Control (SPC)

The inputs of quality control are the work results, operation definitions, quality management plan, and check lists which are a form designed to record the recurrence number of appearance problem. The important tools and techniques for quality control are the inspection (testing) and seven quality tools of Kaoru Ishikawa [2].

A-1 Seven Quality Tools

In 1960 Kaoru Ishikawa integrated the idea of seven statistical tools which used to improve status of work by contacts between employees and identify problems. Of course this need to use the approprate control tools depending on the problem and then analysis, evaluation of manufacturing operations.the results will be issuance of appropriate deciesions,improve work quality,diagnose defect and problems, rework a second time.the statistical quality control tools are the following:

1-Cause and Effect diagram (fishbone diagram): this is Ishikawa which used "to identify the potential or actual causes for a performance problem" [3].There is four main reasons the Man, Machine, Method, Material which called 4M's.In this diagram analysis the problem and determine the most likely reasons then displaying the possible solutions. Figure (1)

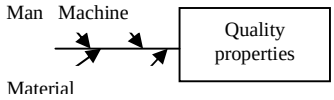

Figure (1) Cause and Effect diagram.

2-Pareto diagram: it is the drawing of vertical bar charts that illustrate the repeated occurrence Figure (2), where many quality problems will generated from few reasons in manufacturing operations. [3]

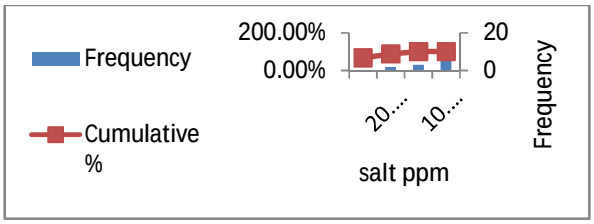

Figure (2) Pareto chart for salt content in crude oil feed.

3-Flow chart: used to analyses how the problem appear and represent a graphically steps of a particular process. Figure (3).

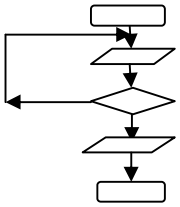

Figure (3) Flow chart.

4-Run chart: it is the chart that displays the observed data across time and used to show changes over time. Figure (4)

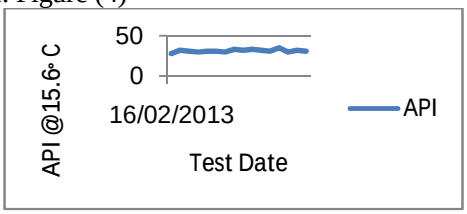

Figure (4) Run chart show variation of API of crude oil feed over time.

5-Scatter chart: display the relationship between two variables, first one independent variable and second depend on it Figure (5). Scatter chart used to show the strength of their relationship.

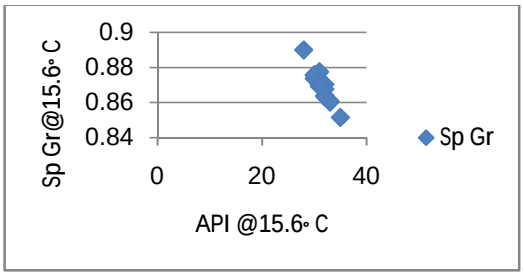

Figure (5) Scatter chart show the relation Between API and Specific Gravity of crude oil feed.

6-Histogram: The Histogram displays the frequency distribution of data. Figure (6).

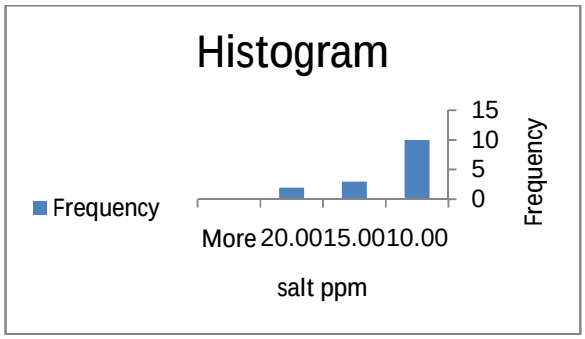

Figure (6) Histogram chart of salt content in crude oil feed.

7-Control chart: used to distinguish between two values of the represents max limit of control, CL the arithmetic mean which give desired quality of the manufacturing operation ,while LCL represent the lower control limit. By them we can know and determine trend of change. Figure (7).

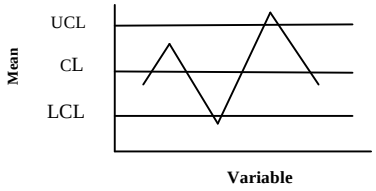

Figure (7) Control chart.

The statistical bases [4] for control charts such as mean and range control Charts are based on using a variable x with a known population mean μ and sigma σ where the average calculated by following equation:

$$\text{Average} \quad \bar{x} = x_{1+}x_{2+\ldots+}x_n / n \qquad \ldots (1)$$

$$\text{Standard deviation } S^2 = 1/m \sum_{i=1}^{n} (Xi - \mu) / n\text{-}1 \qquad \ldots (2)$$

The mean estimated by grand average:

$$\bar{\bar{x}} = \bar{x}_{1+}\bar{x}_{2+\ldots+}\bar{x}_m / m \qquad \ldots (3)$$

$$R = x_{max} - x_{min} \qquad \ldots (4)$$

Range R is related to σ with a constant depend sample size which listed in statistical Tables.

$$\bar{R} = R_1 + R_2 + \ldots\ldots + R_n / m \quad \ldots (5)$$

$$\sigma = \bar{R} / d_2 \quad \ldots (6)$$

The control limits for $\bar{x}$ chart are:

$$UCL = \bar{\bar{x}} + A2\ \bar{R} \quad \ldots (7)$$

$$LCL = \bar{\bar{x}} - A2\ \bar{R} \quad \ldots (8)$$

Center at $\bar{\bar{x}}$

The control limits for R chart are:

$$UCL = \bar{R}\ D_4 \quad \ldots (9)$$

$$LCL = \bar{R}\ D_3 \quad \ldots (10)$$

Center at $\bar{R}$

$$A2 = 3 / d_2 \sqrt{n} \quad \ldots (11)$$

$$D_{3,4} = 1 \pm 3\ D_3 / D_4 \quad \ldots (12)$$

The results of using seven quality control tools are correction actions and prevention to deal with existing manufacturing operations problems.

B.Physical Properties of crude oil

There is a group of laboratory tests are taking place daily or monthly on the crude oil feed to crude distillation unit (first Czech unit) in Daura Refinery which is a blend from many tanks of different sources of crude oil feeding Daura refinery from Kirkuk, Basra, and Basra Med. The important tests which take it in consideration in this research:

1-American Petroleum Institute (API gravity @ 15.6): standard IP-160 or ASTM – D-1298 [5].it is the Density or weight of unit volume of material.

2-Specific Gravity @ 15.6: is the ratio of the weight of a unit volume of oil to the weight of the same volume of water at a standard temperature. [1]

$$\text{Deg API} = 141.5/\text{sp gr} - 131.5 . \quad \ldots (13)$$

From ASTM -IP Petroleum measurement tables the specific gravity of crude oil will measure at certain API value.

3-Density @ 15.6: weight per unit volume, pounds per gallon. [1]

$$\text{Density, lb per gal} = \text{sp gr} * 8.328 \quad \ldots (14)$$

4-Salt content : standard IP -77.determination of total salts content of crude oil in ppm.
5-Water and Sediment: standard IP -75. Determination of Water and Sediment content of crude oil in vol%.
6-Kinematic Viscosity :the viscosity in centipoises divided by the specific gravity at the same temperature.
7-Sulfur content: determination amount of sulfur contained in crude oil by wt%.
8-Pour point: is the lower temperture which the crude oil can be flowing with it .measured in Centigrade.
9-Vanadium : is the amount of vanadium content in crude oil .
10-Nickel: is the amount of nickel content in crude oil .
C.Microsoft office Access 2007
It is a database engine built-in with software development tools and graphical User Interface (GUI) .Used to build database for storing information in order to reference, analysis and reporting stored data. The bases of Access database is the table which contain:
Field: a column of certain type of data. It can store many types of data like: number, text, Date.
Record: it is a row of data about specific entity.
The database in Microsoft Access program can combine more than one table, as well as relating tables by relationship; also Microsoft Access program provides the possibility of creating forms, Queries, generate reports and import or export tables to Microsoft Excel, word, word pad, etc.

DEVELOPING DATABASE AND APPLYING STATISTICAL METHODS

Daura database was developed in Microsoft Access program at February 2013 and include:
A -Tables
1-Daily tests table
Used to store results of daily tests of crude oil feed to first Czech unit and include five fields: test date, API, Density, Specific gravity, Salt content and water &sediment. (As illustrated in Figure (8)).

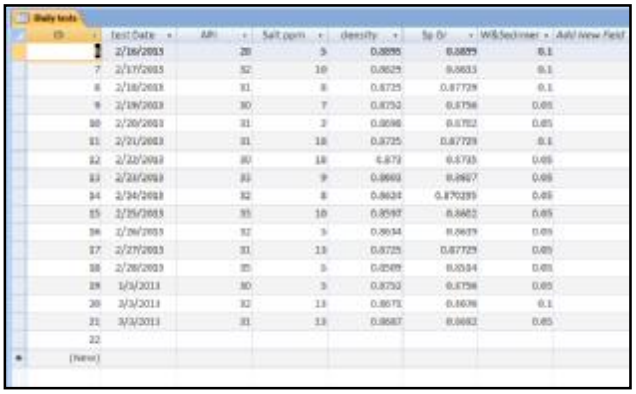

Figure (8) daily test table.

2-Monthly tests Table

It combine many fields to store the information of monthly tests carried on crude oil, such as: tests date, API, Density, Specific gravity, Salt content and water &sediment, sulfur content, kinematic viscosity fields at 10 ^{o}C,21.1 ^{o}C,37.8 ^{o}C,50 ^{o}C, pour point ,R.V.P ,Ram.Carbonresidue ,Asphaltenes content ,vanadium, nickel, KUOP characterization factor, Water content, distillation IBP,Rec @50 ^{o}C,75,100,125,150,175,200,225,250,275,300^{o}C,total distill.(As illustrated in Figure (9)).

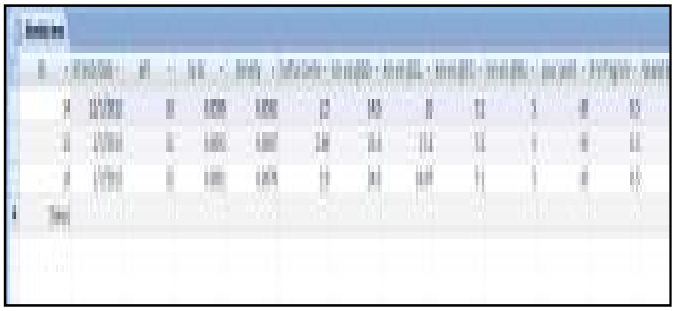

Figure (9) monthly tests Table.

3-Crude oil feed specification

This table store the required specification of crude oil feed to first Czech unit from three sources Kirkuk, Basra, Basra Med,It include following fields: API, Specific gravity, Salt content and water &sediment, sulfur content,H_2S, kinematic viscosity fields at 10 ^{o}C,21.1^{o}C,37.8 ^{o}C,pour point, content ,vanadium, nickel, KUOP characterization factor, Water content, distillation IBP, R.V.P,Ram.Carbonresidue, Asphaltenes,Rec @50 ^{o}C,60,70,80,100,120,150,180,200,250,300^{o}C,350,400,500,total distill and Light ends of C_2,C_3,i-C_4,n-C_4,i-C_5,n-C_5. (As illustrated in Figure (10))

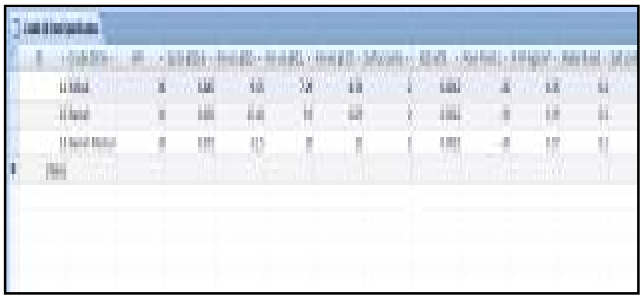

Figure (10) Crude oil feed specification Table.

4-Sulphur, Viscosity final Tank product

It contain: date test, motor spirit sulphur, kerosene sulphur, gas oil sulphur, diesel fuel sulphur, fuel oil sulphur, fuel oil viscosity. (As illustrated in Figure (11))

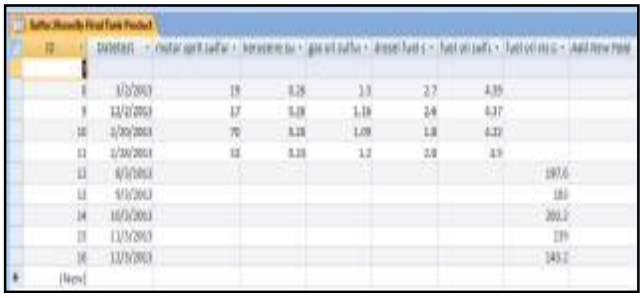

Figure (11) Sulphur, Viscosity final Tank product Table.

5-API Vis final product

Contain the following fields: date test, L Naphtha API, H Naphtha API, kerosene API,gas oil API, gas oil viscosity ,H gas oil API,H gas oil viscosity ,R C API,R C viscosity 100 ^{o}C ,R C viscosity 50 ^{o}C. (As illustrated in Figure (12)).

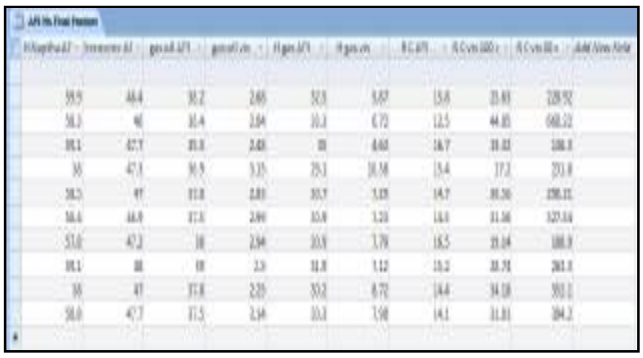

Figure (12) API Vis final product Table.

B-Forms:

Microsoft Access program generate form as interface in database, Daura data base combine three forms first one Daily tests form1 Figure (13), monthly tests, and crude oil feed specification form. The Daily tests form1 equipped with many button for new record, print record, etc.

C-Reports:

There is many reports in Daura data base such as Daily tests report Figure (14), Monthly test1 and monthly test2 Figure (15), crude oil feed specification.

D-Queries:

There is many queries viscosity pour point query2, API Specification query1, salt and water query1 Figure (16), vanadium nickel query, sulphur query.

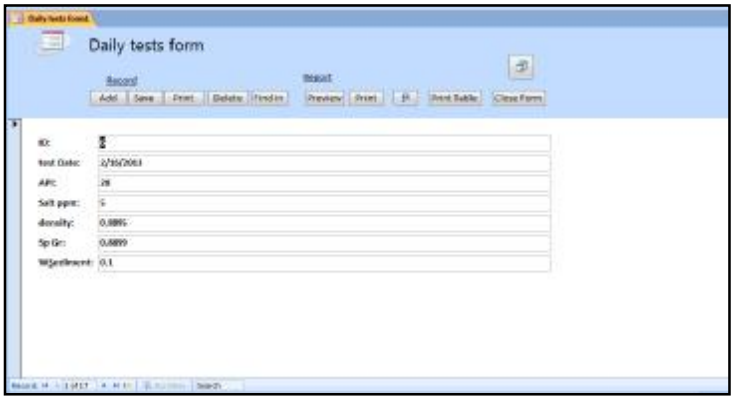

Figure (13) daily tests form1.

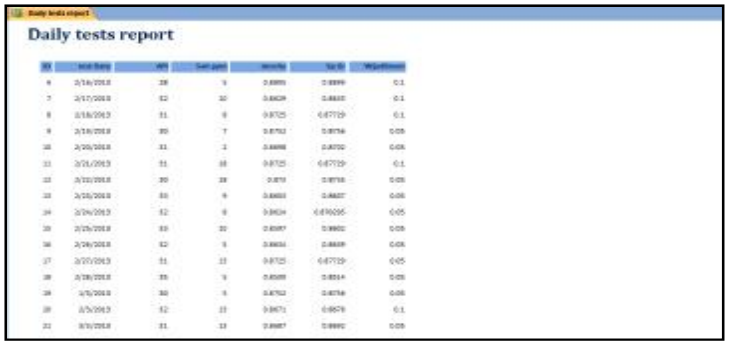

Figure (14) daily tests report.

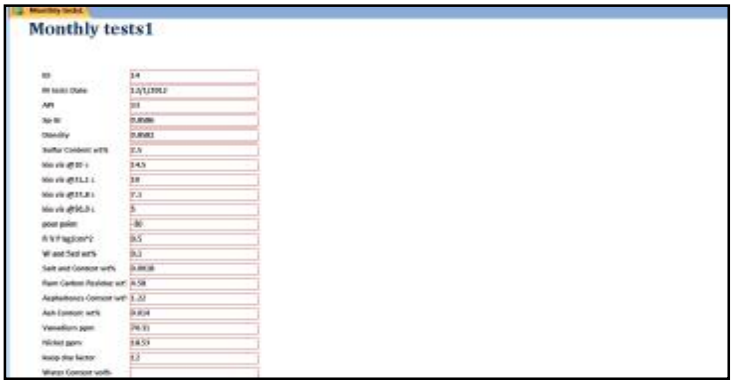

Figure (15) monthly test2 Report.

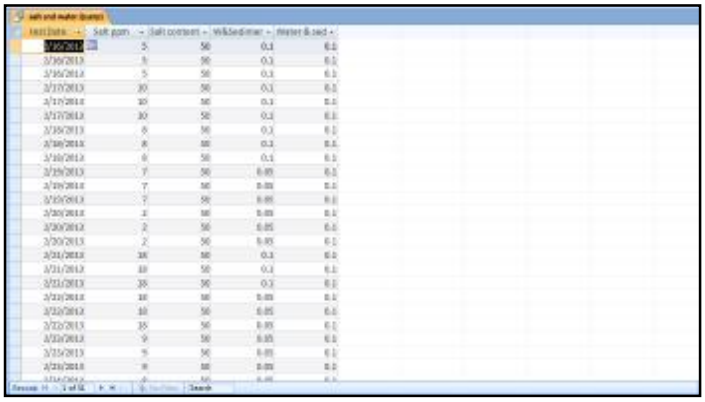

Figure (16) salts and water query1.

RESULTS AND DISCUSSION

The results showing in the following points:

A-the statistical quality control tools applied on laboratory results of crude oil feed stored in Daily tests table which exported to Microsoft Excel program gave the following results:

1-the mean chart, range chart and c-chart applied on API field data. As shown in mean chart Figure (17) all the points fall within the control lines and therefore the quality of crude oil feed for the API property located within acceptable specification.

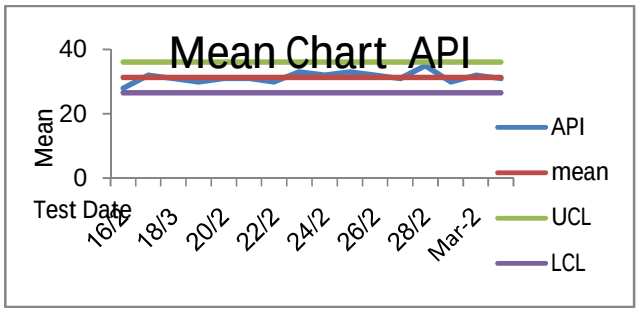

Figure (17) mean chart for API.

While in Range chart Figure (18) there is a single point beyond the control limit. We see a trend of three points up or down .these variation due to blending crude oil feed from three source tanks (Kirkuk, Basra, and Basra Med) which vary in API from 35.8, 33.6 to 30.5 and that depend on the required quantity and which crude oil tank available.

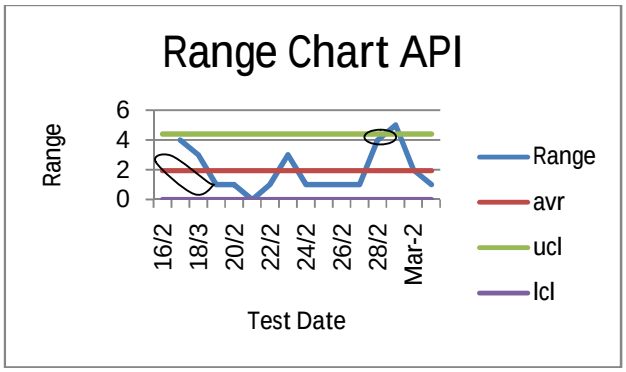

Figure (18) Range chart for API.

In c-chart Figure (19) the quality of API within control limits.

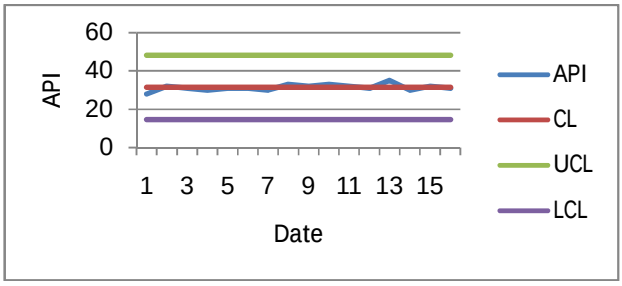

Figure (19) c-charts.

API value is an important property because it related to specific gravity and density of crude oil which sold on these bases and used to verify the consist of the crude oil.

2-Salt content of crude oil feed show many change with time as shown in mean chart Figure (20) but these change within control limit.

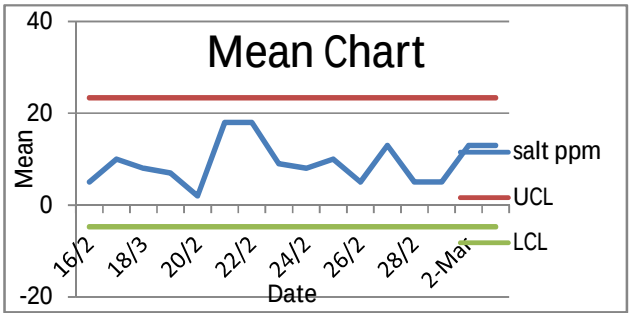

Figure (20) mean chart for salt content.

In Salt Range chart Figure (21) there is a single point beyond the control limit, also there is many variation up and down around average range line due to blending crude oil from various supply.

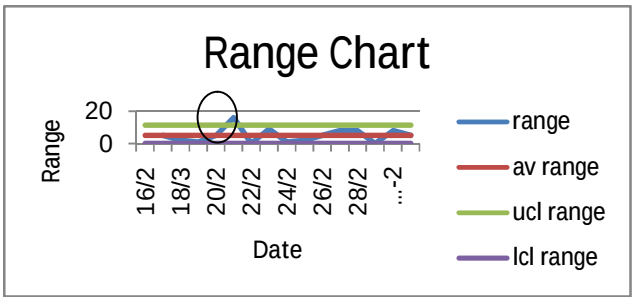

Figure (21) Range chart for salt content.

For c-chart Figure (22) the quality of crude oil feed for salt content located within acceptable specification.

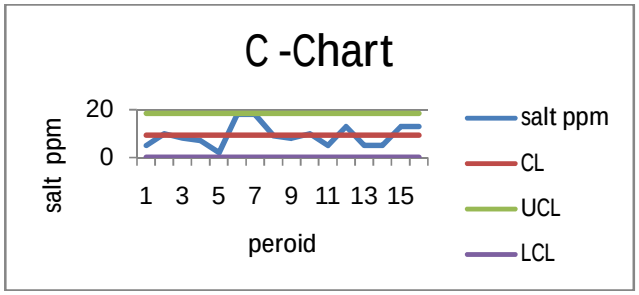

Figure (22) c- chart for salt content.

Salt content(sodium chloride,magnisum chloride,calicum chloride) must be less or no more than 50 ppm and it must be eliminated by desalter otherwise the presence of salt will lead to blocking heat exchanger ,equipment corrosion,and irregulatoriy in distillation operation.

3-for Water & Sediment of crude oil feed the quality located within acceptable specification as shown in mean chart Figure (23).

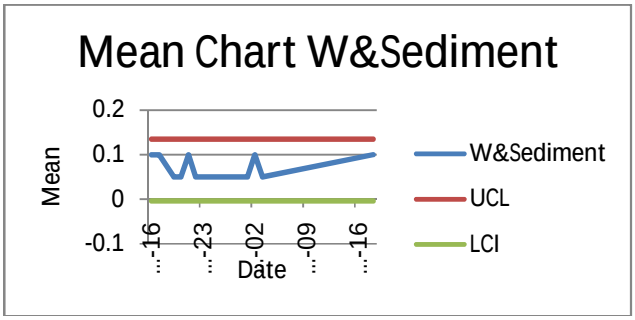

Figure (23) mean chart for Water and Sediment.

For Water & Sediment Range chart Figure (24) there is three points beyond the control limit.

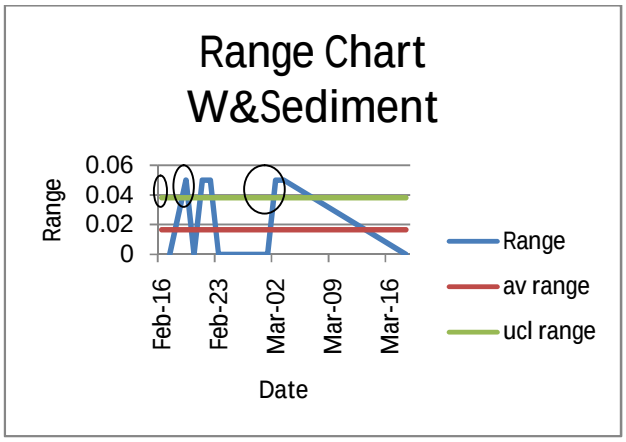

Figure (24) Range chart Water & Sediment.

For Water & Sediment c- chart Figure (25) the quality of crude oil feed located within acceptable specification.

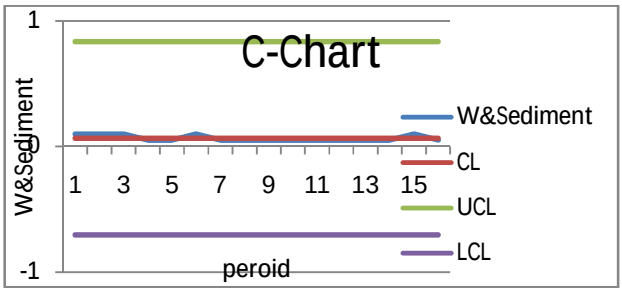

Figure (25) c- chart for Water & Sediment.

Water content in crude oil can found as emulsion or as large drop and it must removed and decreased at oil field otherwise water with dissolved salt will lead salt problem, while water alone will cause irregularity in distillation operation, also if there is a large amount crude oil will consider as condensate .water and sediment will hurts equipment such as heaters and exchanger, also water and sediment are main reason for sludge tank. Water and sediment must be no more than 0.1 vol%.

B-generate Queries in Microsoft Access program is one of database tools .the following points explain it:

1-Viscosity pour point Query2: by comparing kinematic viscosity test result at 10 ^{o}C, 37.8 ^{o}C with the values of kinematic viscosity of crude oil specification from Kirkuk, Basra, Basra med which ranging from 9.55 to 31.5(average kinematic viscosity at 10 ^{o}C =18.83) we will see that monthly test of kinematic viscosity of blend crude oil within acceptable specification. Figure (26) Viscosity is an important property for transportation of crude oil because it was the measure of flow it is depending on temperature.

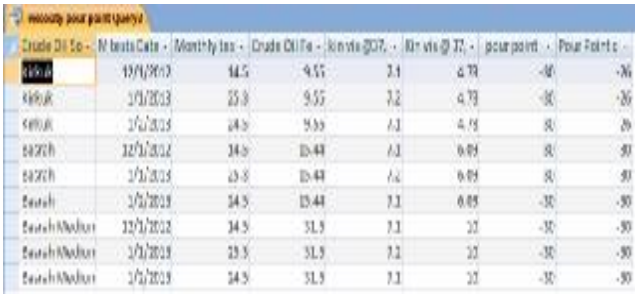

Figure (26) Viscosity pours point Query2.

2- Sulfur Query: The crude oil specification for sulfur content ranging from 2.0 -3.0 wt% and by comparing month sulfur test result of blend crude oil feed we see sulfur content test result oil within acceptable specification. Figure (27)

ID	M test date	M test sulfu	Crude oil sp	crude oil sou
1	1/12/2012	2.5	2	Kirkuk
2	1/1/2013	2.86	2	Basrah
3	1/2/2013	2.9	3	Basrah Med
(New)				

Figure (27) Sulfur Query.

Removal of sulfur contained in crude oil important to avoid sulfur Oder and corrosion by mean of petroleum products especially with high temperature, also sulfur content is one of important properties affect on crude oil price because it is a measure if the crude oil was sour or sweet crude oil.

3-The vanadium content of crude oil specification range from 20 ppm of crude oil source Kirkuk field, 16.5 ppm of crude oil source Basra, and 30-39 ppm of crude oil source Basra Med and by comparing this values with vanadium test results of blend crude oil feed to first Czech unit we see that vanadium content more than required value. (See Figure (28)).

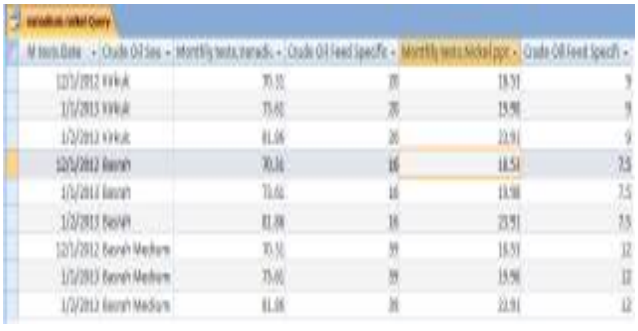

Figure (28) Vanadium Nickel Query.

Vanadium is one of metals content in crude oil affect on activity of catalyst, resulting in side reaction, causing corrosion in unit operation equipment.

4-The nickel content of crude oil specification range from 9 ppm of crude oil source Kirkuk field, 7.5 ppm of crude oil source Basra, and 7-12 ppm of crude oil source Basra Med and by comparing this values with nickel test results of blend crude oil feed to first Czech unit we see that nickel content more than required value. It is range from 18.53 to 23.91 ppm. Nickel cause decreasing catalyst activity and lead to side reaction. (See Figure (28))

CONCLUSIONS

The research showed following conclusions:

1-saving laboratory tests results electronically are better than paper.

2-using database give the employee possibility of recovering stored data again and display it.

3-statistical programs available and inexpensive and easy to use like Microsoft Access program.

4-statistical programs such as Microsoft Access and Excel provides user with statistical tools for quality control as well as created required forms, queries, generate reports for created database.

5-displaying stored laboratory tests results in database give interested employee the opportunity to see data comprehensively especially with using control charts.

6-using control charts give good results even a few data available and give information about the quality of manufacturing process. In Range chart Figure (18) there is a single point beyond the control limit indicating that the crude oil has been withdrawing from one tank have high API instead of blending from many tanks. The same thing with Figure (21) for salt content, while in Range chart Figure (24) For Water & Sediment there is three points beyond the control limit which indicates the presence of water with crude oil has not been removed from crude oil in oil field before sending to Daura refinery.

7-evaluation of crude oil is very important because it give information about crude oil properties and impurities.

8-there is a need to conduct laboratory test on the crude oil expected problems.

9-using database with explained tools will give employee opportunity to compare laboratory tests results with crude oil specification easily.

10-necessity for commitment with set specification of crude oil feed to first Czech unit.

11-the laboratory test result of vanadium and nickel show a high percentage in crude oil supplied to first Czech unit, so there is a need to address this problem and using pretreatment to crude oil feeding to distillation unit and commitment with required specification of crude oil because it will lead to corrosion in distillation tower, decrease the activity of catalyst, get unwanted side reaction. Also vanadium problem will appear in petroleum oil products such heavy fuel oil causing corrosion and damage in equipment.

12-using database electronically will give good quick results in short time comparing with make it manually.

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